This Symposium, held on the occasion of the 5 th anniversary of the Zodiac accommodation (Department of Animal Sciences) was sponsored by:

- Stichting Fonds Landbouw Export Bureau 1916/1918, Wageningen
- Produktschap voor Veevoeder, 's-Gravenhage
- Produktschap voor Vee en Vlees, Rijswijk
- Produktschap voor Pluimvee en Eieren, Zeist
- Centrale Vereniging voor de Coöperatieve Industrie, 's-Gravenhage
- Nederlandse Zoötechnische Vereniging, Driebergen

(PAD)

ANIMALS AS WASTE CONVERTERS

Proceedings of an
International Symposium
Wageningen, Netherlands
30 November - 2 December 1983

Editors: E.H. Ketelaars and S. Boer Iwema

Pudoc Wageningen 1984

CIP-gegevens

Animals

Animals as waste converters : proceedings of an international symposium Wageningen, Netherlands 30 november - 2 december 1983 / editors E.H. Ketelaars and S. Boer Iwema. - Wageningen : Pudoc
ISBN 90-220-0857-6
SISO 633.3. UDC 636.087
Trefw.: veevoeder.

Printed in the Netherlands

Contents

Contents 5

S. Boer Iwema, Preface 7

Session 1

LITTER AND MANURE 9

Opening: F. de Boer: Litter and Manure 10

J.P. Fontenot, Utilization of animal waste by feeding - special emphasis on USA 12
C.L. Benham, Toxicological and other public health aspects of recycling poultry manure 22
Posters
M.A. El-Ashry, A.M. El-Serafy, H. Khattab, H. Seliman, A. El-Mawla, In vitro and in vivo nutritional evaluation of buffalo manure 28
M.E. Ortega, O. Rojas, F. Perez-Gil, Nutritional evaluation of ensiled ground sorghum-pig faeces mixtures 31
M.A. Razzaque, A. Al-Awadi, A. Al-Nasser, A.J. Salman, Utilization of corrugated cardboard boxes and dried poultry manure as dietary ingredients by sheep: in vitro and in vivo studies 33
S.F. Spoelstra, L. Tjoonk, A. Steg, Ensiled mixtures of cage layer manure and whole crop maize for fattening bulls 36
G. Walker, Incorporation of surplus vegetables and fruit into broiler litter for feeding to beef 39
Discussion 42

Session 2

WASTES OF PLANT ORIGIN 45

Opening: A.J.H. van Es: Wastes of plant origin 46

G. Alderman, Chemical treatment of cereal straws by on-farm-processes 48
Ch. V.Boucqué, Feeding value of some waste- and by-products of blend origin and their use by beef cattle 54
Posters
Ch. V. Boucqué, L.O. Fiems, B.G. Cottyn, F.X. Buysse, Sodiumhydroxide-treated strawpellets in complete dry diets for finishing beef bulls 62
H.N.L. Endeley, J.Tchoumboue, M.D.Tchouken, Substitution of cotton seed cake by rubberseed cake in the feeding of broiler chickens 65
H.N.L. Endeley, D. Pone Kamden, The effect of superimposing graded levels of cane molasses on diets containing graded levels of protein on the performance of broiler chickens 67
H.N.L. Endeley, Substitution of dried ground cocoa husk for maize in grower- finisher broiler rations 69
G.A. Kaasschieter, H.B. Perdok, N.M. van Wageningen, M.C.N. Jayasuriya, Performance of lactating Surti buffaloes fed urea ensiled rice straw with or without supplementation of Leucaena Leucocephala, Gliricidia maculata and coconut cake 70
G.A. Kaasschieter, H.B. Perdok, N.M. van Wageningen, M.C.N. Jayasuriya, Economic feasibility of (urea treated) straw based rations for lactating Surti buffaloes in Sri Lanka 72
G. Krishna, Possibilities of ensiling paddy straw with agro industrial by-products and wastes and nutritive value in cross bred cow calves 74
B. Smits, D. Oostendorp, Ensiled maize gluten feed as a feedstuff for pigs and beef cattle 75
A. Steg, D. Oostendorp, B. Smits, Grain stillage and spent mycelium slurry for beef bulls and pigs 77
S.P. Tiwari, G. Krishna, Studies on feeding of culled Guar seed (cyamopsis tetragonoloba (L) Taub) in growing buffalo 79
S.F. Spoelstra, L. Tjoonk, Ensiling kitchen wastes from private homes for animal feeding 80
Discussion 81

Session 3

WASTES OF ANIMAL PROCESSING 85

Opening: S. Boer Iwema, Wastes of animal processing 86

W. Edel, Health aspects of slaughterhouse waste converting by animals 87
J.M. Vandepopuliere, Feeding poultry waste to livestock 92
Posters
H. Meyer, Investigations about conserving and feed value of rumen contents of slaughtered cattles in cattles and pigs 99
R.W.A.W. Mulder, W.M.M.A. Janssen, J.P. Holsheimer, N.M. Bolder, A.W. de Vries, Flocculation-Flotation (F-F) sludge to be used as feedstuff for poultry 100
B. Smits, A. Steg, Flotation sludge from slaughterhouses as a feedstuff for pigs 101
H.N.L. Endeley, Availability of agro-industrial and abattoir by-products and the possibilities of their utilization in livestock feeding in Cameroon 103
A.P. Hopwood, Protein recovery from food processing wasste waters 105
D.H. Machin, D.A. Hector, A. Swan, W.H. Parr, Utilization of poultry offal hydrolysate (POH) as a feed for livestock in the tropics 107
P.J.Newman, Production of edible fibres from recycled waste animal protein 109
P.J.G. Oostenbach, E.H. Ketelaars, C.W. Scheele, Efforts to improve the use of frying fats in poultry diets 118
M.C. Papadopoulos, A.R. El-Boushy, A.E. Roodbeen, E.H. Ketelaars, Feather meal protein and amino acid digestibility under different processing conditions 120
M.C. Papadopoulos, A.E. Roodbeen, L.J.G.M. Bongers, Preliminary study on feather meal lanthionine evaluation 121
C.W. Scheele, A study on variations in feeding value of renderers fat with poultry 122
Discussion 124

Session 4

MICROBIAL PRODUCTS FROM WASTE 129

Opening: P. van der Wal: *Microbial products from waste** –

C.J. Soeder,Bioconversion of faecal residues 130
F. Zadrazil, Bioconversion of lignocellulose rich residues* –
Posters
R. Parra, R.M. Dixon, A. Escobar, O. de Parra, J. Carera, N. Roman, Residual sludge from brewery water treatment plants as a ruminant feed 137
H.C. Reijntjes, Earthworms as converters of organic waste 139
G.L. Schroeder, Manure-loaded fish ponds: Some insight gained by stable-isotope analyses 141
J.C.H. Shih, Biogas and by-products from a poultry waste digester 142
Discussion 144
List of participants 147

Author index 153

*Contribution not received for publication

ANIMALS AS WASTE CONVERTERS

S. Boer Iwema

Agricultural University, Department of Animal Nutrition, Wageningen

With the slogan "Animals as waste converters we understand during this symposium by the word animals the farmlivestock and nowadays also inland fishes. The definition of waste or offals is much more complicated; in any case with waste is meant a large number of quite different products having more or less feeding value for animals. Partly it were - and still are -byproducts from the harvest on the farms and used there (f.i. straw, chaff, beettops and -leaves a.s.o.). Also byproducts from the food- or stimulantsindustry of plant origin are offals or waste. Offals from slaughterhouses, some byproducts from the dairy industry (cheesewhey a.s.o.) and also the products of dead animals are seen as animal feeds. Nowadays quite other products come in the picture, f.i. litter and manure. Besides that, there are new developments to upgrade well known products like straw and chaff, sawdust a.s.o.

During this symposium there will be spoken about the improvement of those products and also about products till now not used for feeding purposes at all. To the first group belongs straw, to the other f.i. litter. It is handling around amelioration or around acceptability by the animals.

There are some aspects we have to keep in mind. Firstly the acceptability and digestibility by the animals, secondly the safety for the animal health, thirdly the acceptability, digestibility and safety for the consumers of the animal endproducts, like milk, meat and eggs.

Already many centuries waste products or offals like straw, chaff, bran, beetpulp, molasses, oilcakes a.s.o. are used and worldwide accepted as normal feedstuffs for the farmlivestock. The utilisation of those products means an important influence on the costprices of the main products, like bread, sugar, oils and fats. These byproducts are nowadays normal ingredients in the feeding of our animals. Nobody will call them waste or waste products, mostly they are called offals or still better byproducts. But that may alter, that is to say the former byproducts called above will stay in animal nutrition, but quite new products may come.

There are two reasons for these alterations: the world shortage in animal feeds (mostly in developing countries) and a surplus of products, more and more seen as a real waste (mostly in industrialised countries). Sometimes the products have to be converted in acceptable form (f.i. chemical or physical treatments), in other cases these products have to be handled and treated to get a quite new feedstuff (treatment of manure, litter, slaughteroffals a.s.o.).

A new development is coming: the utilisation of products, not usable for warm blooded animals, but converted by microbes, flies, worms a.s.o. to get quite new products from animal origin usable - as such or may be partly - for our farmlivestock (f.i. products made from yeast, flies a.s.o.). The start for these new products is given by environmental pollution in the soil, the water and in the air. The aim is to get rid of those unwanted products and to get products usable in the society.

With these new developments I come to the real aim of the symposium: the possibility to convert bad or unacceptable products into products not dangerous to but usable for farmanimals, inclusive fishes.

A part of these problems we can find in the developing countries (f.i. to convert straw chaff from rice and other products) , an other part we find in industrialised countries where some products (like litter and manure) might give problems if there takes no place an conversion to acceptable products.

Of course one has to be aware that one and another must be done on economical scale and that the new wasteproducts (byproducts from the new, unknown feedstuffs) are acceptabel for environmental pollutions. With the increasing world population and the demand for animal endproducts the need for feedstuffs is increasing considerable; the production of more, better and new strains of grasses, grains, pulses a.s.o. can not solve all problems because there is a shortage of soil. The till now produced primary feedstuffs will in the near future decrease pro animal. Our generation has to give a solution of this problem and the organizing committee hopes that this symposium will give us the idea where we are and also an idea about possible solutions in new products that have to be solved in the near future. The world population is waiting for solutions to get more and better animal products in the diet of everybody. In the same time it is hoped that the environmental pollution will decrease.

With these words of welcome and of reflection I declare open the second symposium of " Zodiac ".

****

BYPRODUCTS AND WASTES IN ANIMAL HUSBANDRY

F. de Boer

Institute for Livestock feeding and Nutrition research (IVVO), Lelystad, Netherlands

Summary

Byproducts and wastes -that part of by-products which is not consumed by animals- go always together with any production process. So in vegetable food-production 50% of dm in food crops appears to be by-products and wastes.

Animals readily eat a substantial part of all byproducts and produce about 1/3 of food protein and about 1/6 of food energy for global population.
In that particular food production process large quantities of solid and liquid wastes are produced: In the Netherlands about 10^7 tons dm yearly.
Although pigs and poultry produce only a share of 20-25% of that amount their waste causes most problems (over-fertilization, bad odours, pollution) because of massive concentrations of large units in a few regions.
Amongst various solutions to alleviate these problems consumption of some poultry waste by ruminants may play a modest role. However consumers' acceptability of that procedure appears to be low. Still coprophagia is a wellknown phenomenon in the animal world. Therefore cutting down part of the criticisms may be very well justified.

General introduction

Any production process provides the main products, which it is applied for, and one or more byproducts. So agriculture -and we are all involved in it in this Symposium- produces food and many byproducts.
Even primary food production -vegetable origin- in general produces about 50% of its dry matter in byproducts. Some of these are wastes, that is to say the group of byproducts not being consumed by animals. Byproducts are eaten readily and thus applied abundantly in livestock husbandry.
So livestock is a primary food producer also as far as utilizing materials not or not at all applicable for direct human consumption.
In this country and in this time of the year people always try to say things in "would-be-poetry", such as:

What humans do not like to eat
Becomes through animals milk and meat.

Animals aupply in this world nearly 1/3 of food protein and over 1/6 of food energy. Ruminants provide nearly one half of the protein and some 60% of the energy (Winrock, 1978).

In producing all that food animals eat feed as well as food, digest it, resorb nutrients and excrete waste; large quantities of solid and liquid waste.

Table 1. Average production of excreta by Dutch livestock.

	g dm·day^{-1}		kg dm·year^{-1}	10^6 tons per year
	fae-ces	urine	faeces + urine	(1982)
dairy cow	5200	600	2117	5
fattening pigs	400	50	164*	
laying hens	35	-	13	1.3

* 3 pigs fattened per year, in average

Adding the estimated waste production of other classes of livestock such as calves, heifers, bulls, sheep, sows and broilers the yearly production of animal wastes in the Netherlands is estimated to be about 10 x 10^6 tons dm.
The larger share of it (75-80%) is ruminant waste. As cattle husbandry basically still is area-bound cattle waste accumulation on small spots seldom occurs in the Netherlands. That is much more true still for any area in the world with cattle husbandry except in some regions with feed lot enterprises.
Although pig- and poultry farms produce only 20-25% of all animal excreta in the Netherlands the problems they meet are large. That also is valid for other countries.
Massive populations of pigs and poultry in farms with very limited acreage and, on top of that, heavy regional concentrations of many such enterprises cause ever more frequently unbearable accumulation of wastes. Bad odours for neighbouring villages and overfertilization of soil evoke ever more complaints in society. In a small, densely populated country as the Netherlands -with smaller distance between noses of people and concentrations of pigs or poultry than in

countries with lots of space- that causes much concern. Elsewhere, even in much larger countries, these problems are met also in specific regions.

Various solutions to overcome the inconvenience have been conceived and tried out in research. So, methane production from wastes attracted and still attracts much attention, but economic and reliable systems appear to be very scarce. Moreover it solves only the stench problem, not the bulk problem.

Feeding wastes to livestock is another try to solve part of the problem. That is nothing new. Accepted feedstuffs, byproducts now, were formerly wastes: feathermeal, tankage and condensed molasses solubles are a few examples. There is no opposition any more against their application as animal feedstuff.

Some wastes, especially litter and manure, appear to be hardly acceptable, if at all as a feedstuff. The idea of animals consuming excreta from others evokes opposition in society.

However coprophagia is a known phenomenon in the animal world. So, why -on second thought- not consider seriously possibilities to solve part of a problem in society in this way, when animals are able to cope with it and produce good and safe food at that. And, by the way, some consumers, objecting to this kind of feeding animals, ought again to relativate a bit, remembering that swallow's nests, complete snails and frog's legs seem to be very much appreciated food.

References

Winrock International. 1978. The role of ruminants in support of man.

UTILIZATION OF ANIMAL WASTES BY FEEDING - SPECIAL EMPHASIS ON UNITED STATES OF AMERICA

J. P. Fontenot

Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061, U.S.A.

Summary

Animal wastes have nutritional value, especially for ruminants. It appears that the poultry wastes have the highest nutritional value, followed by swine waste and cattle waste. The level of waste fed will depend somewhat on price of the waste, relative to the price of other ingredients, and the level of production in the animals fed the waste. The waste can be rendered free of pathogenic organisms by heat treatment, a combination of chemical and heat treatments, deep stacking or ensiling. The only documented harmful effect on animal health from feeding of animal waste has been copper toxicity in sheep fed broiler litter containing high levels of copper. It does not appear that this would be a problem in cattle, since they are not as sensitive to high copper levels. Pesticide residues in animal wastes have not been shown to be a serious problem. The medicinal drug residue problem in meat producing animals fed waste such as broiler litter and swine waste does not appear to be serious, but adequate withdrawal periods should be used. Heavy metals do not present a serious problem in feeding animal waste. Sizeable amounts of animal wastes are fed to animals in the U.S.A. Wastes have more monetary value as sources of feed than for fertilizer or methane generation.

Introduction

Animal wastes are valuable resources if managed properly. Approximately 123 million tons of waste, dry basis, are produced annually in the United States (USA), of which 57 million tons may be recovered economically (Van Dyne & Gilbertson, 1978). The distribution of amounts by class of animals is shown in table 1. A large portion of the wastes is from animals managed under intensive systems, frequently close to municipalities, lakes and streams. The wastes may be sources of contamination to water supplies and a risk to human health and comfort, unless they are handled judiciously. However, the wastes contain nutrients which may be utilized by plants and animals.

In the past animal wastes have been used mainly as fertilizer, but at least under some economic conditions the plant nutrient value of the wastes is not high enough to justify the cost of hauling and spreading (Wadleigh, 1968). Furthermore, land disposal or use as fertilizer may be difficult, if not impossible, for large concentrated animal production systems.

Since wastes have nutritional value for certain phases of animal production, feeding should be a more economically feasible approach than disposal or use as fertilizer. The relative value of the nitrogen in animal waste is higher if used as feed than fertilizer (Fontenot and Jurubescu, 1980). Furthermore, some of the energy in the wastes is available to animals and is of essentially no value to plants. Generally, animal wastes are high in fiber and some are high in nonprotein nitrogen (NPN) indicating they are most efficiently utilized for feeding ruminants. Several reviews are available concerning utilization of animal wastes by feeding, including those by Anthony (1971), Smith (1973), Bhattacharya & Taylor (1975), Smith & Wheeler (1979), Fontenot & Jurubescu (1980), Fontenot & Ross (1980), Fontenot et al. (1983) and NRC (1983).

Nutritional Value of Animal Wastes

The relative nutritional values of broiler litter, caged layer waste, swine waste and cattle waste are shown in table 2. The poultry wastes are the most nutritious.

Table 1. Livestock and poultry waste production in the United States in 1974[a] (1000 tons of dry matter)

Class of animal	production	Collectable
Beef cattle (range)	57,331	2,089
Feeder cattle	18,093	17,621
Dairy cattle	27,764	22,421
Hogs	14,714	6,099
Sheep	4,181	1,872
Laying hens	3,716	3,589
Turkeys	1,378	1,083
Broilers	2,297	2,681[b]
Total	122,866	57,455

[a]Van Dyne and Gilbertson (1978).
[b]Includes litter.

Cattle Waste

These wastes are usually lower in protein than poultry wastes. Average values, dry basis (table 2), are 20% for steer and 13% for dairy cow waste. Crude fiber is higher and nitrogen is lower for cattle than poultry waste. Dry matter digestibilities of 22 to 27% were reported for dairy cattle waste

Table 2. Nutritional value[a] of animal wastes

Item	Kind of waste				
	broiler litter[b]	dehydrated caged layer waste[b]	steer waste[b]	cow waste[b]	swine waste[c]
Crude protein, %	31.3	28	20.3	12.7	23.5
True protein, %	16.7	11.3		12.5	15.6
Digestible protein, %	23.3	14.4	4.7	3.2	
Crude fiber, %	16.8	12.7			14.8
Ether extract, %	3.3	2		2.5	8.0
NFE, %	29.5	28.7		29.5	38.3
Dig. energy[d], kcal/g	2440	1884			
Metab. energy[d], kcal/g	2181				
TDN[d], %	59.8	52.3	48	45	
Ash, %	15.0	28	11.5	16.1	15.3
Calcium, %	2.4	8.8	0.87		2.72
Phosphorus, %	1.8	2.5	1.60		2.13
Magnesium, %	0.44	0.67	0.40		0.93
Sodium, %	0.54	0.94			
Potassium, %	1.78	2.33	0.50		1.34
Iron, ppm	451	0.2	1340		
Copper, ppm	98	150	31		63
Manganese, ppm	225	406	147		
Zinc, ppm	235	463	242		530

[a]Dry basis.
[b]Adapted from Bhattacharya and Taylor (1975).
[c]From Kornegay et al. (1977).
[d]Ruminants.

by Smith et al. (1971). Dry matter digestibility of dried fecal waste from beef cattle fed a ration containing 50% roughage was approximately 15% (Lucas et al., 1975a). Evidence was obtained that drying the cattle waste at high temperatures may have adversely affected digestibility. Undoubtedly, the roughage in the ration fed the cattle producing the waste would affect composition and digestibility of the waste. Lucas et al. (1975b) found that dry matter digestibility by sheep, calculated by difference, was 24% for waste from cattle fed a ration containing 50% roughage and 53% for waste from cattle fed a ration containing 10% roughage. Crude fiber contents were 19.6 and 6.7%, dry basis, for the two respective wastes.

Smith & Wheeler (1979) summarized the relative performance of cattle fed cattle waste and a control ration. The cattle fed the waste were fed an average of 12% cattle excreta, dry basis. Daily gains were 1.16 kg for the control cattle and 1.14 kg for those fed cattle waste. Feed intake was similar. The cattle fed the waste required approximately 5% more dry matter per unit of gain than the control animals.

Swine Waste

Kornegay et al. (1977) reported that swine waste contained 23.5% crude protein, 2.72% calcium and 2.13% phosphorus, dry basis. Digestibility of dry matter and crude protein, in swine waste, calculated by difference, was 48% and 60%, respectively. Sheep and cattle were fed various levels of dried swine waste with hay in Australia (Pearce, 1975). In the cattle trial 0 to 45% of the hay in a pelleted diet was replaced by dried swine manure. Large depressions in dry matter digestibility resulted from including 15 or 30% dried swine waste in the ration. Calculations indicated that dry matter digestibility of the waste was about 29%. Similar results were obtained from sheep. The acid detergent fiber and the ash contents were high in the wastes used in Australia, compared to waste from swine fed a conventional corn-soy growing-finishing ration in the USA.

Poultry Litter

The waste may be collected from broiler or turkey houses. Broiler litter is usually high in nitrogen (crude protein), averaging 31% crude protein, dry basis (Bhattacharya & Taylor, 1975), but varies considerably in this component. Approximately 40 to 50% of the nitrogen in litter is in the form of protein (Bhattacharya & Fontenot, 1965, 1966). The main non-protein constituent in broiler litter, uric acid, is utilized efficiently by rumen microorganisms. Uric acid has been shown to be more efficiently utilized by ruminants than urea (Oltjen et al., 1968).

Broiler litter can be an important source of energy for ruminants. Average digestibility by sheep of energy in broiler litter with peanut hulls and wood shavings as base materials, calculated by difference, was 64% (Bhattacharya & Fontenot, 1966). The litter contained 60% TDN and 2240 kcal of digestible energy and 2181 kcal of metabolizable energy per kilogram of dry matter for ruminants, calculated by difference. These values compare favorably with those of high quality roughage such as alfalfa.

As shown in table 2 the litter is rich in calcium and phosphorus and also contains substantial levels of at least some trace minerals.

Limited data are available concerning the nutrient content of turkey litter. Cross & Jenny (1976) reported that turkey litter contained 18.2% crude protein, 34.5% neutral detergent fiber and 36.6% ash, dry basis. Based on the fiber and ash contents the available energy value would likely be lower than for broiler litter.

Performance of animals fed poultry litter has been satisfactory, especially if the level of waste has been limited to that needed for supplementary protein. Performance of gestating-lactating ewes fed a ration containing chicken litter was similar to that of ewes fed a ration containing soybean meal (Noland et al., 1955). Rate of gain was similar for fattening steers fed chicken litter as for those fed cottonseed meal, if energy intakes were equalized. As shown in table 3 rate of gain of steers fed a fattening mixture containing 25% peanut hull or wood-shaving broiler litter plus 1 kg of long hay per day was similar to that of steers fed a control mixture and long hay (Fontenot et al., 1966). Feed efficiency was in favor of the litter-fed cattle. Broiler litter has been used successfully to feed growing cattle and beef cows. Smith & Wheeler (1979) summarized performance data for cattle fed poultry litter. Mean data from 93 control and 179 experimental cattle in which poultry litter comprised an average of 24% of the dietary dry matter were respectively: average daily gain, .99 vs. .94 kg; dry matter intake, 10.0 vs. 10.3 kg; feed to gain ratio, 10.4 vs. 11.4.

Caged Layer Waste

Caged layer waste has been shown to contain an average of 28% crude protein, dry basis (Bhattacharya & Taylor, 1975). Protein nitrogen makes up about 40% of the total nitrogen in the caged layer waste. Nutrient composition of the excreta is variable which may be due to the plane of nutrition of the hens and waste management systems (Evans et al., 1978). Nitrogen and ash in excreta were higher from hens fed high protein and energy diets than for those fed lower protein and energy diets. Also, accumulation of wastes under cages resulted in nitrogen losses.

The TDN content of dried caged layer waste appears to be somewhat lower than for broiler litter (table 2). Digestible energy values were 1875 kcal/kg in sheep and 1911 kcal/kg in cattle, dry basis. The high ash content of caged layer waste will lower the energy value. Evans et al. (1978) reported a 14% decrease in gross enrgy and a 33% increase in ash content in caged layer waste composted for 252 days.

Calcium and phosphorus are high in caged layer waste, especially calcium, resulting in a high calcium to phosphorus ratio (Bhattacharya & Taylor, 1975). The waste is over three times as high in calcium as broiler litter and a little higher in phosphorus.

Data concerning the performance of cattle fed DPW compared to those fed conventional protein supplements were summarized by Smith & Wheeler (1979). Data from 120 cattle in each group showed that rate of gain of cattle supplemented with DPW was similar to that of cattle fed traditional supplements. Feed intake values were 6.34 vs. 6.61 kg per day and feed to gain ratios were 6.49 vs. 7.25, respectively. From a summary of 100 dairy cows fed DPW as a supplement and 100 cows fed a control supplement the mean milk production of the cows fed diets supplemented with DPW was 40.0, compared to 40.5 kg for control cows (Smith and Wheeler, 1979). Milk fat was not affected.

The relative performance of broilers and layers fed diets containing dehydrated caged layer waste and control diets were summarized by NRC (1983). Daily gain of broilers was not markedly altered but feed/gain was increased by 10%. Egg production or feed/dozen eggs was not affected by feeding the layer waste.

Processing of Animal Wastes

Processing is important for destruction of pathogens, improvement of storage and handling characteristics and maintenance or improvement of palatability.

Considerable research has been conducted with dehydrated cattle waste (Smith et al., 1971; Lucas et al., 1975a), poultry litter (Harmon et al., 1974; Cullison et al., 1976, caged layer waste (Smith and Calvert, 1976; Tinnimit et al., 1972) and swine waste (Pearce, 1975; Kornegay et al., 1977). Harmon et al. (1974) reported that dehydration of broiler litter resulted in a substantial loss in nitrogen which could be reduced by acidifying the litter prior to dehydration. Due to the high cost of fossil fuel considerable interest has developed in methods of processing which require minimal levels of fossil fuel energy.

Ensiling Cattle Waste

Feasibility of mixing cattle waste with grass hay and ensiling the mixture was explored by Anthony (1971). The mixture consisted of 57 parts manure and 43 parts of grass hay and the ensiled material was termed "wastelage". Feeding a ration formulated to contain 40% wastelage and corn to steers produced rate and efficiency of gain similar to feeding conventionally formulated high-concentrate rations. Daily gain of 1.27 kg was reported for heifers fed wastelage made with 40 parts of cattle waste and 60 parts of a high-concentrate ration, compared to 1.34 kg for heifers fed the control ration (Newton et al., 1977). Feed efficiency values indicated 0.77 kg of waste dry matter substituted for 0.39 kg of control ration. Grain dry matter per unit of gain was decreased by 10.6% when grain was reconstituted with water and 12.6% when it was reconstituted with cattle waste collected from shallow pits (Schake et al., 1977).

Good ensiling with final pH values below 5 was reported with 70:30 to 30:70 mixtures of cattle waste and rye straw (Cornman et al., 1981). The low pH was reached after 1 wk of ensiling. Apparent digestibility was higher for waste-straw silages than for straw ensiled alone. Mixtures of 60:40 cattle waste and ground rye straw ensiled similarly with dry matter levels of 30, 40 or 50% (Aines, 1982). When sodium hydroxide was added the pH was 5.1 for silages made with waste from cattle fed a high-concentrate ration and 7.6 if the waste was from cattle fed a high-roughage ration. Addition of the alkali increased *in vitro* and *in vivo* dry matter digestibility. Satisfactory ensiling was achieved with mixtures of 60% cattle waste and 40% corn stover (Shorter et al., 1981). Dry matter digestibility was higher for ensiled mixtures than for corn stover ensiled alone.

Ward et al. (1975) reported that a high fiber silage produced by fractionization of feedlot manure, adding dry molasses and fermenting had a TDN value of 60.2%, compared to 65.2%, dry basis, for corn silage, when fed to cattle. This material contained 9% crude protein and 27.5% crude fiber, dry basis.

Ensiling Swine Waste

Good ensiling was observed with mixtures of 30:70 to 70:30 swine waste and orchardgrass hay, wet basis (Berger et al., 1981a).

Table 3. Feedlot performance and carcass quality of steers fed broiler litter (123 days)[a]

	Broiler litter rations		
	wood shav. litter[b]	peanut hull litter[b]	control ration
	kg	kg	kg
Initial wt.	379	376	391
Final wt.	536	524	551
Gain	157	148	160
Daily gain	1.28	1.20	1.30
Daily feed[c]			
mixture	11.9	11.9	13.5
long hay	1.0	1.0	1.0
Feed/gain			
mixture	9.34	9.91	10.40
long hay	0.79	0.84	0.78
total	10.13	10.75	11.18

[a]Adapted from Fontenot et al. (1966).
[b]25% litter in fattening mixture.
[c]Salt and a mineral mixture of 3 parts defluorinated phosphate, 1 part limestone and 1 part salt were provided, in addition.

Digestibility values obtained with sheep indicated that the ensiled waste was digested to a greater extent than orchardgrass hay (Berger et al., 1981b). Dry matter consumptin by sheep of the mixtures which were tested (40 or 60% waste) was comparable to that of orchardgrass hay. The smell of these two silages was similar to that of good hay-crop silage with no swine fecal odor remaining. Mixtures of swine waste and ground corn grain containing 30 to 70% swine waste, wet basis, were also ensiled (Berger et al., 1981a). Satisfactory ensiling occurred as measured by pH values and high lactic acid levels but the smell of these silages was much more disagreeable than those made with mixtures of swine waste and orchardgrass hay. Digestion trials indicate that this material was utilized well with sheep but palatability trials with silages containing 40 or 60% swine waste indicated that these mixtures were not very palatable to sheep. Feeding 25% of the ensiled 40:60 or 60:40 swine waste-ground corn mixtures, dry basis, to swine did not markedly affect digestibility (Berger et al., 1981c). However, including of 50% silage in the diet reduced digestibility of dry matter and crude protein. The dry matter intake was not markedly reduced by including up to 50% of the ensiled mixtures of swine waste and corn in swine diets but incorporating of 25 or 50% of swine waste-orchardgrass silage resulted in a marked decrease in feed intake.

Ensiling Poultry Litter

Good ensiling occurred with mixtures of broiler litter and whole plant corn silage at levels of 45% of litter, dry basis, with pH less than 5 and lactic acid levels similar to those in regular corn silage (Harmon et al., 1975a). Protein content of the silage was increased up to 18%, dry basis, by incorporating 45% broiler litter into corn silage. Voluntary intake of silage with 30% litter, dry basis, by sheep was about 75% greater than that of plain corn silage, and nitrogen was efficiently utilized (Harmon et al., 1975b). In a subsequent finishing experiment similar performance was obtained in heifers fed a corn-broiler litter silage containing 30% litter, dry basis, as for heifers fed corn silage supplemented with soybean meal (McClure et al., 1978). Total concentrate intake was 1% of bodyweight.

Ensiling broiler litter containing 19% moisture with high moisture corn grain containing 26% moisture in 1:2 ratio produced a feed with 20% crude protein, dry basis (Caswell et al., 1977). When included in a finishing ration for cattle there was a trend for higher consumption of the ration containing this silage, compared to one containing soybean meal as the protein supplement.

Broiler litter can be ensiled alone. However, in order to obtain good fermentation the moisture level should be about 40% (Caswell et al., 1978). Digestibility of proximate components and nitrogen utilization by sheep fed a ration containing litter ensiled with 40% moisture was similar as for sheep fed a soybean meal supplemented ration. Adding whey to increase the moisture content of ensiled litter was beneficial in lowering the pH if the litter had been deep stacked previously, but was of no benefit when the litter was removed from the house and ensiled immediately (Duque et al., 1978). Satisfactory performance was obtained in heifer calves fed broiler litter silage <u>ad libitum</u>, supplemented with 3.6 kg of supplement (Creger et al., 1973). Substituting ensiled broiler litter for corn silage did not lower the performance of steers until the level of litter exceeded 30% of the dry matter (Cross et al., 1978). In fact, rate and efficiency of gain were higher for cattle fed 30% broiler litter silage than for those fed no litter. Finishing cattle fed corn silage supplemented with ensiled broiler litter at a level of 30% of the dry matter performed similarly to those supplemented with soybean meal (Chester-Jones et al., 1981). In cattle fed hay-concentrate rations performance was not lowered by substituting up to 40% of the ration, dry basis, with ensiled broiler litter. There was a dramatic depression in performance when the level of litter was increased to 60%, dry basis. Cross & Jenny (1976) reported that substitution of 15 or 30% turkey litter silage for corn silage increased rate of gain in growing dairy heifers. Increasing the level of silage to 45% resulted in similar performance as for those fed the basal ration.

Ensiling Caged Layer Waste

Saylor and Long (1974) reported maximum acidity, lactic acid concentration, crude protein content and <u>in vitro</u> dry matter digestibility with an ensiled mixture of 60 parts of caged layer waste and 40 parts of hay. High levels of butyric acid were reported in mixtures containing more than 60% waste. Caged layer waste and sugarcane bagasse were ensiled in different proportions by Samuels et al. (1980). The pH of the ensiled mixtures, generally below 6, and lactic acid levels (4 to 8%, dry basis) indicated good ensiling had occurred. In metabolism trials with ensiled mixtures containing 40, 50 and 60% caged layer waste, dry basis, it was found that apparent digestibility of dry matter, organic matter and crude protein were highest for sheep fed the diet containing 60% caged waste. Dry matter digestibility of the waste, calculated by difference, averaged 65%. Among the waste-containing silages dry matter intake tended to be highest for the 60:40 silage. Caged layer waste and corn stover in proportions of 60:40 and 40:60 were ensiled alone and with 10% dry molasses (Moriba et al., 1982). The pH and lactic acid levels generally indicated good ensiling for all mixtures. Addition of molasses resulted in dramatic increases in lactic acid. Dry matter digestibility of the caged layer waste in the ensiled mixtures, calculated by difference, averaged 77%. Undoubtedly, this is higher than actual, due to the low digestibility of corn stover ensiled alone. In a palatability study dry matter intake was higher for the ensiled waste-corn stover silages than corn stover ensiled alone but was considerably lower than for a basal ration.

Canadian workers ensiled a mixture of caged layer waste, chopped alfalfa hay, corn, molasses, minerals and vitamins alone and with tannic acid or paraformaldehyde in small glass jars equipped with a gas release valve (Flipot et al., 1975). After a 42 day fermentation period the pH was 5 and lactic acid was over 6% for the control mixture. The pH values for the tannic acid and paraformaldehyde treated silages were 4.9 and 5.4, respectively. There was a decrease in lactic acid for these two silages. Goering and Smith (1977) ensiled corn forage alone or with the addition of dehydrated poultry excreta or liquid from cattle excreta. The pH was 4.26 and 3.83, respectively, for the silages treated with dry poultry excreta and liquid from cattle manure. Lactic acid levels also indicated good ensiling had occurred with the addition of excreta to the silage.

Caged layer waste was ensiled with whole plant corn and sorghum forages by Richter & Kalmbacher (1980). The waste comprised 33 and 42% of the dry matter for the corn- and sorghum-waste silages, respectively. The pH varied between 3.60 and 4.85 and lactic acid was about 4%, dry basis, for the silages. Addition of caged layer waste did not affect digestibility but resulted in a lower dry matter intake. Poultry litter, caged layer waste, corn, dry molasses and water were ensiled with and without enrichment with L. acidophilus culture (Vezey and Dobbins, 1975). Good ensiling was obtained as indicated by pH of less than 5. Addition of the organism did not appear to be helpful in ensiling.

Chemical treatment

Treatment of cattle waste with certain chemicals has been shown to be beneficial in improving digestibility of cattle waste. Smith et al. (1971) found that treating dairy cattle waste with sodium hydroxide, calcium hypochlorite and sodium chlorite increased dry matter digestibility of the waste. Lucas et al. (1975b) showed that treating waste from cattle which had been fed a 50% roughage ration with 3% sodium hydroxide increased dry matter digestibility from 24% for the control manure to 53% for treated manure. An improvement in digestibility of waste from cattle fed a 10% roughage ration was also observed.

Deep stacking

Deep stacking of broiler litter produces considerable heat and has been shown to destroy coliforms (Hovatter et al., 1979). Maximum temperature was reached at 4 to 8 d, then the temperature plateaued and tended to equilibrate with atmospheric temperature. Litter ensiled at 40% moisture or deep stacked produced similar performance in cattle, when incorporated at levels up to 60% of the dry matter of the ration (Hovatter et al., 1979; Chester-Jones et al., 1980). Deep stacking should be in a covered shed with ample air circulation to avoid spontaneous combustion. This type of processing can be used only with waste which has a low-moisture level.

Quality of Animal Products

Feeding animal waste has not affected taste of the meat, milk or eggs (Fontenot and Jurubescu, 1980).

Safety Considerations

The only disease problem which has been shown to be caused by feeding animal waste has been copper toxicity in sheep fed broiler litter with high copper levels (Fontenot and Webb, 1975). The problem would not be severe in cattle since they are not as sensitive to high dietary copper. Beef females have been fed diets containing high levels of broiler litter with high copper levels, alone and in combination with supplementary copper to add the equivalent of 200 ppm to the litter during the winter period for 7 yr with no deleterious effects (Webb et al., 1979).

Pathogenic Bacteria and Parasites

Animal wastes contain certain pathogens. A number of different species of pathogenic organisms were isolated from 44 samples of poultry litter by Alexander et al. (1968). Heat processing destroys potential pathogens (Fontenot and Webb, 1975). Proper ensiling of animal wastes also appears to be effective in destroying pathogens (McCaskey & Anthony, 1979). It appears that a pH of 4 to 4.5 and a temperature of over 25° C are important for destruction of salmonella. Ensiling feedlot cattle manure and grass hay was effective in eliminating parasites (McCaskey & Anthony, 1979). Apparently due to the ammonia and minerals in poultry waste it is rather difficult to reach a pH of less than 5 without additional materials such as whole plant corn forage. However, ensiling of broiler litter with added water has been shown to destroy coliforms even when the pH did not go below 5.4 (Caswell et al., 1978). The potential risks of clostridium in ensiled waste containing rations was suggested by the alleged botulism outbreak in cattle fed poultry waste in Israel (Egyed et al., 1978). The botulism organism (Type D) appears to be endemic in Israel as outbreaks have been reported in animals fed other types of feeds (Tagari, 1978; Gordin, 1978). No botulism has been reported in animals fed waste containing rations in the U.S.A. The survival of Clostridium sporagens as a model for C. botulinum was studied by innoculating in a bovine waste-blended ration and in corn forage which were ensiled for 60 d (McCaskey & Anthony, 1978). A decline in numbers of organisms occurred in both silages.

Residues in Animal Products

Indications are that the mycotoxin problem is no greater in poultry litter than in feed (Lovett, 1972). No evidence of pesticide accumulation in waste or in animal tissue from animals fed waste has been reported (Fontenot and Webb, 1975).

Three heavy metals, arsenic, copper and selenium, are added to livestock and poultry rations and three, cadium, lead and mercury, are not added but occur in feedstuffs. Feeding of arsenicals has been shown to result in increased liver arsenic in cattle after a 5-d withdrawal but the levels were much lower than the accepted safe levels (Webb & Fontenot, 1975). The other heavy metals have not been found to be sufficiently high to present a problem in cattle waste and poultry litter (Westing et al., 1980). Liver copper is increased by feeding waste with high copper levels (Webb & Fontenot, 1975).

Medicinal drug residues were present in broiler litter in variable amounts if the drugs had been included in the broiler diet, but the levels were quite variable (Webb & Fontenot, 1975). However, residues of the three drugs that were in litter, chloratetracycline, nicarbazin and amprolium, did not accumulate in animal tissue of finishing beef cattle after a 5-d withdrawal. Thus, it appears that with a modest withdrawal period there is no serious tissue residue problem from feeding broiler litter. However, it should not be fed to cows producing milk or hens producing eggs for human consumption since insufficient data are available on these aspects.

Regulation of Feeding Animal Waste in the U.S.A.

The Food and Drug Administration (FDA) published a policy (21 CFR 500.4) in the September 2, 1967 Federal Register not sanctioning the use of poultry litter as animal feed (Kirk, 1967). Broad interpretation subsequently extended this policy to include all animal wastes used as ingredients in animal feeds. FDA took this position because the amount of information then available was not believed adequate to conclude that animal waste was safe when used as a feed ingredient. A request to submit data, information and views published in the Federal Register of December 27, 1977 resulted in 72 comments (Taylor & Hansard, 1980). FDA (1980) revoked 21 CFR 500.4 on the use of poultry litter as an animal feed ingredient on December 30, 1980 (45 FR 86272) and is leaving the regulation of animal waste to the individual states. In many states regulation is through an officially adopted model regulation for processed animal waste (AAFCO, 1982).

The salient points of the AAFCO regulation are: 1) the waste must be processed so it will be free of pathogenic organisms, 2) if it can be documented by records that animals producing the waste have not been fed drugs no withdrawal period is required and the waste can be fed to any class of animal, 3) if it cannot be documented by records that the animals producing the waste were not fed drugs a 15-d withdrawal is required prior to slaughtering animals or prior to using milk or eggs for human consumption. Some of the individual states also have regulations.

Utilization of Animal Waste for Feeding Animals

Extent of Feeding Waste

Sizable amounts of animal wastes are fed in the U.S.A., but no reliable estimate is available concerning the actual amounts used. Interest in feeding animal waste rises with feed prices. It appears that more broiler litter is fed than the other wastes. The main reasons can probably be attributed to its high nutritional value, ease and flexibility in use due to low moisture content and a variety of processing methods which can be used.

Value of Animal Wastes

Although it has been shown that non-ruminants can utilize certain wastes, the high fiber and frequently high non-protein nitrogen in animal wastes indicate that ruminants are best suited for utilization of wastes. Possibly, wastes could be used to replace part of the diet of swine which do not have a high energy requirement, such as gestating sows. Smith & Wheeler (1979) estimated the monetary value of different kinds of animal wastes. These values were compared to the value of wastes for alternate uses (Fontenot et al., 1983). Values given in table 4 show that the wastes have considerable monetary value and are much more valuable as sources of feed than for fertilizer or methane generation.

Table 4. Relative value of animal wastes utilized for different purposes[a]

	U.S. dollars per ton		
Kinds of wastes	fertilizer	feed	methane
Beef cattle	25.06	118.14	13.73
Dairy cattle	17.00	118.14	12.74
Swine	18.61	136.57	17.17
Caged layer	36.45	155.14	17.93
Broiler litter	26.54	159.57	16.29

[a]Adapted from Fontenot et al. (1983).

Practical Feeding

The uses of animal wastes by livestock producers were discussed by researchers, livestock producers, regulatory officials and extension specialists (Anonymous, 1978). It appears that the situation has not changed much since that conference, except there has been an increase in use of the wastes.

Broiler litter is processed mainly by deep stacking, with some being ensiled. This waste is fed mainly to beef cows during the winter. It comprises up to 80% of the ration. Usually, the litter is fed mixed with ground grain. It is important that the cattle have access to coarse roughage to prevent digestive disturbances and for optimum feed intake. Litter is used for stocker (store) and finishing cattle. It is mixed with dry ingredients, ensiled with corn forage or mixed with silage at time of feeding.

Caged layer waste is processed by dehydration or ensiling prior to feeding. The dehydrated waste is fairly costly to produce and appears to be used mainly as a protein (nitrogen) supplement. Ensiling involves mixing the high moisture waste with dry materials such as hay or crop residues before ensiling. This procedure increases dry matter to the optimum level for ensiling. The silage can be fed to any class of cattle, the level of feeding being dependent on the level of production of the cattle.

Cattle waste is usually mixed with the other feed ingredients and ensiled prior to feeding. The value of the ensiled material depends on the ration fed the cattle producing the waste and the kind of material(s) mixed with the waste. Undoubtedly, some dry cattle waste is being fed, but the amount of waste used in this manner is rather limited.

No major problems have been reported from sale or feeding animal waste in the U.S.A., as exemplified by the experience in California, the first state to approve feeding animal waste (Helmer, 1980).

References

AAFCO, 1982. Official publication, Association of American Feed Control Officials, College Station, TX.

Aines, G.E., W.D. Lamm, K.E. Webb, Jr. & J.P. Fontenot, 1982. Effects of diet, dry matter and sodium hydroxide treatment on the ensiling characteristics and utilization by lambs of cattle waste-rye straw mixtures. J. Anim. Sci. 54:504-516.

Alexander, D.C., J.A.J. Carriere & K.A. McKay, 1968. Bacteriological studies of poultry litter fed to livestock. Can. Vet J. 9:127-131.

Anonymous, 1978. Alternate nitrogen sources for ruminants. National Fertilizer Development Center, Tennessee Valley Authority, Muscle Shoals, AL.

Anthony, W.B., 1971. Animal waste value - nutrient recovery and utilization. J. Anim. Sci. 32:799-802.

Berger, J.C.A., J.P. Fontenot, E.T. Kornegay & K.E. Webb, Jr., 1981a. Feeding swine waste. I. Fermentation characteristics of swine waste ensiled with ground hay or ground corn grain. J. Anim. Sci. 52:1388-1403.

Berger, J.C.A., J.P. Fontenot, E.T. Kornegay & K.E. Webb, Jr., 1981b. Feeding swine waste. II. Nitrogen utilization, digestibility and palatability by sheep of ensiled swine waste and orchardgrass hay or corn grain. J. Anim. Sci. 52:1404-1416.

Berger, J.C.A., E.T. Kornegay, J.P. Fontenot & K.E. Webb, Jr., 1981c. Feeding swine waste. III. Digestibility, nitrogen utilization and palatability by swine of ensiled swine waste and corn grain or orchardgrass hay. J. Anim. Sci. 52:468-474.

Bhattacharya, A.N. & J.P. Fontenot, 1966. Protein and energy value of peanut hull and wood shaving poultry litter. J. Anim. Sci. 25:367-371.

Bhattacharya, A.N. & J.C. Taylor, 1975. Recycling animal waste as a feedstuff: A review. J. Anim. Sci. 41:1438-1457.

Bhattacharya, A.N. & J.P. Fontenot, 1965. Utilization of different levels of poultry litter nitrogen by sheep. J. Anim. Sci. 24:1174-1178.

Caswell, L.F., J.P. Fontenot & K.E. Webb, Jr. 1978. Fermentation and utilization of broiler litter ensiled at different moisture levels. J. Anim. Sci. 46:547-561.

Caswell, L.F., K.E. Webb, Jr. & J.P. Fontenot, 1977. Fermentation, nitrogen utilization, digestibility and palatability of broiler litter ensiled with high moisture corn grain. J. Anim. Sci. 44-803-813.

Chester-Jones, H. & J.P. Fontenot, 1981. Performance of steers fed corn silage supplemented with deep stacked or ensiled broiler litter. VPI & SU Anim. Res. Rep. 1:174-182.

Chester-Jones, H., J.P. Fontenot, W.D. Lamm & K.E. Webb, Jr., 1980. Growing cattle fed differing levels of ensiled and deep stacked broiler litter. VPI & SU Res. Div. Rep. 156:166-171.

Cornman, A.W., W.D. Lamm, K.E. Webb, Jr. & J.P. Fontenot, 1981. Ensiling cattle waste with rye straw as a diet supplement for ruminants. J. Anim. Sci. 52:1233-1239.

Creger, C.R., F.A. Gardner & F.M. Farr, 1973. Broiler litter silage for fattening beef animals. Feedstuffs 45:25.

Cross, D.L. & B.F. Jenny, 1976. Turkey litter silage in rations for dairy heifers. J. Dairy Sci. 59:919-923.

Cross, D.L., G.C. Skelley, C.S. Thompson & B.F. Jenny, 1978. Efficacy of broiler litter silage for beef steers. J. Anim. Sci. 47:544-551.

Cullison, A.T., H.C. McCampbell, A.C. Cunningham, R.S. Lowrey, E.P. Warren, B.D. McLenden & D.H. Sherwood, 1976. Use of poultry manures in steer finishing rations. J. Anim. Sci. 42:219-228.

Duque, J.A., J.P. Fontenot, K.E. Webb, Jr. & J.C.A. Berger, 1978. Fermentation and digestibility of broiler litter ensiled at different moisture levels by addition of whey or water. VPI & SU Res. Div. Rep. 174:108-117.

Egyed, M.N., N.C. Schlosberg, U. Klopfer, T.A. Nokel & E. Mayer, 1978. Mass outbreaks of botulism in ruminant associated with ingestion of feed containing poultry waste. Refuah Vet. 35:93-115.

Evans, E.E., T. Moran, Jr. & J.P. Walker, 1978. Laying hen excreta as a ruminant feedstuff. I. Influence of practical extremes in diet, waste management procedure and stage of production on composition. J. Anim. Sci. 46:520-526.

FDA, 1980. Recycled animal waste. Federal Register 45:86272.

Flipot, P., M. McNiven & J.D. Summers, 1975. Poultry wastes as a feedstuff for sheep. Can. J. Anim. Sci. 55:291-296.

Fontenot, J.P., A.N. Bhattacharya, C.L. Drake & W.H. McClure, 1966. Value of broiler litter as feed for ruminants. Proc. of Nat'l. Symp. on Animal Waste Management. ASAE Publ. SPO 366:105-108.

Fontenot, J.P. & V. Jurubescu, 1980. Processing of animal waste by feeding to ruminants. In: Y. Ruckebusch & P. Thivend (Ed.): Digestive physiology and metabolism in ruminants. AVI Publishing Co., Inc., Westport, CT. p. 641-664.

Fontenot, J.P. & I.J. Ross, 1980. Animal waste utilization. Proc. 4th Inter. Symp. on Livestock Wastes. ASAE, St. Joseph, MI, p. 4-10.

Fontenot, J.P., L.W. Smith & A.L. Sutton, 1983. Alternative utilization of animal wastes. J. Anim. Sci. 57 (Supp. 2): 221-233.

Fontenot, J.P. & K.E. Webb, Jr., 1975. Health aspects of recycling animal wastes by feeding. J. Anim. Sci. 40:1267-1276.

Goering, H.K. & L.W. Smith, 1977. Composition of the corn plant ensiled with excreta or nitrogen supplements and its effect on growing wethers. J. Anim. Sci. 44:452-461.

Gordin, S., 1978. Personal communication.

Harmon, B.W., J.P. Fontenot & K.E. Webb, Jr., 1974. Effect of processing method of broiler litter on nitrogen utilization by lambs. J. Anim. Sci. 39:942-946.

Harmon, B.W., J.P. Fontenot & K.E. Webb, Jr., 1975a. Ensiled broiler litter and corn forage. I. Fermentation characteristics. J. Anim. Sci. 40:144-155.

Harmon, B.W., J.P. Fontenot, K.E. Webb, Jr., 1975b. Ensiled broiler litter and corn forage. II. Digestibility, nitrogen utilization and palatability by sheep. J. Anim. Sci. 40:156-160.

Helmer, J.W., 1980. Monitoring the quality and safety of processed animal waste products sold commercially as feed. J. Anim. Sci. 50:349-355.

Hovatter, M.D., W. Sheehan, G.R. Dana, J.P. Fontenot, K.E. Webb, Jr. and W.D. Lamm, 1979. Different levels of ensiled and deep stacked broiler litter for growing cattle. VPI & SU Res. Div. Rep. 175:77-83.

Kirk, J.K., 1967. Statements of general policy or interpretation. Federal Register 22:September 2.

Kornegay, E.T., M.R. Holland, K.E. Webb, Jr., K.P. Bovard & J.D. Hedges, 1977. Nutrient characterization of swine fecal waste and utilization of these nutrients by swine. J. Anim. Sci. 44:608-619.

Lovett, J., 1972. Toxigenic fungi from poultry feed and litter. Poultry Sci. 51:309-313.

Lucas, D.M., J.P. Fontenot & K.E. Webb, Jr., 1975a. Composition and digestibility of cattle fecal waste. J. Anim. Sci. 41:1480-1486.

Lucas, D.M., J.P. Fontenot & K.E. Webb, Jr. 1975b. Digestibility of untreated and sodium hydroxide treated steer fecal waste. VPI & SU Res. Div. Rep. 163:115-117.

McCaskey, T.A. & W.B. Anthony, 1979. Human and animal health aspects of feeding livestock excreta. J. Anim. Sci. 48:163-177.

McClure, W.H., J.P. Fontenot & K.E. Webb, Jr., 1978. Ensiled corn forage and broiler litter for finishing heifers. VPI & SU Res. Div. Rep. 174:131-134.

Moriba, J.N., 1982. Digestibility and palatability of caged layer waste and corn stover ensiled alone and with molasses. VPI & SU Ani. Sci. Res. Rep. 2:160-174.

Newton, G.L., P.R. Utley, R.J. Ritter & W.C. McCormick, 1977. Performance of beef cattle fed wastelage and digestibility of wastelage and dried cattle waste diets. J. Anim Sci. 44:447-451.

Noland, P.R., B.F. Ford & M.L. Ray, 1955. The use of ground chicken litter as a source of nitrogen for gestating lactating ewes and fattening steers. J. Anim. Sci. 141:860-865.

NRC, 1983. Underutilized resources as animal feedstuffs. National Academy Sciences, National Research Council, Washington, D.C.

Oltjen, R.R., L.L. Slyter, A.S. Koxak & E.E. Williams, Jr. 1968. Evaluation of urea, biuret, urea phosphate and uric acid as NPN sources for cattle. J. Nutr. 94:193-202.

Pearce, G.R., 1975. The inclusion of pig manure in ruminant diets. ASAE Publ. PROC-275:218-219,221.

Richter, M.F. & R.S. Kalmbacher. 1980. Nutrient metabolism and quality of corn and sorghum silages made with caged layer manure. Proc. Soil and Crop Sci. Soc. of Florida 39:125-127.

Samuels, W.A., J.P. Fontenot, W.D. Lamm & K.E. Webb, Jr. 1980. Fermentation characteristics of caged layer waste ensiled with sugarcane bagasse. VPI & SU Res. Div. Rep. 156: 189-194.

Saylor, W.W. & T.A. Long, 1974. Laboratory evaluation of ensiled poultry waste. J. Anim. Sci. 39:139 (Abst.).

Schake, L.M., B.W. Pinkerton, C.E. Donnell, J.K. Riggs & R.E. Lichtenwalner, Utilization of cattle excrement for growth and maintenance of beef cattle. J. Anim. Sci. 45:166-179.

Shorter, J.K., W.D. Lamm, J.P. Fontenot & K.E. Webb, Jr. 1981. Ensiling crop residues with cattle waste at different moisture levels and added sodium hydroxide. VPI & SU Anim. Sci. Res. Rep. 1:162-171.

Smith, L.W. 1973. Recycling animal wastes as protein sources. Alternative sources of protein for animal production. National Academy of Sciences, Washington, DC. p. 146-173.

Smith, L.W. & C.C. Calvert, 1976. Dehydrated broiler excreta versus soybean meal as nitrogen supplements for sheep. J. Anim. Sci. 43:1286-1292.

Smith, L.W., H.K. Goering & C.H. Gordon, 1971. Nutritive evaluations of untreated and chemically treated dairy cattle wastes. ASAE Publ. PROC-271:314-318.

Smith, L.W. & W.E. Wheeler, 1979. Nutritional and economic value of animal excreta. J. Anim. Sci. 48:144-156.

Tagari, H., 1978. Personal communication.

Taylor, J.C. & S.L. Hansard, II. 1980. Animal waste as a feed component: Regulatory aspects. Proc. 4th Inter. Symp. on Livestock Wastes. ASAE, St. Joseph, MI, p. 13-14.

Tinnimit, P.K., McGuffey & J.W. Thomas. 1972. Dried animal waste as a protein supplement for sheep. J. Anim. Sci. 35:431-435.

Vezey, S.A. & C.N. Dobbins. 1975. Ensiling poultry floor litter and cage layer manure. Proc. 3rd Inter. Symp. on Livestock Wastes, ASAE, St. Joseph, MI, pp. 195-196.

Van Dyne, D.C. & C.B. Gilbertson, 1978. Estimating U.S. livestock and poultry manure and nutrient production. U.S. Rept. Agric. ESCS-12.

Wadleigh, C.H., 1968. Wastes in relation to agriculture and forestry. USDA Misc. Publ. 1065.

Ward, G.M., D.E. Johnson & E.W. Kienholz, 1975. Nutritional properties of feedlot manure fractionated by Cereco Process. ASAE Publ. PROC-275:208-210.

Webb, K.E., Jr. & J.P. Fontenot, 1975. Medicinal drug residues in broiler litter and tissue from cattle fed litter. J. Anim. Sci. 41:1212-1217.

Webb, K.E., Jr., J.P. Fontenot & W.H. McClure. 1979. Performance and liver copper levels of beef cows fed broiler litter. VPI & SU Res. Div. Rep. 175:109-121.

Westing, T.W., J.P. Fontenot, W.H. McClure, R.F. Kelly & K.E. Webb, Jr., 1980. Mineral element profiles of animal wastes and edible tissues from cattle fed animal wastes. Proc. 4th Int. Sym. on Livestock Wastes. ASAE, St. Joseph, MI p. 81-85.

A REVIEW OF THE POSSIBLE MICROBIOLOGICAL AND CHEMICAL RISKS ASSOCIATED WITH THE FEEDING OF ANIMAL MANURES TO LIVESTOCK

C.L. Benham

Ministry of Agriculture, Fisheries and Food, Reading, England.

Summary

The uncontrolled feeding of poultry waste to other animals may present a health hazard both to the stock receiving it and to the final consumer, from the presence of pathogenic micro-organisms and chemical residues. Sufficient information is available on treatments to eliminate the risks from pathogenic bacteria. For many of the chemicals used routinely in the poultry industry there is a shortage of information on the likelihood of their passing into the waste, their persistence, the effect of processing and their possible accumulation in the tissues or by-products of animals receiving the waste. Although there is no evidence available that feeding poultry waste has caused health problems there is need for further research on this aspect before its use can be fully endorsed.

1. Introduction

The ever rising cost of animal feedingstuffs has lead to an increased interest in the use of animal by-products such as manure and litter in ruminant feeds. Such waste, which is often mixed with feed spillage, is of considerable potential value as it contains a variety of nutrients which are re-usable not only by the animal producing it but also by other species. Although use of animal wastes could have a considerable effect on reducing costs its use in an untreated state has implications for the health of the animals to which it is fed and also the ultimate consumer, man.

This paper reviews the likely presence of microbial and chemical contaminants, the evidence of harmful effects from feeding wastes and possible treatment methods to reduce harmful effects.

2. Microbiological Aspects

The use of poultry wastes has recently been reviewed by Benham & Panes (1982) and only the main points from that paper are presented.

2.1 The health aspects of re-using livestock excreta have been reviewed by a number of authors and a number of potential pathogens identified. These include bacteria, fungi and actinomycetes, viruses and coccidia.

2.1.1 Bacteria

The intestinal tract of healthy animals is colonised by a variety of micro-organisms many of which are voided in the faeces. In general they are not pathogenic to the same or other classes of stock although some organisms eg. E. coli may be opportunistic pathogens. Diseased animals may excrete pathogens and studies of poultry litter and manures revealed the presence of a variety of potentially pathogenic organisms. These have included Clostridia, Corynebacteria, Salmonella and Mycobacteria. Poultry are one of the main reservoirs for Salmonella and surveys have shown densities of 1--34,000 Salmonella/g dry excreta. A survey of broiler litter in the UK revealed a number of salmonella serotypes including S. agona, S. bredeney, S. hardar, S heidelberg. S. kedougou, S. senftenberg, S. taksony, S. typhimurium and S. virchow.

2.1.2 Fungi and actinomycetes

Fungi and actinomycetes are common contaminants of feedingstuffs and a number have public health implications. Fungi can cause infections, induce allergic responses and produce mycotoxins. Some of the thermophilic actinomycetes are responsible for the condition known as 'Farmers Lung'.

2.1.3 Viruses

Although several diseases of poultry are caused by viruses there is little information on their excretion and survival in faeces and litter.

2.1.4 Coccidia

The oocysts of coccidia, the organisms causing coccidiosis in poultry are voided in the faeces.

There is little published information on their survival in the litter but their presence would only cause disease if fed to other poultry, coccidiosis in cattle being caused by other species of Eimeria.

2.1.5 Evidence of health risks

Despite the demonstration by a number of authors of organisms capable of causing diseases in faecal material and litter Fontenot & Webb (1975) were unable to find any reports of disease problems caused by inclusion of poultry wastes in the rations of beef cattle, sheep or dairy cattle.

3. Treatment methods

3.1 Drying

3.1.1 Drying - natural

The use of stepped slats beneath cages in a deep pit poultry house was shown to reduce moisture contents to 15% after a 10 month period (Elson (1974)). However the material was still heavily contaminated with E. coli.

3.1.2 Drying - artificial

Droppings - The high temperatures used in artificial dryers (200-300°C) are effective in considerably reducing or eliminating most micro-organisms. However some organisms may survive in the middle of lumps of droppings. Care must be taken to prevent recontamination after drying.

Litter - Various authors have investigated the sterilisation of litter byheat. A temperature of 150°C for a minimum of 3 hours was necessary to completelysterilise broiler litter (Fontenot et al (1971)). However if a criterion of less than 10 coliforms or 20,000 bacteria/g is used a time of 15 minutes was adequate for a litter thickness of 6.3 mm or 30 minutes for litter of 12.6 mm. This was confirmed by Caswell et al (1975) who found that 150°C for 20 minutes was effective in eliminating coliforms and reducing total bacteria.

3.2 Radiation

Although this method has been shown to be effective the complexities and cost of the equipment make it a technique more suited to industrial application.

3.3 Chemical sterilants

This subject has been extensively reviewed by Harry et al (1974).

Chemicals used have included methyl bromide, formaldehyde and ethylene oxide. Although they can be shown to be effective under carefully controlled laboratory conditions they all suffer from the disadvantage of poor penetration into lumps of litter or droppings. Their effectiveness can also be reduced at lower temperatures or if the material is wet. High residual levels of bromide have been shown after treatment with methyl bromide.

3.4 Ensilage

Salmonella may be inhibited by a reduction in pH to at least 4.5 and a number of authors have examined the effect of an ensilage process in litter utilising lactic acid bacteria to ferment naturally present added carbohydrates. From these trials a series of broad conclusions can be drawn.

1) An improved fermentation occurs at moisture contents of 40--50% and and addition of water to the litter may be an advantage.

2) Some form of airtight or anaerobic storage is essential.

3) Addition of a suitable carbohydrate source eg. corn, corn forage, ground or whole barley, fruit or arable by-products is essential to give a reduction to pH 4.5. Such a material is more palatable to stock and has a satisfactory shelf life once the silo or store is opened.

4) Microbiological studies have shown that storage for at least six weeks will eliminate salmonellas, E. coli and coliforms.

3.5 Composting

The self heating process which occurs in composting due to microbial metabolism offers an alternative disinfection process without the use of additional energy.

Three methods are available:

1) Windrow composting

In this process the material to be composted is heaped in long rows. The size of the windrow is important and if larger than 1.5 m may require artificial aeration. Repeated turning of the windrow may be necessary to ensure adequate treatment of all the material.

2) Bioreactors

The limitation of windrow composting has lead to the development of so called "bioreactors" which allow the production of compost of uniform hygienic standard throughout the year. However it is likely that the high capital cost and need for technical expertise would restrict the use of such systems to large enterprises.

3.5.3 Deep stacking

This variation of the composting process has been examined in the USA and UK. In this system litter from the broiler house is heaped up inside an open fronted building. The heat which develops during the subsequent heating process is presumed to be sufficient to destroy any pathogenic organisms present. The heap is not turned during the heating stage and observations in the UK have shown that E. coli will survive on the surface layers even when considerable heating has occurred.

4. Chemical Residues

Poultry waste may contain a wide range of drugs, pesticides, hormones and their metabolites. The range of products marketed by different countries vary and therefore studies of residues in one country may not be applicable to the situation in another.

4.1 Antibiotics

Absorption by the animal is not complete for any antibiotic and at least a portion of the amount ingested is excreted. In a survey of broiler litter Webb and Fontenot (1972) were able to find residues of oxytetracycline, chlortetracycline, penicillin and zinc bacitracin. Neomycin was not detected. Examination of tissues from cattle fed dried poultry waste containing antibiotic residues at levels of up to 50% of their rations showed negligible tissue concentrations after a 5-day withdrawal period (Webb and Fontenot, 1975). Tetracyclines were reported in muscle and heart at levels corresponding to 0.02%-0.1% of the level in the feed. However, no residues were detected after a 5-day withdrawal period and chlortetracycline residues were destroyed in cooking (Jukes, 1973).

4.2 Growth promoters

Several substances are used in the UK as growth promoters for poultry (ADAS 1979). These are listed with available information on the likely occurrence of residues in the droppings.

Zinc bacitracin	Rapid breakdown in faeces. Half-life less than one week
Avoparcin	Half-life 9 days at 24°C.
Virginiamycin	In pig faeces 73% degraded in 3 days.
Bambermycin	No information on persistance. Used as a growth promoter for beef in several European countries.
Nitrovin	Half-life approximately one week.
Bacitracin methylene bisalicylate	No information.

4.3 Coccidiostats

4.3.1 Poultry

In general there is little or no intestinal absorption of coccidiostats or other antiprotozoal substances in poultry and residues will pass into the droppings.

Substances currently in use in the UK are listed with information on levels found in litter and rate of breakdown (ADAS 1979).

Monensin sodium	120 mg/kg in feed gave 4 ppm in fresh broiler faeces. 80% breakdown in 6 days at 27°C.
Amprolium	Residues detected in broiler litter. In feeding trial with litter boosted with extra amprolium no residues were detected in heart, spleen, rib, kidney, liver or brain of lambs.
Ethopabate (used in mixtures with Amprolium and sulphaquinoxaline)	No information available.

Dicoquinate	Nearly all excreted. No information available on breakdown. Used in USA for prevention of coccidiosis in cattle
Sulphaquinoxaline	Found to be absent from poultry litter.
Nicarbazin	Usually absent from litter. Very small amounts detected in one instance.
Clopidol	About 100 mg/kg in litter.Slowly breaks down when applied to soil as manure; about two-thirds lost in 26 months. No significant breakdown when stored anaerobically.
Dinitolmide	No information available but likely to persist.

4.3.2 Turkeys

Dimetridazole	Rapid breakdown in faeces.
Nifursol	Complete breakdown in 10 days
Acinitrazol	No information.
Aminotrothiazole	No information.

Residues of those anti-protozoal agents that have been shown to persist are not extensively carried into the tissue of animals fed on contaminated material and in general a five day withdrawal period was sufficient to give tissue residues no higher than those in control animals.

4.4 Hormones

Hexoestrol, stilboestrol, dienoestrol and diethyl stilboestrol are used as preparations for chemical caponization although their use has declined with developments in broiler breeding. Griel et al (1969) reported on spontaneous abortions in cattle fed low levels of poultry litter from birds receiving dienoestrol in their feed. Detectable amounts of oestrone and oestradial-17B are excreted by layers (Mathur and Common, 1969) and residues have been detected in poultry litter (Webb and Fontenot, 1972).

4.5 Organo-arsenicals

A number of arsenic containing compounds are used as growth promoters or for disease prevention including arsanilic acid, 3-nitro-4-hydroxy phenyl arsenic acid and 4 nitrophenyl arsenic acid. They are only poorly absorbed into muscle tissue but are accumulated in liver and kidney. Between 36 or 86% of the chemical appears largely unchanged in the faeces. Morrison (1969) found levels of 15-30 mg/kg arsenic in poultry litter from houses where roxarsone had been used. This compared with levels of 0.1-2.6 mg/kg in control houses. Surveys by Webb and Fontenot (1975), Messer et al (1971) and ADAS (1979) found levels in broiler litter ranging from 1.1-59.5, 0.2-76.3 and 0.0-28.0 mg/kg respectively. Webb and Fontenot (1975) confirmed that levels of arsenic in muscle tissue rapidly decline following withdrawal of the compound from the feed. In a study by MAFF (unpublished) higher than normal levels of arsenic were fed in the form of dried poultry waste but these were not reflected in tissue levels. It was suggested that arsenicals metabolised or excreted by animals may not be in a form available to other animals.

4.6 Copper and other heavy metals

Copper salts are used as a feed additive for growth promotion in poultry and levels of up to 600 mg/kg have been measured in deep litter. A recent survey of broiler litter (ADAS 1979) gave a mean level of 75.9 (range 34.8-118.1) mg/kg copper on a dry matter basis. Levels in the droppings of caged birds are usually lower.

Sheep are particularly susceptible to high levels of copper and at least one incidence of toxicity has been reported in sheep fed broiler litter (Fontenot et al 1971 a).

Poultry are unlikely to be exposed to other heavy metals, eg lead, inorganic mercury, cadmium and zinc but because these are poorly absorbed by animals there is a potential for increased levels in wastes due to concentration. However, a study has shown that continuous re-cycling of dried droppings for 33 cycles over a period of 400 days did not lead to increased levels of mercury, mercury, copper and zinc in tissues and excreta (Varghese and Flegal, 1974).

4.7 Pesticides

A number of chemicals are used for control of insects in poultry houses. survey in the UK gave the following information on usage (ADAS 1979).

	% of total
carbaryl	39
tetrachlorvinphos	34
iodofenphos	7
fenchlorfos	7
malathion	4
bromophos	4
fenitrothion	3
gamma HCH	1

All the insecticides listed, except gamma HCH, are mostly short lived organophosphorus compounds, carbamates and pyrethroids, and break down quite rapidly because of the alkaline conditions caused by evolution of ammonia as the droppings ferment. The occurrence of significant residues in manure would therefore be unlikely.

4.8 Wood preservatives

Wood is treated with both preservatives and anti-stain agents but it is only the latter that are likely to be present in wood shavings. The most commonly used anti-stain agents are pentachlorophenol and 2.3.4.6-tetrachlorophenol. In a survey of fresh shavings from 32 commercial broiler houses Parr et al (1974) demonstrated that 2,3,4,6-tetrachlorophenol and pentachlorophenol were present at levels of 4-307 (mean 53) and 1-83 mg/kg (mean 12) respectively. Approximately 7-15% of this passed through into the spent litter. These preservatives have been implicated as the cause of musty taint in broilers (Curtis et al, 1974).

Substances used as wood preservatives include dieldrin which is widely used on finished timber products and has occasionally caused death of poultry housed on shavings (Amure and Stuart, 1978). Other substances known to be used are organo-mercury and organo-tin compounds, both of which are highly toxic.

4.9 Nitrosamines

These compounds can be formed by the reaction of secondary amines present in excreta with nitrites in feedingstuffs and excreta, or from the microbiological conversion of nitrates excreted in urine to nitrites.

In a study carried out by MAFF (unpublished) dried droppings were incorporated into the normal rations of beef steers for 40 weeks prior to slaughter. N-nitrosodimethylamine was detected in only 3 samples of waste. None of a range of other nitrosamines was detected in the complete beef rations and N-nitroso dimethylamine was found in only one ration.

It was concluded that the presence of these compounds in feeds would not present a hazard from the consumption of animal products since the animals were likely to detoxify any nitrosamines present.

4.10 Mycotoxins

It has been estimated that 30-40% of all fungi recognised may be capable of producing toxic metabolites and several of the species of fungi in litter, eg Aspergillus, Penicillium and Scopulariopsis are recognised as potential mycotoxin producers. Curtis (unpublished) was unable to produce aflatoxin by infecting poultry litter with toxigenic strains of Aspergillus spp, and a limited survey of broiler litter (ADAS, 1979) failed to reveal the presence of mycotoxins. The mycotoxin contamination of poultry waste should not be any greater problem than that of grains, etc. provided it is stored and processed under conditions which prevent fungal growth.

4.11 Other microbial by-products

Bacteria are able to produce a number of toxins. These are classified as endotoxins, molecular complexes containing protein, lipid and polysaccharides, which are retained within the bacterial cell and exotoxins, simple proteins which are released into the surrounding medium.

Exotoxins are produced by a number of organisms including Clostridium botulinum, the cause of botulism, Cl. tetani, Cl. perfringens and Staphylococcus aureus. Among the endotoxin producers are nearly all the Gram negative pathogenic bacteria, eg. E. coli, Salmonella spp and Shigella spp. In addition the heat killed cells of many non pathogenic bacteria show similar toxic effects.

4.12 Evidence of health risks

Fontenot and Webb (1975) were able to find only two reports of ill health in stock receiving poultry wastes. Fontenot et al (1971) reported on an outbreak of copper toxicity in ewes fed poultry litter containing high levels of copper. As stated previously Griel et al (1969) reported a high incidence of abortion in cows fed low levels of poultry litter in the wintering ration and grazing a pasture in the summer which had been fertilised with poultry litter. The litter was found to contain oestrogenic activity of at least 10 ug of DES equivalent per 100 g of litter.

More recently Egyed et al (1970) and Savir (1978) described an outbreak of a botulism like syndrome in dairy cattle resulting from the feeding of concentrates containing 10% dried poultry waste. No toxin was isolated on this occasion. Smart and Roberts (1977) demonstrated the presence of Clostridium botulinum type C in litter following an outbreak of type C botulism in 3-week-old broiler chickens on deep litter. Toxin could not be detected in the litter and they postulated that the toxin was formed in the guts of the chickens followed by contamination of litter by voided faecal material.

No indication of harmful effects in humans consuming meat, milk or eggs from animals fed animal waste was obtained by Fontenot and Webb (1975) and organoleptic tests conducted on meat, milk and eggs detected no undesirable flavours.

5. Legislation

Published information on controls on the use of animal wastes in feedingstuffs by legislation is scarce. The following information relates largely to the UK.

The sale of feedingstuffs is controlled by legislation and statutory declarations are required for several organic wastes that have been traditionally used in feedingstuffs eg. dried poultry waste - protein, protein equivalent of uric acid, fibre and calcium. However in general there appear to be no specific controls over the use of organic wastes and manufacturers are free to use what material they choose.

In the UK the use of faecal material from any animal, bird, fish, reptile, crustacean or other cold blooded creature as a feedingstuff for livestock or poultry comes under the scope of the Disease of Animals (Protein Processing) Order 1981.

The Order requires that samples of processed animal protein taken by authorised officers from the premises where it is being produced should, when tested in an approved laboratory using the specified test, be free from salmonellas. As well as applying to animal protein produced commercially and intended for sale the Order also embraces materials such as droppings or litter used as a feedingstuff on the same farm.

References

ADAS, (1979) Research and Development into feeding broiler litter to beef cattle. MAFF. London.

Amure, J. and Stuart, J.C. (1978). The Veterinary Record 102:387.

Benham, C.L. and Panes, J.J. (1982) Research and Development Report: Animal Science 1982. Reference Book of the Ministry of Agriculture, Fisheries and Food. London, No 254 (82) p. 3-19.

Bhattacharya, A.N. and Taylor, J.C. (1975) Journal of Animal Science 41:1438-1457

Caswell, L.F. et al (1975) Journal of Animal Science 40:750-759.

Curtis, R.F. et al (1974) Journal of the Science of Food and Agriculture 25: p. 811-828.

Egyed, M.N. et al (1978) Refuah Veterinarith 35:93-99.

Elson, A. (1974) Fachdigest Geflugel VII/1, p. 9-10.

Fontenot, J.P. and Webb, K.E. (1975) Journal of Animal Science 40:1267-1277.

Fontenot, J.P. et al (1971) Proceedings of the International Symposium on Livestock Wastes ASAE Pub PROC 270:301.

Fontenot, J.P. et al (1971(a)) Journal of Animal Science 33:283 (abstract).

Griel, L.C. and Kradel, D.C. (1969) Cornell Veterinarian 59:226.

Harry et al (1974) World's Poultry Science Journal 30:(3) 193.

Jukes, J.M. (1973) Advances in Applied Microbiology 16:1-30.

Mathur, R.S. and Common, R.H. (1969) Poultry Science 48:100-104.

Messer, J.W. et al (1971) Poultry Science 50:874-881.

Morrison, J.L. (1969) Journal of Agricultural and Food Chemistry 17:1288.

Parr, L.J. et al (1974) Journal of Science of Food and Agriculture 25:835-841.

Savir, D. (1978) Refuah Veterinarith 35: 105-108.

Smart, J.L. and Roberts, T.A. (1977) Veterinary Record 100:378-380.

Varghese, S.K. and Flegal, C.J. (1974) Poultry Science 53:1986.

Wasti, S. et al (1970) J. Econ. Entomol. 63:1355.

Webb, K.E. and Fontenot, J.P. (1972) Feedstuffs 44:(1) 39-40.

Webb, K.E. and Fontenot, J.P. (1975) Journal of Animal Science 41:1212-1217.

IN VITRO AND IN VIVO NUTRITIONAL EVALUATION OF BUFFALO MANURE

M.A. El Ashry, A.M. El Serafy, H.M. Khattab, H.S. Soliman and S.M. Soliman

Faculty of Agriculture, Ain Shams University
Shoubra El Khiema, Cairo, Egypt

Summary

Manure disposal problem is expected to get worse as a result of increased intensification of both poultry and animal production. On the other hand, such wastes contain many nutritional compounds which can be utilized by ruminants. The objectives of the present study were to investigate the effect of method of drying on the composition and nutritive value of buffalo manure.

Materials and methods

Fresh faeces were collected from two buffalo groups, fattening male calves and lactating buffaloes. The fresh manure was either left in the sun to be dried where its moisture content reached about 10% (7-10 days) or dried in oven at 75 c for 48 hrs. Proximate analysis of dried faeces was carried out according to A.O.A.C. (1970). In vitro dry and organic matter disappearance was determined for the dried manure collected from different animal groups either alone or in a mixture with concentrate or clover hay. The percentage of manure in these mixtures were 75, 50 and 25%.

Sun dried manure was then used in experimental rations to fullfil either 50 or 75% of the maintenance nitrogen allowances for fat tailed mature Ossimi sheep. Feeding and nitrogen balance trial was carried out to estimate the feeding value of the mixture containing two levels of buffalo manure.

Results and discussion

The chemical analysis of manure obtained from fattening calves and lactating buffaloes, which was either sun or oven dried are shown in table 1. It is clear that manure of lactating buffaloes had slightly higher organic matter and less ash. While other nutrients were almost similar in the manure of fattening and lactating animals.

Method of drying did not affect neither moisture content nor ash and organic matter in manure. However, crude protein content of oven dried samples were higher than sun cured manure from fattening and lactating animals by 12 and 13%, respectively. That indicated some nitrogen losses in sun dried samples.

In vitro dry matter and organic matter disappearance data of sun dried manure obtained from fattening calves showed higher values than those of oven dried by about 12% (table 2).

Using mixture of sun dried fattening - manure plus clover hay showed higher values for IVDMD ranging from 19.6 to 31.7% as compared with mixtures contained oven dried manure. The same trend was recorded for IVOMD. On the other hand, IVDMD of sun cured lactating buffalo manure was lower than those of oven dried.

In general, IVDMD for sun cured fattening manure and its mixtures with good quality roughage were higher than the corresponding values for lactating buffalo manure.

Table 1: Chemical composition of different kinds of dried manure (OM, DM basis)

Item	Fattening sun	Buffalo calves oven	Lactating sun	Buffalo oven
Moisture	6.0	6.2	6.9	6.6
DM	94.0	93.8	93.1	93.4
OM	80.7	81.7	84.5	84.6
Ash	19.3	18.3	15.5	15.4
C.P.	12.65	14.2	13.4	15.2
C.F.	36.0	37.85	38.7	38.1
E.E.	4.85	3.72	4.09	4.64
N.F.E.	27.21	25.93	28.3	26.66

Table 2: IVDMD and IVOMD of dried manure with different levels of berseem hay (on dry matter basis, %)

Item	Sun dried IVDMD	Sun dried IVOMD	Oven dried IVDMD	Oven dried IVOMD
1-Fattening Buffalo Calves				
100% manure	29.0	24.0	26.0	20.5
75% manure + 25% hay	33.5	25.0	28.0	23.0
50% manure + 50% hay	41.5	41.0	31.5	31.5
25% manure + 75% hay	41.5	39.5	34.0	23.0
0% manure +100% hay	51.0	47.0	-	-
2-Lactating Buffalo Cows				
100% manure	24	25	27	26
75% manure + 25% hay	31	26	28	28
50% manure + 50% hay	34	29	33	29
25% manure + 75% hay	39	36	35	25
0% manure +100% hay	51.0	47.0	-	-

Table 3: IVDMD and IVOMD of dried manure with different levels of concentrated (on dry matter basis, %)

Item	Sun dried IVDMD	Sun dried IVOMD	Oven dried IVDMD	Oven dried IVOMD
1. Fattening Buffalo Calves				
100% manure	29.0	24.0	26.0	20.5
75% manure + 25% conc.	38.5	33.0	35.5	31.5
50% manure + 50% conc.	49.0	37.0	45.5	44.0
25% manure + 75% conc.	61.5	61.0	60.5	60.5
0% manure +100% conc.	79.0	76.0	-	-
2. Lactating Buffalo Cows				
100% manure	24.0	25.0	27.0	26.0
75% manure + 25% conc.	33.0	33.0	35.0	31.0
50% manure + 50% conc.	44.0	42.0	42.0	36.0
25% manure + 75% conc.	46.0	46.0	61.0	59.0
0% manure +100% conc.	79.0	76.0	-	-

Using mixture of 75 and 50% manure with concentrate (table 3) indicate that fattening sun dried manure had superior DM & OM disappearance compared to oven dried.

The in vivo data (table 4) indicate that a gradual decrease in the digestion coefficient of DM, OM, EE, CP and NFE were recorded with increasing the level of manure inclusion in the diet (O, 25, 33% on dry matter basis). On the other hand, a gradual and significant increase in ash, CF digestibilities were noticed with increasing manure level in diet. Moreover, the TDN values were found to correlate negatively with the level of manure which was in full agreement with IVDMD and IVOMD values for the whole diets used. Finally, it is worthly to note that the nitrogen balance was positive in the control treatment while it was negative when manure covered 50 or 75% of the dietary nitrogen.

Table 4: Mean percentage values for nutrients digestibility coefficients of diets containing graded amounts of buffalo manure

Nutrient Diet	Dry matter	Organic matter	Ash	Ether Extract	Crude fiber	Crude protein	N. F. E.	Nitrogen balance g	T D N	IVD MD %
Control	72.1	77.1	18.4	82.85	55.5	63.66	81.11	+5.6	75.5	73.6
50% of Nitrogen from manure	65.75	70.1	41.8	62.9	72.23	22.11	74.76	-1.44	60.6	51.0
75% of Nitrogen from manure	63.7	60.1	54.6	58.8	76.75	23.05	61.6	-1.13	55.9	39.2

NUTRITIONAL EVALUATION OF ENSILED GROUND SORGHUM-PIG FAECES MIXTURES

M.E. Ortega, O. Rojas. F. Perez-Gil.

National Institute of Nutrition, Mexico City

Summary

Excreta from 20-30 kg liveweight piglets, fed commercial balanced rations were obtained and mixed whith ground sorghum in 60/40, 50/50 and 40/60 percent sorghum-fresh pig faeces - ratio. The mixtures were allowed to ferment during 15 and 30 days. Proximate analysis and true protein determinations were performed on fresh faeces, ground sorghum and fermented silage samples. In addition, pH and volatile fatty acids content were determined in the silage samples. High crude and true protein values (40 and 30% respectively) were obtained for fresh faeces samples. There were no significant differences ($P \leq 0.05$) when silage percent humidity was compared among samples (% humidity= $\bar{x}$ 55.58). The comparison of silage ash content revealed significant differences among all treatments. The highest value (8.09%) was found in the 30-days fermented silage containing 40/60 % ground sorghum-pig faeces ratio. The lowest ash content value (3.53%) was found in the 60/40% sorghum-faeces silage fermented 30 days. The highest crude fiber content (5.90%) was determined in the 50/50% sorghum-faeces silage that had fermented 30 days, and the lowest value -- (2.89%) was obtained from the 40/60% sorghum-faeces 15-day fermented silage. The highest crude and true protein levels (19.75 and 14.77% respectively) were also found in the 40/60% 15 day-fermented silage. pH ranged from 3.98 in the 60/40% sorghum-faeces 15 day fermented silage to 4.4 in the 40/60% 30 day fermented silage. The highest concentration of acetic (0.145 g%), propionic (0.093 g%) and butyric (0.144g%) acids were found in the 40/60% -- 30-days fermented silage. We conclude from the results obtained, that the 15-day 40/60% sorghum-faeces silage has the highest potential in pig nutrition, since it contains the highest crude and true protein percentages and the lowest crude fiber level while maintaining adequate amounts of other nutrients.
Keywords: silage, pig faeces, ground sorghum, pig nutrition.

Introduction

Waste produced from pork industry, presents both and odor and an organic matter pollution problem. Since animal wastes contain some nutrients (Fontenot & Webb, 1975), it is po-- ssible to use them as a feed ingredient in pig rations. In some countries, like Mexico, the low protein availability, high cost of protein, and pig manure pollution, represent the most serious problems for pork producers. Perhaps, recúcling of pig excreta could help to dimihish pig faeces pollution and feed costs. The ensiling of mixtures of manure and other feedstruffs (Anthony, 1971) appear to be a cheap and simple method of processing pig excreta. The objetive of this study was to evaluate the chemical composition of ensiled pig faeces-ground sorghum mixtures, mixed in three different proportions, and ensiled either during 15 or 30 days in order to determine the most suitable mixture for feeding pigs.

Results and discussion

High crude and true protein values (40 and 30% respectively) were obtained for fresh -- faeces samples, higher values than those mentioned by Pearce, 1977; also, they contained 72% humidity, 4% ether extract, 8% crude fiber, and 32% N-free extract. While ground sorghum contained 15% humidity, 9% crude protein, 3% ether extract, 2% crude fiber, 2% ash and 84% N-free extract.

There were no significant differences -- ($P \leq 0.05$) when silage percent humidity was compared among samples (% humidity $\bar{x}$ 55.58). The comparison of silage ash content revealed significant differences; the highest value (8.09%) was found in the 30 day fermented silage containing 40/60% sorghum-faeces ratio, the highest ash content in this silage can be due to dust pollution when excreta was collected. The lowest ash content value (3.58%) was found in the 60/40% sorghum-faeces silage fermented 30 days. The highest crude fiber content (5.90%) was determined in the 50/50% sorghum-faeces silage fermented 30 days, and the lowest value (2.89%) was obtained from the 40/60 sorghum-faeces 15 day fermented silage. The highest crude and a true protein levels (19.75 and 14.77% respectively) were also found in the 40/60%. pH ranged from 3.98 in the 60/50% sorghum-faeces 15 days fermented silage to 4.40 in the 40/60% 30 days fermented silage. Similar results were obtained by Berger, et al., 1977, for pig manure hay silages. The highest concentration of acetic (0.145 g%) propionic (0.093 g%) and butyric (0.144 g%) acids were found in the 40/60% 30 days fermented silage. The high crude and true protein values obtained for the 40/60 sorghum faeces silage fermented during 15 days, confirm what was mentioned by Lezcano, et al., 1977, that it is possible to increase protein content in animal rations - when animal excreta is included, at a lower cost than other protein supplements used in animal nutrition. We conclude from the results obtained, that the 15 day 40/60% sorghum-faeces silage has the highest potential in pig nutrition, since it contains the highest crude and true protein percentages and the lowest crude fiber level, while maintaining adequate amounts of other nutrients. In addition, the inclusion of ground sorghum-pig faeces silages, in pig rations, could diminish feed costs and pig faeces pollution.

References

Anthony, W.B. 1971. Animal waste value nutrient recovery and utilization. J. Anim. Sci. 32: 799-801.

Berger, J., E.T. Kornegay & K.P. Fontenot. 1977. Ensiling characteristics of varying combinations of swine faeces and grass hay and the utilization of ensiled swine faeces grass by ruminants. UPI & su Res. Div. Rep. 174-158.

Fontenot, J.P. & K.E. Webb. Jr. 1975. Health aspects of recycling animal waste by feeding J. Anim. Sci. 40:1267-1277.

Lezcano, P.A. Elias. & C. Hardy. 1977. Uso del ensilaje de excreta vacuna y miel final como una nueva fuente de alimentos para puercos en ceba. Rev. Cubana Cienc. Agric. 11: 289-194.

Pearce, G.R. 1979. Generation and utiliza-- tion of wastes from intensive piggeries. 48th AN ZAAS Congress, Melbourne, Aug., 1977.

UTILIZATION OF CORRUGATED CARDBOARD BOXES AND DRIED POULTRY MANURE AS DIETARY INGREDIENTS BY SHEEP: IN VIVO AND IN VITRO STUDIES

M.A.Razzaque, A.Al-Awadi, A.Al-Nasser and A.J.Salman

Kuwait Institute for Scientific Research, Kuwait

Summary

Silages prepared from untreated cardboard and poultry manure had a good appearance after both three and six weeks of ensiling. Digestibility of dry matter in vitro ranged between 35 and 51%. The digestibility of dry matter and acid detergent fiber in vivo increased when cardboard was added to the diets. The sheep utilized the cellulose of cardboard better than that of ryegrass straw. Yearling lambs showed satisfactory growth when fed rations containing 13-26% cardboard and 10% poultry manure. The results of this study show that cardboard as roughage and poultry manure, as concentrate substitute, can be used in the rations by sheep.

Methods

Cardboard from municipal solid waste and poultry manure, i.e., cage hen manure (CHM) or broiler litter, from poultry farms were sundried and shredded or ground so they would pass through a 2-3 mm screen.

Silage preparation

Six silages were prepared with the following components:

Components of silage (g/100 g DM)	Silage no.					
					(without lacto-bacillus	
	1	2	3	4	5	6
Cardboard	89.4	82.5	73.4	64.3	55.0	89.0
Poultry manure	7.5	12.0	25.0	35.0	45.0	7.5
Urea	3.1	2.5	1.6	0.7	-	3.1

DM = dry matter

Molasses and lactobacillus were added to 150 g of these mixtures each containing 40% dry matter; each silage had a 6:5 ratio of crude protein (CP) to dry matter (DM). The mixtures were packed in polythene bags and ensiled for either three or six weeks. They were then opened and tested for pH.

Digestibility studies

Freeze-dried silage was used for the in vitro DM digestibility tests.

Introduction

Many workers have investigated the potential values of either cardboard (Belyea *et al.*, 1979) or poultry manure (Fontenot and Jurubescu, 1980; Flipot et al., 1975; Martin *et al.*, 1983). However, studies on the use of cardboard and poultry manure combination in a complete diet for sheep are limited. The present study was undertaken to investigate digestibilities and growth performance in sheep when cardboard and dried poultry manure were used as dietary ingredients.

For the in vivo digestibility studies, five wether lambs were randomly assigned to each of the four dietary treatments listed below. The CP/DM ratio was 8:5. Trace mineralized salt blocks and water were available ad libitum.

Table 1. Composition of used in vivo digestibility trial.

	Ration			
	1	2	3	4
Ingredient (kg/100 kg rations)				
Ground corn	43.4	42.8	42.4	39.4
Ryegrass straw	35.5	21.9	8.6	8.0
Cardboard	-	13.1	25.9	24.2
Molasses	8.9	8.8	8.6	8.1
Limestone	1.0	1.0	1.0	1.0
Cottonseed meal	11.2	12.4	13.6	9.8
Dried cage hen manure	-	-	-	9.5
DM(kg/100 kg)	875	894	910	901
Analysis (kg/100 kg DM)				
Crude protein	155	159	163	161
Acid detergent fiber	222	290	323	332
Lignin	52	61	71	72
Cellulose	163	218	248	253
Ash	65	53	48	80
Gross energy (K cal/g)	43	44	44	42
Amount fed per day (g as fed basis)	1200.0	1200.0	1200.0	1200.0
DM basis (g)	1050.2	1072.2	1092.0	1081.4

Vitamin A added to all rations at the rate of 4,400 I.U. per kg mixed ration.

After a two-week adjustment period, feed intake was recorded and total faeces collected for seven days.

Table 2. Composition of ration used in growth trial

	Ration				
	1	2	2	4	5
Ingredients (kg/100 kg rations)					
Cardboard	-	13.1	25.9	24.2	24.0
Dried cage hen manure	-	-	-	9.6	-
Dried broiler litter	-	-	-	-	10.0
Rice straw	35.5	21.9	8.6	8.0	8.0
Corn	41.3	40.6	40.0	37.4	37.0
Soyabean meal	16.2	17.4	18.5	13.8	14.0
Date	6.0	6.0	6.0	6.0	6.0
Limestone	1.0	1.0	1.0	1.0	1.0
Total	100.0	100.0	100.0	100.0	100.0

Growth trial

Twenty female yearling Erbi lambs (local breed), housed in individual pens, were randomly assigned to the five experimental diets listed below. Water and trace mineralized salt licks were available ad libitum. Vitamin A added to all rations at the rate of 4,400 I.U. per kg mixed ration.

The animals were fed once each day and live weight changes were recorded each week during the 49-day trial, which followed a 15-day adjustment period.

Results

Silage

All silages appeared good from a physical standpoint. The three-week silages with 3.1% urea (Nos.1 and 6) had higher pH values and a distinct ammonia odour; pH values became fairly uniform ranging from 6.2 - 7 after six weeks of ensiling.

After silages 4 and 5 were ensiled for seven months, they had excellent appearance and flavour, and the pH values were reduced to 4.1 and 4.2. Longer ensiling seems to be beneficial.

The amount of CP dropped in some silages, especially Nos. 1 and 6, indicating an appreciable loss of nitrogen. Silages with high levels of poultry manure contained high levels of CP.

Digestibility

In vitro DM digestibility depended on the proportions of cardboard and poultry manure. In general, it improved with increased poultry manure. In vitro digestibility of DM ranged from 35-51%.

In vivo studies showed that diets containing 24-26% cardboard (Nos 3 and 4) were more digestible than the others (Table 3). Less CP was digested when CHM was added (No.4) and cottonseed meal seems to be a better source of CP. The digestibility of fibrous components was better with higher levels of cardboard and improved with the addition of CHM. The date indicate that cardboard is a better source of fiber than ryegrass straw. Gross energy digestibility was higher when the diet contained more cardboard (Nos.3 and 4) but was depressed when CHM was added (No.4).

Table 3. Digestibility of various diet components in vivo

Ration / Component	Digestibility (%) 1	2	3	4
Dry matter **	68.6^a	69.1^a	72.7^b	69.4^a
Organic matter **	69.5^a	70.1^a	74.0^c	72.4^b
Crude protein **	69.1^b	69.1^a	70.2^b	65.5^a
Acid detergent fiber**	36.1^a	48.0^b	54.0^c	57.4^d
Cellulose **	43.7^a	54.2^b	63.2^c	66.8^d
Ash ***	56.2^d	51.4^c	48.0^b	35.6^a
Gross energy **	68.7^a	68.9^a	72.7^c	70.7^b

Means in the same row with different superscripts are different at the ($P<0.05$ level).
** $P<0.01$
*** $P<0.001$

Growth performance

There was no significant difference in total live weight gain, daily gain or feed conversion ratio in Erbi yearling lambs fed the experimental diets although those receiving rations containing cardboard and poultry manure gained at a slightly faster rate than those on other rations (Table 4). Feed intake rates suggest that diets with a cardboard and poultry manure combination are more palatable than the others.

Table 4. Feed intake and growth performance of sheep

Parameters	Rations 1	2	3	4	5
Daily dry matter intake (g)	937^b	1003^b	1074^{ab}	1233^a	1199^a
Daily live weight gain (g)	156	146	151	163	156
kg dry matter required per kg live weight gain	6.068	6.615	7.278	7.968	7.872
Dry matter intake as a percentage of initial live weight	2.84^b	3.15^{ab}	3.09^{ab}	3.56^a	3.60^a

Means in the same row with different superscripts are different at the ($P<0.05$) level.

References

Belyea, R.L., B.K.Darey and K.S.Jones, 1979. Rate and extent of digestion and potentially digestible cell wall of waste papers. Journal of Animal Science. 49:887-892.

Flipot, P.M. McNiven and J.D.Summers. 1975. Poultry waste as feed stuff for sheep. Canadian Journal of Animal Science. 55:291-296.

Fontenot, J.P. and Jurubescu. 1980. Processing of animal waste by feeding to ruminants. In Digestive Physiology and Metabolism of Ruminants edited by Ruckebuscu and P.Thivend. West port. Connectivut; Avi Publishing Co.

Martin, J.H., R.C. Loehr and T.E. Pilbeam. 1983. Animal manure as feedstuffs: Poultry Manure Feeding Trials. Agricultural Wastes 6:193-220.

ENSILED MIXTURES OF CAGE LAYER MANURE AND WHOLE CROP MAIZE FOR FATTENING BULLS

S.F. Spoelstra, L. Tjoonk and A. Steg

Institute for Livestock Feeding and Nutrition Research (I.V.V.O.)
P.O. Box 160, 8200 AD Lelystad, The Netherlands

Introduction

Dried poultry manure is a useful ingredient in rations for ruminants. However, raised fuel prices have made artificial drying economically unattractive. Ensiling, being a low energy process, could be an alternative to drying. Cage layer manure (clm), which under Dutch conditions seems to be the most suitable type of poultry manure, does not ensile well without an additive.
Mixing clm with whole crop maize would in addition to the preservation of the clm by the maize offer the advantage that the low crude protein and mineral contents of the maize are enhanced.

Ensiling clm with maize

Inclusion of clm in freshly harvested forage maize gave after ensiling in laboratory silos well preserved silages with pH values up to 4.2. The content of organic acids (predominately lactic acid) in the silages increased with the amount of clm added (figure 1).

In practice mixing of clm and maize is hampered by the extra labour and mixing machinery required during harvest and ensilage of maize. Furthermore, fresh maize, as a preservative of clm, is only available during the harvesting period. These drawbacks might, partially, be overcome when clm could be mixed with maize silage and the mixture succesfully re-ensiled. Thus the advantage of preserving clm in the mixture to be fed would be retained and the process would be applicable the year round.

Laboratory experiments showed that addition of clm to well preserved maize silage and re-ensiling the mixture gave silage with pH-values of about 5 and elevated amounts of acetic acid (Figure 2).

Although no significant amounts of butyric acid were formed, these silages could not be considered as well preserved. In pilot farm scale experiments badly preserved silages were obtained. So it is concluded that re-ensiling maize silage after admixing clm is hardly feasible.
Ensiling clm after addition of organic acids was also considered. Experiments showed that about 4% formic acid is needed for preservation.

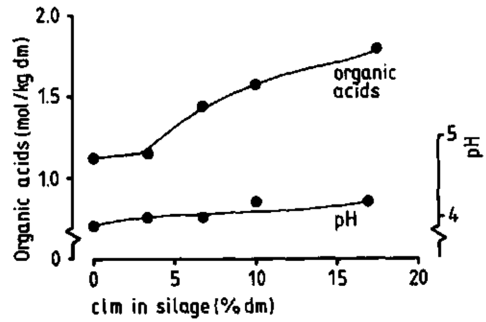


Fig. 1. Influence of amount of clm added to freshly harvested maize on silage quality.

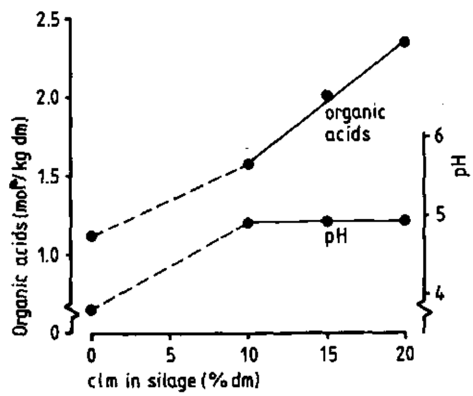


Fig. 2. Influence of amount of clm added to maize silage on silage quality after re-ensiling.

Feeding clm

Two of the described systems of ensiling poultry manure were extended to farm scale experiments and the obtained silages were evaluated in a feeding trial with bulls.
The silages made were:
a) - 30 tonnes of maize containing 16% clm (dm-basis). The clm and the maize were

Table 1. Composition of forages and concentrates. Mean (g/kg dm) and S.E. of samples taken during feeding.

Analysis	Maize silage	Silage of maize + clm	Mixed silages	Concen-trate 1	Concen-trate 2
Dry matter (g/kg)	260±13	267±16	270±5	890±16	885±3
Ash	58±2	92±7	89±6	106±7	79±3
Crude protein	87±3	139±2	123±13	160±4	125±0
Crude fibre	224±10	207±7	210±11	113±9	103±7
Crude fat	30±1	33±2	30±2	30±1	31±3
Digestibility* In Vitro (%)	71.5±0.5	72.6±0.6	72.4±0.6	86.1±0.9	86.8±1.0
Metabolisable Energy** (MJ/kg dm)	11.2	10.8	10.8	12.5	12.9

* In Vitro digestibility of organic matter (Tilley and Terry, 1963)
** Metabolisable energy calculated according to ARC 1977

Table 2. Animal performance and carcass quality.

Item	Maize silage	Silage of maize+clm	Mixed silages
Weight (kg)	289-495	288-495	293-499
Duration of experiment (days)	174	174	174
Forage intake (kg dm/day. animal)	4.7±0.3	4.9±0.7	5.1±0.5
Intake conc. 1 (kg dm/day.animal)	2.6±0.1	-	-
Intake conc. 2 (kg dm/day.animal)	-	2.7±0.1	2.6±0.2
Intake VEVI* (units/day.animal)	7415	7515	7680
Intake dcp (kg dm/day.animal)	0.571±0.027	0.691±0.074	0.658±0.058
Live weight gain (kg/day.animal)	1.184±0.128	1.190±0.124	1.185±0.078
Chilled carcass weight (kg)	265±15	266±12	275±14
Dressing (%)	53.3±1.0	53.1±1.3	54.2±0.9
Fat covering**	2.4±0.3	2.4±0.3	2.2±0.2
Internal fat**	2.9±0.3	3.0±0.2	2.8±0.2
Fleshiness**	3.5±0.5	3.4±0.5	3.1±1.1

* Dutch feed unit for intensive fattening
** Arbitrary units. Score from 1-6.

mixed batch-wise in a forage mixing wagon
b) 5 tonnes of clm preserved by addition of 3.5% (w/w) formic acid. The formic acid was sprayed on the clm while mixing in the forage mixing wagon and ensiled
c) control silage of maize.

The silages were fed to three groups of 10 bulls of the Dutch red and white (MRY) breed for 174 days in a randomised block experiment. The animals received 3 kg concentrate and forage to appetite daily. The clm silage preserved with formic acid and the control maize silage were mixed in a forage mixing wagon. This mixture, containing 17% (dm-basis) of clm silage, will be referred to as mixed silages (MS). The two groups of bulls receiving clm in their diet were supplemented with a (cheaper) concentrate mixture (concentrate 2) lower in protein and minerals than the control group (concentrate 1 in Table 2). Table 1 summarises information about chemical composition, digestibility and calculated energy values. When the bulls were first provided with clm containing forage they were reluctant to eat.
Over the whole period the average daily intake of the experimental silages was somewhat, non-significantly, higher than of the control thus compensating for initial low intake and lower

energy content of the clm containing ration (Table 2).

Intake, growth rate, dressing percentage and carcass characteristics were not significantly different between treatments. Animals on MS consumed on average slightly more energy, resulting in a slightly higher dressing percentage. Live weight gain in these experiments was quite satisfactory (Table 2). From this feeding trial it is concluded that animal performance on clm-containing forage did not differ from the control maize silage diet. The economic advantages for the farmer are found in the exchange of a part of the maize silage by clm and by the use of a cheaper (lower protein and mineral content) concentrate.

However, work in progress indicates that adequate mixing is a prerequisite to obtain both the silage quality and animal performance reported in this paper.

INCORPORATION OF SURPLUS VEGETABLES AND FRUIT INTO BROILER LITTER FOR FEEDING TO BEEF

G. Walker

Agricultural Development and Advisory Service, Ministry of Agriculture, Fisheries and Food, Wolverhampton, England

Summary

Broiler litter has been successfully ensiled under commercial conditions for feeding to beef animals. A variety of carbohydrate sources have been used including:- molasses, barley, wheat, cassava, sugar beet, fodder beet, purple beet, carrots, potato peelings and apples. Root crops must be chopped or macerated and cereal grains ground, before thorough mixing with the litter. Moisture content should be in the range 40-65%. Anaerobic storage is essential.

Introduction

The rearing of fowls and animals under modern farming conditions has led to a number of problems concerning the disposal of waste. Traditionally, excreta were used by farmers to manure the land but the intensification of rearing processes has increased the volume of waste beyond the point where this is feasible. Overmanuring of the land can cause pollution of waterways which collect the run-off and may lead to complaints from local residents about the smell and the potential health hazards of the practice. In addition the application of untreated manure to pasture can obviously pose a serious health risk to grazing animals.

The changeover to battery farming of poultry from free range has created a new type of waste which generally consists of droppings, feathers, bedding and unused feed. Numerous attempts have been made to feed this poultry litter to ruminant livestock (Thomas, et al 1972; Cross and Jenny 1975; Khattab et al 1982) as it has been shown to be a valuable source of protein and energy which can be efficiently utilised by ruminants (Bhattachanja and Fontenot 1965; Fontenot et al 1976). Thomas et al (1972) found that dehydrated poultry litter could be used cost effectively to replace up to 25% of a corn cob-corn-soyabean ration for fattening sheep whilst Khattab et al (1982) concluded that incorporation up to 40% of a wheat bran-poultry litter-molasses mix in a ration seemed to be a promising way of minimising the cost of production for growing lambs.

In the early days of feeding trials the poultry waste was dried in order to make it more hygienic, easy to handle and pleasant to use. The escalating cost of fuel during the 1970's made the cost of drying litter more and more expensive until it was not cost effective to supplement feed in this way any more. As early as 1972, Duga et al were looking at poultry manure recycling using the manure to eventually produce a relatively clean effluent and algae which can be used as a feed supplement. Whilst litter cannot be effectively treated in this way ensilage has become a more feasible method of treatment. The lactic fermentation process produces organic acids which are fully utilised by ruminants as a source of energy and will preserve the feed and eliminate pathogens if the pH is sufficiently reduced. McCastey and Anthony (1975) found that the development of sufficient acid to kill Salmonellae was dependant to some degree on an ensiling temperature greater than 25°C but the salmonellae did not grow in the presence of lactic acid at pH 4.0. The buffering capacity of poultry litter is such that the addition of a high carbohydrate supplement is necessary in order to produce sufficient lactic acid to lower the pH adequately. Various supplements have been used including ground corn and molasses (Vezey and Dobbins 1974) and corn forage or grain (Fontenot et al 1966) but the cost of these may counteract the use of poultry litter in the first case. Furthermore, many of the mixing and ensiling processes required for these supplements were too labour intensive or expensive for general farm use. What is therefore required, it would appear, is a cheap, readily available high carbohydrate source which can be easily mixed with poultry litter and successfully and reliably ensiled.

In 1979 a report on Research and Development into Feeding Broiler Litter to Beef Cattle was published by a National ADAS Working Party in which the results of a preliminary series of investigations were given. In that report it was stated that work was in progress in using alternative sources of fermentable carbohydrate for the ensiling process. Since that report was published work has continued at Wolverhampton in which the cost of the final ensiled material has been a main consideration. Also that the methods recommended for mixing and ensiling could be used on the majority of farms without the purchase of expensive additional machinery.

Farm Ensilage

Advice can now be given to farmers on the ensilage of broiler litter using molasses, barley, wheat, cassava, sugar beet, fodder beet, purple beet, carrots, potatoes, potato peelings and apples all of which have been successfully used under commercial conditions.

The equipment required on the farm is a clamp silo, a tractor with a fore loader and a muck spreader. The correct proportions of litter and carbohydrate are layered in the spreader and discharged into the clamp. The clamp should be of such a size that it is completely filled with the litter-carbohydrate mix. When the clamp is filled sealing to exclude air is vital, preferably butyl sheeting should be used, if this is not available, heavy duty polythene spreading at least 1 metre down the sides of the clamp and 3 layers thick should be used. Straw bales or clean gravel should be placed on top of the polythene sheets to prevent the ingress of air, tyres are not suitable for this purpose. After ensiling for 6 weeks the material is ready for feeding.

The three parameters which are essential are:-

- moisture - between 40-65%
- mixing - root crops must be chopped or macerated in rotary muckspreader
  - grain must be ground
  - must be thorough
- storage - anaerobic.

Provided the instructions are correctly carried out a material of pH 3.8-4.6 is obtained which has an acceptable odour and which is readily eaten by cattle. Fat soluble vitamins (A D & E) must be added to the animals diet or injected intramuscularly at regular intervals.

IT MUST BE REMEMBERED THAT THE PRACTICE OF FEEDING BROILER LITTER TO CATTLE ON FARMS SHOULD BE CARRIED OUT WITH VETERINARY CONSULTATION.

Microbiological aspects

It has been shown both in the laboratory and under commercial conditions that wood and straw based broiler litter can be satisfactorily ensiled to pH below 5.0 provided sufficient fermentable carbohydrate is available and that storage is anaerobic. It is not necessary to add Lactobacilli to help fermentation and in no case where the parameters of moisture, mixing and anaerobic storage were correctly carried out has Salmonellae been detected in the finished product.

PROPORTIONS OF VARIOUS MATERIALS TO BE MIXED WITH BROILER LITTER

	Litter	Vegetables	Molasses	Barley/ wheat	Cassava	Whey molasses
Mixtures by weight	4	4		1		
	16			1		5
	4	4			1	
	10		1			

References

Bhattachanja, A N and Fontenot, J P, 1965. Utilisation of different levels of poultry litter nitrogen by sheep. J. Anim. Sci. 24 (4) 1174-1178.

Cross, L L and Jenny, B F, 1975. Turkey litter silage in rations for dairy heifers. Journ. Dairy Science 59 (5) 909-922.

Dugan, G L, Golueke, C G and Oswald, W J, 1972. Recycling system for poultry wastes. Journal of Water Pollution Control Federation 44 (3) 432-440.

Fontenot, J P, Bhattachanja, A N, Drake C L and McClure, W H, 1966. Value of broiler litter as a feed for ruminants. Proc. Natl. Sym. on Animal Waste Management. ASAE Publ. SP - 0366, 105-108.

Khattab, H M, E L - Ashry, M A, El - Serafy, A M and Solimar, H S, 1982. Wood shaving duck litter in ration for growing lambs. Agric. Wastes 4 25-31.

McCastey, T A, and Anthony, W B, 1975. Health Aspects of Feeding Animal Waste Conserved in Silage. Managing Livestock Wastes. 230-233.

Thomas, J W, Yu YU, Tinnimitt, P and Zindel, H C, 1972. Dehydrated Poultry Waste as a feed for milking cows and growing sheep. Journal of Dairy Science 55 (9) 1261-1265.

Vozey, S A and Dobbins, C N, 1975. Ensiling Poultry Floor Litter and Cage layer manure. Managing Livestock Wastes. 195-196.

Discussion session I: Litter and Manure.
Chairman: F. de Boer

Discussion summarized by A. Steg

Steg: We have many problems of adaptation of beef cattle in our trials to rations containing caged layer manure, because the animals obviously do not like the smell of it at first hand. Perhaps professor Fontenot can tell about the way that problem is solved in the U.S.A.

Fontenot: Cattle and sheep have an adaptive characteristic of taste. They will adapt to the taste of animal waste as we have demonstrated in trials with swine waste, cattle waste, broiler litter and caged layer manure. It is however recommended to increase the level of animal waste in the ration gradually during a 1 to 2 week period. When animal waste should be a ration ingredient, it is also recommended to start at a young age.

Steg: Dr Benham was mentioning the "bioreactor" for composting of animal waste. Could you tell us some more details about the process?

Benham: The bioreactor consists of a rotating drum with sometimes forced aeration. The material is put in at one end and progresses slowly through the drum, staying in for 5-10 days. This ensures good mixing and thorough heating, so the pathogenic organisms hopefully died out.

Newman: Dr Ortega, is the ensiling and feeding of a mixture of sorghum and pig faeces already applicable in practice?

Ortega: One of the silages mentioned in the short paper was fed to pigs. We had two groups: one fed a commercial feed mixture and the other commercial feed + the mixed silage (30%).

No special problems were encountered in this trial, there were no feed refusals and weight gain and feed efficiency were similar. The experimental ration reduced feed costs by 15%. So the approach seems applicable in practice.

Krishna: Could dr Razzaque tell us a little more about the in vitro dry matter digestibility (IVDMD) and cell wall digestibility of card board with supplements?

Razzaque: In vitro digestibility studies on both dry matter and cellulose were conducted of cardboard as such and after additions. IVDMD and cellulose digestibility were fairly low (35-40%) when cardboard was tested as such. However, in vitro digestibility was significantly increased when cardboard was supplemented with dried caged hen manure or feather meal. Production of total VFA also increased with these supplements.

Treatment of cardboard with NaOH and addition of starch and nitrogen further improved the digestibility and VFA-production in the in-vitro system.

Barber: Dr Fontenot has said that there are few animal health problems associated with the feeding of composted or ensiled animal waste. Does this information relate only to experimental data and could he commend upon the commercial farm situation, where the treatment processes may not be carried out so effectively?

Fontenot: I refer to experimental work, but I have also attempted to persue problems arising in practice. Most of the problems are technical problems, e.g. with regard to the adequate moisture content of litter at ensiling or the heating up and even burning with the deep stacking procedure. The feeding problems I know of were essentially digestive disturbances because of lack of coarse roughage.

Spoelstra: As I understood, composting of animal manure is used as a method to kill micro-organisms. On the other hand, it is likely, that composting leads to loss of feeding value. Could you tell us, to what extent feeding value is decreased by composting and whether any fungi involved in composting are capable of producing mycotoxins?

Fontenot: We have never done experiments with unprocessed waste and we do not recommend that either. We have done some comparisons between deep stacking and ensiling of broiler litter. We obtained similar performance for both types of processing when fed with corn silage or dry rations to cattle.

Benham: The heating process which occurs must inevitably lead to a loss of energy. High temperatures may also denature proteins, although that may not be important for ruminants.

Fungi and actinomycetes will readily grow in composted litter. Some of the moulds are theoretically capable of producing mycotoxins, although there is little indication that they do so based upon limited surveys. Given the choice we would always go for ensiling rather than composting.

Van Wageningen: Do you consider ruminant manure suitable in practical ruminant feeding, after it has passed through a biogas digester?

Fontenot: One should keep in mind, that the fermented product will have less available energy per unit dry matter than the original waste. However, the nitrogen and the minerals remain and are of value as is demonstrated by dr Hashimoto for the residue of poultry manure. I would say: it has a value, but a limited one and whether it is viable in practice depends upon circumstances.

De Boer: The feeding of biogas reactor residue is not yet put into practice?

Fontenot: As far as I know not yet or to a very limited scale.

Shih: From our research studies we conclude, that anaerobic digestion of animal waste to produce biogas and solid product is a feasible process. The solid products retain nitrogen and minerals and contain single-cell protein and vitamins produced by bacteria. These solid products can be used for feed supplements.

Fontenot: Surely the solid products could have a certain value for mineral and nitrogen supply, but we should forget, that most of the available energy has gone into biogas. We should compare the solids with limestone and urea rather than with feed sources.

Summers: A large beef feedlot operator in Canada (5000 cattle) uses the manure to fuel a methane digester. He claims that the solids are a good protein supplement for this operation. (He feeds wastes from potato chip plants, bakery, etc. thus high in available carbohydrates.) He keeps good records on his operation and can show that he is saving a significant amount of money by reducing his purchase of protein concentrates for his animals. Mathíesen: Can you commend about the influence of the attitude of various religions to the practice of recycling of manure?

Fontenot: I have no information concerning religion effects. In the USA we have very little consumers' resistance to feeding animal wastes, if there are no health hazards.

De Boer: I have the impression, that there seems to be a difference between USA and Europe as regards the concern about health risks involved in feeding of manure. Is that right?

Fontenot: I did not say there are no risks at all, I said they are minimal. We have more faith in data, I think.

Boer Iwema: We in the Netherlands hesitate to use manure also because we are so much dependent upon export of our animal products.

Edel: According to AAFCO regulations, all animal waste fed to animals should be processed and free of pathogens. It is well known, that some of the processing methods professor Fontenot advocated do not reach temperatures high enough to kill the more heat resistant sporeforming bacteria and virusses. How do you bring this in line with the above mentioned regulations?

Fontenot: Regulations state that testing should include at least Salmonella and E.Coli and with proper processing these micro-organisms will be inactivated.

Benham: I think the answer to the problem is, that in practice no problems are encountered when processing makes sure, that Salmonella is inactivated.

★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★

WASTE OF PLANT ORIGIN

Some introductory remarks

A.J.H. van Es

Institute for Livestock Feeding and Nutrition Research, Lelystad and Department of Animal Physiology, Wageningen, the Netherlands

Summary

Most plant wastes have a high content of β-linked carbohydrates. Therefore these wastes can only with success be utilised by herbivores with the help of cellulolytic bacteria in forestomachs or hindgut. These animals may benefit more if the wastes receive some treatment before being fed and/or, if the conditions for cellulolysis in their forestomachs or hindgut are made more favourable. The suitability of plant wastes rich in cellwall as food for other animals is much smaller. Some other plant wastes are low in fibre but contain less palatable or toxic substances. Their value as a feed for animals results from their non-cellulose part. The degree of the negative properties determines how much can be included in a ration. Recently also wastes with a high water content which formerly were dried are used as feed.

Animals succeed very well in excluding most contaminants, if present in the wastes, from their milk, eggs and meat. Slaughter loss of animals fed wastes rich in cellwall is often increased, so is faecal output.

For successful use of plant wastes in animal nutrition the advantages should be carefully weighed against the disadvantages.

Introduction

Two types of plant wastes can be distinguished: those with high content of cellulose and hemicellulose and those containing unpalatable or toxic substances. The latter may also have high cellulose contents but there is more interest in animal husbandry in those with a low cellulose content and therefore higher levels of valuable starch, protein and/or fat. What is needed for their use is to know to what extent they can replace better but also more expensive feeds. Because of their effect on intake and digestibility of other parts of the ration, it is not easy to determine their full nutritive value with sufficient precision. Recently to this category of feeds wastes with a high water content have to be added. Formerly these wastes were dried but this has become too expensive. They are to be fed either in the fresh state or after preservation, usually ensiling.

Wastes with high fibre content

In the course of evolution the animal species, among these man, lost the capacity to digest β-linked carbohydrates like celluloses and hemicelluloses. As a result a considerable part of plant produce could not serve as a food source for several animal species and thus was not liked much because in most cases stems, leaves and roots of plants contain the β-type rather than the easily digestible α-type carbohydrates starch and sugars. Of these animal species man became still more particular in his food choice for sociological reasons, in the past more than at present, and more recently because of the great variety of foods from which he can choose.

Nevertheless a very great surplus of inedible plant produce did not occur because various animal species developed digestive systems that made use of a symbiosis with bacteria, which could utilize the β-linked carbohydrates. At first these bacteria lived in great number in the hindgut of some species. Much later also animal species with forestomachs appeared in which the microbes were housed. Because of anaerobiosis in hindgut as well as forestomachs the microbes do not use all energy of the β-carbohydrates for themselves but leave some 60-70% of it as volatile fatty acids, i.e. as an absorbable and useful form of energy for the host animal. Moreover in the case of animals with forestomachs the microbes themselves serve as a source of digestible protein with a high biological value for the host. Of course forestomach microbes also degrade those constituents of the feed which the host would be able to digest itself, and leave again only some 60-70% of the energy for him. Furthermore, in case of mature plant material in the long state, its slow breakdown in the forestomachs to particles which can pass the narrow reticulo-omasal orifice, leads often to low intake. Hindgut fermenters do not have this difficulty and in such a case can increase their intake but the lack of palatable components, the bulk of the feed and, sometimes, the small size of the stomach limit the size of this increase. Animals like rabbits have still another strategy of making use of fermentation by separating the digesta at the end of the small intestine in an easily fermentable part which stays some time in the cecum and a hardly fermentable part which is excreted quickly. Like other rodents they also use coprophagy to recycle some of the microbial protein resulting from fermentation.

Plant cellwall fermentation may differ considerably in rate and extent. It depends on the maturity of plant parts, their treatment and the environment in the forestomachs or hindgut. At higher maturity further crystallization of cellulose and increased lignin and sometimes silica content reduce the speed and extent of microbial breakdown. When temperature during plant growth is high, all maturity processes increase in speed and extent which explains the low intake and nutritive value of many (sub)tropical plant wastes. With alkali, steaming or other technological treatments these negative aspects may be lessened but of course not without costs. Microbial fermentation of plant material requires time. Thus in general in a large animal it is of more importance than in a small one because the size of the gastrointestinal tract and the energy needs for maintenance are related to the body weight's first and the ¾ power, respectively. So large ruminants can more rely on fermentation than small ones; so the latter have to select higher quality feed. The less optimal the environment for the microbes is - too little or unavailable N, S or/and energy, a pH below 6.0 -, the slower is their activity. As a result digestibility of cellwalls will be low and the same is the case with intake. In theory means to improve this internal environment can easily be indicated but their realisation under practical circumstances is not always easy.

It will be clear that also for these plant wastes with high cellulose levels it is difficult to determine their full nutritive value with sufficient precision.

Other aspects

Plant wastes with low digestibility have a relatively great influence on gut fill and thus on slaughter loss. Of course also faecal output increases.

During their growth many plants produce unpalatable or even toxic compounds for their own defence against animals and insects. In this respect ruminants have some advantage over hindgut fermenters because the microbes in the forestomachs may use these compounds or convert these into less toxic substances. In most cases very little of these compounds end up in the meat, milk or eggs. The same holds true for most other contaminants of the wastes. All animals have a very effective defence system by not absorbing such substances and/or by storing them temporarily in liver and kidney, usually for later excretion with faeces and urine.

Conclusion

It will be clear that successful use of plant wastes in animal husbandry depends mainly on the animal species used, the costs of the wastes, their palatability and possible negative effects on intake of other feeds of the diet, costs of transport, treatments, storage and feeding, and their nutritive value. Because of variation in circumstances the balance between advantages and disadvantages may vary from farm to farm. In the papers and posters of this session attention is paid to nearly all these aspects.

CHEMICAL TREATMENT OF CEREAL STRAWS BY ON-FARM PROCESSES

W. P. Barber, G. Alderman, A. H. Adamson, and R. J. Mansbridge

Agricultural Development and Advisory Service Feed Evaluation Unit, Stratford, UK

Summary

The accuracy of *in vitro* DOMD as a means of measuring feed value of straws was examined in a ring test on 22 samples. Five laboratories collaborated and the results showed an acceptable within laboratory error, but unacceptable between laboratory differences. In addition there was no correlation with *in vivo* DOMD values determined on the same samples. There was good agreement between three out of four centres for *in vivo* DOMD determinations on two straw samples.

For treated and untreated straws, correlations between all chemical parameters and *in vivo* DOMD were found to be very low ($r^2 < 0.4$; rsd > 5.0). There is, therefore, a continuing need to find a relatively simple laboratory procedure to predict the nutritive values of straws using *in vivo* measurements as a base line. The effects of hammer milling the samples during sample preparation and the effects of residual alkali upon rumen microbes in *in vitro* procedures require study.

Fifty nine samples of untreated, 15 samples of sodium hydroxide treated and 17 samples of ammonia treated cereal straws have been examined *in vivo* for digestibility (DOMD) and metabolisable energy (ME) value. They were also subjected to extensive chemical analysis for proximate constituents, structural carbohydrates and mineral content.

The mean *in vivo* ME and DOMD value for each species of untreated straw agreed with published data. For winter wheat DOMD % was 41.0 ± 5.2 (n = 24), spring barley 45.1 ± 5.1 (n = 25) and winter barley 45.1 ± 6.5 (n = 5). For winter wheat and spring barley straws there are already strong indications of a variety effect. Variety A winter wheat has a mean DOMD % of 39.4 ± 1.8 (n = 3). Variety B spring barley averaged 40.5% compared to variety C at 53.9% (n = 2).

The addition of sodium hydroxide increased the *in vivo* ME value by approximately 2 MJ/kg DM and the *in vivo* DOMD value by approximately 15 units. The degree of improvement varied, SD ± 6.0 units, and was not influenced by the initial value of the untreated material or apparently by the level of inclusion of sodium hydroxide.

Stack and oven methods of treating with aqueous or anhydrous ammonia produced a mean of 9 units increase in *in vivo* DOMD values, varying 5 to 17 units All samples also showed an overall increase of about 5 per cent units of crude protein in dry matter following treatment.

Introduction

Cereal straws are characterised by their high content of heavily lignified cell walls, resulting in levels of digestibility by cattle and sheep (expressed as % digestible organic matter in dry matter, DOMD) of the order of 30 to 50 per cent. They also have very low crude protein contents and demonstrate low voluntary intakes. The contribution of untreated cereal straw to the nutrient needs of ruminant is therefore rather limited.

Lignins are soluble in strong alkali and methods using various alkalis to delignify straw have been developed since the early 1900's. Workers at the Bioteknisk Institute Kolding, Andersen et al (1978) however developed techniques using caustic soda or ammonia solutions, which omitted the washing out stages of the earlier Beckman process. The alkali and the dissolved lignin are therefore retained in the straw, but the cell walls have been opened up for faster attack by rumen microbes. Substantial increases in DOMD % and voluntary intake have been recorded and the techniques developed for use both on the farm or in purpose built plants.

Because of the difficulties and expense of carrying out *in vivo* digestibility trials with straw, most workers have used either the Tilley and Terry (1963) *in vitro* rumen liquor technique, or the more recently developed cellulase enzyme assay, Jones and Hayward (1973), Dowman and Collins (1982). ADAS laboratories relied mainly on the Tilley and Terry technique, either as published, or as modified by Alexander and MacGowan (1966), but also with a 72 hour rumen liquor digestion phase. Terry (1983) has pointed out that the *in vitro* rumen liquor technique was not designed to evaluate low digestibility forages, and that it was likely to give high results compared to *in vivo* measurements.

Both caustic soda (NaOH) and ammonia (anhydrous or aqueous solution) treatment of cereal straws are currently being used on many farms in the UK, following substantial research effort demonstrating the benefits achieved. Staff of the Agricultural Development and Advisory Service (ADAS) have monitored many of these installations, and collected paired samples of wheat and barley straw both before and after treatment. The results of in vitro analyses did not give a clear picture, and the various centres involved suspected that as well as between laboratory effects there were other effects which were not understood.

The reference point for chemical and in vitro methods of laboratory assessment of digestibility is of course a carefully executed and standardised measurement of digestibility in vivo with cattle or sheep, fed at maintenance. Straw presents particular technical difficulties in executing such trials, since it cannot be fed alone, and there was no agreement amongst involved research workers on the amount and nature of supplement to be used, nor was it known whether such differences significantly affected the results obtained.

This paper presents the preliminary results of work carried out by ADAS laboratories, the ADAS Feed Evaluation Unit and other research centres during 1982/83 to resolve some of these problems.

Ring Test on the 'in vivo' digestibility of straw

Four centres participated in a collaborative trial to determine the in vivo DOMD in two samples of straw - one wheat and one barley. Each centre used its existing preferred technique which meant that three different systems of feeding straw plus supplement were used:-

1) Ad lib straw + 25 g/d urea - using 4 sheep.

2) Straw and soya bean meal fed in ratios of 80/20 and 60/40 - using 4 sheep. DOMD calculated by simultaneous equations.

3) 0.6 kg straw + 0.5 kg dried grass of known DOMD fed per day to each of 4 sheep.

One centre compared methods 1) and 3). The precision of digestibility measurements by difference is lower than that for feeds that can be fed alone such as dried grass. Soya bean meal's digestibility value is itself the result of a previous difference trial. The summarised results obtained are in Table 1.

The repeatability standard deviation, rSD between sheep at one centre, was ± 3.1. The reproducibility standard deviation, RSD, between centres was ± 4.4, excluding method 3 at centre D. The values for centre B contributed largely to the high value for RSD. Excluding centre B, the values for rSD became ± 3.2 and RSD ± 3.3. Thus the between centre variability was of the same order as the between animal variability, and

Table 1. In vivo DOMD % of wheat and barley straw measured at 4 centres

Centre	A	B	C	D	D
Method	1	1	2	1	3
Wheat	42.6	48.2	42.8	42.4	47.3
± SD	0.9	1.6	-	1.4	3.4
Barley	48.2	53.2	46.6	44.7	47.3
± SD	0.8	2.0	-	0.8	2.7
Overall Mean	45.4	50.7	44.7	43.6	47.2

no significant differences were found. It was concluded that 3 out of 4 centres produced similar results but that centre B should investigate further the reasons for the elevated values obtained.

Ring Test on the 'in vitro' digestibility of straw

Five laboratories participated in a collaborative analysis of 22 samples of cereal straw by various in vitro rumen liquor techniques.

The samples comprised:-

- 7 untreated barley straws
- 4 untreated wheat straws
- 2 untreated oat straws
- 2 NaOH treated barley straws
- 2 NaOH treated wheat straws
- 2 NaOH treated oat straws
- 2 NH_3 treated barley straws
- 1 NH_3 treated wheat straw

The centres differed in the details of the technique used, and the methods of correcting the basic data by the use of standard samples of known in vivo or in vitro digestibility. Four of the laboratories analysed in triplicate and one in duplicate. All of the straws samples had been subjected to in vivo DOMD measurement at the ADAS Feed Evaluation Unit, using method 3) above.

The data was not examined for outlier's since this would defeat the object of obtaining realistic measures of repeatability (r) and reproducibility (R). For most of the samples, r values were satisfactory, with a mean of 3.2, varying from 1.9 for the best to 5.6 for the worst. The values for R were much higher with a mean of 8.8, due to the between laboratory component of variance being very high. When the samples are pooled, the laboratory/sample interaction becomes the largest component.

It was possible that the between laboratory component depended on the type of straw or treatment so further statistical analyses were carried out on 7 untreated barley straws, 4 untreated wheat straws and the 6 NaOH treated straws. Although the values for r and R were similar, between laboratory variance increased and interaction variance decreased.

It was concluded that the repeatability rSD for all 22 samples was ± 1.2, and the reproducibility RSD ± 3.2 units. Therefore any one centre achieves fairly repeatable results for replicate analyses at that centre, but each laboratory would be unable to reproduce the results of another with any precision. Consequently steps are now being taken to standardise the methods used more exactly, including the use of standard samples and mathematical correction of raw data.

Correlation of 'in vivo' and 'in vitro' digestibility results for straws

The mean in vitro DOMD values recorded by each laboratory were compared with the in vivo DOMD mean results obtained with four sheep at the FEU.

All laboratories had a positive bias varying from 0.8 to 3.4 units. Two laboratories showed a decreasing bias with increasing DOMD (c.f. Terry, 1983). NaOH treated straws showed larger biasses and if they are excluded, all laboratories show a highly significant relationship between bias and measured DOMD, a sure indication that the two methods (in vivo and in vitro) are not measuring the same thing.

A separate regression line was fitted for each laboratory so that both slopes and intercepts could be compared. An analysis of variance showed no difference between intercepts and the slopes were parallel. A pooled regression analysis gave the following equation:-

$$\text{in vivo DOMD} = 11.11 + 0.73 \text{ (in vitro DOMD)}$$

$$r^2 = 0.42, n = 22, \text{NS.}$$

The NaOH treated straws form a separate group as may be expected, and omitting them from the calculations gave the following equation for untreated cereal straws:-

$$\text{in vivo DOMD} = 1.22 \text{ (in vitro DOMD)} - 0.64$$

$$r^2 = 0.39, n = 16, \text{NS.}$$

In the case of the 6 NaOH treated straws, it was clear that no significant relationship between in vivo and in vitro results existed. The latter results only varied between 57 and 62 DOMD %, whereas in vivo values varied from 40 to 66%.

Prediction of 'in vivo' DOMD of cereal straws from chemical or enzymatic procedures

All the samples subjected to in vivo DOMD and ME measurement are being subjected to extensive analysis in the laboratories using procedures in use at various research centres. They are:-

MADF	Modified acid detergent fibre %	Clancey and Wilson (1966)
NDF	Neutral detergent fibre %	Goering and Van Soest (1970)
ADF	Acid detergent fibre %	Goering and Van Soest (1970)
IVD	In vitro DOMD %	Tilley and Terry (1963)
CD	Cellulase DOMD %	Jones and Hayward (1973)
NCD	Cellulase DOMD %	Dowman and Collins (1982)

The results of regression analysis of the data to hand so far are given in Tables 2 and 3.

Table 2. Prediction of in vivo DOMD % of untreated cereal straws

DOMD % =					n	r^2	rsd ±
0.670	NCD	%	+	18.3	16	0.26	5.0
0.676	CD	%	+	26.6	17	0.25	5.8
0.176	IVD	%	+	37.1	18	0.08	6.6
- 0.952	MADF	%	+	91.9	23	0.22	5.6
- 0.921	NDF	%	+	118.9	22	0.27	5.5
- 1.138	ADF	%	+	103.8	22	0.36	5.1

Table 3. Prediction of in vivo DOMD % of alkali treated cereal straws

Method	n	r^2
NCD	15	0.02
CD	17	0.02
IVD	18	0.04
MADF	18	0.07
NDF	16	0.22
ADF	16	0.12

Discussion

The results of the collaborative study on in vitro rumen liquor techniques are disappointing, but on deeper enquiry, should have been expected. The original Tilley and Terry (1963) technique used centrifugation to separate the supernatant liquid after 48 hour incubation with rumen liquor. Lignin attacked by NaOH and solubilised would dissolve at normal rumen liquor pH 6 - 6.5. However the effects of the residual alkali in the straw upon the activity of the microbes does not appear to have been studied. The undigested residue from the first stage digestion is now subjected to 48 hour digestion in pepsin HCl solution. This highly acid solution would precipitate any remaining solubilised lignin, which would therefore be recorded (correctly) as indigestible by this technique. However the major proportion would be recorded as digestible.

In the case of the Alexander and McGowan (1966) modification of this technique, centrifugation (or filtration) is omitted, the rumen liquor being acidified and the pepsin added directly to it. This results in all solubilised lignin being precipitated and regarded as indigestible.

Similar arguments can be deployed about the two cellulase techniques used in these studies. That of Jones and Hayward (1973) starts with pepsin HCl treatment which would precipitate solubilised lignin, whilst the Dowman and Collins (1982) technique commences with neutral detergent extraction to achieve a cell wall preparation. Whilst the reagent is chosen so as not to dissolve lignin, alkali treated straws will supply lignin already solubilised and which will be discarded and counted as digestible when it is not.

The dry processes for straw treatment must rely for their effects upon some break up of the lignin molecules and loosening their attachment to the cell walls, since clearly rumen microbes find it easier to attack the cellulose of the cell walls. If we are dealing with a process which is in part a physical loosening of attachment of lignin to the cell walls, then we might expect that further vigorous processing would affect this still further. The standard procedure for preparing samples for analysis - hammer milling to pass a 2 mm sieve must surely be regarded as vigorous processing. Tilley and Terry (1963) adjusted their original method to take account of the effect of hammer milling upon rate of microbial attack. Presumably cellulase enzyme would be affected similarly in its rate and extent of attack upon delignified cell walls.

The source of nitrogen used in rumen liquor procedure when straw samples are tested is another source of variation. Some centres use urea, others ammonium salts and others pure casein.

Effect of 'on farm' treatment with NaOH on 'in vivo' digestibility

Paired samples of cereal straw before and after treatment with caustic soda (NaOH), either as the strong solution (35% W/V) or as the solid pellet, using purpose designed machines, or by dispensing caustic soda into tub grinders being used to process straw, were collected by ADAS staff. Sufficient material was collected to run a full length standardised digestibility trial using four sheep at the ADAS Feed Evaluation Unit. The results are shown in Table 4.

Table 4. Effect of caustic soda treatment of cereal straws on *in vivo* DOMD %

Variety	n	Treatment	DOMD %	SD
Barley	6	Control	49.7	± 2.9
		Treated	64.5	± 6.3
		Increase	15.3	± 6.2
Wheat	7	Control	40.6	± 7.2
		Treated	55.3	± 6.5
		Increase	14.7	± 6.0

The mean increase achieved, 15 units, is in agreement with published research, mostly based on *in vitro* results. At present prices in the UK, the degree of improvement is economic, particularly since on the larger farms, chopping of straw is essential for the inclusion of the straw in the ration. The alkali treatment is therefore available for little more than the cost of the chemical, plus a charge for handling. The treated straw does not require special air tight storage - a standard bunker with roof will suffice. The residual alkali is felt to be an advantage when feeding with acid silages, but salt should be omitted from the mineral supplements used. In the main, the process is operated in the UK by contractor mill and mixing services, who can train their operators in the safe handling of the corrosive solution, using appropriate protective clothing. They can also obtain and handle the alkali in bulk quantities.

Effect of 'on farm' treatment with ammonia on 'in vivo' digestibility

Paired samples of cereal straw before and after treatment with ammonia were collected in a similar manner to that described above. Two sources of ammonia are available in the UK, aqueous ammonia solution, and anhydrous (or liquified) ammonia. The latter has to be kept under pressure and is regarded as more hazardous to handle on farms. Straws were treated in large polythene covered stacks of bales, or in purpose built ovens of the An-stra-verter type, involving heating and retention in the oven for 24 hours. A more recent development is the construction of large gas tight boxes to hold substantial tonnages of straw undercover at ambient temperature. The results of standardised *in vivo* digestibility trials on 15 pairs of samples are shown in Table 5.

The mean increase achieved, 9 units of DOMD is less than published research findings, mostly based on *in vitro* results. At present prices in the UK for contractor

Table 5. Effect of ammonia treatment of cereal straws on in vivo DOMD %

Variety	n	Treatment	DOMD %		SD
Barley	9	Control	44.9	±	5.3
	9	Treated	53.9	±	4.6
		Increase	9.0	±	2.8
Wheat	6	Control	39.9	±	3.8
	6	Treated	49.2	±	4.4
		Increase	9.6	±	4.8

treatment of straw (£20 - 30/t), the increase in nutritive value only reaches break even on average, whilst a number of cases of improvement of only 5 units DOMD have been recorded, which are uneconomic. Other cases are known to the author where treatment in an oven has failed to give significant improvement in digestibility, despite the obvious signs of treatment effect - colour change, softer texture and increased N content.

A number of factors are known to affect ammonia treatment of straw, particularly moisture content of straw, ambient temperature and retention time. Stack treatment relies on long retention time at ambient temperature, whilst oven treatment uses short duration (24 hours) but elevated temperatures (90 - 100°C). The data show conflicting results when oven and stack treatments are compared as between wheat and barley. For barley, the increase for stack treatment is 12.0 ± 2.5 compared to 7.2 ± 0.4 for oven treatment. However the control samples for stack treatment averaged 40.6 ± 1.2 compared to 47.4 ± 5.3 for those selected for oven processing. If the degree of improvement is positively correlated to basal DOMD % this would explain the finding.

For the wheat samples tested to date, the findings were as expected, stack treatment 6.7 ± 1.4 and oven treatment 11.1 ± 6.0. The large standard deviation observed in oven treated wheat straw digestibility is particularly worrying. The possibility that lignin solubilised by ammonia reverts with time appears to need investigation.

Conclusions

Dry processes for the improvement in nutritive value of cereal straws present formidable technical problems to the nutritionist because the process removes nothing from the straw. The standard procedures for forage analysis reveal little of significance, hence the reliance on enzyme assays and rumen liquor procedures. The work reported here shows that whilst the latter technique can be run with acceptable repeatability at one centre, and can measure improvements in in vitro DOMD %, extrapolation of these results to in vivo DOMD results is not reliable.

The process of digestion of straw in vivo is arguably very different from that occurring in vitro, particularly the fact that the latter sample has been subjected to a further vigorous processing - hammer milling. The effects of this processing on the adhesion of lignin to the cell walls may be worthy of study. A further problem is that lignin that has been solubilised by treatment is still indigestible to the ruminant, but in vitro may often move into the filtrate and be counted as digestible. The error involved is low for normal forages, because of their low lignin content, but when the lignin content is high, this becomes an important source of bias and error. It would appear necessary to turn to more sophisticated techniques such as near infra-red reflectance spectroscopy to get a new approach to this difficult problem.

Acknowledgements

The assistance of Mrs J. F. B Altman in carrying out the statistical analyses of the two ring tests is gratefully acknowledged. Also the development and execution by ADAS Analytical Chemists of the specialised analyses reported above.

References

Alexander, R. M., & M. McGowan, 1966. The routine determination of in vitro digestibility of organic matter in forages - investigations of the problems associated with continuous large scale operation. J. Brit. Grassld. Soc. 21: 140-

Clancey, J. J., & R. K. Wilson, 1966. Development and application of a new method for predicting the digestibility and intake of herbage samples. Proc. 6th. Int. Grassld. Cong., p 445.

Dowman, M. G., & F. C. Collins, 1982. The use of enzymes to predict the digestibility of animal feeds. J. Sci. Food Agric. 33: 689-696.

Goering, H. H., & P. J. Van Soest, 1970. Forage fiber analysis. Agr. Handbook No. 379. USDA, Washington, D. C..

Jones, D. I. H., & M. V. Hayward, 1973. A cellulase technique for predicting the dry matter digestibility of grasses. J. Sci. Food Agric. 24: 1419-1426.

Friis Kristensen, V., P. E. Anderson, P. Stigsen, K. Vestergaard Thomsen, H. Refsgaard Andersen, M. Sorensen, C. S. Ali, V. C. Mason, M. Israelsen & J. Wolstrup. 1978. 464 Beretning fra Statens Husdybrugsforsog, Kobenhaven.

Tilley, J. M. A., & R. A. Terry, 1963. A two stage technique for the *in vitro* digestion of forage crops. J. Brit. Grassld. Soc. 18: 104-111.

Terry, R. A., 1983. Personal communication.

FEEDING VALUE OF SOME WASTES AND BY-PRODUCTS OF PLANT ORIGIN AND THEIR USE BY BEEF CATTLE*

Ch.V. Boucqué, L.O. Fiems, B.G. Cottyn & F.X. Buysse

National Institute for Animal Nutrition, B - 9231 Melle-Gontrode, Belgium

Abstract

During the last decades there is an increased investigation concerning the utilization of wastes and by-products of food production and processing in livestock husbandry. This is the consequence of a more rigid pollution control and of the competition with food for human consumption.

The chemical composition, digestibility and feeding value vary largely between by-products, but also within by-products the variation is sometimes considerable. This phenomenon can be explained by differences in origin, factory, fermentation process or harvesting system. Moreover, the feeding value can also be affected by the basic diet and the feeding level. Traditional methods to predict digestibility are not always accurate for by-products.
The feeding value of low quality fibrous by-products can be improved by physical and or chemical treatment.

For wet by-products ensiling mostly can be successfully applied. For pressed beet pulp and maize gluten feed storage losses can be limited at 10 % or less.
The utilization of by-products for animal production depends on the nutritive properties of the materials. With maize gluten feed, brewers grains, pot ale syrup and pressed beet pulp, excellent animal performances can be obtained. With low quality fibrous materials only small amounts can be incorporated in the diet without adverse effects.

Introduction

The paramount intention of agriculture is to produce enough food of good quality for the human population. However, only a part of the agricultural production is edible for mankind, mostly after industrial processing. For instance in the Netherlands de Boer (1983) cited a ratio of produced non-food on the total yield of 54 % for wheat, 62 % for sugarbeet and either 41 or 24 % for potatoes when they are used for starch production or direct consumption. Methods of by-product disposal in the past were burning, land spreading, burying or releasing into streams ... The increased number of regulations concerning pollution control and the public opinion regarding the quality of the environment emphasize the necessity to investigate an alternative use of wastes and by-products.

The rumen, with its extensive microbial population producing cellulases and urease, makes ruminants unique in their ability to convert fibrous, low-quality products and NPN into energy and animal protein. Consequently, energy and protein can come from sources which are not competing with humans.

To be currently used it is desirable that by-products are readily available in sufficiently large quantities, with a constant nutritional composition, without detrimental contaminants and with a lower purchase price than the traditional feedstuffs. Due to the enhanced price of fossil energy, it is not always economical feasible to use the by-products in a dried form. For the wet by-products preservation aspects must be taken into account. Some of these topics in relation with by-products of plant origin are discussed in this paper.

Chemical composition, digestibility and feeding value of some wastes and by-products

It is worthwhile to emphasize that there is a considerable variation in chemical composition for some by-products, e.g. : dry matter range of 31.0 - 44.7 % for maize stover (Lanari et al., 1983), of 16.0 - 20.7 % for pressed beet pulp (Drennan, 1983), of 40.0 - 50.0 for pot ale syrup (Kay, 1983) and 62.6 - 72.5 for condensed molasses solubles (Weigand, 1983); crude protein range of 2.5 - 10.5 % for cane molasses (Drennan, 1983), of 18.5 - 41.2 % for condensed molasses solubles (Weigand, 1983), of 19.0 - 30.0 % for dried brewers grains (Griffiths, 1983) and of 8.0 - 12.4 % for corn stower (Møller, 1983); crude fibre range of 4.7 - 9.5 % for grain stillage (Steg & Oostendorp, 1983), of 22.3 - 29.3 % for corn stover (Møller, 1983), of 15.0 - 18.0 % for dried brewers grains (Griffiths, 1983) and of 24.2 - 29.0 % for grape marc (Reyne & Garambois,

* Review of the main results communicated at the EEC-Seminar on "Feeding value of by-products and their use by beef cattle" held at Melle-Gontrode, Belgium, 26-29 September 1983.

Communication of the institute n° 552

Table 1. Chemical composition, digestibility and feeding value of wastes and by-products from plant origin

By-product	Dry matter (g/kg)	Crude protein	Crude fibre	OM digestibility (%) (1)	Feeding value per kg DM.	Reference
		g per kg DM.				
Treated sawdust	-	-	-	-	0.42 UFV	Tisserand, 1983
Wheat straw	-	-	-	41.4	-	Hagemeister et al., 1983
" " , steamed	-	-	-	61.0	8.4 MJ ME	"
Wheat straw	-	36	405	46.3	-	Aufrère & Michalet-Doreau, 1983
" " , + NaOH	-	28	396	57.1	-	"
Wheat strawpellets	866	38	420	41.9	215 g SU	Boucqué et al., 1983b
" " , + NaOH	842	39	392	56.8	343 g SU	"
Wheat straw	848	24	449	51.6	554 VEM	Cottyn, unpublished
" " , + 3 % NH_3	829	90	446	59.2	612 VEM	"
Rice straw	-	-	-	52.2	-	Hagemeister et al., 1983
" " , steamed	-	-	-	55.1	6.6 MJ ME	"
Corn stover	-	69	256	57.0	-	Aufrère & Michalet-Doreau, 1983
" "	310-447	36-69	-	43.9-52.4	4.9-7.5 "	Lanari et al., 1983
" "	-	80-124	223-293	63.2-77.4	0.72-0.95 FU	Møller, 1983
Soybean hulls	857-879	140-158	327-343	79.7-87.8	577-694 g SU	Cottyn, 1971
" "	-	152	314	55.1	-	Aufrère & Michalet-Doreau, 1983
Sunflower husks	-	52	530	18.1	-	"
Bran	-	185	93	71.8	-	"
Maize gluten feed	-	235	181	83.8	-	"
" "	904	215	95	75.8	-	Smits & Oostendorp, 1983
" "	885	224	81	80.8	12.4 MJ ME	Barber, 1983
Maize gluten meal	892	684	10	97.5	17.9 "	"
Citrus pulp	-	73	408	75.4	-	Aufrère & Michalet-Doreau, 1983
" "	877	67	133	86.1	714 g SU	Cottyn & Boucqué, 1969
Orange pulp	175	68	130	-	-	Lanza, 1983
" "	918	72	122	86.1-93.2	-	"
Lemon pulp	164	73	142	-	-	"
" "	903	90	182	-	-	"
Grape pulp	-	147	217	30.0	-	Aufrère & Michalet-Doreau, 1983
Grape marc	897	139	225	28.0	4.5 MJ ME	Lanari et al., 1983
" "	295-328	119-131	242-290	14.0-28.0		Reyne & Garambois, 1983
" "	872	120	204	45.7	-	Dumont et al., 1983
" ", + 5 L/T HCOOH	330	135	245	38.4	0.42 UFL	"
" ", + 5 L/T HCOOH + 3 % NaOH	308	143	267	30.2	0.31 "	"
Grape seed oil meal	855-868	110	496-533	24.9-28.2	170-171 g SU	Cottyn et al., 1981
" " + NaOH	850	108	516	22.5	136 g SU	"
Apple pomace	230	67	205	56.8(3)	8.0 MJ ME	Barber, 1983
Pectin extracted fruit	155-176	106	385-414	58.8-62.8 (3)	9.5-10.2 "	"
Banana leaves	-	-	-	46.9	-	Hagemeister et al., 1983
" " , steamed	-	-	-	50.7	6.4 MJ ME	"
Pinapple leaves	-	-	-	49.3	-	"
" " , steamed	-	-	-	57.2	8.1 MJ ME	"
Potato pulp	206	58	171	-	802 g SU	Cottyn et al., 1975
Beet pulp	-	174	151	82.6	-	Aufrère & Michalet-Doreau, 1983
" "	893	93	240	83.9(2)	12.1 MJ ME	Lanari et al., 1983
" "	172-182	87-92	276-280	79.2	11.3 "	"
" "	180	112	209	75.0(3)	11.8 "	Barber, 1983
" "	160-207	132-139	-	88.1(2)	-	Drennan, 1983
" "	165-195	97-112	193-212	-	0.99 UFV	Cadot & Morel d'Arleux, 1983

Table 1. (continued)

Beet pulp	253	107	270	-	-	Thêwis et al., 1983
"	135	100	178	82.6	686 g SU	Boucqué et al., 1983a
"	224	109	200	88.6	784 "	"
"	867	105	193	84.8	745 "	"
Bagasse	-	-	-	26.0	-	Hagemeister et al., 1983
" , steamed	-	-	-	55.0	8.0 MJ ME	"
Molasses, cane	708-740	25-105	-	-	-	Drennan, 1983
" , beet	755	140	-	85.0	11.8 "	Weigand, 1983
Cond. mol. solubles	626-725	185-412	0	72.0-85.0	8.2-11.7 "	"
"	621	349	0	-	-	Manfredini et al., 1983
"	636-652	381-386	0	-	453-497 g SU	Fiems et al., 1983
Pot ale syrup	400-500	350	0	-	14.5 MJ ME	Kay, 1983
Grain stillage	61-69	331-342	47-95	83.1	1365 VEVI	Steg & Oostendorp, 1983
Brewers grains	-	310	115	57.6	-	Aufrère & Michalet-Doreau, 1983
"	280	193	177	64.4	10.4 MJ ME	Barber, 1983
"	860-920	190-300	150-180	59.0-74.0	9.6-10.4 "	Griffiths, 1983
"	237	327	-	-	0.73 UFV	Cadot et al., 1983
"	250	304	160	62.7	609 g SU	Cottyn et al., 1975
Spent mycelium slurry	95	490	65	84.0	1075 VEVI	Steg & Oostendorp, 1983
Oil palm residue	-	-	-	20.0	-	Hagemeister et al., 1983
" , steamed	-	-	-	37.1	5.3 MJ ME	"

(1) determined with sheep
(2) dry matter digestibility
(3) *digestibility of the organic matter in the DM instead of digestibility of the OM.*

1983). Variations are due to a different origin, factory, fermentation process or harvesting system. Considering the feed cost price and the supplementation of the diet, the knowledge of the dry matter content and the chemical composition is important for the livestock producer.

Besides the chemical composition some authors mention a large variation in digestibility within samples of the same by-product. Digestibility coefficients of wet brewers grains ranged from 64 to 85 % for crude protein, from 87 to 97 % for ether extract, from 12 to 57 % for crude fibre and from 45 to 73 % for the N-free extracts (Barber, 1983). The organic matter digestibility ranged between 14.0-28.0 % for grape marc (Reyne & Garambois, 1983), 63.2-77.4 % for Danish maize stover (Møller, 1983), 43.9-52.4 % for Italian maize stover (Lanari et al., 1983) and between 72.0-85.0 % for condensed molasses solubles (Weigand, 1983).

When some by-products are characterized by a considerable variation in digestibility this statement is a fortiori valid between by-products. Aufrère & Michalet-Doreau (1983) mentioned an organic matter digestibility from more than 80 % for maize gluten feed and beet pulp to less than 30 % for grape pulp and sunflower husks. Also Reyne & Garambois (1983) found a low digestibility for grape pulp, which is in agreement with results obtained by Aufrère & Michalet-Doreau (1983). The chemical composition and the organic matter digestibility of a lot of by-products is listed in table 1.

A large variation in chemical composition coupled with a wide range of digestibility coefficients must result in considerable fluctuations of feeding value. However, it is not always possible to give a constant net energy value for some by-products. Aufrère & Michalet-Doreau (1983) found that the organic matter digestibility was affected by the feeding level. Digestibility obtained with ad libitum feeding was lower than at maintenance level. Further there was also an interaction between the by-product and the forage. For instance, organic matter digestibility of maize gluten feed determined at maintenance level, increased from 70.6 to 83.9 % when its amount in the diet varied from 0 to 100 % (calculated by regression). For ad libitum feeding, maize gluten feed organic matter digestibility amounted to 66.3 and 77.8 % when the diet contained 0 or 100 % of it respectively.

An interaction between the basic feed and the by-product was also found by Sauvant et al. (1983). From a rumen degradation investigation they found differences between concentrates with by-products or with cereals in relation with the kinetics of the transit time, although both concentrates had the same energy content and in vivo digestibility. Instead of a constant value as in tables with the nutritive value of feedstuffs, the value of by-products shows an asymptotic pattern. As a consequence, this variation has an impact on feed formulation and diet composition.

Since the determination of the in vivo digestibility is cumbersome and time-consuming a simple technique to estimate digestibility quickly and accurately is an absolute necessity. Aufrère & Michalet-Doreau (1983) proposed a pepsin-cellulase method to predict the in vivo digestibility : OMD = 0.212 +

0.717 OCd (OMD : *organic matter digestibility*; OCd : organic matter cellulase digestibility). The accuracy of this equation is fairly good : RSD = 0.032 and r = 0.975.

The nylon bag technique is not always a good predictor of the in vivo digestibility. Hagemeister et al. (1983) found that the 48 hrs nylon bag results will be better comparable with the in vivo digestibility when untreated material is concerned, while the 24 hrs nylon bag results may be better comparable for treated material.

Improvement of the nutritional characteristics

The lignification of cellulose and hemicellulose makes it difficult for rumen micro-organisms to attack these components. The treatment of fibrous waste products with saturated steam at 175-190°C for 8-20 minutes increases the organic matter digestibility as a consequence of the destruction of H-bridges and the mechanical enlargements of the caves between the fibrils (Hagemeister et al., 1983). Improvements of 19.5 units were obtained for wheat straw, 17 for oil palm residues, 29.0 for bagasse, 8.9 for pineapple leaves, 3.8 for banana leaves and 2.9 units for rice straw. Further there was a reduced rumen retention time and intake was markedly increased.

The treatment of ground straw with 5 % NaOH resulted in a dry matter digestibility of 56 % compared with 40 % for the untreated material, which means an improvement of 40 % (Boucqué et al., 1983).

In experiments of Tisserand (1983) a treatment with nitric acid under high temperature and pressure (Jelks method) was applied on sawdust.

It is not excluded that the physical form of the by-product may have an impact upon the energy value. As a mean of 5 sources of dried brewers grains, Griffiths (1983) found a ME value of 10.1 MJ per kg dry matter, compared with 10.4 MJ for wet brewers grains (Barber, 1983).

Also for beet pulp (Boucqué et al., 1983a) the energy value of the pressed material was higher than for the dried pulp.

Preservation

The shift to an increased availability of wet by-products necessitates investigation on storage and preservation. Questions about storage equipment, preservation method and nutrient losses are important in deciding whether or not the by-product fits into a feeding system. Ensiling is an easy method of conservation resulting in a controlled fermentation instead of putrefaction.

A good quality silage was obtained with maize gluten feed resulting in low dry matter losses (Smits & Oostendorp, 1983). The preservation of ensiled pressed beet pulp *was good in experiments of Théwis et al.* (1983) and Lanari et al. (1983) and resulted in a dry matter loss of about 10 % (Boucqué et al., 1983a). Also for maize stover ensiling appears to be the most suitable method of conservation. Adding water in order to lower dry matter content to 35-37 %, is convenient and may be sufficient to assure a good preservation (Lanari et al., 1983).

For liquid by-products as pot ale syrup the keeping qualities were excellent due to its acid nature : pH = 3.8 (Kay, 1983).

Utilization of wastes and by-products and animal performances

The feeding of maize stover silage instead of maize silage to young bulls resulted in a remarkable lower daily gain, as a result of the reduced dry matter intake. However the growth rate of bulls was significantly increased by the supplementation of the stover diet with monensin (Bonsembiante et al., 1983). On the other hand the feeding of large amounts of fermentable starch resulted in a depressed maize stover utilization. In 2 subsequent periods dry matter intake of heifers per kg gain amounted to 32.9 kg for maize stover silage combined with maize ears silage compared with 14.2 kg for maize stover alone. Also Cadot et al. (1983) observed a decreased growth rate when the amount of cornstalk silage in the diet was increased.

The supplementation of maize silage with 0, 3, 6 or 9 kg maize gluten feed slightly affected daily gain of bulls (Smits & Oostendorp). Hardly any difference in dressing percentage and slaughter quality could be measured.

Different alcohol by-products as brewers grains, distillers grains, pot ale syrup and condensed molasses solubles are available for ruminant feeding. Steg & Oostendorp (1983) mentioned a daily liveweight gain of 1.052 kg when 2.4 kg stillage dry matter was fed besides concentrates and maize silage. The comparison of ensiled brewers grains with peanut meal and soybean meal as protein supplements in maize silage diets resulted in a 5.5 % higher daily gain (Cadot et al., 1983). As dry matter intake was lower for the bulls fed brewers grains, it improved feed efficiency with 12 %.

Trials with complete diets containing 0, 22, 25 or 30 % pot ale syrup were carried out with heifers (Kay, 1983). It can be concluded that as much as 30 % pot ale syrup can be included in the diet without affecting daily liveweight gain. Only with the feed containing 22 % pot ale syrup intake and growth rate were somewhat lower.

The incorporation of 10 % condensed molasses solubles in concentrate for fattening bulls did not adversely affect daily gain or feed intake in experiments of Manfredini et al. (1983). However, the substitution of concentrate nitrogen by condensed molasses solubles reduced daily liveweight gain in our experiments (Fiems et al., 1983). With a maize silage diet the difference was significant and this was also true for ensiled pressed beet pulp as basic feed. Energy efficiency was not in favour of the condensed molasses solubles. We suggested that the value of condensed molasses solubles seems to be affected by the energy content of the diet. When we fed dried sugar beet pulp containing about 10 % condensed molasses solubles supplemented with a low protein concentrate in comparison with ordinary pulp supplemented with concentrate with either soybean meal or urea as nitrogen source, we did not observe a different growth rate. However daily gain during the initial period was lower and differed significantly with soybean meal; feed conversion of the 3 diets were similar.

The incorporation of dried orange pulp in a complete diet for baby beef bulls resulted in an inferior daily gain, a high feed intake and an unfavourable feed conversion (Lanza, 1983). On the contrary, carcass composition was similar for all groups, but the dressing percentage varied between 53.2 and 55.3 %. In our experiments the effect of incorporating citrus pulp was less unfavourable and feed conversion did not differ significantly (Boucqué et al., 1969).

The comparison of ensiled pressed beet pulp with a concentrate diet containing 60 % dried beet pulp resulted in a similar liveweight gain, but feed conversion was slightly better for the pressed sugar beet pulp (Théwis et al., 1983). With both diets a fast growth rate of about 1.4 kg daily was observed. The findings of Théwis et al. (1983) were confirmed by the experiments of Boucqué et al. (1983) with dried and ensiled pressed sugar beet pulp. Also in these trial a daily liveweight gain of about 1.4 kg was realized and the best feed conversion was obtained with pressed beet pulp. Pressed beet pulp did not affect dressing percentage or carcass composition in comparison with dried pulp.

Feeding pressed beet pulp supplemented with soybean meal or urea resulted in a similar gain in experiments of Cadot & Morel d'Arleux (1983), but the urea group had a slightly better feed conversion.

When ensiled pressed beet pulp was compared with rolled barley, both fed to appetite, daily gain of steers receiving barley was significantly higher and also feed conversion was higher. When pulp and barley were used as a supplement to grass silage there was no significant difference in gain or feed conversion (Drennan, 1983).

Another by-product of the sugar industry is molasses. Besides its sugar content, molasses has other interesting properties such as the improvement of pelleting characteristics, the avoidance of dustiness in dry mixed diets and its palatability. An evaluation of molasses relative to barley was investigated by Drennan (1983) and Karalazos et al. (1983). The utilization of molasses at about 21 % of the total dry matter intake in silage diets did not result in a significantly different gain in comparison with barley. However when 31 % or 38 % of the diet came from molasses daily gain was somewhat depressed.

These data indicate that cane molasses is used more efficiently at low ration inclusion rate where it compares favourable with barley At higher inclusion rates, the feeding value of cane molasses dry matter relative to barley dry matter is 76 and 64 % for maintenance and production respectively (Drennan, 1983). In experiments of Karalazos et al. (1983) the replacement of barley by 20 or 30 % beet molasses did not result in significant differences in daily gain, but feed intake and feed conversion were higher for the molasses diets. Dressing percentage was similar for the 3 groups.

With spent mycelium slurry Steg & Oostendorp (1983) found a daily gain of 1.025 kg which was in good agreement with the predicted one based upon energy intake.

The utilization of NaOH-treated strawpellets in a complete diet (without long straw) for beef bulls in substitution for dried beet pulp depressed daily gain at a lower incorporation rate. When more treated straw was used in the pelleted feed daily gain increased (Boucqué et al., 1983). This phenomenon can be explained by rumen fermentation disorders for the diet with 15 % treated strawpellets. (lack of sufficient physical structure).

In two experiments with young Charolais beef bulls Tisserand (1983) fed two isoenergetic and isonitrogeneous diets containing 11 and 20 % chemically treated sawdust; two control diets were based on cereals, beet pulp and alfalfa hay. Daily liveweight gain amounted to 1.21 kg for the sawdust group compared to 1.12 kg for the control group in the first experiment while in the second one, the figures were 1.31 and 1.63 kg respectively. Animal performances obtained with different wastes or by-products are summarized in table 2.

Conclusion

Due to food technology and processing a lot of by-products and wastes are available. Composition, digestibility and feeding value can fluctuate largely.

This makes continuous research on efficient utilization in livestock husbandry necessary. Traditional feed evaluation methods are not always applicable because of interactions of specific by-products with the basic diet.

The chemical and or physical treatment of fibrous products can improve digestibility and feeding value and offers promising perspectives.

The ensiling of wet by-products seems to be a good preservation method. However, the storage losses must be kept as low as possible.

The utilization of by-products as maize gluten feed, brewers grains, pot ale syrup, molasses, beet pulp, citrus pulp, resulted in good animal performances. With low quality fibrous products as straw, maize stover, grape pulp, ..., animal performances decreased when the amount in the diet was increased. These by-products are more suitable for animals with lower requirements.

Table 2. Animal performances with wastes or by-products

Diet/by-product	Animal sp.	Liveweight interval (kg)	LW. gain (kg/d)	Intake per kg gain	Reference
Maize silage	bulls	258-415	1.308	6.1 kg DM	Bonsembiante et al. (1983)
Maize stover	"	259-313	0.633	9.2	
Maize silage	"	254-419	1.369	5.7	
Maize stover	"	260-327	0.777	7.6	
Maize stover	heifers	377-415	0.542	14.2	
Stover + ears	"	415-461	0.331	32.9	
Stalklage + pulp	steers				
2.63 kg + 3.06 kg		238-404	0.776	8.16 kg DM	Cadot et al. (1983)
3.40 kg + 1.54 kg		238-371	0.623	8.72	
0 % grape seed oil	bulls	332-626	1.259	6.84 kg DM	Cottyn et al. (1981)
10 % " meal	"	332-619	1.253	7.33	
10 % " + NaOH	"	331-633	1.295	7.19	
Maize silage	bulls				
+ 0 kg gluten feed		421-548	1.245	6.6 k VEVI	Smits & Oostendorp (1983)
+ 3 kg " "		409-532	1.206	6.5	
+ 6 kg " "		435-561	1.235	6.5	
+ 9 kg " "		442-572	1.275	7.2	
Grain stillage	bulls	100-550	1.052	6.5 kg DM	Steg & Oostendorp (1983)
Maize silage	bulls				
+ meal		192-552	1.114	7.28 kg DM	Cadot et al. (1983)
+ brewers grains		191-549	1.199	6.40	
0 % pot ale syrup	heifers	340-540	1.21	9.4 kg DM	Kay (1983)
22 % "	"	"	1.08	9.0	
25 % "	"	"	1.13	10.1	
30 % "	"	"	1.13	9.7	
0 % cond. mol. sol.	bulls	267-585	1.02	7.51 kg DM	Manfredini et al. (1983)
10 % "	"	256-578	1.02	7.33	
Maize silage	bulls	284-618	1.14	6.54 kg DM	Fiems et al. (1983)
+ cond. mol. sol.	"	286-586	1.01	7.63	
Pressed beet pulp	"	291-611	1.39	5.79	
+ cond. mol. sol.	"	290-595	1.27	6.24	
Pulp + soybean meal	bulls	264-558	1.07	6.62 kg DM	Fiems et al. (1983)
" + cond. mol. sol.	"	263-536	1.01	6.68	
" + urea	"	265-549	1.05	6.61	
Concentrate	bulls	448-526	1.407	7.2 kg DM	Thêwis et al. (1983)
Pressed beet pulp	"	439-518	1.403	6.2	
Concentrate	"	361-543	1.377	6.7	
Pressed beet pulp	"	367-558	1.469	6.5	
Dried beet pulp	bulls	297-631	1.47	5.92 kg DM	Boucqué et al. (1983)
Pressed beet pulp	"	296-613	1.40	5.82	
+ 5 % molasses	"	298-632	1.48	5.74	
+ 1 % prop. acid	"	298-610	1.37	5.71	
Pressed beet pulp	bulls				Cadot & Morel d'Arleux
+ soybean meal		321-600	1.222	5.92 kg DM	(1983)
+ urea		321-605	1.207	5.83	
Pressed beet pulp	steers	305-477	1.132	7.0 kg DM	Drennan (1983)
Rolled barley	"	305-497	1.262	7.5	

Table 2. (continued)

Silage + pressed pulp	steers	305-482	1.163	6.7 kg DM.	Drennan (1983)
Silage + barley	"	305-495	1.249	6.7	
0 % orange pulp	bulls	221-360	1.211	5.38 kg feed	Lanza (1983)
25 % "	"	220-348	1.120	6.43	
50 % "	"	220-342	1.098	6.54	
0 % citrus pulp	bulls	144-471	1.215	4.94 kg DM	Boucqué et al. (1969)
25 % "	"	142-467	1.191	5.02	
50 % "	"	143-464	1.175	4.91	
Silage + barley	bulls	446-535	1.060	7.42 kg DM	Drennan (1983)
" + 30 % mol.	"	446-530	1.000	8.62	
" + barley	"	510-605	0.952	10.04	
" + 21 % mol.	"	510-605	0.952	10.18	
" + barley	"	510-616	1.056	9.70	
" + 38 % mol.	"	510-608	0.981	11.00	
Straw + barley	steers	450-546	0.785	10.22 kg DM	Drennan (1983)
" + 21 % mol.	"	450-557	0.880	9.39	
" + barley	"	450-577	1.037	8.99	
" + 33 % mol.	"	450-568	0.964	10.29	
0 % molasses	bulls	150-450	1.13	5.46 kg DM	Karalazos et al. (1983)
20 % "	"	"	1.06	6.22	
30 % "	"	"	1.13	6.03	
Mycelium slurry	bulls	250-650	1.025	7.80 kg DM	Steg & Oostendorp (1983)
0 % treated straw	bulls	349-676	1.36	7.36 kg DM	Boucqué et al. (1983)
15 % "	"	348-615	1.09	8.27	
30 % "	"	349-649	1.24	8.19	
45 % "	"	348-660	1.28	8.30	
Control	bulls	500-576	1.12	-	Tisserand (1983)
11 % treated sawdust	"	502-580	1.21	-	
Control	"	326-463	1.63	-	
20 % treated sawdust	"	328-438	1.31	-	

References

1. Aufrère, J. & B. Michalet-Doreau, 1983. In vivo digestibility and prediction of digestibility of some by-products. See 17.
2. Barber, W.P., 1983. Nutritional value of brewing, maize, sugar beet and fruit by-products. See 17.
3. Bonsembiante, M., G. Bittante & I. Andrighetto, 1983. Feeding trials on young bulls, once bred heifers and suckling cows with maize stover silage. See 17.
4. Boucqué, Ch.V., B.G. Cottyn & F.X. Buysse. 1969. Production intensive de viande bovine à base de pellets de pulpes séchées d'agrumes et de pulpes séchées de betteraves sucrières. Revue Agric., Brux. 22 : 1553-1570.
5. Boucqué, Ch.V., B.G. Cottyn, L.O. Fiems & F.X. Buysse. 1983a. Ensiled pressed sugar beet pulp for finishing white-blue bulls. See 17.
6. Boucqué, Ch.V., L.O. Fiems, B.G. Cottyn & F.X. Buysse, 1983b. Sodium-hydroxide treated strawpellets in complete diets for finishing beef bulls. See 21.
7. Cadot, M., N. Grenet, J. Legendre & F. Morel d'Arleux, 1983. The use of ensiled brewers' grain and cornstalks for beef cattle. See 17.
8. Cadot, M. & F. Morel d'Arleux, 1983. Energy and nitrogen supplementation of pressed sugar beet pulp for fattening Charolais and Charolais x Salers young bulls. See 17.
9. Cottyn, B.G., 1971. Digestibilité et valeur alimentaire des enveloppes de soja. Revue Agric., Brux. 24 : 305-316.
10. Cottyn, B.G. & Ch.V. Boucqué, 1969. Digestibilité et valeur alimentaire de pellets de pulpes séchées d'agrumes. Revue Agric., Brux. 22 : 1543-1551.
11. Cottyn, B.G., Ch.V. Boucqué, J.V. Aerts & F.X. Buysse. 1975. Digestibilité et valeur alimentaire des drêches de brasserie fraîche ou ensilées. Revue Agric., Brux. 28 : 1519-1525.
12. Cottyn, B.G., Ch.V. Boucqué, J.V. Aerts & F.X. Buysse. 1981. NaOH-treated grape seed oil meal in complete diets for intensive bull beef production. Agric. Environm. 6 : 283-294.
13. Cottyn, B.G., Ch.V. Boucqué, D.L. De Brabander & F.X. Buysse. 1975. L'utilisation d'ensilage de drêches de brasserie et d'ensilage de pulpes de pommes de

terre dans des rations pour taureaux de boucherie. Revue Agric., Brux. 28 : 1527-1539.
14. de Boer, F., 1983. Availability and utilization of byproducts and wastes in EC-countries. See 17.
15. Drennan, M.J., 1983. Evaluation of molasses and ensiled pressed beet pulp for beef production. See 17.
16. Dumont, R., L. Messaoudi & J.L. Tisserand, 1983. Feeding value of dried or ensiled grape marc. See 17.
17. EEC-Seminar on "Feeding value of by-products and their use by beef cattle", Melle-Gontrode, Belgium, 26-29 Sept. 1983.
18. Fiems, L.O., Ch.V. Boucqué, B.G. Cottyn & F.X. Buysse, 1983. Supplementation of beet pulp and maize silage diets with condensed molasses solubles as protein source for beef production. See 17.
19. Griffiths, T.W., 1983. The chemical composition, digestibility and feeding value of dried brewers grains and its use in diets for beef cattle. See 17.
20. Hagemeister, H., M. Sinner & W. Kaufmann, 1983. The effect of high pressure steam treatment on different tropical waste products. See 17.
21. International symposium on "Animals as waste converters", Wageningen, The Netherlands, 30 Nov. - 2 Dec. 1983.
22. Karalazos, A., J. Katanos & G. Moustakas, 1983. The feeding value of sugar-beet molasses in comparison with barley grain for growing-fattening bulls. See 17.
23. Kay, M., 1983. The feeding value and use of pot ale syrup in diets for steers and heifers. See 17.
24. Lanari, D., M. Pinosa, E. Tibaldi & L. Buttazonni, 1983. Digestibility and nutritive value of ensiled maize stovers, ensiled pressed beet pulp and dry grape marc. Chemical characteristics of saw dust grass silage and waste vegetables. See 17.
25. Lanza, A. 1983. Composition, digestibility and feeding value of dried citrus pulp for fattening bulls. See 17.
26. Manfredini, M., C. Cavani & L. Rizzi, 1983. Distillery effluents as animal feed : the use of condensed beet molasses stillage (CBMS) in the fattening of young bulls. See 17.
27. Møller, E., 1983. Investigation on the feeding value of maize stover in Denmark. See 17.
28. Reyne, Y. & X. Garambois, 1983. Nutritive value of whole grape marc silage for sheep. See 17.
29. Sauvant, D., D. Bertrand, S. Giger & P. Chapoutot, 1983. Variation of the byproducts degradation in the rumen, consequences for feed formulation. See 17.
30. Smits, B. & D. Oostendorp, 1983. Ensiled maize gluten feed as a feedstuff for pigs and beef cattle. Preliminary information. See 21.
31. Steg, A. & D. Oostendorp, 1983. Grain stillage and spent mycelium slurry for beef bulls. See 17.
32. Théwis, A., J. Renard, J. Paques & R. Renaville, 1983. Feeding value of ensiled pressed sugar beet pulp added with urea and molasses and their use by beef cattle. See 17.
33. Tisserand, J.L., 1983. Feeding value and utilization of chemically treated sawdust for young beef bulls. See 17.
34. Weigand, E., 1983. Composition of various molasses residues and their feeding value for ruminants. See 17.

SODIUMHYDROXIDE-TREATED STRAWPELLETS IN COMPLETE DIETS FOR FINISHING BEEF BULLS

Ch.V. Boucqué, L.O. Fiems, B.G. Cottyn & F.X. Buysse

National Institute for Animal Nutrition

Scheldeweg 68, B 9231 Melle-Gontrode, Belgium

Introduction

Due to the high crude fibre content, the low digestibility and the restricted intake, straw is not extensively used in diets for high producing ruminants. However, feeding value of fibrous feedstuffs can be improved by a chemical treatment with sodiumhydroxide or ammonia (Van Hoecke & Cottyn, 1979 a, b).

This paper deals with the effects of NaOH-treated straw on animal performances.

Material and methods

A feeding experiment involving 104 Belgian white-blue bulls was conducted with 4 diets, including (I) 0, (II) 15, (III) 30 or (IV) 45 % NaOH-treated strawpellets in substitution for dried sugar beet pulp. After grinding, the straw was mixed with 10 % of a solution containing 50 % NaOH and pelleted. With increasing amounts of treated strawpellets in the diets, a gradual increase of soybean oil meal from 8 to 10.5, 13 and 15.5 %, was necessary to cover the protein needs; the amount of barley decreased from 15.95 to 13.95, 11.45 and 8.95 %.

The animals had an initial weight of about 350 kg and were housed on slatted floors.

Table 1. Chemical composition

Diet (%)			Dry matter	Crude protein	Ether extract	Crude fibre	N-free extract	Ash
	Treated strawpellets	Dried pulp	Chemical composition (g/kg)					
				Dry matter basis				
I	0	65	885	130	10	138	621	101
II	15	50	886	129	9	169	593	100
III	30	35	876	135	11	202	546	106
IV	45	20	878	137	10	218	524	111
	100	-	842	39	11	392	436	122
	-	100	879	97	6	194	622	81

Table 2. Digestibility and feeding value

Diet (%)			Digestibility coefficients (%)						Feeding value (g/kg)	
	Treated strawpellets	Dried pulp	Organ. matter	Dry matter	Crude protein	Ether extract	Crude fibre	N-free extract	Starch units	DCP
I	0	65	87	82	70	47	85	91	750	91
II	15	50	83	78	71	39	79	87	695	91
III	30	35	79	75	69	44	76	84	640	92
IV	45	20	75	72	70	61	73	78	586	95
	100	-	57	56	-	43	69	54	343	-
	-	100	86	81	62	-	85	92	755	61
Untreated strawpellets			42	40	-	23	51	39	215	-

Communication n° 537 of the institute.

The diets were fed to appetite and only the control animals (group I) received long straw in the rack.
Besides the beef production trial a digestibility trial was performed with wethers fed at maintenance.

Results

The chemical composition of the diets is presented in table 1. Table 2 contains the digestibility and the feeding value. The incorporation of treated straw resulted in an increase of crude fibre and ash and a decrease of the N-free extract.
Although there was an improvement of the DM digestibility of the straw by the treatment, the DM digestibility of the diets was gradually decreased by including higher amounts of treated strawpellets. This resulted in a diminishing energy content of the diets (table 2).
Daily gain, feed intake and feed conversion of the bulls are given in table 3.
The incorporation of treated straw resulted in a decrease of daily gain, but the effect was not lineair. Normally we would expect a gradual reduction of the growth rate due to a smaller energy concentration (Boucqué et al., 1980b). In this trial the lowest gain of group II can be explained by a disturbed rumen fermentation. Piatkowski & Nagel (1975) stated that the chemical treatment of chopped straw with liquid NaOH reduced the ruminating activity by 53 %. However with 12 % untreated ground straw in a complete diet, we did not observe rumen disorders (Boucqué et al., 1980a).
Dulphy et al. (1982) mentioned also a considerable reduction of the ruminating activity. This statement is still valid for group III, but to a smaller extent. For group IV a good daily gain of 1.28 kg was realized, compared with 1.36 kg for group I. Feeding a diet with 40 % treated straw resulted in a growth rate of 1.32 kg per day in the experiments of Ali & Andersen (1979).
The dry matter intake per kg gain was enhanced with increasing quantities of straw.
On the other hand energy intake per kg gain was similar for group I and III, but was most favourable for group IV. This is not in accordance with daily gain of group IV in comparison with group I. A possible explanation can be an underestimation of the digestibility of straw with wethers, since Aerts et al. (1981) found a lower digestibility for low quality forages with sheep in comparison with cattle.
Table 4 presents the slaughter and carcass data of the bulls.
The incorporation of treated straw always resulted in a significant higher weight loss during a 20 hours fasting period prior to slaughter ($P < 0.01$).
Dressing percent, blockiness and carcass composition of group II were always significantly lower than for the other groups. Once again this phenomenon must be interpreted as a result of the rumen fermentation disorders.

Table 3. Beef production results ($\pm s_{\bar{x}}$)

	I	II	III	IV
Number of bulls	26	27	25	26
LW. interval (kg)	349-676	348-614	349-649	348-660
Daily gain (kg)	$1.36^{a}\pm0.03$	$1.09^{b}\pm0.03$	$1.24^{c}\pm0.04$	$1.28^{ac}\pm0.04$
Carcass gain (kg/d)	0.92	0.67	0.82	0.86
Feed intake (kg/d)				
- dry matter	10.0*	9.0	10.2	10.6
- starch units	7.15	6.28	6.50	6.22
Intake per kg $W^{0.75}$ (g/d)				
- dry matter	92.9	87.8	96.2	99.8
- starch units	66.4	61.1	61.5	58.4
Feed conversion (kg)				
Per kg liveweight gain				
- dry matter	7.36	8.27	8.19	8.30
- starch units	5.26	5.75	5.24	4.86
Per kg carcass gain				
- dry matter	10.86	13.43	12.44	12.33
- starch units	7.77	9.37	7.93	7.23
Feed cost (BF/kg)				
- per kg feed**	11.50	11.00	10.46	9.93
- per kg LW gain	91.4	102.5	97.8	93.7

a, b, c : values with different superscripts are significantly different ($P < 0.05$)

* The mean daily intake of long straw amounted to 0.73 kg (0.62 kg DM)

** Unit prices : 5.3 BF/kg treated strawpellets; 9.5 BF/kg dried beet pulp; 3 BF/kg long straw; 15.5 BF/kg soybean oil meal.

In a previous experiment where barley was gradually substituted by haypellets we also found an increased fasting weight loss, but the higher amount of haypellets significantly decreased dressing percentage (Boucqué et al., 1971).
So we can conclude that even with high amounts of treated straw an acceptable daily gain can be realized. To prevent bloat and consequently a lower daily gain, a lower feed intake, an unfavourable feed conversion and an inferior carcass quality it is advisable to make long straw or hay available.
At the present unit prices of the feedstuffs (table 4), the use of NaOH-treated strawpellets for intensive bull fattening, is less profitable than dried sugar beet pulp.

Table 4. Slaughter and carcass data ($\pm s_{\bar{x}}$)

	I	II	III	IV
Number of bulls	26	25*	25	26
Fasting weight loss prior to slaughter (%)	$2.84^A \pm 0.14$	$3.71^B \pm 0.18$	$3.88^B \pm 0.19$	$4.18^B \pm 0.18$
Dressing percentage	$64.4^A \pm 0.3$	$62.0^B \pm 0.5$	$63.9^A \pm 0.4$	$64.9^A \pm 0.4$
Blockiness (kg/cm)	$3.13^A \pm 0.03$	$2.76^B \pm 0.04$	$2.97^A \pm 0.04$	$3.04^A \pm 0.04$
Carcass composition (%)				
- meat	$67.1^A \pm 0.5$	$69.6^B \pm 0.5$	$66.4^A \pm 0.5$	$67.3^A \pm 0.6$
- fat	$19.4^A \pm 0.4$	$15.6^B \pm 0.5$	$19.8^A \pm 0.5$	$19.1^A \pm 0.7$
- bone	$13.5^A \pm 0.2$	$14.8^B \pm 0.3$	$13.8^A \pm 0.2$	$13.6^A \pm 0.2$

A, B : values with different superscripts are significantly different ($P < 0.01$)

* Two bulls remained only 168 days in experiment (acidosis)

References

Aerts, J.V., D.L. De Brabander, B.G. Cottyn & F.X. Buysse, 1981. Vertering van ruwvoeders door koeien of door schapen. Med. Fac. Landbouw, Rijksuniv. Gent, 46/4 : 1249-1250.

Ali, C.S. & H.R. Andersen, 1979. Sodium-hydroxide-treated barley straw in pelleted diets for beef cattle. Acta Agric. scand. 29 : 24-28.

Boucqué, Ch.V., B.G. Cottyn & F.X. Buysse, 1971. Effect of varying haypellets barley rations on performance of beef cattle. Atti del VI Symposio Internazionale di Zootecnia, Milano, 15-17 Aprile, pp. 361-376.

Boucqué, Ch.V., L.O. Fiems, B.G. Cottyn & F.X. Buysse. 1980a. Taux d'incorporation de paille broyée dans les rations sèches complètes pour taureaux à l'engrais. Revue Agric., Brux. 33 : 1045-1059.

Boucqué, Ch.V., L.O. Fiems, R.J. Moermans, B.G. Cottyn & F.X. Buysse, 1980b. Effect of energy density of diets for intensive bull beef production on intake, growth rate and feed conversion. Ann. Zootech. 29, n° h.s. 233-250.

Dulphy, J.P., J. Breton, A. Bienaimé & J.M. Louyot, 1982. Etude de la valeur alimentaire des pailles de céréales traitées ou non à la soude. I. Influence du traitement à la soude. Ann. Zootech. 31 : 195-213.

Piatkowski, B. & S. Nagel. 1975. Ergebnisse über die Kau- und Wiederkauaktivität von Kühen bei Rationen mit Getreidestroh verschiedener physikalischer Form und nach chemischer Behandlung mit Natronlauge. Arch. Tierernährung 25 : 575-582.

Van Hoecke, P.P. & B.G. Cottyn, 1979a. Comment améliorer la valeur alimentaire de la paille, utilisée comme aliment pour le bétail. Etude bibliographique. 1. Traitement à la soude. Revue Agric., Brux. 32 : 71-88.

Van Hoecke, P.P. & B.G. Cottyn, 1979b. Comment améliorer la valeur alimentaire de la paille, utilisée comme aliment pour le bétail. Etude bibliographique. 2. Traitement à l'ammoniaque. Revue Agric., Brux. 32 : 89-93.

SUBSTITUTION OF DRIED GROUND COCOA HUSKS FOR MAIZE IN GROWER-FINISHER BROILER RATIONS

Endeley, H.N.L.

National Advanced School of Agriculture, Yaounde, Cameroon

Summary

600 unsexed broiler chickens, 7 weeks of age were used in an experiment to determine the optimum level of cocoa husks in grower-finisher broiler rations.

Dried ground cocoa husks were substituted for maize in diets at 0,10,20 and 30% respectively.

Statistical analysis revealed better growth performances in the group of birds fed 10% ground cocoa husks while there were non significant differences between the control and the birds fed 20% cocoa husks.

Cost analysis showed no significant differences between diets at all levels of inclussion, the direct result of compensatory increases in consumption as the level of cocoa husks in the diets increased.

Results indicate the possibility of the use of dried cocoa husks at levels up to 13% in grower-finisher broiler rations without any detremental effects.

Introduction

Cameroon produces over 125,000 tons of cocoa beans annually which is mainly exported. In the preparation of cocoa for market, the usual practice is the removal of the beans from the pods and the ultimate fermentation and drying of the beans for sale. In this practice the cocoa pods are completely discarded and are usually butied or burnt.

Due to its high fibre content, cocoa pods seem to be efficiently utilised by ruminants. Traditionally however, there are no cattle in the cocoa producing zones. While quite an amount of work has been done on the feeding of cocoa husks to ruminants with considerable success(Ndumbe, 1980), very little work has been carried out on the use of this residue in monogastric feeding.

Experiments carried out in this light by Adeyunju et. al.(1975,1977) on chickens at the University of Ife didnot give definite conclussions, while Branckaert et. al.(1973) obtained results with pigs.

The purpose of this study was therefore to evaluate the utility of dried cocoa husks in grower-finisher broiler rations.

Methods

Fresh cocoa pods(husks) were collected from farms around Nkolbisson, Mbankomo and the farm of the Institute of Agronomic Research in the Centre South province of Cameroon. At the time of harvest the pods had about 85% water They were then dried using forced drought ovens and sunlight and then ground producing a brown powder.

600 unsexed broiler chicks originally imported from Israel, 7 weeks of age and weighing approximately 525g on the average, were randomly divided into four groups representing four levels of incorperation of cocoa husks (0,10,20 and 30% substitution for maize thus the diets contained 0, 6.5, 13 and 19.5% cocoa husks). The birds were individually taged and their individual weights and consumptions recorded weekly.

Results and discussions

Average weekly weights

The average weekly weights of the chickens ranged from 580.5±77.14 and 682.0±126.67g at the onset of the experiment to 2695.83±386.77 and 2189±304.26g for the 10 and 30% levels of substitution respectively at the end of the experimental period. There was an absolute superiority of the birds on the 10% level over the others while there were no significant differences between weights of the 20% level and the control. The birds on the 30% level had significantly($p<0.05$) lower weekly weights.

The trend of average weekly weights and daily gains of the birds in this study are similar to those reported in literature by Adeyanju et. al.(1975, 1976 and 1977). However, though Brankaert et. al.(1967 and 1973) suggested that poultry and pigs could utilise cocoa husks up to 20% in their diets the results of this experiment show that after 13% the performance of the birds declined. Their diets were however, boasted with synthetic amino-acids and this could have improved growth at higher levels of inclussion.

Average daily weight gains

There were variations in weight gains from one bird to another in the same group and between treatments. Once more, the higher performances were found in the birds fed the 10% level of inclusion (40.8 g/day) while the control and those fed on the 20% level had fairly the same average daily gains (37.36 and 36.15 g/d). The birds on the 30% level had the lowest gains.

Feed consumption

The average daily feed consumption per bird ranged from 77.35 and 103.85g for the control and the 10% level respectively during the first week to 153.27 and 219.79g for the control and the 30% level respectively at the end of the experiment. Generally the control had the lowest consumption rates while the birds on the 30% level consumed more feed than any other group.

The daily feed consumption increased with increases in the level of cocoa husks in the diets. These observed increases are in agreement with reports of Adeyanju et al. (1976 and 1977) and Branckaert et al. (1973). The increases were likely the result of decreased metabolisable energy content of the rations as a consequence of increased crude fibre content of the cocoa husks diets thus, to satisfy their energy requirements the birds fed cocoa husks had to consume more feed.

Efficiency of feed conversion

Feed conversion ratios varied from 2.77 and 6.57 for birds fed diets with 10 and 20% levels respectively during the first week to 4.57 and 8.56 during the last week of the experiment for the control and 30% level respectively. Though there were exceptions, the general tendency was that the feed conversion ratio increased as the level of cocoa husks in the diets increased.

Conclusion

This study reveals strikingly that maize could be gradually replaced in the diets of grower finisher broilers up to about 20% consequently increasing quantities available to humans.

However, more work should be done on this subject particularly on the detailed chemical composition of the cocoa husks.

References

Adeyanju, S.A., D.B.A. Ogutuga and J.O. Ilori, 1975. Cocoa husks in maintenance rations for sheep and goats in the tropics. Nutr. Reports International Vol. 11 No. 4.

Adeyanju, S.A., D.B.A. Ogutuga and J.O. Ilori, 1976. Cocoa husks in poultry diets. Malaysian Agricultural J. Vol. 4.

Adeyanju, S.A. D.B.A. Ogutuga and J.O. Ilori, 1977. Performance of chicks on diets containing graded levels of cocoa husks. Nutr. Reports International Vol.15 no. 2:165-170.

Adeyanju, S.A., D.B.A. Ogutuga and J.O. Ilori, 1977. Evaluation of cocoa husks in finishing diets for broilers Turialba Vol. 27. No 4: 371-375.

Branckaert, R., F. Vallerand and J.C. Vincent, 1973. La farine de cabosse de cacao dans l'alimentation du porc in café cacao. Vol. 17 no 4: 313-320

Ndumbe R.D., 1980. Utilisation of Agro-industrial by-products in beef fattening rations preliminary results of F.A.O. pilot project Cameroon.

SUBSTITUTION OF COTTON SEED CAKE BY RUBBER SEED CAKE IN THE FEEDING OF BROILERS

H.N.L.Endeley, J. Tchoumboue and M.D.-Tchouken
National Advanced School of Agriculture, Yaounde, Cameroon.

Summary

500 unsexed broiler birds, 7 weeks of age were used in a trial designed to study the possibility of replacing cotton seed cake by rubber seed cake in broiler rations.

Five diets were formulated to contain 0, 2.25, 4.5, 6.75 and 9% rubber seed cake thus replacing 0, 25, 50, 75 and 100% cotton seed cake in the diets. Birds were randomly divided into the five treatment groups such that average group weights were almost equal.

Though feed consumption decreased significantly with increases in the level of rubber seed cake, no significant differences were obtained in terms of average daily gain, efficiency of feed utilisation and feed cost needed to produce 1 kg live weight gain.

Accordingly, it seems rubber seed cake can validly replace cotton seed cake and to some extent other classical oil cakes in broiler rations.

Introduction

The intensification of animal production in Cameroon in recent years, has encountered serious problems of insufficiency of some classical agro-industrial by-products among which àre plant protein concentrates.

World bank reports estimate that Cameroon has rubber estates covering a span of over 25,000 hectares without taking into account peasant plantations, which are capable of producing large quantities of rubber seed.

This study was therefore an attempt at evaluating the utility of rubber seed cake in the feeding of our ever increasing numbers of broiler birds.

Methods

Rubber seed were collected from peasant farmers around the Mbalmayo area of Central Cameroon. They were manually decorticated, soaked in boiling water for fifteen minutes to librate the Cyanic acid and dried. The cake was produced by expression using a handler NBK press.

500 cornish birds, seven weeks of age and weighing approximately 825 g, were randomly alloted into five diet groups containing 0, 2.25, 4.5, 6.75 and 9% rubber seed cake respectively thus replacing cotton seed cake at 0, 25, 50, 75 and 100%. The birds were fed and watered ad libitum and their weekly weights and feed consumption recorded.

Results and discussion

Average daily consumption

During the first phase (first three weeks), the highest average daily consumption (102. 13$\pm$ 11.30g/day) and the lowest (97.50 $\pm$ 5.70g/d) were recorderd in diets containing 6.75 and 9% rubber seed cake respectively, though there were no significant differences (P 0.05) between diets.

During the second phase (second three weeks), the highest rates of consumption were recorderd in diets containing lower levels of rubber seed cake.

When the whole experimental period was analysed, a similar picture to that of the second phase was observed, with the highest rate being found in the diet with 0% rubber seed.

These observations give the impression that the level of rubber seed in the diet influenced feed consumption, but this was not uniform and therefore might have been due to other factors such as the proportion of males to females.

Average daily gains

During the first phase, average daily weight gains (ADWG) ranged from 39.14 ± 6.64 to 31.30 ± 5.34 g/d. with the highest being recorded on the 2.25% rubber seed diet. There were however no significant differences (P 0.05) between diets with 0, 2.25 and 6.75% rubber seed.

During the second phase, the ADWG were generally lower than in the previous phase. The birds on the 2.25% rubber seed maintained their higher ADWG, but there were no significant (P 0.05) differences in the ADWG between birds on the 0, 6.75, and 9% rubber seed diets.

When the whole experimental period was analysed, the picture was quite similar to that of the second phase, though the values were higher than the former.

These results show a definite trend of reduction in ADWG as the level of rubber seed increased in the diet. This observation is similar to that reported by Radhamma (1978) that after a 15% level of introduction of rubber seed in poultry diets ADWG is compromised, probably due to the deficiency of rubber seed meal in some essential amino acids particularly methionine.

Efficiency of feed utilisation

Independent of the period considered, there were no significant differences in the efficiency of feed utilisation between treatments.

These results are similar to those of Radhamma (1978) who found that weight gain and efficiency of feed utilisation were not negatively influenced by level of rubber seed in the diets up to 15% level of inclusion.

Economic analysis

The prices of the diets tended to increase with increases in the level of rubber seed in the diets. However, on evaluating the cost necessary for the production of 1 kg liveweight, it was observed that the lowest cost of production was achieved in the diet containing 2.25% rubber seed. There were no significant (P 0.05) differences in the cost of production of 1 kg liveweight between the rubber seed diets and the control.

Conclusion

Inclusion of rubber seed in the diets of broilers up to the levels in this study did not affect the efficiency of utilisation of the diets and the cost of producing 1 kg liveweight gain.

Our conclusions are therefore in agreement with those of most other workers particularly in India, that rubber seed meal can validly replace classical plant protein concentrates especially cotton seed cake in broiler rations.

References

Amrith Kumar, M.N. and S.R. Sampath, 1979. Chemical composition and nutritive value of rubber seed. Indian J.Dairy Sci. 32: 58-61.

Amrithvally Panam, 1978. Feeding value of rubber seed meal for laying hens. M.Sc. Thesis. Kalera Agricultural University, Trichur.

Buvanendran, V. and J.A. Siriwardene, 1970. Rubber seed meal in poultry diets. Cylon Vet. J. N° 18.

Obuyemi, J.A., B.L. Fetuga and H.N.L. Endelev, 1979. The metabolisable energy values of some feed ingredients for young chicks. Poultry Sci. 55(2) : 611-618.

Radhamma Pillai, 1978. Evaluation of rubber seed meal in broiler diets. M.V.Sc. Thesis. Kalera Agricultural University, Trichur.

THE EFFECT OF SUPERIMPOSING GRADED LEVELS OF CANE MOLASSES ON DIEST CONTAINING GRADED LEVELS OF PROTEIN ON THE PERFORMANCE OF BROILER CHICKENS

Endeley, H.N.L. and D. Pone Kamdem
National Advanced School of Agriculture, Yaounde, Cameroon

Summary

532 unsexed Cornish x Warren chickens were divided into 12 groups and fed 12 diets representing 0,4,6,and 8% cane molasses and 17,19,and 20% crude protein levels for a period of 7 weeks.

Results showed no significant differences between different levels of cane molasses. However, increase in level of molasses appeared to improve performance, the best being recorded at the 4% molasses and 21% crude protein level.

There are clear indications that cane molasses could be used in broiler rations up to 8% without detremental effects on performance.

Introduction

While the utilisation of cane molasses dates as far back as 1829, investigations on its use reveal the complexity of the ingredient on the performance of chickens.

This study was aimed at investigating the effects of differnt levels of cane molasses in broiler diets as well as differing levels of protein on its utilisation.

Methods

532 unsexed cornish x warren chicks, 35 days of age were randomly divided into four groups representing 0,4,6, and 8% cane molasses in their diets. These groups were further divided into three goups representing 17,19 and 21% crude protein.

Food was given ad libitim to the chicks and their consumption, weights and mortality were recorded weekly. Their weight gains, consumption and efficiency ratios were computed and statistically analysed.

Results and discussions

Results from this study indicated that final body weights were generally higher for birds fed cane molasses. The values obtained, compared quite favourably with those obtained for Indian type broiler chicks (Olomu, 1976) and white rock chicks (Babatunde and Fetuga,1976) in the tropics. The best final body weight was obtained in the 4% cane molasses 21% crude protein diet.

There were increases in average daily live weight gain(ADLG) as the level of cane molasses increased from 0% to 6% at the 8% level ADLG decreased though not significantly(P 0.05). This is in accordance with the findings of Rosemberg(1955), who used levels of up to 34.5% cane molasses without adversely affecting performance of chickens.

Of particular interest were the comparative responses of the birds between 5 to 8 weeks and 9 to 12 weeks. While differences were expected between them they were not expected to be so large. The most satisfactory growth response was got at the 4% cane molasses and 21% crude protein level.The gains obtained were not however comparable to gains obtained in temperate countries probably due to the abnormally low intake and poorer metabolisable energy densities of the diets(Endeley,1975).

Birds ate more as they got older and the rate also increased with increasing level of cane molasses in the diets up to the 4% level after which consumption decreased.

The efficiencies of feed utilisation progressively improved with increase in level of cane molasses. The absolute values obtained(2.84 to 4.04) compare quite favourably with those obtained by Babatunde and Fetuga(1976) for the same period.

Conclussion

Results from this study indicate that molasses could be conviniently utilised in broiler rations up to a level of 8% without affecting the performance of the birds. However, when used, protein level should be kept at about 21% for optimal performance.

References

Babatunde, G.M. and B.L. Fetuga 1976. Determination of minimum crude protein requirements for broiler staters and finishers in the tropics. Niger. J. Anim. Prod. 3(1).

Endeley, H.N.L. 1975. The metabolisable nergy values of some feed ingredients for poultry. Project report, University of Ibadan, Nigeria.

Olomu, J.M. 1976. Determination of optimum protein and energy levels for broiler chicks in the tropics. Niger. J. Anim. Prod. 3(1).

PERFORMANCE OF LACTATING SURTI BUFFALOES FED UREA ENSILED RICE STRAW WITH OR WITHOUT SUPPLEMENTATION OF LEUCAENA LEUCOCEPHALA, GLIRICIDIA MACULATA AND COCONUT CAKE

G.A. Kaasschieter[1], H.B. Perdok[2], N.M. van Wageningen[1] and M.C.N. Jayasuriya[3]

Introduction

Rice straw, despite it's abundance in most S.E. Asian countries, has a limited use as a dry season ruminant feed due to it's low nutritive value. Increased digestibility and intake can be achieved by treatment with 4 to 5% urea resulting in substantial increases in milk production and liveweight gain (Dolberg et al., 1981; Khan & Davis, 1981; Perdok et al., 1982; Saadullah et al., 1982).

Leaves and stems of Leucaena l. and Gliricidia m. can serve as supplements to straw based diets, being excellent sources of protein and minerals, available throughout the dry season. To establish the responses of supplementation with both legumes, and to compare their effect with coconut cake supplementation, a feeding trial was conducted with lactating Surti buffaloes. This paper focusses on nutritional aspects and production responses. An economic evaluation of this experiment will be given in a second paper (Kaasschieter et al., 1983).

Materials and Method

Rice straw was treated by ensiling it for approximately 18 days with a 4% solution of urea in water in cement lined brickwork silo's covered with polythene. Equal weights of urea solution and straw dry matter were used. Six diets were fed to groups of 10 buffaloes during a 14 week period and weekly records were kept of milk yield (handmilked and suckled) and bodyweight. Diets are presented in table 1. Suckled milk yield was determined by pre- and post suckling weighing of the calves. Fat content of the milked quantity was determined, whereas the fat content of the suckled milk was assumed to be equal to this percentage. Feed intake was measured during two separate weeks. Chemical composition and in vitro digestibility of organic matter was determined in diet components as well as in untreated straw. The data were subjected to a two-way analysis of variance.

Results

Urea treatment caused an increase in in vitro organic matter digestibility of straw of 15 percentage units (from 39% to 54%). Crude protein content increased from 6.1% to 7.0%. Dry matter (DM) intake of treated straw reached 3.3% of the liveweight of the animals (table 2). Legumes caused no increase in straw intake. In diets supplements with both coconut cake and legumes, intake of straw DM was below 3%. Milk yield was significantly increased by coconut cake supplementation only. A drop of milk fat content of 4 g/kg milked in Leucaena fed buffaloes was compensated by a slightly higher milk yield, resulting in a milk fat production similar to other diets. Although Leucaena contains the alkaloid mimosin, no toxic effects appeared. All buffaloes showed liveweight gains but the coconut cake group gained significantly more weight than the other groups.

Discussion

The small increase in protein content was probably due to overheating the material prior to analysis. The slow rate of fermentation of untreated straw is believed to limit voluntary intake to 2 to 2.5% of bodyweight (Dolberg et al., 1981; Saadullah et al., 1982). The observed intake of 3.3% of bodyweight can be contributed to the higher nitrogen content of treated straw and the increased OM digestibility. Jayasuriya et al. (1982) suggested that Gliricidia and Leucaena protein was comparatively insoluble. An effect of these by-pass protein sources on intake, as described in general by Kempton et al. (1977), could, however, not be detected in our experiment. This holds for both diets with and without coconut cake. The positive effect of coconut cake on milk yield suggests that both energy and protein limited milk production in buffaloes on treated straw only as well as on treated supplemented with legumes.

1. Department of Tropical Animal Production, Agricultural University, Wageningen, The Netherlands
2. Department of Biochemistry and Nutrition, University of New England, Armidale, Australia
3. Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka

Table 1. Experimental groups, amount of dry matter and crude protein supplemented per animal per day and percentage of crude protein in the dry matter of the total diets. Basic daily allowences of all animals included ad libitum treated straw, 100 g of a commercial mixture and added sodiumsulphate, dicalciumphosphate and coppersulphate to a total of 36 g Na, 38 g Ca, 21 g P, 17 g S and 80 mg Cu.

Group	Supplement	kg DM	g CP	% CP in DM
		of supplement		of total diet
TS	none	---	---	7.0
TS + GM	Gliricidia m.	0.9	212	8.2
TS + LL	Leucaena l.	0.9	251	8.4
TS + CC	coconut cake	0.9	194	7.9
TS + CC + GM	coconut cake + Gliricidia m.	0.9 + 0.9	406	9.2
TS + CC + LL	coconut cake + Leucaena l.	0.9 + 0.9	448	9.3

Table 2. Milk yield (kg/day), milkfat yield (g/day), milkfat percentage, daily gain (g) and dry matter intake of treated straw (DMITS, % of liveweight) of buffaloes fed urea ensiled rice straw with or without supplements.

Group	Milk yield	Milkfat yield	Milkfat %	Gain	DMITS
TS	$2.41^{a'}$ ± 0.42	221^{a} ± 34	9.18	115^{a} ± 182	3.3^{ab}
TS + GM	2.60^{a} ± 0.34	242^{a} ± 39	9.34	113^{a} ± 137	3.1^{ab}
TS + LL	2.73^{ab} ± 0.38	238^{a} ± 34	8.71	229^{ab} ± 137	3.1^{ab}
TS + CC	3.09^{bc} ± 0.45	311^{b} ± 29	10.08	236^{ab} ± 172	3.3^{a}
TS + CC + GM	3.18^{c} ± 0.49	319^{b} ± 50	10.03	286^{b} ± 121	2.7^{c}
TS + CC + LL	3.36^{c} ± 0.81	325^{b} ± 45	9.65	324^{b} ± 187	2.9^{b}

' means with different superscript within the same column are significantly different; ($p < 0.05$) values are means ± S.D. of 10 animals in each group.

References

Dolberg, F., M. Saadullah and R. Hague, 1981. Straw treatment in a village in Noakhali District, Bangladesh. Paper presented at the Seminar 'Maximum Livestock Production on Minimum Land', Mymensingh, Bangladesh.

Jayasuriya, M.C.N., C. Wijeyatunge and H.D.G. Perera, 1982. Rumen and post-rumen fermentation of spent tea leaf protein and other protein sources studied by the nylon bag method. Animal Feed Sci. Technol. 7: 221-224.

Kaasschieter, G.A., H.B. Perdok, N.M. van Wageningen and M.C.N. Jayasuriya, 1983. Economic feasibility of (urea treated) straw based rations for lactating Surti buffaloes in Sri Lanka. Paper presented at Symposium 'Animals as Waste Converters', Wageningen, The Netherlands.

Kempton, T.J., J.V. Nolan and R.A. Leng, 1977. Principles for the use of non-protein and by-pass proteins in the diets of ruminants. World Animal Review 22: 2-10.

Khan, A.K.M.N. and C.H. Davis, 1981. Effect of treating paddy straw with ammonia (generated from urea) on the performance of local and crossbred lactating cows. Paper presented at the Seminar 'Maximum Livestock Production on Minimum Land', Mymensingh, Bangladesh.

Perdok, H.B., M. Thamotharam, J.J. Blom, H. van den Born and C. van Veluw, 1982. Practical experiences with urea-ensiled straw in Sri Lanka. Paper presented at the Seminar 'Maximum Livestock Production on Minimum Land', Joydebpur, Bangladesh.

Saadullah, M., M. Hague and F. Dolberg, 1982. Treated and untreated rice straw to growing cattle. Trop. Animal Prod. 7: 187-190.

ECONOMIC FEASIBILITY OF (UREA TREATED) STRAW BASED RATIONS FOR LACTATING SURTI BUFFALOES IN SRI LANKA

G.A. Kaasschieter[1], H.B. Perdok[2], N.M. van Wageningen[1] and M.C.N. Jayasuriya[3]

Introduction

In the framework of the Straw Utilization Project (SUP) in Sri Lanka field testing of different methods of urea-treatment of rice straw started in 1981 (Perdok et al., 1982). Based on promising results, the SUP chose, for the time being, to adopt the silo-system and to focus research on supplementation of treated straw, which resulted in a.o. the previous paper (Kaasschieter et al., 1983).

As the application of straw treatment depends more on economic considerations than on animal performance, in this paper an economic evaluation of the previously decribed experiment has been made to obtain information on the economic feasibility of rations based on urea treated straw.

Method

Revenues are based on milk sold (on the base of Rs. 70.0 per kg milkfat), cow- and calf gain (on the base of market prices, Rs. 5.50 per kg liveweight). Costs, including labour, are based on farm expenditures (price level 1982).

To enable comparison between similar ensiled treated straw and untreated straw diets, the same price level was applied to evaluate the feeding trial conducted with the same herd in 1981 (Perdok et al., 1982).

Results

Major items in the feed costs are treated straw (31-45%) and minerals (20-25%). If coconut cake and legumes are supplemented, the latter amount to 15% and 10% respectively.

A break-down of treated straw costs shows that (subsidized) urea accounts for 35% of the total. Labour, silo construction and polythene represent 20%, 13% and 14% respectively of the costs inherent to this treatment method (further details will be shown on the poster).

Comparison of diets reveals that straw treatment improves the margins, as does coconu cake (table 1). Of the legumes tested, only Leucaena is economically attractive.

Discussion

Part of the differences in the quantity of salable milkfat between 1981 and 1982 is due to the use of coconut cake. It should be noted that all calculations are restricted to the period of observation, i.e. no allowances are made for dry buffaloes, weaned calves and bull If the real price of urea is taken into accoun instead of the subsidized price, all margins are Rs. 1.80 smaller. In view of the high cost of urea the question arises to which extent urea will be used as a delignificating agent and to what extent as a fertilizer. In the course of 1982 several alternative methods hav been field-tested with promising results (Jayasuriya et al., 1983; Kumarasuntharam et al., 1983; Perdok et al., 1983).

Present prices of slaughter cattle do not warrant treated straw feeding (Kumarasuntharam et al., 1983; Perdok et al., 1983). Dairy production with buffaloes fed treated straw is more promising though highly dependent on government-controlled prices of milk, minerals concentrates and urea. Straw treatment can play a useful role in dry season feeding in Sri Lanka, provided there is a production promoting price policy, and a simple method of storage of urea treated straw is developed.

1. Department of Tropical Animal Production, Agricultural University, Wageningen, The Netherlands
2. Department of Biochemistry and Nutrition, University of New England, Armidale, Australia
3. Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka

Table 1. Cost-benefit review of the 1981 and 1982 experiments with lactating Surti buffaloes fed ad libitum (urea ensiled) rice straw with or without various supplements

Year	Ration (supplements in DM)	Daily revenue MF	BG	CG	Daily costs per buffalo	calf	Margin'
1981	US 0.9 conc.	5.73	- 0.52	0.91	8.19	0.60	- 2.67
1981	US 0.9 kg Conc. + 1.8 kg Gliricidia m.	7.43	0.32	1.46	10.62	0.60	- 2.01
1981	TS 0.9 kg conc.	10.24	0.32	1.62	12.75	0.60	- 1.17
1981	TS 0.9 kg conc. + 1.8 kg Gliricidia m.	11.73	0.69	1.89	15.18	0.60	- 1.47
1982	TS	10.08	0.63	1.44	11.40	0.60	0.15
1982	TS 0.9 kg Gliricidia m.	10.36	0.62	1.79	11.75	0.60	0.42
1982	TS 0.9 kg Leucaena l.	11.77	1.26	1.76	12.09	0.60	2.10
1982	TS 0.9 kg coconut cake	15.05	1.30	1.47	13.43	0.60	3.79
1982	TS 0.9 kg coconut cake + 0.9 kg Gliricidia m.	14.63	1.57	2.04	13.81	0.60	3.83
1982	TS 0.9 kg coconut cake + 0.9 kg Leucaena l.	15.82	1.78	1.58	14.22	0.60	4.36

US = untreated straw; TS = treated straw. MF = Salable milkfat (Rs. 5.50/kg MF); BG = cow gain (Rs. 5.50:kg gain); CG = calf gain (Rs. 5.50/kg gain).

' in Rs. per buffalo per day (Rs 25 = 1 US $)

References

Jayasuriya, M.C.N. and K. Sannasgala, 1983. Activity and behaviour of urease enzyme from plant and animal sources. 3rd AFAR meeting, Peradeniya, Sri Lanka, 17-22 April 1983.

Kaasschieter, G.A., H.B. Perdok, N.M. van Wageningen and M.C.N. Jayasuriya, 1983. Performance of lactating Surti buffaloes fed urea ensiled rice straw with or without supplementation of Leucaena Leucocephala, Glricidia Maculate and Coconut Cake. Paper presented at Symposium 'Animals as Waste Converters', Wageningen, The Netherlands.

Kumarasuntharam, V.R., M.C.N. Jayasuriya, M. Joubert and H.B. Perdok, 1983. The effect of method of urea ammonia treatment on the subsequent utilization of rice straw by draught animals. 3rd AFAR meeting, Peradeniya, Sri Lanka, 17-22 April 1983.

Perdok, H.B., G.S. Muttettuwegama, G.A. Kaaschieter, H.M. Boon, N.M. van Wageningen, V. Arumugam, M.G.F.A. Linders And M.C.N. Jayasuriya, 1983. Production responses of lactating Surti buffaloes and young Sahiwal cattle to urea-ammonia treated paddy straw fed with or without supplements and of Sahiwal and local bulls to paddy straw treated in various ways with urea. 3rd AFAR meeting, Peradeniya, Sri Lanka, 17-22 April 1983.

Perdok, H.B., M. Thamotharam, J.J. Blom, H. van den Born and C. van Veluw, 1982. Practical experiences with urea-ensiled straw in Sri Lanka. Paper presented at the seminar 'Maximum Livestock Production on Minimum Land', Joydebpur, Bangladesh, 15-18 February 1982.

POSSIBILITIES OF ENSILING PADDY STRAW WITH AGRO-INDUSTRIAL BY-PRODUCTS AND WASTES AND NUTRITIVE VALUE IN CROSS BRED COW CALVES

Gopal Krishna[1]

Department of Animal Nutrition, Haryana Agricultural University
Hissar, Haryana, India

Summary

The deleterious substance (oxalic acid) present in the paddy straw may be reduced to a considerable extent by ensiling with agro-industrial by-products and wastes, and good quality silage may be obtained. In general, cross bred calves could not meet the nutrient requirement for maintenance and growth, if maintained solely on paddy straw (ensiled).

Introduction and objectives

The present experiment was conducted with the main objectives:

1. To reduce the concentration of oxalic acid present in paddy straw by ensiling process.
2. To assess the quality, palatability and nutritive value of ensiled paddy straw based on *in vivo* study.
3. To explore the possibilities of raising cross-bred calves solely on ensiled paddy straw without feeding concentrate mixture.

Materials and methods

Approximately one hundred quintals silage was prepared using the formula given below:

Paddy straw	10 quintals
Molasses	3.3 quintals
Cotton ginning trash	13.33 quintals
Malt sprouts with hulls	16.66 quintals
Water	56.66 quintals
Supplemented with	minerals

Sodium sulphate	9 kg
Calcium phosphate	6 kg
Calcium carbonate	20.5 kg

Twelve crossbred calves of approximately two years of age were divided into two comparable groups of six each in a randomised block design. The control group calves were maintained on *ad libitum* berseem (*Trifolium alexandrinum*) hay feeding, while the experimental group calves were kept on *ad libitum* silage feeding. In addition to this 1 kg green berseem was also fed to the experimental group of calves so as to meet the carotene requirement. The duration of feeding period was 39 days only, during the last 7 days a metabolism trial was conducted.

Results

Deleterious substance (Oxalic acid) was reduced from 3.12% (paddy straw) to 0.425% (silage). The titrable alkalinity of urine (ml N/10 H_2SO_4 per 5 ml urine) of calves maintained on ensiled paddy straw was considerably reduced and they were in positive calcium and phosphorus balance. As per Breirem and Ulvesli International standard silage was graded as a good quality one. The silage was fairly palatable with a dry matter intake of 2.3 ± 0.15 kg/100 kg body weight. The silage contained 4.3% DCP and 52% TDN. It was not possible to raise cross bred calves solely on ensiled paddy straw without feeding any concentrate mixture, as growth rate was not satisfactory.

1. Present address: Institute für Tierphysiologie und Tierernährung, Der Universität Göttingen, Oscar-Kellner Weg 6, 3400-Göttingen

ENSILED MAIZE GLUTEN FEED AS A FEEDSTUFF FOR PIGS AND BEEF CATTLE

Preliminary information

B. Smits* and D. Oostendorp**

*Institute for Livestock Feeding and Nutrition Research,
P.O. Box 160, Lelystad, The Netherlands

**Research and Advisory Institute for Cattle Husbandry,
Runderweg 6, Lelystad, The Netherlands

Introduction

Maize gluten feed is a protein rich by-product of the maize starch production. It is a mixture of bran and steep water. As a consequence of increasing fossile energy costs there is a growing interest in the possibilities of using the product fresh or ensiled rather than dried. Investigations are in progress to get information about the ensiling qualities and the feeding value of ensiled maize gluten feed for pigs and cattle. This short paper deals with the first results.

Materials and methods

Silage experiments

The moist product (40% dm) was delivered at the farms at a temperature of 20 - 30°C. The silages were made on a concrete floor. The clamps had a longitudinal and narrow shape and were sealed with two P.E. sheets of 0.15 mm. Samples were taken before ensiling and at unloading.

Digestibility trial

A digestibility trial was performed with 4 pigs (± 70 kg live weight). The daily ration consisted of: 550 g barley (incl. min. + vit.) and 3500 g ensiled product. The pigs were fed twice a day. The total ration was fed as a slurry. Digestibility was measured using a total collection technique (10 days).

Feeding experiments

A feeding experiment was performed with 32 individually fed G.Y. pigs from ± 37 kg to ± 105 kg live weight. Three inclusion levels were tested: 0, 12.5 and 25% of the daily energy intake was supplied by the ensiled product.

Two experiments with beef bulls were performed. In the first trial the ensiled product was fed to 4 groups of 10 beef bulls each during the last 100 days of the fattening period. The daily ration of the bulls in the different groups is shown in table 1. The bulls were housed and fed in groups.

In the second trial 40 bulls with an initial average live weight of ± 170 kg were split up into 2 groups. The treatments are given in table 1. In this trial the bulls were also housed and fed in groups.

Table 1. Treatments in the 2 experiments with beef bulls. Daily allowance in kg per animal.

Exp.	live-weight	maize silage	maize gluten feed silage	conc. mixt.
I				
A		ad lib	-	3
B		"	3	1.5
C		"	6	-
D		"	9	-
II				
A	<300 kg	ad lib	-	2.5
	> " "	"	-	3
B	<300 kg	"	5	-
	> " "	"	6	-

Results and discussion

The results of the silage experiments are summarized in table 2.

Table 2. Silage quality (Corporaal, 1982).

	at ensiling	at unloading
dry matter (g/kg fresh)	416	424
pH	4.2	4.2
butyric acid (g/kg dm)	0.4	0.8
acetic acid (g/kg dm)	3.4	2.2
lactic acid (g/kg dm)	53.8	35.8
NH_3-N	4	4
dry matter losses (%)	-	0.9

From the data in table 2 it is clear that the maize gluten feed was already fermented at ensiling. During storage hardly any additional changes occurred. With a proper ensiling procedure dry matter losses will be low. For practical circumstances the losses are estimated at at least 3%.

Digestibility trial

Table 3 gives the average chemical composition of 19 samples of wet maize gluten feed and the digestibilities measured in the pig trial. In this table the corresponding figures for the dried product are also given.

Table 3. Average chemical composition and digestibility measured with pigs of wet and dried maize gluten feed (Oostendorp & Smits, 1983).

	g/kg fresh	g/kg dm			
	dry matter	cp	cfat	cfibre	Nfe
Comp.:					
wet	422	202	31	94	625
dried 1)	904	215	46	95	589
Digest.:					
wet	-	75	13	46	66
dried 1)	-	79	60	56	79

1) Dutch Feedstuffs Table (1983)

The chemical composition of the wet and the dried product is rather similar. Except for protein the digestibility of the organic components in the wet product was low as compared to the figures of the dried product. However, in recent experiments with samples of dried maize gluten feed lower digestibilities than tabulated were obtained (Smits & Jongbloed, 1982).

Feeding experiments

The results of the feeding experiment with pigs are summarized in table 4. The performance of the animals was very good. The slaughter quality and characteristics were excellent. No significant differences were found between treatments.

The results of the feeding experiments with beef bulls are given in table 5. The daily live weight gain of all groups in the first experiment and also the control group in the second trial was quite good. Hardly any differences in growth rate, feed conversion, dressing percentage and slaughter quality (conformation and fatness) were measured between treatments in the first experiment. In the second trial growth rate and feed conversion of the bulls in the test group was less favourable. The maize gluten feed silage suppressed the intake of maize silage more than the equivalent amount of concentrates. This resulted in a lower total energy intake and consequently in a lower growth rate and a lower feed efficiency. No differences were found in dressing percentage, conformation and fatness between treatments in this experiment. At the start of both feeding experiments with pigs as well as those with beef bulls intake problems were encountered.

Table 4. Average results of the feeding experiment with pigs (Oostendorp & Smits,1983).

	A	B	C
inclusion level (% energy)	0	12.7	24.7
feed refusals (%)	4.9	1.3	5.6
live weight gain (g/day)	797	829	795
energy conversion (MJ NE_f/kg gain)	24.5	24.4	24.9
backfat thickness (mm)	11.6	12.2	12.1
dressing percentage	77.5	77.1	76.7

Table 5. Average results of the feeding experiments with beef bulls (Oostendorp & Smits, 1983).

	Experiment 1			
Maize gluten feed silage (kg)	-	3	6	9
live weight gain(g/day)	1245	1206	1235	1275
kVEVI/kg gain	6.6	6.5	6.5	7.2
dressing percentage	54.7	54.9	55.1	55.4
carcass weight (kg)	300	292	309	317

	Experiment 2	
Maize gluten feed silage (kg)	-	5/6
live weight gain(g/day)	1232	1103
kVEVI/kg gain	6.2	6.7
dressing percentage	55.3	55.2
carcass weight (kg)	299	294

References

Corporaal, J. 1982. Jaarverslag nr. 9. Proefstation voor de Rundveehouderij, Lelystad.

Oostendorp, D. & B. Smits, 1983. Proceedings EEC-Seminar, Gent (in press).

Smits, B. & A.W. Jongbloed. 1982. Pers. Communication. I.V.V.O.

Veevoedertabel. 1983. Gegevens over voederwaarde, verteerbaarheid en samenstelling. Centraal Veevoeder Bureau, Lelystad.

GRAIN STILLAGE AND SPENT MYCELIUM SLURRY FOR BEEF BULLS AND PIGS

A. Steg*, D. Oostendorp** and B. Smits*

*Institute for Livestock Feeding and Nutrition Research, Lelystad, The Netherlands

**Research and Advisory Institute for Cattle Husbandry, Lelystad, The Netherlands

Introduction

Whole grain stillage (WGS) is the by-product originating from the fermentation of grain (in The Netherlands mainly maize and wheat) to produce alcohol.

Spent mycelium slurry (SMS) is a residue of penicillin production by the fungus Penicillium at a highly digestible substrate. Until recently this slurry was disposed of by draining in open water.

Both products of the fermentation industry are characterised by a high moisture content. They are normally transported, stored and fed at elevated temperatures for reasons of adequate preservation and palatability.

Feeding value of WGS and SMS was studied in ruminants and in ruminants as well as pigs respectively.

Materials and methods

Digestibility of WGS was studied in 4 adult wether sheep. Daily ration consisted of 300 g grass hay, 200 g dried beet pulp and 8000 g WGS. Feeding value of the product for beef bulls was studied on a practical scale. In 3 years time over 400 animals were fattened from 100 to 550 kg on a ration, consisting of ensiled forage maize, concentrates and WGS.

Digestibility of SMS was determined in sheep (daily ration 300 g grass hay, 250 g dried beet pulp and 5000 g SMS) and two trials with growing pigs (4 animals per trial; daily rations consisted of 1500 g compound feed + 7000 g SMS and 1400 g compound feed + 6000 g SMS respectively). Feeding was additionally studied in a comparative feeding trial (block design) with 24 individually fed bulls (trial 3) and at a practical scale with 100 bulls (trial 2). Rations again consisted of ensiled forage maize, concentrates and SMS. In a comparative feeding trial (block design) with 32 pigs two levels of SMS (7.5 and 15% on dry matter basis) were tested from 30 to 105 kg live weight.

Results and discussion

Chemical composition

In table 1 average of some chemical characteristics of both product types are given, based upon 70 and 47 samples of WGS and SMS respectively.

Table 1. Average chemical composition of WGS and SMS.

	g dm/kg	g/kg dm				N-recovery (%) in amino acids
		ASH	CP	CFAT	CF	
WGS	64	60	335	131	71	80
SMS	95	84	490	20	65	70

Variation in chemical composition of WGS was considerable, even within the same distillery for the same substrate. SMS was slightly less variable in composition. Both products are protein-rich: lysine and cystine + methionin contents were 9 and 12; 22 and 19 g/kg dry matter for WGS and SMS respectively. For SMS about half of the N not recovered in amino acids was present in amino sugars, the remaining in nucleic acids.

Digestibility

Table 2 gives the average results of the trials performed with sheep and pigs.

Table 2. Average digestibility data of WGS and SMS determined in sheep and pigs. (Steg et al., 1981; Smits & Jongbloed, 1982).

	OM	CP	CFAT	CF	NFE
WGS					
sheep	83	69	93	85	92
SMS					
sheep	84	80	46	67	95
pigs	77	72	-	73	91

Digestibility of the organic matter of WGS was very high when compared with tabulated data of artificially dried WGS (DLG, 1968). SMS was digested better in sheep than in pigs; the two products tested in pigs differed markedly in protein digestibility (on average 75 and 68% respectively), presumably due to slight differences in production process.

Digestibility of amino acids for pigs was 0-16 percentage units higher than crude protein digestibility.

Feeding trials

Table 3 and 4 give some results of the feeding trials with beef bulls and pigs respectively.

Table 3. Average results of experiments with beef bulls (Harmsen, 1982; Steg et al., 1981).

exp.nr.	1	2	3		
live weight range (kg)	150 - 550	250 - 650	400 - 500		
daily intake (kg dm):					
maize silage	2.3	3.6	3.9	3.9	3.9
concentrate mixt.	2.1				
dried beet pulp		1.8	2.2	2.2	1.3
soya bean meal			0.8		
WGS	2.4				
SMS		2.6		0.9	1.9
live weight gain, g/day	1052	1025	998	1007	1038

Table 4. Average results of the experiment with pigs (Smits & Jongbloed, 1982).

Level of inclusion of SMS (%)	0	7.5	15
live weight gain, g/day	730	730	740
energy intake, MJ NE_f/day	18.3	18.5	18.6
backfat thickness, mm	11.4	11.8	11.7
dressing percentage	75.0	75.4	74.9

For the two practical scale studies with beef bulls intake and live weight gain were satisfactory, even with very high inclusion rates of WGS and SMS. It meant, that animals consumed on average 140% and 200 % of tabulated protein requirements. Maize silage intake in the bloc experiment with 400 kg bulls was somewhat disappointing, resulting in rather low growth rates. Differences between treatments were not significant.

Results of the feeding trial with pigs were very satisfactory with regard to feed conversion, growth rate and carcass characteristics. Differences between treatments were not significant.

For an adequate utilization of feeding value (especially protein) over-consumption of both WGS and SMS should be avoided. A practical upper limit to the daily allowance could be 10% of live weight for WGS and 5% of live weight for SMS, for beef bulls as well as for pigs.

For SMS still some additional toxicological research is under way.

References

D.L.G. 1968 and 1982. Futterwerttabelle für Wiederkaüer. Publ. D.L.G., Frankfurt am Main.

Harmsen, H.E. 1982. Spoeling in rantsoenen voor vleesstieren. Rapport nr. 78 P.R.

Smits, B. and Jongbloed, A. 1982. Myceliumspoeling als voedermiddel voor varkens. Rapport nr. 146 I.V.V.O.

Steg, A., Wentink, H.J. and Donselaar, B. van 1981. Myceliumspoeling als voedermiddel voor herkauwers. Rapport nr. 137 I.V.V.O.

STUDIES ON FEEDING OF CULLED GUAR SEED (Cyamopsis tetragonoloba (L) Taub) IN GROWING BUFFALO CALVES

S.P. Tiwari and G. Krishna[1]

Department of Animal Nutrition, Haryana Agricultural University
Hissar, Haryana, India

Summary

It is possible to raise male buffalo calves of about one year age solely on the ration consisting wheat straw and culled crushed boiled guar seed in the ratio (60:40) on metabolizable energy basis, supplemented with vitamin and salted mixture.

Introduction and objectives

The present experiment was conducted with the main objectives:
1. To assess the nutritive value of culled crushed boiled guar seed in buffalo calves.
2. To study the effect of crushed boiled guar seed feeding on growth, feed gain ratio and digestibility of proximate nutrient.
3. To study the effect of crushed boiled guar seed feeding on blood biochemical constituents and in vivo rumen fermentation pattern.

Material and methods

Twenty four male growing buffalo calves of one year age were divided into four groups of six each, following complete randomised design. These buffalo calves were resorted to treatments T_1 (W.straw: Guar seed 60:40), T_2 (W. straw: GNC 60:40), T_3 (W.straw: Guar seed 70:30), T_4 (W. straw: GNC 70:30) randomly to groups I, II, III and IV, respectively on ME basis. The duration of feeding trial was 94 days and digestion trial was of 7 days.

Results

The buffalo calves maintained on (W. straw: Guar seed 60:40) attained highest daily body gain (approximately 400 g), having a best feed/gain ratio. Simultaneously, the efficiency of ME utilization and protein utilization for deposition of gained biomass was of highest order in the same treatment. The data of present investigation reveal that the crushed boiled guar seed contained DCP 24%, TDN 72.94%, ME 2.64 Mcal/kg and DE 3.21 Mcal/kg. Overall, the solubility of guar seed protein in water as well as artificial saliva was significantly ($P < 0.05$) less as compared to groundnut cake. This parameter was found interlinked with the higher concentration of strained rumen liquor ammonia in groundnut cake fed buffalo calves. The concentration of blood urea and ammonia nitrogen was significantly ($P < 0.05$) higher in groundnut cake fed buffalo calves. Guar seed exhibited hypocholesterolaemic and hyperglycaemic trend in buffalo calves.

1. Present address: Institute für Tierphysiologie und Tierernährung, Der Universität Göttingen, Oscar-Kellner Weg 6, 3400-Göttingen

ENSILING KITCHEN WASTES FROM PRIVATE HOMES FOR ANIMAL FEEDING

S.F. Spoelstra and L. Tjoonk

Institute for Livestock Feeding and Nutrition Research (IVVO), P.O. Box 160, 8200 AD Lelystad, The Netherlands

Introduction

The annual amount of kitchen waste in the Netherlands comes to 1.2 million tons. Depositing this amount of wet material represents an environmental problem. Recycling as an animal feed is hampered by the necessary source separation and consequently laborious collection procedures.

The present work was performed primarily as an attempt to improve collection efficiency. This was achieved by construction of a 40-l container in which kitchen wastes could be stored anaerobically. These kitchen silo's were placed in 9 private homes during the first half year of 1983. The silo's were collected once a month and the contents weighed homogenised and analysed.

The kitchen silo

The kitchen silo consists of a 1 m pvc tube (ø 25 cm) with a pvc bottom. After addition of waste the silo was closed by a fitting plunger.

Results

The amount of waste collected per family ranged from 5 to 16.5 kg/month (average over 6 months). Also the chemical composition varied between families, but was per family rather constant over the collection period. Mean dry matter content ranged from 15% for a family discarding mainly vegetable products to 35% when bread was the main waste, ash contents ranged from 62–133 g/kg dm and crude fibre from 22–79 g/kg dm. Crude protein contents were rather constant (19 to 24 g/kg dm). Table 1 shows the amount of wastes collected per month and the composition.

The pH values of the homogenised wastes were rather high, this because the upper layers in the silo are hardly fermented. Re-ensiling after collection showed a fast fermentation resulting in low pH-values and high amounts of lactic acid. Levels of yeast and moulds were reduced and enterobacteria eliminated (Table 2).

Preliminary short term experiments indicated a reluctant intake of this heavily fermented, re-ensiled, feed by beef bulls, whereas it was eaten readily by fattening pigs.

Table 1. Content (kg) of the kitchen silo and composition (g/kg dm) of kitchen waste per month (mean of 9 families, 28 persons).

Month	1	2	3	4	5	6
Content	11.3	12.0	11.9	9.6	9.6	12.2
Dry matter[1]	235	235	228	218	205	200
Ash	78	78	115	92	106	99
Total-N	22	25	21	20	21	24
Crude fibre	53	60	63	59	61	65
pH	5.5	5.2	5.4	5.1	5.3	4.5
Ethanol[1]	0.6	1.6	1.2	1.7	2.1	4.4
Acetic acid[1]	1.0	1.7	5.3	1.3	1.4	2.7
Butyric acid[1]	0.0	0.2	0.0	0.0	0.0	1.3
Lactic acid[1]	2.1	3.9	4.0	4.6	5.4	13.3

[1] g/kg

Table 2. Fermentation products and microbial counts of kitchen waste as present in the kitchen silo (day 0) and 32 days after re-ensiling (lab-experiments, mean of 7 families).

	Days after re-ensiling	
	0	32
pH	5.08 ± 0.46	3.89 ± 0.24
Ethanol (g/kg)	2.9 ± 2.0	5.4 ± 1.7
Acetic acid (g/kg)	1.6 ± 0.7	5.2 ± 2.2
Butyric acid (g/kg)	0	0
Lactic acid (g/kg)	6.6 ± 4.1	42.8 ± 15.9
NH_3-N/total N (%)	5.7 ± 2.9	15.2 ± 4.1
Lactobacilli (log units/g)	8.6 ± 0.4	6.9 ± 0.6
Enterobacteria (log units/g)	7.5 ± 1.2	<1
Yeasts (log units/g)	6.7 ± 0.5	2.3 ± 1.4
Moulds (log units/g)	6.4 ± 0.5	1.4 ± 0.6

Conclusion

Technically more efficient collection of kitchen waste by use of the kitchen silo appears to be possible. But more work needs to be done on processing after collection (heat treatment or re-ensiling) and evaluation of the product by feeding trials.

Discussion session 2: Wastes of plant origin.
Chairman: Prof. A.J.H. van Es.

Discussion summarized by G. Zemmelink

Smits: As Dr. Boucqué said some research workers found an interaction between test and basal feed in digestibility trials. If this holds true: how can the feeding value of those products be calculated for practical conditions and which value should be used in linear programming?

Boucqué: The interaction was clearly demonstrated by Aufrère and Michalet-Doreau as well as Sauvant et al. This phenomenon results in fluctuating digestibility coefficients and fluctuating net energy values depending on the percentage used, even at the same feeding level, e.g. at maintenance. For practical use in linear programming to calculate least cost rations some by-products should be given varying values depending on the percentage which is included in the ration. Both research teams emphasized the need for more research.

Schurch: Could Dr. Boucqué elaborate on the treated sawdust (which kind of wood, details on methods of treatment, required installations, method and level of feeding, results)?

Boucqué: The sawdust was treated in the USA according to the Jells method. In his paper Prof. Tisserand did not mention details of the treatment. He only wrote that the sawdust was treated with nitric acid at high temperature and pressure. In the feeding experiment with young Charolais bulls the treated sawdust was first mixed with cereals, oil cakes and molasses at a 50% level for the first experiment and at a 40% level for the second experiment. From both premixes a different amount was fed to the bulls so that in the first experiment sawdust represented about 11% of the total diet and in the second experiment about 20%. The feed conversion data are not cited in the publication.

Razzaque: According to the paper of Dr. Alderman the Tilley and Terry method appears to be not suitable for evaluating the nutritive value of high-lignin feeds. In vivo studies are however time consuming and expensive.

Alderman: The questioner has correctly identified our concern that the Tilley and Terry procedure is not suited to the evaluation of high lignin forages such as cereal straws. Particularly in the case of alkali or ammonia treated straws, the conventional oven drying and grinding to less than 2 mm particle size before commencing the in vitro test would on theoretical grounds significantly change the characteristics of the forage used in the laboratory test. It appears to me that a non-destructive testing procedure needs to be developed which is sensitive to the changes induced by chemical treatment. Near infra-red reflectance measurements seem to be one likely prospect since the resonances observed are a function of chemical structures and binding. Unfortunately in vivo tests are both slow and expensive but they supply the nutritionist with evidence of animal x feed interactions which are not yet properly understood.

Newman: Is Dr. Alderman justified in assuming that his in-vivo techniques are sufficiently reliable when (a) one set of data, shown to be statistically different, is rejected by subjective judgement and (b) small experimental numbers and relatively large standard deviations may well mask actual differences?

Alderman: One data set could not be used for a pooled analysis of variance because only 3 sheep completed the digestibility trial satisfactorily at centre D, compared to 4 sheep at the other centres. One data set was significantly different from the remainder. From observations made at the centre concerned it appeared that the sheep used were highly selective so that the consumed material may have differed from that offered.

Steg: Could Dr. Alderman tell how the in vitro procedures were standardized and calibrated?

Alderman: All collaborating laboratories used a set of standard samples of known in vivo or in vitro digestibility in each batch run. The methods of correcting the raw data were found to differ between centres, but these differences were not the main cause of the between centre differences observed.

Steg: We find at IVVO, Lelystad, that reliable data on digestibility of ammonia treated straw can be obtained by in vitro procedures, provided that standard samples include also treated straw of known in vivo digestibility and that such standard samples are included in each run.

Hof: Treatment of straw gave varying increases of in-vivo digestibility. Did it result in comparable variation in improvement of feed intake?

Alderman: We have not measured the effect of alkali or ammonia treatment on voluntary intake. This is partly because voluntary intake measurements with sheep are not easily extrapolated to cattle. Measurements with cattle are much more expensive. However, judgements on the economic viability of a treatment process are not dependent on increases in intake. Unless the treated straw shows a significant cost benefit per kilo compared to other feeds such as cereals and soya beans, the amount eaten is irrelevant. Once a real cost benefit is established for each kilo eaten, then increases in voluntary intake contribute to the overall cost benefit achieved.

Hathout: In Egypt shortage of feedstuffs is the major constraint for developing animal production. There is no scope to use additional land for forage production. Our aim is therefore a better utilization of agricultural by-products in animal feeding. The same holds true for many developing countries. Our Animal Production Research Institute has therefore developed a research programme with support from FAO/UNDP. Two promising technologies have now been introduced:

1. On-farm treatment of straw with anhydrous ammonia. Results of digestibility trials with sheep and feeding trials with cattle fed rice straw ad lib. with different levels of concentrates showed a 15-20% increase in the voluntary intake of straw, a similar increase in digestibility, an increase in cp content from 3-4% to 6-7% and better performance of animals on treated straw. The return on national income is great. It was calculated that treating one ton of straw with 3% ammonia can save 0.25 ton of concentrates. This is a big advantage indeed as we import 1/2 million ton of maize for animal feed.

2. Preparation and distribution of molasses liquid supplements. The liquid supplement is prepared on a base of molasses (91%), urea, mineral premix and vitamine AD_3 premix. It serves as a supplement to rations which are primarily based on straws and other by-products. The farmer is advised to sprinkle 1/2 l of the liquid supplement (2/3 kg),diluted with water (1:1), per animal per day on the straw.

Two distribution centres were established in Behira Governate to serve farmers with both liquid supplement and ammonia. The former can either be collected by the farmers or distributed in bulk, while the latter requires a delivery service to inject straw stacks at the farm. The Ministry of Agriculture will decide shortly how the programme can be extended to other parts of the country. It is noted that several factors favour the use of ammonia for treatment of straw in Egypt: ammonia is produced in the country, plastic sheets are not expensive and the high temperature (30-40°C) adds to the effectiveness of the treatment. Treatment of 1 ton of straw costs about 10-12 Egyptian pounds as compared to 20-30 pound Sterling in Britain. I like to quote one of the major recommendations of the "2nd Workshop on utilization of low quality roughages with special reference to developing countries" held at Alexandria University in March 1983: "Ammonia treatment (including urea) seems to be an appropriate method for developing countries and should therefore be given special attention in future work on low quality roughages".

Alderman: The consistently high environmental temperatures of 30-40°C would theoretically improve the consistancy of reponse to ammonia treatment. Moreover if the cost of ammonia in Egypt is low, then a favourable cost benefit would be established at much lower levels of response than are needed with present prices in the UK. I wish to stress that in my paper I refered to the efficacy of on farm treatment of cereal straw with ammonia under prices currently extent in the UK.

Schurch: What is the relation between overall energy cost and gain of metabolizable energy in NaOH-treatment of straw, including the energy required for producing NaOH?

Alderman: Dr. Wilson has calculated that for commercial plants producing NaOH treated straw pellets the fossil energy input per kg is about 2 MJ greater than the increase in ME. He claims, however, that if the straw had not been treated, it would have been burnt and lost as a feed resource. He calculates therefore that the fossil energy input effectively reclaims 8 MJ of ME for each kg of straw processed. This gives a return of better than 2 to 1 over the energy input.

Zemmelink: Treatment of straw with urea requires large amounts of this product, 30-40 kg per ton of straw. Especially in developing countries this could also be used as a fertilizer and where urea is now subsidized, governments may be reluctant to continue this if it is used for treating straw rather than as fertilizer. Therefore, not only the efficiency of utilization of feed energy is of interest, but also the efficiency of utilization of N. A specific concern is that when urea is used for treating straw, a large part of the added N is lost and only a certain fraction is actually consumed by the animal. The N consumed by the animal is partly bound in the straw. Are any data available from research in the UK on the digestibility of this N, and are there studies on the efficiency of N utilization comparing the use of urea for treating straw and using a smaller amount of urea as a supplement to untreated straw.

Alderman: I am not aware of such work. One difficulty is that oven drying of treated straw (the usual preliminary to chemical analysis) is likely to drive off loosly attached ammonia which could be utilized by rumen microbes. The form of N attached to the straw which survives oven drying does not appear to have been studied. Suckler cows have been maintained and calved normally when fed only on ammonia treated cereal straw. This must imply that sufficient N was available for normal rumen digestion. However, Dr. Smith of NIRD, Shinfield, UK, observed a reduced N retention in heifers fed on ammonia treated straw, compared to the method of supplementing untreated cereal straw. Studies are under way in UK on the use of urea to treat straw but the efficacy seems to be lower than for ammonia and the residual urea is a cause of unpalatability. Urea is not widely used as a supplement for straw in the UK because most straw is fed as part of a mixed diet, often including grass silage, which has a high NPN content anyway. Liquid urea supplements for application to straw are available and are to be preferred to feeding of concentrates containing urea because the intake is spread out over the day when the liquid supplement is sprinkled on the straw.

Razzaque: Could the presence of oxalic acid in paddy straw affect animal performance and if so what is the specific effect of oxalic acid?

Boer Iwema: Oxalic acid interferes with the absorption of Ca and can cause Ca-deficiency if the ration is low in Ca. Problems may be avoided by feeding extra Ca or including high Ca legumes (e.g. berseem in Egypt) in the ration.

Shih: Has any work been done in the field of ensiling or composting by adding or inoculating known microorganisms, including bacteria or fungi, to enhance the process?

Alderman: A number of microbial inoculants for ensilage have been introduced into UK from U.S.A. These are mostly cultures of Lactobacterium, sometimes with added enzymes (cellulases, proteases, amylases). The effects on fermentation characteristics of grass silage as measured by conventional techniques have not been promising. However, American work suggests that faster acidification and consequent saving on dry matter loss are significant effects. UK work confirms faster acidification but work on dry matter loss has yet to be completed.

****

Session 3

OPENING

S. Boer Iwema

Department of Animal Nutrition, Agricultural University, Wageningen, The Netherlands

There are two sources of products from animal bodies. In the first place wastes from slaughterhouses and in the second place animals died on farms.

In the first case it are the residues of animal bodies, not usable for human consumption (lungs, most part of the intestines, reproduction organs a.s.o. Of course the skin does not belong to the waste.) In the Netherlands these slaughterhouse offals have to be transported to our three renderers. But there are other waste products in slaughterhouses, like the contents of the alimentary tract: rumencontents, contents of pigstomachs a.s.o. Also the extracted flesh for the production of broth or beef-tea is used for the production of a well-known animal feed: meatmeal From the slaughter offals are made meat- and bonemeal, bloodmeal as well, and after hydrolysing feather meal. Also parts of fish a.s.o. are converted into dried fishmeal.

In the case of dead animals (e.g. of cows and horses), the skin is usually removed. The claws, horns a.s.o. are removed as well. The contents of the rumen is removed before the bodies are dried and defatted. The intention is to get animal products as pure as possible. That is the reason why there is a maximum of crude fiber in animal products in the Netherlands.

Today our attention is asked for slaughterhouse waste or offals. Of course we are not only interested in the feeding value of these products but also in the health aspects of the animals eating those products and in the health of the human beings consuming animal products produced by those animals fed with slaughterhouse offals.

As you know three papers are announced, but because of the illness of Prof. Meyer from Germany this speaker cannot be here. We hope he will recover very soon. Instead of Prof. Meyer two researchworkers who sent in a poster, will give a short introduction to their posters.

After this introduction I give the floor to Dr Edel to read his speech called: 'Health aspects of slaughterhouse waste converting by animals'.

Now I give the floor to Prof. Vandepopuliere who will tell us about 'Feeding poultry waste to livestock'.

HEALTH ASPECTS OF SLAUGHTERHOUSE WASTE CONVERTING BY ANIMALS

Dr. W. Edel

Veterinary Public Health Chief Inspectorate of the Ministry
of Welfare, Public Health and Cultural Affairs
P.O. box 439
2260 AK Leidschendam, The Netherlands

Summary

When $FeCl_3$ is added to effluents from slaughterhouses followed by anionic polyelectrolyt a precipitate is formed which mainly consists of protein and fat. This precipitate can be separated from the wastewater with dissolved air flotation, resulting in a partial (65-85%) purification.
This flocculation-flotation process is in use in eleven Dutch slaughterhouses and produces the so called flotation sludge. This sludge contains usually high numbers of micro-organisms, even pathogenic ones. The contamination may be from normal clinical healthy slaughter animals and can be of bacterial, parasitic, protozoic and viral nature.
From the toxicological point of view and contents of trace elements there is no objection in flotation sludge converting by animals by adding a certain amount to their feed ration. There was no negative effect on carcass quality and on the taste of the meat.
From the microbiological point of view direct feeding of flotation sludge to animals is not safe, therefore a heat treatment (15-20 min. at 70°C) should be performed or a treatment with gamma-radiation (4 kGy).
The safest method of utilization of this sludge is through the production of animal protein and fat in dry rendering plants, where temperatures are reached of 130°C for at least 30 minutes.

Introduction

Offals/wastes originating from the slaughteringproces may be divided into two categories, viz (i) a category, which is dilivered to specialized processing plants and rendering plants, and (ii) a category which is disposed of more or less uncontroled.
To the first category belong offals/wastes like blood, hides, bones, condemned meat/carcass, filth from the slaughtering floor and fat from fatcollectingunits (Anon., 1981). These offals will not be dealt with in this paper.

To the second category belong offals/wastes like manure (solid manure, rumen ingesta, intestinal contents) and wastewater, as well as substances removed from the wastewater or obtained by treatment of the wastewater, substances such as sieveremainings, sedimentation from sedimentation-tanks, and sludge from flocculation-flotation units, sludge from aerobic biological sewage treatment plants and sludge from flocculation-flotation units -the so called flotation sludge- in animal production.

Origin and nature of the flotation sludge

Slaughterhouses and meat processing plants produce great quantities of wastewaters with considerable demand for their purification and decontamination not only from the hygienic but also from the economical point of view.
These wastewaters are heavely polluted with organic materials, rich in protein and fat. In many countries the wastewaters from slaughterhouses and meatprocessing plants are discharged into the municipal sewarage system and led to a sewage treatment plant. But due to the rapid increasing payments for waterpurification more and more the treatment of wastewater is carried out by the slaughterhouse or meat processing plant itself in one way or another. In The Netherlands the pollution by slaughterhouses through their wastewaters is approximately 800.000 population equivalents (p.e.) of which approximately 120.000 p.e. are treated in the flocculation-flotation proces.
When $FeCl_3$ is added to effluents from slaughterhouses followed by anionic polyelectrolyt, a precipitate is formed which mainly consists of protein and fat. This precipitate can be separated from the wastewater with dissolved air flotation, resulting in a partial (65-85%) purification. Dissolved air flotation is based upon the principle that air, dissolved in water under very high pressure, when suddenly released through expansion till atmospheric conditions formes very small air bubbles with a diameter of 0.05-0.1 mm. With these microbubbles small solid particles being in suspension as well as grease globules can be removed rather quickly in a

mechanically skimmed basin (Rispens, 1983). See Fig. 1.

This flocculation-flotation process produces the flotation sludge. This process is in use in eleven Dutch slaughterhouses. However slaughterhouse wastewaters contain usually high numbers of micro-organisms, even pathogenic ones, and so is the sludge derived from these waters. The contamination may be from normal clinical healthy slaughter animals and can be of bacterial, parasitic, protozoic and viral nature.

It is known that often Salmonella is present (Pollach, 1964; Rosocha et al., 1980; Strauch, 1974; Zutter and Van Hoof, 1980) but also could be mentioned bacteria like Bacillus anthracis, Campylobacter, Clostridium spp, Erysipelothrix insidiosa, Escherichia coli (enteropathogenic, enterotoxicogenic), Leptospira, Listeria monocytogenes, Mycobacterium and Yersinia; parasites like Trichuris spp, Ascaris and Strongyloides; protozoa like Eimeria and viruses like adeno-, and reoviruses.

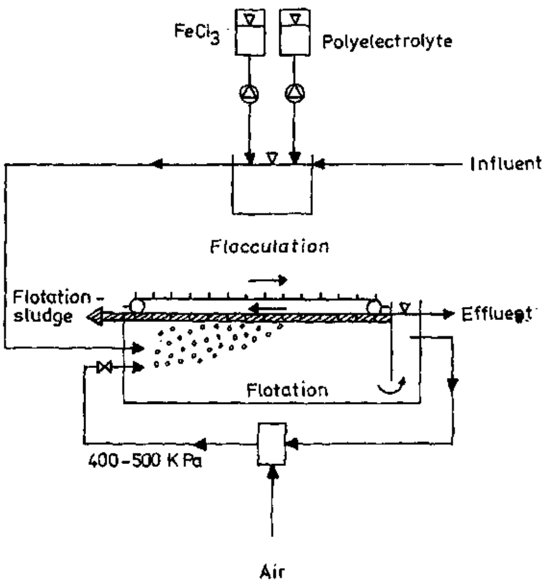


Figure 1. Flowsheet of the flocculation - flotation process

Investigations on flotation sludge

In The Netherlands the last three years many investigations with regards to the flotation sludge were carried out as a close collaborated study between five institutes, viz.:

- Central Institute for Nutrition and Food Research TNO, Zeist
- Organization for Applied Scientific Research, TNO, Apeldoorn
- The Netherlands Spelderholt Institute for Poultry Research, Beekbergen
- Institute for Livestock Feeding and Nutrition Research IVVO, Lelystad
- Government Agriculture Waste Water Service, RAAD, Arnhem

Financial support was provided by the Governement and the Production Board for Cattle and Meat (through the Research-group for Meat and Meatproducts TNO).

The report of this outstanding collaborative study on flotation sludge is at the moment being prepared by Ten Have (1983) from the Government Agriculture Waste Water Service.

The total amount of money for the study is more than 1 million dutch guilders and for this sum a great number of different research projects was carried out. Flotation sludge from slaughterhouses for broilers (poultry sludge) received by far the most attention, but much time was also spent on flotation sludge from slaughterhouses for pigs (pig sludge) and cattle (cattle sludge). The flotation layer from fattraps at slaughterhouses for poultry and flotation sludge from flaughterhouses for laying hens were also studied. In the digestibility and feeding trials for pigs and poultry attention was paid to the possible effect of pretreatment methods like pasteurization and drying on the digestibility and the feeding value.

The results of the different research projects are laid down in 18 different reports and could be devided into the following subjects:

- chemical and microbiological composition
- pasteurization and preservation
- feeding value
- sensorial, chemical and histopathological investigation of meat and organs from animals being fed with flotation sludge
- toxicology
- dewatering.

Results

It is not here the place to go too far into the technical details and therefore the main results will be summarized as follows: The dry matter (dm) content and the chemical composition of the dm vary considerably for a certain type of sludge and even for a certain factory. The dm content of cattle-, poultry- and pig sludge is comparable to each other and is 5-7.5%. Crude protein is about 40% and crude fat about 30% of the dm.

The flotation layers of fattraps and the flotation sludges from slaughterhouses for laying hens show a much higher dm and fat percentage. The protein in flotation sludge is relatively rich in the essential amino acids lysine, methionine and cystine and poor in proline and glycine in comparison to feed components such as animal protein, bonemeal and soybean. The percentage of polymeric fatty acids and glycerides in the fat of flotation sludge is much higher than in fat which is normally

used in concentrate feed mixtures. Contrary to common assumption these polymers have showed to be partly digestible. The contents of the trace elements Cu, Zn and Mn are on a somewhat higher level in pig-sludge, because of the fact that these elements are added to pigfeed. Using $FeCl_3$ for flocculation resulted in a high Fe-content.
High bacterial numbers were found e.g.: total aerobic count 10^8; total anaerob count 10^7; Enterobacteriaceae 10^6; yeasts and molds 10^6; Staphylococcus aureus 10^5; fecal streptococci 10^5; Bacillus cereus 10^3; Clostridium perfringens 10^3; Salmonella 10^3 and a few times adenovirus was isolated. Campylobacter was not detected.

Heat treatment of the sludge for 60 seconds at 70°C performed complete inactivation of this virus.
Flotation sludge can be preserved by the addition of a number of acids; untreated sludge needs somewhat more acid than pasteurized sludge.
Besides that, variations in the buffercapacity have their influence on the required dosage. Generally, about 0.5% sulfuric or formic acid, respectively about 0.5-1% acetic acid (v/v), has to be added.

The average amount of digestible crude protein for pigs in poultry-, pig- and cattle sludge is about 300-350 g/kg dm. The digestability of the organic material is, on the average, for pigs about 40% higher than for poultry; particularly the protein is less well digested by poultry than by pigs. There was no effect of pretreatment methods like pasteurization and drying on the digestibility and the feeding value.
Flotation sludge has proved to be very usable in the ration of pigs and poultry. For pig feed the maximum of flotation sludge is about 12% (on dm basis). A higher percentage results in unacceptable feed refusals. For poultry feed a maximum of 7.5% is allowable. When more flotation sludge is incorporated in the ration, the daily live weight gain is reduced and the feed conversion is not so good.
In a flavour test the taste of ribcutlets of pigs fed with pig sludge was not or almost not adversely affected by the incorporation from pig sludge in the ration. Simular results were obtained with poultry fed with poultry sludge.
Toxicological experiments, like a 4 week and a 13 week rat trial and an Amestest, plus histopathological, microbiological and chemical tests on organs and meat from pigs and poultry fed with flotation sludge, showed no effects of the feeding of flotation sludge which impede this application. There where, however, some deviations from the normal pattern in some parameters, but there was no significant dose-effect relation or the deviations were contrary to those which are normally caused by toxid effects. Before dewatering flotation sludge has to be conditioned. Three conditioning methods were tested, namely: addition of chemicals, heating to temperatures around 100°C and freezing. Freezing showed the best dewatering results. A method was developed for the continuous thermal conditioning on (semi) technical scale. This method involves the use of a steamlance. Flotation sludge can be dewatered to at least 25 à 35% dry matter, dependent on type of sludge, method of conditioning and dewatering. Belt presses and decantercentrifuges appeared to be very well suited for the dewatering of the sludges.

Discussion

From the toxicological point of view and contents of trace elements there is no objection in flotation sludge converting by animals by adding a certain amount to their feed ration. From the microbiological point of view direct feeding of flotation sludge to animals is not safe. Campylobacter was not isolated in this study, may be due to the method of isolation, because Havelaar et al. (1983) were able to isolate Campylobacter in high numbers from poultry flotation sludge. Although no investigation were carried out on parasites, it is known that eggs from parasites are also present in high numbers especially Ascaris suum (Bürger, 1978, 1982), but these eggs will also be killed by heattreatment for 15-20 min at 70°C (Liebmann, 1966) the same yields for eggs of Toxocara (Van Knapen, 1979).
With regard to viruses it is often said that a product is garranteed free from viruses when it is also free from sporoforming bacteria. This can only be done by the sterilization proces, which means heating far above 100°C.
The safest method of utilization of the flotation sludges is through the production of animal protein and fat in dry rendering plants, where temperatures are reached of 130°C for at least 30 minutes. The animal protein and fat are used as feed compounds for feed factories to produce concentrate feed mixtures. In this case sludges should be dewatered in order to save energy costs in the dry rendering plants. See Fig. 2.
Utilization/disposal of flotation sludge without any treatment may be a hazard in spreading pathogens and might intensify infection transmission cycles. These cycles have been extensively documented for Salmonella (Edel et al., 1972, 1973, 1976, 1978; Edel and Kampelmacher, 1976; Kampelmacher, 1977; Oosterom et al., 1980, 1982). The cycle of this species may be considered as a model for those of other pathogens,

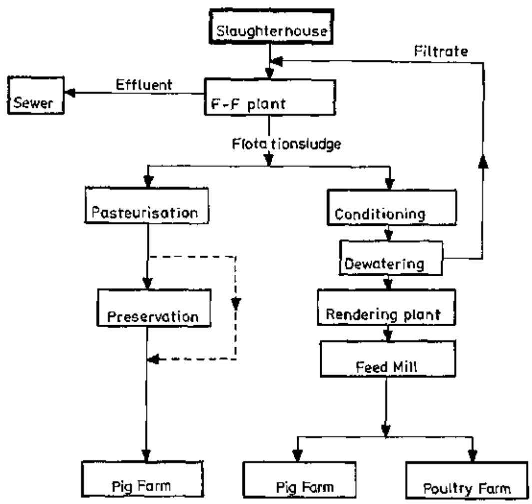


Figure 2 Pathways for the use of flotationsludge as a feedingredient

and precautions taken to avoid infections will largely reduce the risks from other pathogens. Any treatment to inactive pathogens will increase the costs of flotation sludge handling, but farmers may be more willing to accept the sludge if it is quaranteed to be free from pathogens (Havelaar et al., 1983).
The direct feeding of slaughterhouse waste to animals, particularly fattening pigs, is not recommended on the grounds of hygiene and maintaining human and animal health. In many countries, the direct use of slaughterhouse waste as animal feed is prohibited by law (Weiers and Fischer, 1978).
I was asked to take into account a few short communications on wastes fed to animals. I am doing this briefly by saying: What is said for flotation sludge yields mutatis mutandis for kitchen offals -the so called swill- and for any other waste. Any waste provided to animals should be in a condition that is eventually not a health hazard for man, animal and environment.

Literature

Anon (1981) Rapport van een werkgroep Slachthuisafvalwaterproblematiek (Report of a workinggroup Slaughterhousewastewaterproblem) Verslagen, Adviezen, Rapporten, Ministerie van Volksgezondheid en Milieuhygiëne, Leidschendam, The Netherlands, no. 61

Bürger, H.J. (1978) Parasitologische Risiken bei der Verfütterung getrockneter oder silierter Schlachtabfälle. Übers Tierernährg., 6, 184-188

Bürger, H.J. (1982) Large-scale management systems and parasite populations. Prevalence and resistance of parasitic agents in animal effluents and their potential hygienic hazard. Vet. Parasitol. 11, 49-60

Edel, W. and Kampelmacher, E.H. (1976) Epidemiological studies on Salmonella in a certain area (Walcheren project). II Salmonella in the mesenteric lymph nodes and rectal contents of normal pigs. Zbl.Bakt., I.Abt.Orig.A. 236, 74-82

Edel, W.; Van Schothorst, M. and Kampelmacher, E.H. (1976) Epidemiological studies on Salmonella in a certain area (Walcheren project). I. The presence of Salmonella in man, pigs, insects, seagulls and in foods and effluents. Zbl.Bakt.Hyg., I.Abt.Orig.A. 325, 476-484

Edel, W.; Guinée, P.A.M.; Van Schothorst, M. and Kampelmacher, E.H. (1973) Salmonella cycles in foods with special reference to the effects of environmental factors, including feeds. Proc.Symp. Microbial. Food borne infections and intoxications, Ottawa. 17-20

Edel, W.; Van Schothorst, M.; Guinée, P.A. M. and Kampelmacher, E.H. (1972) Mechanism and prevention of Salmonella infections in animals. In Hobbs, B. and Cristian, J.H.B. (eds.) The Microbiological safety of Food, England. p. 247-255

Edel, W.; Van Schothorst, M.; Van Leusden, F.M. en Kampelmacher, E.H. (1978) Epidemiological studies on Salmonella in a certain area ("Walcheren project III") Zbl.Bakt.Hyg., I.Abt. Orig. A. 242, 468-480

Havelaar, A.H., S.H.W. Notermans en J. Oosterom (1983) Oriënterend onderzoek naar de microbiologische gesteldheid van het afvalwater van een pluimveeslachterij en het effect van chemisch-biologische zuivering (Pilot study into the microbiological nature of the wastewater from a slaughterhouse for poultry and the effect of chemical-biological treatment. Report of the National Institute of Public Health, The Netherlands. no. 831001

Havelaar, A.H., J. Oosterom, S.H.W. Notermans and F. van Knapen (1983) Hygienic aspects of the application of sewage sludge to land Proceedings of the International symposium on Biological reclamtion and land utilization of urban wastes. Naples, Italy. 11-14 October 1983, p. 167-200

Kampelmacher, E.H. (1977) Spread and significance of Salmonella in surface waters in the Netherlands. In Hoadley, A.W. and Dutka, B.J. (eds). Bacterial indicators/Health hazards associated with water. Am.Soc.Test.Mat. STP 635, Philadelphia, III., 148-158

Knapen, F. van, J.H. Franchimont and G.M. Otter (1979) Steam sterilization of sand pits. Brit. Med. J., 1, 1320

Liebmann, H. (1966) Folgerungen für die Praxis aus den Ausführungen über die Verwertung und Beseitigung von häuslichen und industriellen Abwasserschlämmen. Verlag. R. Oldenbourg, München-Wien,13,327-333

Oosterom, J.; Van Erne, E.H.W. and Van Schothorst, M. (1982) Epidemiological studies on Salmonella in a certain area ("Walcheren project V"). Zbl.Bakt.Hyg., I.Abt. Orig.A. 252, 490-506

Oosterom, J.; Wit, J.C. de; Van Schothorst, M.; Van Leusden, F.M. and Kampelmacher E.H., (1980) Epidemiological studies on Salmonella in a certain area ("Walcheren project IV") Zbl.Bakt.Hyg., I.Abt.Orig.A. 248, 190-201

Pollach, W. (1964) Untersuchungen von Abwässern der Wiener Schlachthofanlagen auf Salmonellen. Wien, Tierärztl. Mschr. 51, 161-164

Rispens, A. (1983) Nieuwe ontwikkeling in mechanische voorzuivering van slachthuis- en aanverwant afvalwater (New development in mechanical pretreatment of slaughterhouse and similar waste water) Vleesdistr. en vleestechn., 18, 4, p. 16-20

Rosocha, J., O. Garaj, M. Vargová, M. Ondrasovic and J. Venglovsky (1980) Hygienic Problems of slaughterhouse Wastewaters. ZBL.Bakt.Hyg., I.Abt. Orig.B 170, 337-341

Strauch, D., (1974) Zur Frage der Notwendigkeit einer Desinfektion von Schlachthofafwässern. Fleischwirtschaft, 54, 1179-1186

Ten Have, P.J.W. (1983) On behalf of the members of a workinggroup: De bruikbaarheid van flotatieslib van slachterijen als veevoeder (The usability of flotation sludge from slaughterhouses as feedstuff.) (in preparation)

Weiers, W. and R. Fischer (1978) The disposal and utilization of abattoir waste in the european communities, Commission of the european communities EUR 5610 E

Zutter, L. de and J. van Hoof (1980) Bacteriological contamination in wastewaters from slaughterhouses Zbl.Bakt.Hyg., I.Abt. Orig. B 171, 269-279

ANIMALS AS CONVERTERS OF BYPRODUCTS FROM ANIMAL PROCESSING

Dr. J. M. Vandepopuliere, Professor

University of Missouri, Columbia, Missouri, U.S.A.

Continued growth in the human population along with the trend for greater numbers to migrate from the city to the urban and country areas is placing an ever increasing pressure on the livestock industry. Local, state and federal laws are becoming more stringent on disposal of processing by-products due to land, air and water pollution.

A general recession is having an influence on the number of livestock produced. In 1983, the United States produced 115 and 53 million cattle and hogs, respectively. This was a slight decrease from 1982, however, chicken, broiler and turkey production showed a slight increase with 5.6 and 1.2 million metric tons produced, respectively. Egg production was down slightly with 68.7 billion eggs (Table 1, Olentine, 1983).

Table 1. LIVESTOCK NUMBERS IN THE U.S.A.

	1982	1983
Cattle (million head)	115.7	115.1
Hogs (million head)	58.7	53.2
Broilers (million metric tons)	5.5	5.6
Turkeys (million metric tons)	1.1	1.2
Eggs (billion)	69.2	68.7

Vertical and horizontal integration and technological advances in the animal industry have vastly improved production efficiencies. Small units gave way to larger and larger enterprises. This development produced a concentration of animals that put great pressure on the generally accepted disposal practices of small farm units. On the other hand this change produced larger unit sizes which made processing and utilization of the residuals economically feasible. What was a pollution problem and cost center was converted to a potential and desirable profit center. Packing plant further processing programs producing box beef and prepackaged chicken parts for convenience and efficiency, has concentrated bones and trimmings for the production of quality feedstuffs. It appears that this trend will continue in the United States.

The discussion of the animal utilization of byproducts from animal processing will be divided into three sections, (poultry, cattle-hogs, and dairy).

POULTRY

Livebird processing

The primary feedstuffs produced at the processing plants are poultry byproduct meal, poultry oil and feather meal. In general the quantity of blood is insufficient to process separately and consequently it is often cooked with the feathers. In some plants, all of the residuals are processed together producing a "whole" poultry byproduct meal. This technique provides for either under or over cooking of some fractions which reduces the total nutrient availability and utilization. The combination type products are frequently produced and used in an integrated operation.

Poultry byproduct meal: Poultry byproduct meal consists of the ground, dry-rendered or wet-rendered clean parts of the carcass of slaughtered poultry exclusive of feathers. It must contain not more than 15% ash and not more than 4% acid-insoluble ash. Properly processed, it commands a premium in dog and cat formulation due to its light color and superior palatability qualities. It has an excellent amino acid profile and energy content for use in the other monogastric diets.

Poultry oil: The handling characteristics of poultry byproduct meal is improved if some of the poultry oil is expelled. A screw press is generally used to extract the oil immediately following cooking. Poultry oil is an excellent energy source and commands a premium as a palatability enhancer when sprayed on cat food (Corbin, 1983). It can also be used as an energy source in general livestock diets.

Hydrolized poultry feathers: Hydrolyzed poultry feathers (feather meal) a feedstuff resulting from the wet treatment under pressure of feathers from slaughtered poultry. Not less than 75% of its crude protein content must be digestible by the pepsin digestibility method (Feedstuffs, 1983).

The protein content is quite high (84%), however, it is sometimes considered to be of poor quality protein due to certain limiting amino acids (methionine, lysine, histidine, tryptophan). Utilizing computer formulation techniques, the use level of ingredients are restricted when the amino acid contribution becomes restrictive. Baker et al. (1981) demonstrated that with methionine and lysine supplementation, up to 40% of the dietary crude protein could be supplied by feather meal with little depression in chick growth rate and efficiency of weight gain. In practical poultry diets feather meal levels of 0.5 to 1.5% are experienced.

Interest in feather meal as a source of rumen nitrogen and bypass protein has increased potential uses. Church et al. (1982) reported that when feather meal was substituted for soybean meal in sheep, diets containing 40% roughage nitrogen retention was comparable to the soybean meal control In a subsequent study by Alderibigbe et al. (1983) the utilization of feather meal by growing lambs was not affected when the feathers were processed at various pressures and time periods to achieve pepsin-HCL digestibilities of between 57 and 78%. Utilization of feather meal was low in vitro but high in vivo studies indicating some potential for reticulo-rumen bypass. These data indicate satisfactory utilization when feather meal supplied one-half of the dietary nitrogen.

Shell egg processing

The producing industry has two merchandising outlets for its product. The majority of the eggs are washed, graded and cartoned for the retail trade. The rejects are placed in the inedible egg product category which is unfit for human consumption. Based on industry claims, Schupe et al. (1972) estimated that an average of 5% breakage occurs in typical egg processing plants. Cotterill (1978) reported that a survey of 77 producers showed an average of 1.7 percent of all eggs produced were inedible.

Egg grading and cartoning plant: Considering the quantity of inedible eggs, disposal problem and nutrient value, a processing method was needed to permit utilization. Many states consider inedible eggs as garbage and require heating throughout to boiling for 30 minutes prior to feeding to swine.

In a study at the University of Missouri, a deep-fat fryer was designed to provide continuous processing inedible eggs with minimum labor (Britton, 1981). The eggs were broken mechanically and augered into a constant temperature (149°C) oil bath cooking chamber. After a 10 seconds cooking time, the egg product was removed by a wire mesh conveyor which permitted drainage. The cooked egg product contained 10.2% protein, 54.5% fat, 5.8% ash and 29.1% water. Using linear programming, a least cost feed formulation was used and calculated the value of a ton of inedible raw egg after cooking to be $80 greater than the processing cost. This procedure eliminates a disposal and pollution problem and produces high quality byproduct feedstuff.

Egg breaking plants: The demand for liquid egg solids for industrial use and institutional cooking has increased dramatically in the past 25 years. The 150 egg breaking plants in the USA produces over 45,000 metric tons of egg shell waste annually. Disposal presents a serious problem in some areas.

Egg shell waste: The chemical composition of the waste was reported by Walton et al., 1973. The findings suggested the use of the processed egg shell meal as a feedstuff. The nutritional evaluation of a commercially produced egg shell meal was reported by Vandepopuliere et al. in 1975. The calcium availability was equal to ground limestone. The amino acid availability measured by performance, was comparable to that from a combination of wheat middlings and meat and bone meal or soybean meal. The egg shell meal ingredient value of $37/metric ton was $22 per ton greater than total production cost (Vandepopuliere et al., 1978). In addition, the process generates two economic values: an increased quantity of inedible eggs for sale and savings in disposal of the wet wastes.

Wastewater: Effluent guidelines are becoming more stringent and sewer charges are being levied on the level of organic content of the wastewater. Jewell et al. (1976) estimated that 12% of the liquid egg in an egg breaking plant ends up in the sewer system. The wastewater is characterized by a high level of colloidal solids and alkaline pH. Harris and Moats (1975) described a method to precipitate egg solids from a dilute wastewater by heating to 75°C and acidifying to pH 4.7. Dewatering the unstable floc was investigated using coagulant aids centrifugation filtration and foamation (Sievers et al., 1982). The most promising process was foamation. A high level of egg solids removal was attained with simple equipment that could be used continuously on-line. In sizing up the foamation process to a plant scale, problems were encountered with the required rapid heat transfer to the effluent. The second phase was to test a pilot scale on-line continuous centrifuge (Vandepopuliere et al., 1983). The highest removals (94% COD, 89% total kjeldahl nitrogen, 79% total solids) occurred with a centrifuge flow rate of 0.21 l/s. The recovered sludge solids had a protein content of 50.5% and a calculated feed ingredient value of $0.24/kg (dry basis).

Hatchery operations

Considering the increasing anti-pollution pressures and the needs for improvement in production efficiencies and economics, the conversion of hatchery wastes into a feedstuff is desirable.

Broiler and turkey hatchery waste consists of infertile eggs, dead embryos, dead chicks or poults, and the shells of the hatched eggs. The hatchery waste from the commercial egg-type hatchery contains all the components of broiler type hatchery waste plus the male chicks that are normally destroyed at the time of sexing.

Early work on broiler hatching waste was reported by Kempster (1945), Wisman (1964) and Wisman and Beane (1965). When fed as a replacement for a part of the soybean meal satisfactory performance was obtained.

Using linear programming, Vandepopuliere et al. (1977a) evaluated broiler and egg-type chick hatchery byproduct meal as a feedstuff for laying hens. Fresh broiler and egg-type chick hatchery waste was ground, heated and dehydrated in a triple pass rotary dehydrator (The Heil Company, Milwarkee, Wisconsin, 53201) to a moisture level of approximately 5%. Table 2 provides some hatching byproduct meal nutrient composition information.

Table 2. COMPOSITION OF HATCHERY BYPRODUCT MEAL

	Broiler	Egg-Type
	%	%
Original moisture	65.00	71.00
	Dried basis	
Protein	22.20	32.30
Calcium	24.60	17.20
Phosphorus	0.33	0.60
Fat	9.90	18.00

Both types of poultry byproduct meal were incorporated at levels of 8 and 16% in laying diets substituting for soybean meal, meat and bone meal, wheat middlings and ground limestone. Egg production, feed conversion and egg shell and interior quality at both levels of each hatchery by-product meal were comparable to or better than the control diet. The apparent utilization of the amino acids, energy and calcium in broiler and egg type chick hatchery byproduct meal was comparable to those in the ingredients that were replaced.

Processing costs in these studies range from $46 to $95 per ton depending on the hatchery size and type, capital investment and labor cost. The market value of the hatchery byproduct meals will vary depending on the market value of the ingredients that they replace. At the time of the study, the calculated value for broiler and egg-type chick hatchery byproduct meal was $111 and $154, respectively (Vandepopuliere et al. (1977b).

CATTLE AND SWINE

The on-farm processing of cattle and swine has decreased markedly resulting in more centralized processing. This has the advantage of providing larger quantities of fresh packing plant residuals for processing into feedstuffs. The profitability of a packing plant depends on its ability to produce and market a quality product at the highest possible price. Several ingredients will be discussed here that result from processing plant operations.

Animal fat

The chemical make-up of animal and poultry fat is predominantly glyceride esters of fatty acids and contains no additions of free fatty acids or other materials obtained from fat. It may be tallow, lard or grease.

Fat has been used at relatively high levels in growing chicken broilers and turkeys. The energetic efficiency of broiler finishing diets containing poultry fat or corn oil at levels of 5, 10, 15 and 20% was determined by Fuller et al. (1979). Diets were formulated so that energy and nutrient density increased at each increment of added fat and caloric: nutrient ratios remain constant for all diets. Body weight gains were significantly greater with added fat, however, feed efficiency adjusted to the same metabolizable energy and nutrient density was similar for all diets. In general, high efficiency commercial broiler, turkey and swine diets contain substantial levels of fat.

Significant quantities of vegetable oils are available for use in the feed milling industry. It can be used as an ingredient or it can be combined with an animal fat. In 1978, Sibbald reported that when 2% soybean oil was added to tallow, the true metabolizable energy values (TME) was greater than the sum of the means of the component parts. When lard was added to tallow, the TME values were additive.

Animal tallow has been used extensively in the diets of beef cattle, but the practical upper limit of tallow in cattle fattening diets has been 5% (NRC, 1976). In an attempt to produce a bypass ingredient, McCartor et al. (1979) fed protected tallow. The formaldehyde-treated protein protected tallow product provided a level of 7.65% tallow to the diet. This level of protected tallow did not reduce feed intake. The protected tallow reduced the feed per kilogram gain by 3.3% for steers fed 89 days and 1.4% for steers fed 118 days.

The "Extra-Caloric" effect of fat in poultry diets, using stabilized animal tallow at levels ranging from 2-6% in laying hen rations based on various cereal grains, reduced feed consumption and increased rate of egg production slightly (Sell et al., 1976). Marked improvement in efficiency of feed utilization were also observed. The metabolizable energy (ME) as measured experimentally exceeded the values calculated from reference tables. Dietary fat appears to improve the production efficiency of hens by causing an "extra-caloric" increase in ration ME and by improving the efficiency with which the ration ME is used for egg production.

Meat and bone meal

The nutritional value of meat and bone meal, the dry rendered product from mammal tissues, can be highly variable. A review of the evaluations was published by Skurray, G. R. in 1974. High quality meat and bone meal can be used in poultry diets, however, maximum dietary level is generally limited to 10%. In cattle and lamb diets the slowly degraded meat and bone meal was compared to soybean meal (Loerch et al., 1981). The performance of both steers and lambs on the meat and bone meal were comparable to the soybean control.

Blood meal

Blood meal is produced from clean, fresh animal blood. The conventional cooker dried meal has a dark-like color and is rather insoluble in water. The water in flash dried blood meal is removed rapidly and has a minimum lysine biological value of 80%.

Raw blood was cooked at 85° for 10 minutes or 126°C (20 p.s.i.g.) for 60 minutes then dried under various conditions at temperatures ranging from 23°C to 193°C, with and without forced air movement (Hamm and Searcy, 1976). As the temperature and time of exposure increased, available lysine decreased. A batch processing method, similar to commercial rendering operations produced a satisfactory blood meal if the processing temperature did not exceed 135°.

Due to its high lysine content, blood meal is frequently called for in swine and poultry diets at a limited level. Talmadege et al., 1980 studied the energy value of ring dried blood meal for chicks. It contained 15.8% nitrogen on a dry matter basis, indicating it contained 98.75% protein assuming N x 6.25 equals crude protein. It contained 3.81 kcal MEn/g of dry matter which was 61% of the gross energy. Broiler type chicks were used to study the lysine and methionine replacement value of ring dried blood meal in practical type commercial diets (Runnels, 1982). Ring dried blood meal was fed at 1.5% level to replace the lysine and methionine deficiency. Performance, growth and feed conversion, on the blood meal supplemented diet was significantly better than the synthetic amino acid supplemented diet.

Lactating cows producing at least 27 kg milk per day were used to study various protein sources (Hawkins et al., 1983). The diets consisted of 50% corn silage and 50% grain with protein sources and were balanced according to National Research Council standards. Four diets were tested: 18 and 14% crude protein using soybean meal and 14 and 12% crude protein using a 50:50 mixture of corn gluten meal and blood meal. The 12% protein corn gluten meal-blood meal supported milk yields and milk quality similar to the 18% protein meal diet.

Hair meal

Hydrolyzed hog hair is a byproduct of the swine slaughtering industries. It has a very high concentration of protein (95-100%) which has created an interest in its use as a source of supplemental protein in livestock diets.

In feedlot study, hydrolyzed hog hair meal was used to substitute for 8 to 30% of the dietary crude soybean meal protein for steer calves (Wray, 1979). Feedlot performance as measured by daily gain, feed efficiency, feed consumption and carcass quality was comparable on all levels tested.

DAIRYING

Fresh pasteurized whey as it comes from the vat is the simplest form to use for feeds. High moisture content and transportation cost decrease the feasibility of using the large quantities from centrally located processing plants. Efforts to concentrate the solids producing whey paste or blocks have been used extensively in some animal feeding programs. Dried whole and delactosed whey can be utilized most efficiently in the modern feed milling industry.

The world energy situation has placed a great economic burden on the dehydration of whey. In many cases the return to the manufacturers, when whey is sold as a feedstuff, is barely enough to cover the cost of processing. This has given whey handlers added incentives to upgrade the value of whey as an animal feed or human food.

Long before whey was utilized in human food, it was fed as a fluid to hogs, poultry and other farm livestock. This technique was an effective means of disposal, however, it didn't provide for efficient nutrient utilization.

Subsequent to liquid whey feeding, semisolid processed whey blocks were produced for use by poultry and swine. These were fed as a free choice supplement. Delactosed spray and roller dried whey product was readily accepted by the feed manufacturing industry. The cost/unit nutrient supplied by whey was in competition with other feedstuffs. With inexpensive commercial vitamins and an abundance of quality protein-energy ingredients, dried whey was used in decreasing amounts. During the recent years there has been renewed interest in utilizing whey in a concentrated and liquid state.

Dairy animals readily accept liquid whey (Gillies, 1978). Even though calves fed acid and sweet wheys obtained normal growth the total quantity consumed would be only a small percent of the available supply. Dairy cows with access to sweet whey and water bowls consumed large quantities of whey and very little water. By using dry fed milking cows, whey could be recycled by returning it to approximately 25% of producing farms which are shipping milk to a plant.

ANIMALS AS WASTE CONVERTERS will determine the future of the animal industry in many parts of the world. The efficiency of the various species in converting the different types of wastes will govern how each species flourishes. With adequate research efforts, large quantities of under utilized animal waste will be converted efficiently into high quality human food. Spiraling energy costs encourges the use of agricultural and industrial byproducts on a wet or as is produced basis. Converting from conventional dry feed milling and feeding systems to high moisture or wet feeding programs will require many new innovative approaches. The animals requirement for water provides a unique opportunity to take advantage of the wet byproduct-high fuel cost situation.

References

Alderibigbe, A. O. and D. C. Church, 1983. Feather and hair meals for ruminants. I. Effect of degree of processing on utilization of feather meal. J. of Anim. Science 56:1198-1207.

Baker, David H., Robin C. Blitenthal, Katherine P. Boebel, Gail L. Czarnecki, L. L. Southern and Gawain M. Willis, 1981. Protein-amino acid evaluation of steam-processed feather meal. Poultry Science 60:1865-1872.

Britton, D. E., 1981. Deep-fat frying inedible eggs for use in animal feeds. M.S. Thesis, University of Missouri, Columbia, Missouri 65211.

Church, D. C., D. A. Daugherty and W. H. Kennick, 1982. Nutritional evaluation of feather meal and hair meals as protein sources for ruminants. J. of Animal Science 54:337.

Corbin, J. E., Dr. Professor (1983). Personal Communication. University of Illinois, Urbana, Illinois.

Cotterill, O. J., 1978. Are there better ways to utilize leaker eggs? Presented at the Fact Finding Conference, Houston, Texas, September 12-15.

Feedstuffs, 1983. Reference Issue. Vol. 55, No. 30:124.

Fuller, H. L. and Mario Rendon, 1979. Energetic efficiency of corn oil and poultry fat at different levels in broiler diets. Poultry Sci. 58:1234-1238.

Gillies, M. T., 1978. Animal feeds from waste materials. Noyes Data Corporation, New Jersey, p 304-341.

Hamm, Douglas and G. K. Searcy, 1976. Some factors which affect the availability of lysine in blood meals. Poultry Science 55:582.

Harris, C. W. and W. A. Moats, 1975. Recovery of egg solids from wastewaters for egg grading and breaking plants. Poultry Science 54:1518-1523.

Hawkins, E. E., F. G. Owen, T. J. Klopfenstein, R. A. Britton and S. R. Lowry, 1983. Protein sources for early lactation rations for dairy cows. ADSA Annual Meeting and Divisional Abstract Supplement #1, J. Dairy Sci. 66.

Jewell, W. J., W. Siderewicz, R. C. Loehr, R. R. Zall, O. F. Johndrew, Jr., H. R. David and J. L. Witherow, 1976. Egg breaking and processing wastes control and treatment. In Proc. 6th Nat. Symp. Food Process. Wastes Environ. Protect Agric. Technol. Ser. EPA-600/2-76-224, Cincinatti, Ohio.

Kempster, H. L., 1945. The use of dried incubator offal in chick rations. Poultry Sci. 24:396-398.

Loerch, S. C. and L. L. Berger, 1981. Feedlot performance of steers and lambs fed blood meal, meat bone meal, dehydrated alfalfa and soybean meal as supplemental protein sources. J. of Animal Science 53:1198-1203.

McCartor, M. M., Z. L. Carpenter and David Hutcheson, 1979. Substitute of a protected tallow product for grain sorghum in the diet of fattening steers fed for 89-118 days. J. of Animal Sci. 48:1057-1064.

NCR, 1976. Nutrient requirements of domestic aniamls, No. 4. Nutrient requirements of beef cattle. Fifth revised ed., 1976. National Academy of Sciences-National Research Council, Washington, DC.

Olentine, Charles, 1983. Looking at Europe. Feed Management, Vol. 34, No. 7:10-14.

Runnels, Tom D., 1982. The value of ring-dried blood meal as an ingredient in broiler diets. Poultry Sci. 61:1534.

Schupe, W. L., E. W. Spangler, J. A. Hamann and A. W. Brant, 1972. Reduced egg breakage in mechanized egg grading-packing lines. ARS 52-73, U.S.D.A.

Sell, Jerry L., Farouk Horani and Robert L. Johnson, 1976. The "Extra-Caloric" effect of fat in laying hen rations. Feedstuffs, July 5.

Sibbald, I. R., 1978. The true metabolizable energy values of mixtures of tallow with either soybean oil or lard. Poultry Science 57:473-477.

Sievers, D. M. and J. M. Vandepopuliere, 1983. Dewatering characteristics of precipitated egg solids. Poultry Sci. 62:985-989.

Skurray, G. R., 1974. The nutritional value of meat meals for poultry. World's Poultry Science Journal. 30:129.

Talmadege, S. Nelson, Linda K. Kirby, Randall L. Hanks, Zelpha B. Johnson and P. W. Waldroup, 1980. The metabolizable energy content of wheat and animal products for the chick. Poultry Sci. 59:1227.

Vandepopuliere, J. M., H. V. Walton and O. J. Cotterill, 1975. Nutritional evaluation of egg shell meal. Poultry Science 54:131-135.

Vandepopuliere, J. M., H. V. Walton, W. Jaynes and O. J. Cotterill, 1978. Elimination of pollutants by utilization of egg breaking plant shell waste. EPA 600/2-78-044.

Vandepopuliere, J. M., D. M. Sievers, W. Jaynes and C. E. Harris, 1983. On-line egg solids recovery from egg breaking plant wastewater. (submitted for publication).

Vandepopuliere, J. M., H. K. Kanungo, H. V. Walton and O. J. Cotterill, 1977a. Broiler and egg type chick-hatchery by-product meal evaluated as laying hen feedstuffs. Poultry Sci. 56:1140-1144.

Vandepopuliere, J. M., L.A. Voss and H. B. Jones, 1977b. The potential of hatchery waste as a feed ingredient. Univ. of Missouri-Columbia Ag. Exper. Station SR 200.

Walton, H. V., O. J. Cotterill and J. M. Vandepopuliere, 1973. Composition of shell waste from egg breaking plants. Poultry Sci. 52:1836-1841.

Wisman, E. L. 1964. Processed hatchery byproduct as an ingredient in poultry rations. Poultry Sci. 43:871-876.

Wisman, E. L. and W. L. Beane, 1965. Utilization of hatchery by-product meal by the laying hen. Poultry Science 44:1332-1333.

Wray, Mary I., W. M. Beeson, T. W. Perry, M. T. Mohler and E. Baugh, 1979. Effect of soybean, feather and hair meals and fat on the performance of growing-finishing beef cattle. J. Animal Science 48:748-757.

INVESTIGATIONS ABOUT CONSERVING AND FEED VALUE OF RUMEN CONTENTS OF SLAUGHTERED CATTLES IN CATTLES AND PIGS

H.Meyer

Institut für Tierernährung, Tierärzliche Hochschule, Hannover

After pressing (increase of dry matter content up to 25%) rumen contents can be conserved by adding urea (2% of the fresh material) and stored (compressed and airtight packed). The stability of the preserved material and the losses during conservations were equal to those of silages.

Dry matter of urea conserved rumen contents contains 40% crude fibre about 5.5% nitrogen and 38% N free extracts. 70% of the nitrogen are non protein nitrogen (NPN). From the minerals strikes a P (4.6 g/kg DM) and Na content (8.76 g/kg DM). Copper content (average 46.5 mg/kg DM) in some samples rised up until more than 200 mg/kg DM. The values for Zn, Fe and Mn were 81, 1595 and 98 mg/kg DM.

In none of the investigated (n = 22) samples salmonella were found. Under experimental conditions salmonella (salmonellas typhimurium) were destroyed after storage urea conserved rumen contents for 21 days. Bovine herpes virus (IBR/IPV virus) could not be detected in the fresh or conserved rumen contents after in vitro infection.

Eggs of ascaris suum did not loose their ability for development during storage in urea conserved rumen content.

Risk of infection by bacteria, viruses and parasites feeding urea conserved rumen contents (conservation before feeding at least 4 weeks) seems to be low.

In feeding experiments with ruminants the acceptance of urea conserved rumen contents was increased by mixing with conventional feeds. Highest dry matter intake of the conserved material was observed by combination with pressed sugar beet pulp silage and manioc (0.49, 0.65% of body weight respectively).

In ruminants apparent digestibility of organic matter, crude protein, total nitrogen and crude fibre amounted to 45, 85, 50.8 and 43.5%, which means about 7.8 MJ DE and 6.5 MJ ME per kg DM. In 6 fattening trials with bulls and heifers (n = 82) urea conserved rumen contents was used as sole source of roughage, alternatively to hay. On average 1.44 kg urea conserved rumen contents could substitute 1 kg hay (DM), which corresponded to 6 MJ ME/kg DM. In combination with pressed sugar beet pulp silage higher daily gain was obtained by use of urea conserved rumen contents in comparison to equal - amounts of straw.

During feeding the material rich in NPN no disturbances of health were observed. However, after intake of urea conserved rumen contents in amount of 0.86% of body weight significantly higher pH values (7.09) and ammonia concentration (248 mg/l) in rumen liquid and blood urea levels (28.5 mg/100 ml) were estimated compared with feeding hay.

In swine acceptance of fresh rumen contents is low. Up to 20% of total ration (dry matter) were accepted in combination with offals. During pregnancy sows took about 250 g dry matter per day of urea conserved rumen contents, mixed with conventional feed.

Digestibility of organic matter of fresh rumen contents (n = 11) amounted to 25%, of crude protein to 50%. Digestibility was not improved by cooking. According to the digestibility trials 4.9 MJ DE/kg DM were calculated.

After the results of a fattening trial (with 5, 12, 24% rumen contents respectively added to high fat slaughter offals; n = 20) feeding value of rumen contents was calculated on 3 MJ DE/kg DM. During a second trial (+ 15% rumen contents or + 15% alfalfa respectively to high fat slaughter offals; n = 20) an energy value of rumen contents was not measurable, while for alfalfa the excepted value calculated by digestion trial was exceeded.

References

Coenen, M., H. Meyer und E. Ebers, 1984. Untersuchungen zur Verfütterung des Panseninhalts von Schlachtrinderen. 2. Harnstoffkonservierter Panseninhalt in der Rinderfütterung. Berl. Münch. tierärztl. Wschr. In print.

Kamphues, J., 1981. Möglichkeiten und Grenzen für eine Rezuklisierung des Panseninhalts von Schlachtrindern in der Tierernährung. übers. Tierernährg. 9, 259-292.

Meyer, H., G. Amtsberg, H.J. Bürger, M. Coenen und H.R. Frey, 1984. 1. Konservierung von teilentwässertem Panseninhalt mit Harnstoff und Zusammensetzung des Konservates. Berl. Münch. tierärzltl. Wschr. In print.

Meyer, H., M. Coenen und C. Schünemann 1984. 3. Einsatz von Panseninhalt in der Schweinefütterung. Berl. Münch. tierärzl. Wschr. In print.

FLOCCULATION-FLOTATION (F-F) SLUDGE TO BE USED AS FEEDSTUFF FOR POULTRY

R.W.A.W. Mulder, W.M.M.A.Janssen, J.P. Holsheimer, N.M.Bolder and A.W.de Vries

Spelderholt Centre for Poultry Research and Extension, Ministry of Agriculture and Fisheries, 7361 DA Beekbergen, The Netherlands

Flocculation of waste water of processing plants, followed by flotation, produces effluents with about 20% of the original BOD and COD. At the same time a sludge is formed, which is very rich in protein and fat. Although the F-F process requires a small space and is simple, the production of large quantities of sludge is a disadvantage to the process.
Till now, the sludge was mainly used as fertilizer in agricultural areas.

Table 1. Chemical composition of F-F sludge from poultry processing plants.

	Range
Dry matter (%, DM)	3.4 - 15.2
Ash (% DM)	6.4 - 24.7
Crude protein (CP)	23.3 - 24.9
Crude fat (CF)	25.7 - 62.7
Crude fibre (CF)	0.7 - 3.7
NFE	20.5 - 31.5

The products contain low levels of Cd, Hg and Pb

Feeding value

Experiments with poultry were carried out to study the possibilities of this animal by-product as a feedstuff in poultry diets. For this purpose, F-F sludge from a poultry (broiler) processing plant were dried and mixed with a basic ration in order to determine the metabolizable energy (ME) and the digestibility of the nutrients with mature cocks.
The inclusion levels of the dried sludge in the diets were 15, 25 and 50%.

Table 2. Metabolizable energy (ME) and digestibility of F-F sludge.

% sludge in the diet	ME		Coefficients		
	MJ/kg DM	kcal/kg DM	CP	CF	organic matter
15	14.11	3372	64	83	59
25	13.83	3305	58	82	57
50	12.78	3054	56	78	53
25	14.25	3406	66	80	59
50	12.89	3081	59	74	53

F-F sludge proved to be a feedstuff with a variable chemical composition, which results in a variable metabolizable energy content. These ME values also depend on the inclusion level of the sludge in the diets.

Zootechnical results and product quality

In the last experiment the effect was studied of mixing a recovered by-product of a poultry processing plant in a traditional broiler diet. Levels of 0, 7.5 and 15% were used during a six-week experiment with broilers (males and females in separate groups).
Weight gain, feed conversion and quality of the slaughtered product were determined.

Table 3. Weight gain and feed conversion after a 6-week feeding experiment.

% Sludge in the diet	0 - 6 weeks	
	Weight gain (g)	Feed conversion
0	1719	1.72
7.5	1702	1.74
15.0	1619	1.83

With 7.5% of dried F-F sludge in the diet, feed conversion and weight gain were slightly worse compared with the control group. With 15% sludge, this effect was more pronounced and statistically significant.
No adverse effects could be found with respect to the histo-pathology of tissues and organs.
Quality of the slaughtered product was not affected by the inclusion of the dried sludge in the diets.
Sensory tests with breast- and leg meat as well as microbiological tests, as measured by total and Enterobacteriaceae cfu-counts, showed no adverse effects.
Residues of heavy toxic metals could not be detected in the end-products.

General conclusions

F-F products proved to be a feedstuff with a variable feeding value, depending on its origin, chemical composition and inclusion level in the diets. The dried sludge from a poultry processing plant, mixed in a broiler diet at a level of 7.5%, did not have a significant effect on the zootechnical results and product quality.

FLOTATION SLUDGE FROM SLAUGHTER-HOUSES AS A FEEDSTUFF FOR PIGS

B. Smits* and A. Steg*

*Institute for Livestock Feeding and Nutrition Research,
P.O. Box 160, Lelystad, The Netherlands

Introduction

Waste water of slaughter-houses is highly pollutive, primarily because of considerable wastages of protein and fat. For the Dutch slaughteries as a whole pollution is estimated at 800.000 population equivalents a year. The disposal of the waste water is very costly to the slaughter-houses. To reduce the costs, partly purification can be employed by the so-called floculation/flotation process, recovering protein and fat by addition of $FeCl_3$ to the waste water and collecting the flocs formed. The resulting flotation sludge has potential as a feedstuff.

Recently a joint research effort of several institutions was finished, gathering information with regard to chemical composition, hygienic and toxicological aspects, dewatering and feeding value of the product for pigs and poultry. Some results of trials with pigs are reported here.

Materials and methods

In 10 digestibility trials (4 animals/trial) the digesitbility of flotation sludge from slaughter-houses for poultry, pigs and cattle was investigated after (1) preservation of the products with formic acid, (2) pasteurisation followed by preservation with formic acid or (3) drying. The daily ration of the pigs consisted of a concentrate mixture and the product to be tested. On a dry matter basis about 25% of the daily ration was supplied by the sludge.

In 3 feeding experiments with in total 123 pigs flotation sludges, originating from a poultry- and a pig slaughter-house, were investigated. In each experiment the sludge was acidified with ± 1% formic acid to achieve a pH of ± 4.0. In two trials the sludge was also subjected to a heat treatment (min. 15 minutes at 70°C). Up to 18% sludge (dry matter basis) was included in the ration. The initial live weight of the pigs was ± 40 kg and pigs were slaughtered at a live weight of ± 105 kg.

Results and discussion

Chemical composition

In table 1 the average chemical composition, based upon in total 60 samples, is given.

Table 1. Average chemical composition of the different types of sludge (Ten Have, 1983).

		g/kg dm			
Sludge	g/dm kg	ash	cp	$cfat_B$ 1)	cfibre
"poultry"	71	150	391	338	20
"pigs"	75	214	436	249	22
"cattle"	55	197	455	225	31

1) $cfat_B$: HCl/hexane extraction

These results show that flotation sludge contains in dry matter high levels of ash, protein and fat. There were, however, substantial differences between sludges, depending upon the type of animals slaughtered and also from one batch to another. Moreover, dry matter content was low and rather variable.

Digestibility

Average results are given in table 2.

Table 2. Average digestibility and feeding value (in dry matter) of the different types of sludge (Smits, 1982).

	sludge		
	"poultry"	"pig"	"cattle"
digest.coeff.			
om	76	67	68
cp	81	77	81
$cfat_B$	76	41	59
cfibre	-	-	48
Nfe	66	91	47
feeding value			
dcp, g	317	336	369
NE_f, MJ	13,7	8,5	9,4

Organic matter digestibility of "poultry"-sludge was higher than of "pig"- or "cattle"-sludge. On average protein digestibility was about 80% and only small differences were

Table 3. Average results of the 3 feeding experiments with pigs (40-105 kg live weight) (Smits et al., 1983).

	Experiment								
	I			II			III		
type of sludge	"poultry"			"poultry"			"pigs"		
inclusion level (dm)	0	9.5	18.8	0	5.8	11.6	0	6.2	12.2
daily live weight gain (g)	718	742	652	735	777	784	757	818	822
energy conversion ($MJ\ NE_f$/kg gain)	25.9	25.8	28.6	26.4	24.9	24.6	25.8	24.0	23.7
feed refusals (%)	1.3	3.3	8.4	1.2	1.5	1.9	0.2	2.5	3.9
backfat thickness (mm)	10.6	11.4	12.2	11.5	13.2	13.5	10.6	10.2	9.9
dressing (%)	73.0	74.2	74.6	75.7	75.9	76.0	73.9	74.3	74.3

found between the various types of sludge. In general the digestibility of crude fat was rather low, especially in the case of "pig"-sludge.

Feeding trials

Table 3 shows the average results of the 3 feeding experiments with pigs. The daily live weight gain and energy conversion ratio in all groups, except for the 18.8% inclusion level in the first trial, was favourable. The rather low daily live weight gain of 652 g of the 18.8% group in the first experiment was due to the rather low daily energy intake as a result of a high percentage of feed refusals (8.4%).

The slaughter quality of the carcasses of the pigs was excellent. Within experiments no significant differences ($p < 0.05$) in performance and slaughter characteristics were measured.

The percentage of feed refusals increased with an increasing inclusion level of the sludge in the ration; especially with high (> 12%) inclusion levels.

General conclusions

- Flotation sludge is a protein- and fat rich waste product with a large variation in chemical composition.
- The protein digestibility is ± 80% and varies little between the various types of sludge. The fat digestibility is rather low.
- Up to 12% (on a dry matter basis) can be used in pig rations without negative effects on performance and slaughter quality.

References

Have, P.J.W. ten. 1983. De bruikbaarheid van flotatieslib van slachterijen als veevoer (in press).

Smits, B. 1982. De verteerbaarheid van flotatieslib, afkomstig van pluimvee-, varkens- en grootveeslachterijen. Rapport nr. 147, I.V.V.O.

Smits, B., Steg, A., Jongbloed, A.W. en Koorn, T. 1983. Flotatieslib in voederproeven met varkens. Rapport nr. 153, I.V.V.O.

AVAILABILITY OF AGRO-INDUSTRIAL AND ABATTOIR BY-PRODUCTS AND THE POSSIBILITIES OF THEIR UTILISATION IN LIVESTOCK FEEDING IN CAMEROON

Endeley, H.N.L.
National Advanced School of Agriculture, Yaounde, Cameroon

Summary

Cameroon has a large number of agro-industrial complexes which supply products for which they are installed together with a variety of by-products whose re-evaluation could give additional resources in the form of livestock feed ingredients thereby boosting national economy. Presently little or no information exists on their availability and possibilities for usage.

This study was aimed at investigating the availability and level of the by-products of the main agro-industrial and the municipal abattoir of the city of Douala.

Information obtained revealed enormous potential for the production of several by-products. The general lack of awareness in Cameroon of the possible uses of these products for animal feeding can be attributed to such factors as lack of information on their composition and nutritive value, unavailability of adequate handling and processing facilities, variations in composition, the problem of availability in sufficient quantities and season ability of supply and the need for transport and processing.

By-products of the milling and brewery industries can serve as sources of energy, protein and vitamins for ruminants, pigs and poultry. The major products of the sugar processing industry have potential for use in ruminant feeding, while blood and rumen content from abattoirs could serve as ultimate sources of protein in livestock feeding.

Introduction

Even with the tendency towards industrialisation, the Cameroonian economy remains and for long will remain based on agriculture which occupies more than three quarters of the population and produces about 33 percent of the Gross National Product.

This is why Government has created development societies charged with the dynamisation of agricultural and livestock industries and also agriculture based complexes. These complexes produce a variety of products and by-products whose re-evaluation could give additional resources for livestock feeding.

This study was aimed at investigating the availability and level of usage of the by-products of some of these agro-industries and the municipal abattoir of Douala.

Method

Questionaires were established highlighting the potentials of production, actual production and uses to which the different by-products of processing of some agriculture based industries, were being put. This information was supplemented with those from annual reports and also discussions with authorities concerned when the need arose.

In cases were actual figures of by-products were not available, computations were made from theoretical proportions in the process of extraction of the final product.

A total of eleven agriculture based industries and one municipal abattoir were visited.

Results and discussions

By-products of the sugar industry

The total production of the by-products of the sugar industry were 194,600 tonnes of Bagasse, 19,464 tonnes of froth 25,952 tonnes of molasses and about 162,201 tonnes of white fragments. These figures represent only about 50% of the production potentials of the two existing sugar plants.

Globally, the actual level of utilisation of the by-products is low, bagasse is presently only used as a heat source while the froth is just thrown into fields as waste and only 2% of the molasses produced is used for animal feeding.

The basic set backs in the utilisation of molasses lies in the difficulty of transportation. The creation of a cattle fattening ranch next to the plants has recently led to some judicious use of this by-product. There are also projects under study for the utilisation of bagasse in basket making and the utilisation of industrial alcohol.

By-products of the rice industry

While the potential for the production of by-products of the tice industry is high (16,200 tonnes husk, 13,500 tonnes bran, 13,500 tonnes remains of polishing and 14,175 tonnes broken particles), however, the actual production of these products is less than 1% of the potential.
All the bran and polishings actually produced (127.8 tonnes each) are used in livestock feeding while the broken particles serve human and livestock populations.

By-products of palm oil extraction

Of all the by-products produced during the extraction of palm oil only about 2,200 tonnes of palm kernel cake finds its way into the livestock feeding industry. The rest are just thrown as waste .

By-products of Breweries

The fabrication of bevarages particularly bear, gives rise to two main by-products : Spent brewers grains (29,150 tonnes) and barm or yearst (645.20 tonnes).
These by-products which are rich in vitamins and glocosides, could be used validly in animal feeding. While the total quantity of dried spent brewers grains produced (117 tonnes) is completely utilised in animal feeding, the wet spent grains has not found great use. The total amount of yeast produced is also not used.
The greatest obstacle in the use of brewers grains has been the installation of drying facilities which are at the moment too small or non existent.

products of cocoa harvesting

It was estimated that about 4,200 tonnes of cocoa pods are discarded on farms annually. Experiments carried out with this product shows that with treatment, it could serve in animal feeding.

By-products of the municipal Abattoir, Douala

Investigations revealed that the volume of by-products produced in the Douala municipal abattoir is not negligible (1,756.5 tonnes bones, 846 tonnes blood, 109.7 tonnes horns, 14.9 tonnes hooves and dung). But except for the horns which are exported all other products are lost.
The non utilisation of abattoir by-products appear to result mainly from lack of information on their usage and methods of processing.

Conclussions.

Information obtained reveal enormous for the production of several by-products. The general lack of awareness in Cameroon of the possible uses of these products for animal feeding can be attributed to such factors as lack of information on their composition and nutritive value, unavailability of adequate handling and processing facilities, variations in compositions, the problem of availability in sufficient quantities and seasonability of supply and the need for transport and processing.

PROTEIN RECOVERY FROM FOOD PROCESSING WASTEWATERS

A.P. Hopwood

Director, Alwatech UK Limited, 33A Park Parade, Hazlemere, Bucks., England

Introduction

The recovery of protein from waste waters by precipitation with purified lignosulphonates (LS) was first established by Jantzen in the 1960's. Lignosulphonates occur in sulphite lye which is a byproduct of the sulphite cellulose production process, where the lignin in wood is dissolved in water by sulphonation, and thereby separated from the cellulose.

When lignosulphonate is in solution there is, owing to the ionization of the sulphonate groups, a net negative charge on the molecule; with increased acidity this charge is not lost until the pH value is below 1. Owing to the amine groups, protein molecules carry a net positive charge when the pH value is below the isoelectric point (pH3.5 for most proteins). Therefore, at about pH 3 the molecules of protein and lignosulphonate carry opposite ionic charges and precipitation occurs. The acid conditions also tend to break the emulsions holding the fats in solution, and these are released for inclusion in the lignoprotein flocs.

Although the above mechanism is believed to be the primary reaction in protein precipitation, it is probably an incomplete description of the complex bonding which occurs.

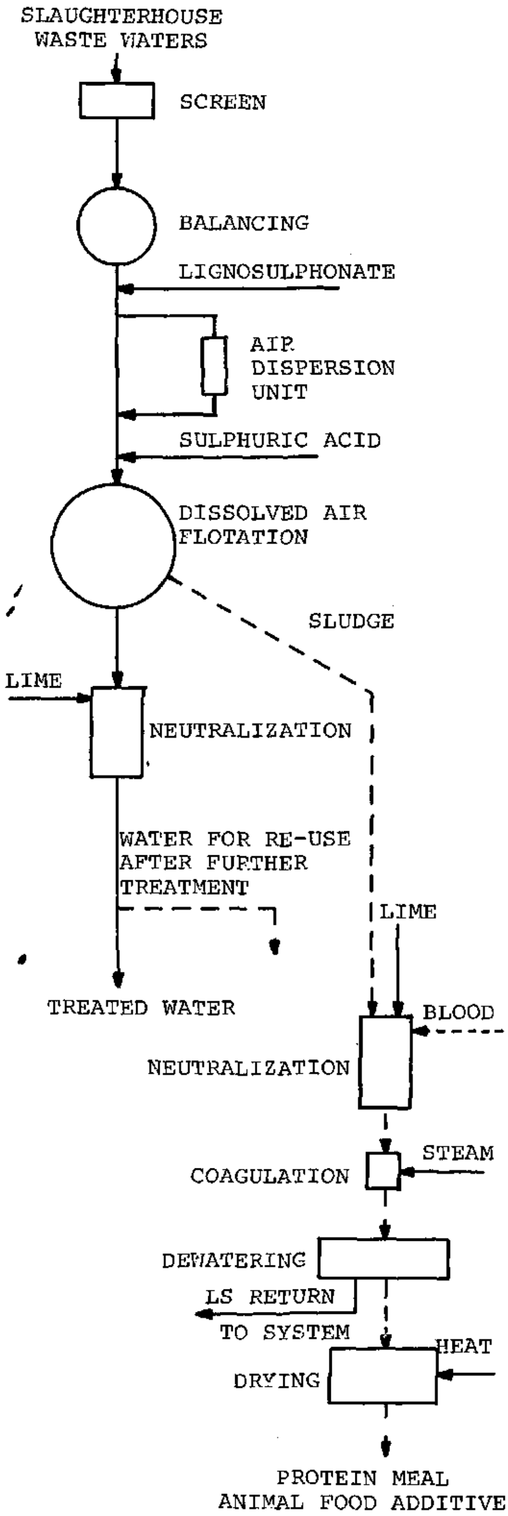
The LS Process

The above reaction has been developed to provide a complete primary wastewater treatment system for food industry effluents, which is shown in the flow diagram. Before treatment by the LS process the wastewater is screened and collected in a balancing tank equivalent to at least one hours average flow. From the balance tank it is pumped to a circular dissolved air flotation tank constructed of glass fibre reinforced plastic. A solution of sodium lignosulphonate is dosed in line to give a concentration in the waste water of 100-1000 mg/l, varying with strength of the wastewater, the ratio of dissolved to suspended protein and the product which is being processed. After the addition of lignosulphonate, 15-25 per cent of the wastewater is separated and pumped by a high-pressure pump via an air injector into a pressure vessel. Air is introduced to the injector at a pressure of 5 bars. In the pressure vessel a partially saturated solution of air in water is formed, which is returned at a controlled rate to the main flow of wastewater at the point of its injection into the flotation tank, whilst at an adjacent point diluted sulphuric acid is added under automatic control to give a pH value of 3. In line into the flotation tank the dissolved proteins are precipitated forming loose flocs, which incorporate fat and other suspended solids. The fine air bubbles, which are formed as the air dispersion water is returned to atmospheric pressure, adhere to and are entrained in the flocs which rise to the top of the flotation tank forming a sludge containing 5-15 per cent total solids. The clarified effluent is withdrawn from the bottom of the flotation tank and neutralized before discharge or further treatment.

After optional admixture with surplus blood, the flotated sludge is neutralized and heat coagulated with live steam at 95°C: the coagulated sludge is dewatered using a filter-belt or a decanter centrifuge. A filter belt will normally dewater to 30-35 per cent solids (TS), while a decanter will achieve better than 50 per cent TS. During the neutralization/coagulation process about 30-50 per cent of the LS in the precipitate is released into the aqueous phase and can be recycled to the inlet of the plant, leading to a reduction in chemical costs. The dewatered blood /sludge can be dried alone or in admixture with other byproducts to produce an animal feed additive which usually contains 40-70 per cent protein and 10-30 per cent fat on a dry weight basis. The recovered material is acceptable as an animal feed ingredient and has a current value of £100-£200/tonne depending upon protein prices.

Safety of LS Precipitated Proteins as Animal Feed Supplements

The economic basis of any recovery process rests upon the saleability of the product, and for edible products the basic criteria is safety. Although lignosulphonates have long been used as a pelletizing agent in animal feedstuffs, and have been approved as an additive by both the EEC and the American authorities, the safety of lignosulphonate recovered protein in animal and poultry rations has been studied in detail. Herstad and Hvidsten found that the substitution of lignoprotein recovered from herring processing wastewater as a replacement for soya bean or herring meal had no effect upon weight gain, or upon the efficiency of food utilization in growing chickens. Nass discovered that during experiments feeding lignosulphonates to pigs a concentration of 3-6 per cent LS in the feed had no effect upon weight gain, although when the concentration was increased to 13 per cent a reduction in weight gain was observed. Further experiments have shown that up to 50 per cent of the soya bean meal in the diet of growing pigs could be replaced with LS precipitated protein without detrimental effect upon weight gain, feed conversion efficiency or slaughter quality.



UTILISATION OF POULTRY OFFAL HYDROLYSATE (POH) AS A FEED FOR LIVESTOCK IN THE TROPICS

D.H. Machin*, D.A. Hector*, G. Swann** and W.H. Parr*

* Tropical Development and Research Institute, London, United Kingdom
** Ministry of Agriculture and Fisheries, Nassau, Bahamas

Summary

When biological proportions of broiler heads, guts, feet and blood are comminuted below 8mm and mixed with 3% formic acid (v/w) a safe, stable, semi-liquid hydrolysate is produced. Typical analyses are (%) dry matter (DM) 27.13, crude protein (CP) 10.81, fat 12.41 and ash 2.40.

In the first experiment groups of 20 unsexed Hubbard broilers were fed a control diet or diets where POH supplied 6% CP in cassava or maize based diets. At 55 days of age the weight gains, food conversion efficiencies and killing out percentages of chickens fed diets with POH were similar to those fed control diets. It was considered that this was possibly due to the high levels of wheat bran used in POH diets causing increased bulk densities.

In the second experiment groups of 10 crossbred pigs, 5 hogs + 5 gilts (34 kg live weight) were fed either a 16% CP control diet or diets where 10 and 20% of the dietary DM was supplied by POH. After 35 days the daily live weight gains were greater in the 20% POH diet than in the other treatments, and the FCE of the pigs improved greatly as the level of POH in the dietary treatment increased. KO %s were similar for all treatments and the P_2 back fat measurements were smallest where the high level of POH was fed.

Carcase analysis and taste panel assessment of broilers and pigs demonstrated no unacceptable effects.

Introduction

In many developing countries it is uneconomic to process poultry packing house waste by rendering due to high capital and fuel costs. Preservation with acid and ensuing autolysis could offer a cheaper alternative (Norman et al., 1979). A similar product made from waste fish (Disney et al., 1978) has been fed to pigs successfully (Smith, 1977; Machin et al., 1982) and a hydrolysate made from poultry offal has been made and fed to pigs at low levels without problems (Francis & Turnbull, 1979). The objectives of this study were to see if the production of poultry offal hydrolysate could be carried out using formic acid in the tropics and to determine the effects of feeding the hydrolysate at high levels on the performance and carcase composition of growing pigs and broiler chickens. In the case of broiler chickens the POH was sun dried onto wheat bran.

Table 1. Analyses of POH (as %).

Dry matter	27.13
Crude protein	10.81
Crude fat	12.41
Ash	2.40
Calcium	0.37
Phosphorus	0.33
Total lysine	0.51
Methionine + cystine	0.51
Salt (NaCl)	0.15
ME (poultry) calculated	6.99 MJ/kg
DE (pigs) calculated	7.54 MJ/kg

Methods

Pig Trial

Groups of 10 Duroc x Hampshire x Large White pigs, 5 hogs and 5 gilts, were fed either a 16% Crude Protein Control diet or diets where 10 and 20% of the dry matter was supplied by POH. The remainder of the diets were formulated from maize, extracted soyabean meal, wheatbran, limestone, dicalcium phosphate and pig fattener premix (Pauls & Whites, Ipswich). The control diet also contained fish meal. It was not possible to formulate diets of uniform densities but the amount fed to each group was adjusted so that all pigs received the same intake of nutrients based on those prepared in the ARCs (1967) scale. The feeds were mixed with water to contain one part dry matter to 2 parts water. After 35 days half the pigs were slaughtered ie 3 hogs and 2 gilts and the carcase analysed and assessed by a taste panel.

Table 2. Results of pig trial

Means	Dietary treatment		
	control	low POH	high POH
In. wt (kg)	31.1	37.1	33.2
Final wt (kg)	55.9	62.3	61.5
DLWG (g)	675	685	771
FCE	2.78	2.55	2.15
FCE (adj to 100% density)	2.78	2.80	2.60
KO %	72.7	71.5	72.7
Carcase wt (kg)	43.7	47.1	49.4
P_2s (mm)	11.88	12.00	11.32
Density as % control	100	107.5	116.7

Broiler Trial

Groups of 20 unsexed Hubbard broilers were fed a control diet or diets where POH supplied 6% Crude Protein in cassava or maize based diets. These were formulated to PRC (1974) broiler starter and finisher standards and fed for the first 19 and the last 29 days of the trial respectively. The remainder of the diets were formulated using similar materials as the pig trial. The broilers were slaughtered at 55 days of age and their carcases analysed and assessed by a taste panel.

Table 3. Results of broiler trial.

Means	Dietary treatment		
	control	POH maize	POH cassava
In. wt (g)	146.2	146.0	146.1
Final wt (g)	1907.2	1806.2	1826.2
Wt Gn (g)	1761.0	1660.6	1680.1
FCE	2.16	2.32	2.23
KO %	63.4	61.9	61.7
Carcase wt (g)	1209.1	1118.1	1125.9
Liver wt (g)	31.4	28.1	31.1

Conclusion

The results of these preliminary trials showed that when fed poultry offal hydrolysate the performance of broilers was as good as, and that of pigs better than, locally produced livestock. No deleterious effects of feeding POH on carcase quality were identified by carcase analysis or taste panel assessment. However, it is considered that the greatest economic returns from feeding poultry offal hydrolysate will result when it is used as a pig feed, since the drying stage at present required for poultry feeding, is not essential. On the basis of these encouraging results, it is considered that further work is justified.

References

ARC, 1967. The nutrient requirements of farm livestock. No.3. Pig Technical Review & Summaries. Agricultural Research Council, London.

Disney, J.G., W.H. Parr & D.J. Morgan, 1978. Fish silage preparation, utilisation and prospects for development. Proc. Indo. Pacific Fishery Comm/FAO Symp. on fish utilisation. Technol. and Marketing. Manila, Philippines.

Francis, G.H. & A.T. Turnbull, 1979. The use of formic acid treated blood and broiler processing waste in the diet of finishing pigs. State Vet. J. 34:210-215.

Machin, D.H., R.H. Young & K. Green, 1982. The formic acid preserved fish silage made from shrimp by-catch in the diets of fattening pigs. Trop. An. Prod. 7:120-216.

Norman, G.A., D. Silverside, D.A. Hector & Sarah Francis, 1979. The acid treatment of animal by-products. Trop. Sci. 21: 221-229.

PRC, 1974. Poultry Nutrition by W Bolton & R Blair. Bull. 174. Ministry of Agriculture & Fisheries & Food, HMSO, London.

Smith, P. 1977. An evaluation of liquid fish as a protein source for fattening pigs. Exptl. Husb., 32:34-41.

THE PRODUCTION OF EDIBLE FIBRES FROM RECYCLED WASTE ANIMAL PROTEIN.

PAUL B. NEWMAN

Meat Research Institute, Langford, Near Bristol, England, BS18 7DY

Summary

A combined mechanical - enzymic process has been devised for the controlled breakdown, at low cost in a single unspecialised vessel, of waste and scrap meat into their major components of fat, connective tissue and a muscle protein concentrate suitable for human consumption. Mechanically recovered meat was most easily separated.

A processing system was also developed for converting the recovered protein concentrate into edible fibres incorporating varying proportions of vegetable proteins. The apparatus is described and the advantages over conventional extrusion techniques are discussed.

The properties of the extracted protein slurry, the combined suspension of proteins (the dope) and the extruded material are presented. The final content of animal and vegetable protein, fat and other constituents can be formulated according to the functional properties required in a wide range of meat products. The process is very effective in controlling contamination by micro-organisms. The fibres were bland, and flavours could be added, as required, to the other dope constituents.
Keywords: recycling, waste, edible, protein processing, food.

Introduction

As sources of protein for human food have become more expensive and less plentiful the major protein-consuming countries are investigating ways of using existing protein foods more efficiently and searching for new sources of both animal and vegetable protein. Meat is an expensive source of protein and therefore must be used to its full potential. With continuing improvement in technology, new food materials, such as blood plasma protein, bone protein and mechanically recovered meat from sources previously classified as waste, are now available to the processor in a form which can be incorporated into products for human consumption.

The recovery of meat protein from abattoir by-products is not new. Solublisation of muscle proteins for analytical purposes is well documented (Keller and Black, 1960). However, for reasons such as high cost or protein denaturation, these processes have not been commercially developed. The increased availability of alternative food ingredients has led to the development of new production processes. Two main techniques are used in the food industry for producing retextured protein. Extrusion processes force 'dope' through dies under high temperature and pressure. Although rapid and relatively inexpensive, the high temperature and pressure tend to destroy the native properties of the protein and this usually restricts its use to products such as pie fillings and patties.

The 'spun-fibre' method is more costly and less rapid, but it produces protein in a more usable form. The protein, dissolved in alkaline solution, is passed through minute orifices into a bath of acid, where it precipitates as long continuous slender filaments, often possessing considerable strength. The physical properties of this type of product are generally superior to that produced by the extrusion process (Braun, 1975).

In the preparation of any textured protein product, the dope must contain a number of basic constituents; a protein source as the main food ingredient, an extender to substitute wherever possible for any high cost protein and a binder to hold the individual ingredients together. Animal proteins, in the form of by-product raw materials such as blood serum proteins (Swingler and Lawrie, 1977), bone protein (Jobling, 1978), connective tissue protein (Henning, 1974), stomach and lung proteins (Lawrie, 1975), casein (Ansen and Packer, 1957) and mechanically recovered meat (Newman, 1980) or scrap chicken and fish meat (Obata, Yamato and Yaniguichi, 1976) are all being investigated as potential sources of protein.

Binders, used singly or in combination, are usually heat coaguable proteins, such as albumin, (Hayes et al, 1975), casein (Hoer, 1974), or gelatin (Yang and Olsen, 1974). Alternatively, fat (Howard, 1976), polysaccharide (Schmitt, 1974), or gums (Corliss and Furgal, 1975) may be used. The action of heat on the major protein ingredient in the dope may also cause it to function as a binder (Nakayama and Sato, 1971a, 1971b). Consequently, air-dried blood serum proteins have been used both as a high quality protein extender and binder. The selection of the extender will depend on the functional characteristics required in the formulated product, the total cost of the other ingredients and the intended market.

The system described has the rapidity of the extrusion method but operates at much lower temperatures and pressures. It also provides limited control over the final water content. Using simple techniques in low energy- consuming processes it produces a protein product which can be used as a basic nutrional ingredient in novel processed foods.

Materials and methods

Pork and beef, mechanically recovered by a Protecon deboner, was obtained from Scot-Bowyers Ltd., Trowbridge, Wilts. Brisket, flank and neck from old dairy cows and cured bacon and ham scrap were obtained as required. Except for pepsin (1:10,000 ex hog mucosa), all other chemicals were of laboratory grade. All meat was stored frozen at -20C until required.

The following protein sources were obtained: Soya Protein in a variety of grit sizes and powder form (T.M. Lucas Ltd.) Dursley, Gloucs); Soya Bean Meal, casein and lima bean meal (B.D.H. Ltd., Poole, Dorset.); Serum protein and haemoglobin in spray-dried form (Regal Foods Ltd., Craigavon, Northern Ireland.); Potato protein (in two forms) (Tunnel-Avebe Starches Ltd., Rainham, Kent.); Gelatin (300 bloom) (Sigma Ltd., London.). Lucerne protein was kindly donated by Prof. R. Lawrie, Nottingham University and grass protein was given by Mr R. Porter, Reading University. Flavourings used were from a range produced for processed foods by Haarman and Raimer Ltd., Marlow, Bucks. Caramel colouring was obtained from Heinz Foods Ltd.

Meat processing

The apparatus consisted of a thick-walled glass vessel, 50cm high, 20cm in diameter, around which coils of polythene tubing were wrapped to circulate either hot water at 50C or cold water at 10C. The processing stages are summarised in Figure 1.

Waste or scrap meat was comminuted in a cooled bowl chopper with two volumes of ice-cold 0.9% saline solution. The thick suspension was then pumped into the glass processing tank. Where mechanically recovered meat was used it was added directly to the saline solution in the vessel. The meat suspensions were continuously agitated by compressed air entering the base of the vessel through a perforated plate and by a rotating stainless steel paddle with multiple blades. At intervals during stirring the paddle was raised so that entrapped connective tissue could be removed and resuspended in fresh saline for further processing. This procedure was repeated several times.

The pH of the suspension was then lowered from approximately 6.0 to 3.0 with 6N hydrochloric acid and 5 g Pepsin per kg of meat (original wet weight), dissolved in a

PROCESSING FLOW DIAGRAM

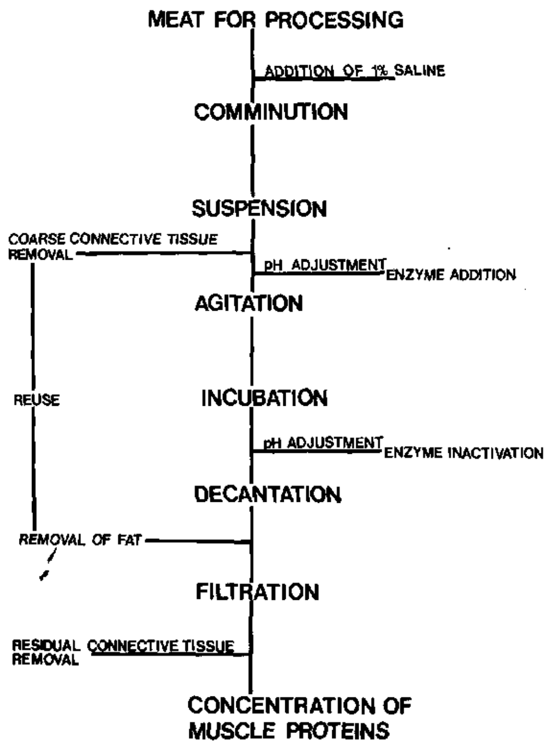


FIGURE 1

small amount of 0.01N HCl was added. Agitation was maintained by aeration and the suspension incubated overnight (18 hours) at 20C. At the end of this period, the pH of the suspension was readjusted to pH7.0 with 6N sodium hydroxide to inactivate the enzyme.

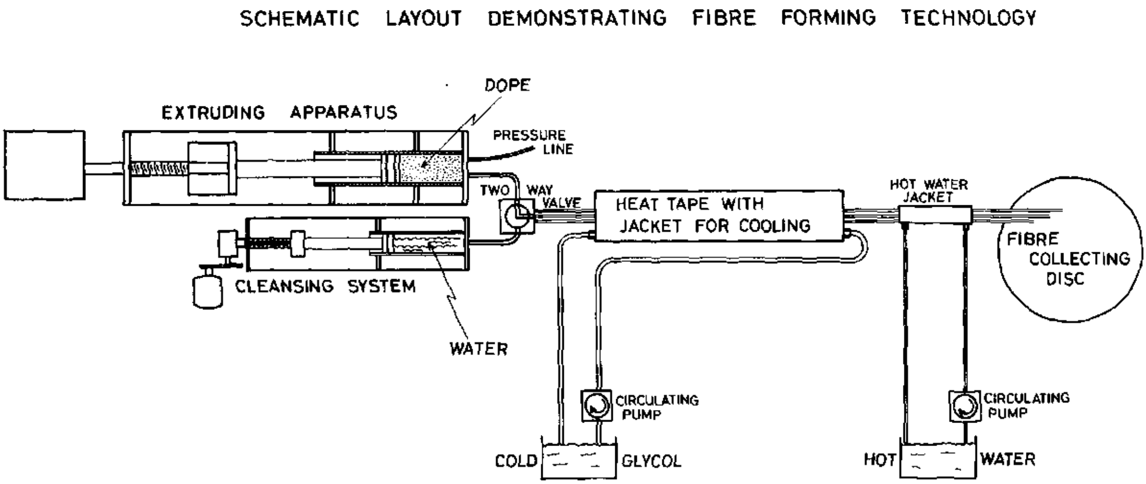
With the agitation stopped, the temperature of the meat suspension was raised to 40-45C, causing the fat to rise to the surface. The temperature was then lowered to 10-12C and the solid fat layer was now easily separable from the muscle protein suspension. The meat suspension was then pumped through a domestic high-speed juice extractor (Kenwood model number 791) and the last vestiges of fat and connective tissue were retained on the plastic filter (size 50 mesh). The protein slurry was concentrated by slow speed continuous or batch centrifugation.

Dope preparation and extrusion:

The 'dry' ingredients (Table 1) were mixed and added to the concentrated meat suspension, remixed and allowed to stand for 30 minutes. The dope was extremely viscous at this stage with a temperature of approx. 20C. (Figure 2).

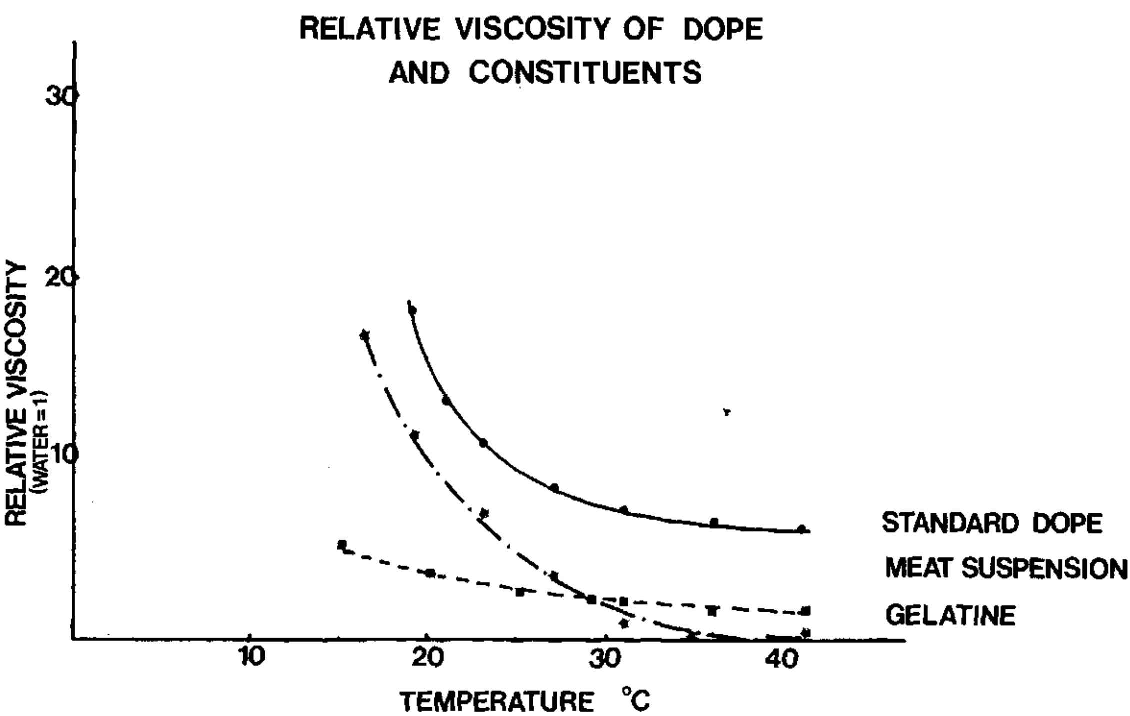
When heated above 55C, the proteins in the dope began to coagulate and flow characteristics were again lost. However,

FIGURE 2



Fibre forming tubes continuously monitored for temperature and pressure

FIGURE 3



between 40-45C, viscosity decreased and the dope flowed easily. The dope was therefore prewarmed to 40C before loading into the extruder through a pre-filter to remove any remaining large particulate matter.

A schematic diagram describing the extrusion method is shown in Figure 3. The design of the extruder was based on conventional pasta-making machinery. A power drive was coupled to a threaded bar the rotation of which caused the forward movement of the plunger into a barrel and displaced its contents at an even rate. The distal end of the barrel had two outlets, one connected to a diaphragm pressure gauge to indicate working pressure and the other to pass the 'dope' into the heating chamber. This consisted of narrow bore (1.4mm) stainless steel tubes 1 m in length, surrounded by a large glycol-filled electrically heated, insulated jacket. Temperature was monitored by thermocouples at the entrance, mid and exit points of the chamber. Usual operating conditions were 130C jacket temperature and 11.25 Kg/cm^2 pressure. Lower temperatures than this resulted in incomplete fibre formation, higher temperatures caused excessive denaturation and water loss in the heating chamber, blocking of tubes and a substantial increase in pressure.

After leaving this chamber, the hot fibres passed through another shorter jacketted chamber whose temperature was accurately controlled. This, as described later, regulated the final water content of the material which was collected on a rotating platform, and cooled.

The complexity of operation necessitated the incorporation of a variable speed drive, temperature control (to accommodate the production of different fibre types), automatic washing and sequencing into the system design. After extrusion, the fibres were treated in a number of different ways depending on the final product formulation. Generally, after collection, weighed portions were compressed in a mould under a known pressure. The resulting slight exudation from the material improved fibre-fibre binding. The temperature was then dropped to 10C and the pressure released. Alternatively the moulded material was broken into chunks of approx. 2cm^3.

Histology

Sections of fibres were prepared in two ways. For fat determinations, frozen sections were taken from samples in blocks of isoPentane chilled in liquid Nitrogen and stained with Oil Red O according to the method of Disbrey and Rack (1970).

Animal and vegetable components were identified by fixing sections (5mu in thickness) in Formal-saline, dehydrating in graded alcohols, clearing in xylene and impregnating with paraffin wax before sectioning and staining with Hematoxylin and Eosin or Reticulin.

Microbiology

The constituents of the dope, the dope itself and the extruded fibre were monitored for bacterial and yeast contamination. In addition, the dope was innoculated with common food bacteria, in both vegetative andspore forms to test the effectiveness of the heating stage in controlling bacterial numbers.

The organisms used were vegetative cells of Escherischia coli, strain AB 10 2 21, isolated from pig and resistant to streptomycin, penicillin, tetracycline and sulphonamide. Spores were obtained from Bacillus cereus, strain t, viable vegetative cells having been destroyed by prior heating. For the artificial inoculations, 1ml of known spore cell suspension was added to the dope and thoroughly mixed. The dope was extruded in the normal manner and samples taken before and after extrusion. Samples were plated out on Plate Count Agar, incubated at 37C for 24-48 hours and counted. Incorporation of streptomycin into some of the plates to prevent growth of all organisms except the Streptomycin resistant E. coli, enabled counts of vegetative cells to be made.

Biochemical analyses

Amino acid analysis of the extruded material was carried put on an acid hydrolysate of the fibre, rotary evaporated and dissolved in 0.001N HCl. The analyser used was a Joel, model 581, using a dual column system based on the method of Moore and Stein (1964).

Total protein was estimated using the method of Lowry (1951) as modified for the Technicon AutoAnalyser. Calorific values were determined by bomb calorimetry. Fat and dry matter content of the extruded material were assessed using methods published as standards by the Society for Analytical Chemists (1973) Nitrogen was determined by micro-Kjeldahl technique.

Calcium, copper, magnesium and zinc were determined by atomic absorption with iron, potassium and sodium estimated by flame emission. In both cases samples were prepared as described in Methods for Analysis (Society for Analytical Chemistry, 1973) and estimated on a IL 251 (Instrumentation Laboratories Inc.) double beam AA/AE spectrophotometer. Chloride was determined using the AOAC method (1975 - Volhard method). Phosphorus was estimated using the standard method of the S.O.C. (1973).

The relative viscosity of the dope was measured using a length of clear narrow bore glass tubing mounted vertically and surrounded by a water jacket. Pre-heated solutions were drawn into the tube and allowed to equilibrate for 15 seconds. The time taken for the solution to pass between two points on the tube was recorded and expressed in arbitrary units relative to the outflow time of water over the same distance.

Results and discussion

a) Processing of scrap meat

With a 2:1 dilution, the meat slurry was easily pumped from the bowlchopper to the processing vessel after comminution. Mechanical removal of connective tissue proved extremely effective, 5-7 x 10 minute stirring periods removing the bulk of the material (Table 1). As the pH was lowered to 4,5-5.0, the mix became thick and gelatinous due to considerable swelling of residual connective tissue; below this pH the mix became less viscous. Lowering of the pH acts as an effective bacteriostat during the incubation period. Secondly, if enzymic degradation is to be used, lowering the pH swells the connective tissue and makes it more susceptible to the enzymic degradation. Finally, if the enzyme used is pepsin, the lower pH produces conditions closer to the enzyme's optimal activity. After digestion and agitation, the slurry was much less viscous. Air agitation was the most effective means of mixing the slurry during this stage. Increasing the temperature of the mix to 40C with hot water without agitation (approx.20-25 minutes), caused the fat to rise to the surface and form a solid layer on cooling (Table 2).

The concentration of muscle protein in suspension after processing was between 6.0-7.2% w/v dependant on the source of the meat. A two-fold concentration to 14%w/v was required for direct incorporation into the extrusion process. If lower levels were used, fibres were softer and wetter. A number of different concentration techniques were initially tried - partial freeze drying, air drying, freeze concentration and freeze thawing. The last two produced excessive losses of solid material; the others were unlikely to be economic. Low speed centrifugation was the most suitable concentration process as most of the protein was insoluble. Furthermore, the amount of total salt was reduced whilst limiting losses of α-watersoluble protein to 1-2% of the total protein, thus improving the efficiency of the process without causing excessive salt concentrations in the resultant fibres.

A number of interesting observations were made during the development of the processing technique. Mechanically recovered meat, particularly that produced by the hydraulic Protecon system, had low connective tissue content and required no enzymic treatment. Cured meats contained connective tissue that was stringier than uncured meats but it was easily removed by mechanical means. The viscosity of cured meats was little affected by a fall in pH; fat removal was also easier. The connective tissue and fat removed from these different mixes are very clean and ideal starting material for further processing. The origin of the meat, whether scrap or MRM, made little difference to the processing or final product. However, mechanically recovered meat proved especially suitable since it required no comminution. Cured meats, such as ham and bacon scrap, also processed well, but their high salt content limits their inclusion in some formulations. While the pH of comminuted

Table 1. Formulation for production of protein fibres.

Constituent	% of Total	% of Total protein
Gelatin	1.33	4.09
Potato protein	0.74	2.27
Recovered meat protein	12.45	38.24
Serum proteins	10.65	32.70
Soya protein	7.39	22.70
Flavouring	0.89	-
Water	66.55	-

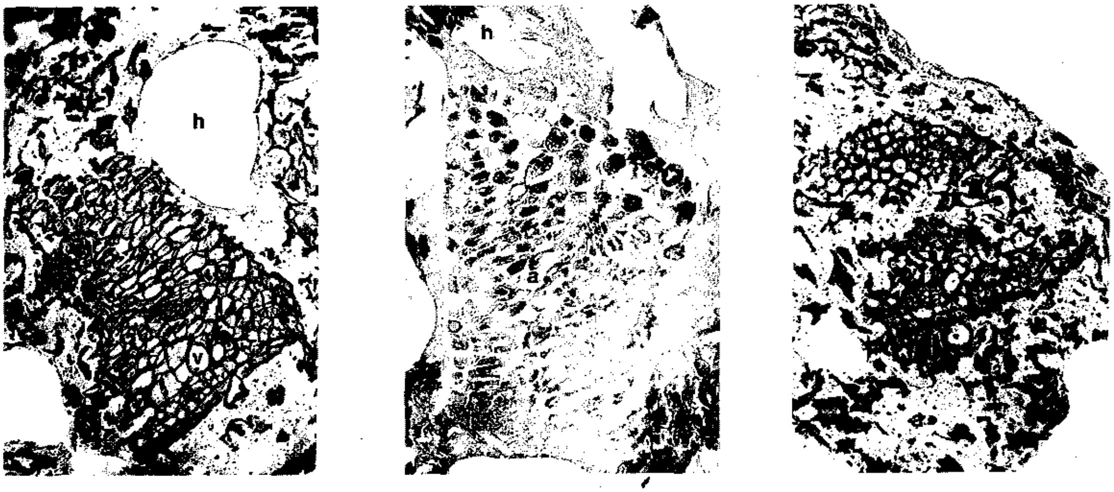
Table 2. Change in connective tissue content after mechanical/enzymic processing.

Meat Source	% Collagen Control	Mechanical /enzymic	Enzyme only
Mechanically recovered pork/beef	1.22	0.25	0.40
Cured meat scrap	19.44	0.19	-
Brisket/ shin/neck	7.05	0.68	-

Collagen content was measured indirectly using the hydroxyproline assay of Woessner (1961), modified by Grant (1964) for the Technicon AutoAnalyser.

PLATE 1

MICROSCOPICAL DETAIL OF EXTRUDED FIBRE



A — Animal Protein   H — Steam Vacuoles   V — Vegetable Protein

Table 3. Changes in fat content after mechanical/enzymic processing.

Meat source	% Fat Control	Mechanical /enzymic	Enzyme only
Mechanically recovered pork/beef	25.46	1.64	1.05
Cured meat scrap	26.11	0.26	-
Brisket/ shin/neck	26.20	0.92	-

Fat values were obtained by continuous Soxhlet extraction with petroleum ether for 12 hours, rotary evaporation and drying according to therecommended method of the S.O.C. (1973).

meats at 6.1-6.5 was as expected, the initial scrap meat at 5.5 - 5.8 and that of cured pH of mechanically deboned meat was high at pH 6.2-6.5, due to cellular disruption, removal of connective tissue and an increase in bone marrow content.

b) Extrusion

The original concept to produce fibres continuously using a self-priming slurry pump, forcing the dope through steadily decreasing diameter tubing and immersing the final length of stainless steel tubing in a bath of hot oil, producing a fibre by heat coagulation, failed because the necessary working pressures could not be produced and maintained. Furthermore, it was not flexible enough to compensate for small changes in flow rate from variations in dope formulations. A forced flow system was therefore adopted, incorporating flexibility in both flow rate and temperature, details of which are shown schematically in Figure 1.

Pressure was monitored at the dope input stage, but the pressure inside the heated tubes was probably considerably greater as a result of protein coagulation and steam formation. At the usual operating conditions of 130C and 11.25 kg/cm^2 pressure, steam was generated, around and within the fibres as small bubbles (Plate 1).

Direct heating was not practicable because of the narrow diameter of the tubes. However, temperature was easily maintained by indirect heating (hot glycol) and losses were reduced by insulating the heating jacket, (see Fig. 2). The short auxillary water jacket (J2, Figure 2), through which water at controlled temperatures was circulated, was used to control the rate of fibre cooling and its exit temperature. With water circulating at 55C, the fibres emerged at approximately 70C; (water at 50C produced fibres at 67C). This cooling process served a number of purposes. It condensed much of the steam formed during the heating stage, eliminating a pressure difference between the internal and external environment, thus preventing the disintegration of the fibres as they left the tubes. The tackiness of the moist fibres, provided good fibre-fibre adhesion which was further improved by pressing them in moulds whilst still warm. This resulted in a small quantity of the liquid within each fibre being exuded under pressure (approx. 15-20 cm Kg), coating all the fibres within the mould. Thus by regulating the cooling process, the wetness and cohesiveness of the fibres could be controlled.

Pre-heating the dope to 40-45C resulted in a considerable decrease in viscosity and allowed simple and rapid filtering of the dope, which, at this temperature had the consistency of thick cream. The pre-heating allowed the heated section to be reduced in length as less heat was required to produce the fibres. Figure 3 shows the effect of temperature on the viscosity of the standard mix, gelatin and the meat suspension. Under static conditions the dope coagulates above 55C. While the dope was in motion this presented no problems, but, if flow ceased at high temperatures, the dope became hard and 'set' in the tubes.

Table 4. Changes in bacterial numbers after fibre formation and storage

(Total Viable counts/ml) Material	Before heating	After heating
Meat solution after processing	3.24×10^3	5.09×10^2
Dried serum proteins	2.04×10^3	3.69×10^2
Soya protein concentrate	1.36×10^3	2.98×10^2
Potato protein grit (60 mesh)	1.46×10^3	2.06×10^2
Standard dope mix	1.17×10^4	1.64×10^3
Standard dope + B.cereus	1.18×10^7	2.86×10^3
Standard dope + E.coli	7.18×10^6	1.65×10^3
Standard fibre after pressing	-	1.91×10^3
Standard fibre 1 month at -20C	-	1.48×10^3
Inoc. fibre (B.cereus) 1 month at -20C	-	2.37×10^3
Inoc fibre (E.coli) 1 month at -20C	-	1.48×10^3

Production problems:

During the course of heating, a thin layer of coagulated protein formed on the inner walls of the tubes, progressively increasing in thickness until it blocked the tubes. Although this occurred with all formulations, in early formulations the principle cause was haemoglobin. The introduction of small amounts of insoluble proteins into the dope, in the form of grits of 60-100 mesh, comprising about 1% of the mix, produced a continuous scouring action and eliminated blockage. Initially soya protein grits were used, but latterly, potato protein grit was more effective. Although warm water (45C) was used to flush out the tubes between runs, the system required a daily clean with warm 0.1N sodium hydroxide containing 1% 'DECON 90' to remove any remaining deposits. When 100% animal protein was used to produce fibres, they were soft and lacked cohesion, although several different formulations were tried. It was also impossible, even with control of piston drive, to accommodate the excessive fluctuations in the flow rate, caused by the accumulation and release of steam both within the heating jacket and on exit from it. Under these conditions the temperature could not be effectively controlled. For this reason, mixtures of vegetable and animal protein have been investigated, including a number of novel protein sources. Lucerne and grass proteins, although they had a high capacity to absorb water and swell, were rejected because they were pale green in colour, and possessed a bitter taste, both difficult to mask. Lima bean protein, behaved like soya protein but was much more expensive; cereal proteins were difficult to obtain. The addition of small

Table 5. Amino acid analysis - extruded fibre compared with beef

Amino Acids	g/100g protein Beef	Fibre
Essential		
iso-Leucine	5.0	3.1
Leucine	7.7	8.7
Lysine	8.8	7.1
Methionine	2.6	1.6
Phenylalanine	4.5	4.6
Threonine	4.3	4.8
Tryptophan	1.3	N/A
Valine	5.1	5.5
Histidine (essential only in infants)	3.7	3.4
Non-essential		
Alanine	6.2	5.8
Arginine	6.7	6.2
Aspartic Acid	9.3	7.6
Cysteine	1.3	2.3
Glutamic acid	16.6	18.8
Glycine	5.6	5.8
Proline	5.1	5.3
Serine	4.5	5.7
Tyrosine	3.8	3.7

Source of beef data : Food Standards Committee Report on Novel Protein Foods (1974) percentage of soya protein resulted in firmer, less soft fibres; potato protein, because of its hardness, also continually scoured the internal surfaces of the system, as well as introducing a nutritionally desirable level of dietary fibre to the material.

Of the animal proteins evaluated, casein was discarded because of its tendency to form very soft fibres, and hemoglobin because of its tendency to block the tubes. For optimum

Table 6. Levels of inorganic constituents compared with beef

Constituent	mg/100g dry matter Beef	Fibre
Calcium	18	44
Chloride	150	1255
Copper	0.4	0.7
Iron	7	15
Magnesium	60	181
Phosphorus	630	449
Potassium	990	381
Sodium	150	1220
Zinc	14	16

Source of beef data: Foods Standards Committee Report on Novel Protein Foods (1974)

Table 7. Comparison of general composition of raw beef with extruded fibre

Constituent	Raw steak /low fat	Extruded fibre
Carbohydrate (% dry matter)	-	1.1
Fat (")	20.5	0.6
Total protein (")	56.7	90.36
Calorific value (Kcals/s)	1.77	1.57
Water content (% wet weight)	74.2	27.60

Results expressed as grams per 100 grams dry matter. Water expressed as grams per 100 grams fresh wet weight. Calorific values expressed as Kcls per gram.
Source of beef data : Food Standard Committee Report on Novel Protein Foods (1974).

use of animal protein sources, blood serum proteins and recovered meat protein were maintained at the highest levels and the other ingredients were proportionally modified to produce the most nutritive fibre with the minimum of production problems. Fibres produced from the formulation shown in Table 3 had a pleasant cooked-beef colour; without the addition of flavour compounds they were very bland, making them highly suitable for incorporation into products.

The process was effective in reducing bacterial numbers. Despite the fact that the fibre was in the heated tubes for only 10 seconds, the internal micro-environment substantially reduced total bacterial numbers Table 4 shows that each of the major ingredients possessed its own bacterial flora, some of which were not removed by the heating stage. However, the resultant numbers were low and quite acceptable in a processed product with both vegetative cells and spore counts reduced; a further fall in numbers occurred with frozen storage.

Tables 5-7 demonstrate the nutritional value of the extruded fibre. The very low fat content indicates the effectiveness of fat separation during the processing stages. This together with low carbohydrate and calorific values, and very high protein content with all the essential amino acids, suggests that this type of material could be used in supplementing or replacing milk casein given to people with protein deficient diets, especially in the developing countries, not only for its nutritional qualities but because it is capable of >90% rehydration after drying.

Histologically, (Plate 1), the presence of discrete animal and vegetable components within the fibre demonstrated that the processes did not destroy all structural integrity although much of the animal protein was essentially without structure although occasional muscle cell fragments could be seen. Vegetable cellular material, particularly parenchymatous storage cells which appeared more resistant to disruption during processing, was also visible. The presence of air holes was to be expected, having been caused by the formation and release of steam during the heating stage of the extrusion process. Consequently, the diameter of the fibre expanded slightly after leaving the tubes; slight pitting of the fibre outer surface also resulted; there was no visible fat. It was also noticed that the air holes were smaller in area but more numerous the drier the fibre.

This work was carried out at laboratory level, but it clearly demonstrates that this novel approach to both the recovery and restructuring of waste protein materials is sufficiently flexible to make use of many types of raw materials, which in their own right are unsuitable for human consumption. Production effectiveness was achieved by designing two processes requiring little energy input and using relatively unspecialised equipment working in low temperature and pressure environments. This in itself should substantially reduce its capital cost whilst the processing costs are minimised by utilising readily available inexpensive waste as its source material. As world demand for good quality protein increase and the cost of conventional animal protein rises, novel processes such as these will undoubtedly become more economically attractive.

References

Anson, M.L. & M. Pader, U.S. Patent 2, 813 794.

AOAC (1973) Official Method of Analysis, 12th Ed. Assoc. of Off. Agr. Chem., Washington D.C.

Brian, R., 1976. J. Am. Oil Chem. Soc. 53:325-326.

Corliss, G.A. & H.P. Furgal, 1973. U.S. Patent 3930 033.

Disbroy & Rack (1970), Histological Laboratory Methods Livingstone, London, 161.

Hayes, J.T. et al[11,14] 1973. U.S. Patent 3 840 677.

Henning, W., 1974, FeinKost Wirtschaft, 11(2): 42-44.

Hoer, R.A., 1974 U.S. Patent 3 928 641.

Howard, N.B., 1976; U.S. Patent 3,935 319.

Jobling, A. 1978; Edible Fractions of Bone and their use in Food Projects in 'Recovering Meat from Bones', MLC, Bletchly, U.K. 41-47.

Keller, S. & R.J. Block, 1960. Separation of Proteins in 'Analytical Methods of Protein Chemistry', Pergamon Press, London, 1-30.

Lawrie, R.A. & R.H. Young, 1975, J. Food Tech. 10(4):453-464.

Lowry, O.H. et al. (1951); J.Biol.Chem. 193: 265-275.

Nakayama, T. & Y. Sato, 1971(a) J.Text. Studies 1 309-320.

Nakayama, T. & Y. Sato, 1971(b) Agr. Biol.Chem. 35(2):208-218.

Newman, P.B. 1980. Meat Sci. 5:171-200.

Obata, S.; Y. Yamato & H. Taniguichi, 1976. U.S. Patent 3 982 004.

Schmitt, E.E., 1974. U.S. Patent 3 792 175.

Swingler, G.R. & R.A. Lawrie, 1977. Meat Sci. 1(3):161-167.

Yang, Sie Olsen, R.A., 1974. U.S. Patent 3814 823.

EFFORTS TO IMPROVE THE USE OF FRYING FATS IN POULTRY DIETS

P.J.G.Oostenbach* , E.H.Ketelaars*, W.M.M.A. Janssen and C.W. Scheele

Spelderholt Centre for Poultry Research and Extension
7361 DA Beekbergen, The Netherlands
* Agricultural University, P.O. Box 338
6700 AH Wageningen, The Netherlands

Introduction

The increasing use of fried products in human nutrition leads to an increasing application of used frying fats and oils in poultry diets. During frying at high temperatures the composition of the fats changes.

Besides volatile oxidised compounds with a smell and taste of rancidity, dimers, trimers and higher polymers of glycerides are formed. Billek and Rost(1974) found in experiments with rats, that the greatest part of polymers of glycerides was not digested. It is not known to what extent frying fats mixed in poultry diets disturb the digestion process.

The objective of the research was firstly to compare used frying fats of different origin with soy bean oil, in digestion studies with chickens. Secondly the effect was tested of different emulsifiers, added to the frying fats, on AME values of the added fat and on digestibility of fat and protein in the complete diets.

Materials and methods

A basal diet was mixed up with respectively

1 10% used frying oil, containing 20% polymers (= FF1)
2 10% used frying fat, containing 10% polymers (= FF2)
3 10% pure soy bean oil

FF1 is orginated from soy bean oil, used for meat frying.

FF2 is orginated from hydrogenated soy bean oil, used for frying meat and patatoes.

Both kinds of fat were heated during a period of approximately 50 hours at a temperature of 160-180° C.

Polymerised glycerides in the fats were determined according gelpermeation-chromatography (GPC). 0,5 ml of a solution of the oil or fat in methylethyl keton(MEK) was injected on a column with Biobeads SX_2 (35 x 2,5 cm).

Elution with a flow of 200 ml MEK/hour and detection with a differential refractive indexdetector followed.

To a part of the diets, containing frying fats, 5% of two different emulsifiers were added. Emulsifier A is a product used in veal calf milk replacers. Emulsifier B is a natural product without known applications.

Basal diet, diets with added fats and with added fats plus emulsifiers were fed to ten, three weeks old, male chickens per group. Each treatment consisted of three groups.

Total excreta were collected during three days.

Standard AME of the added fat and digestibility values of nutrients were determined.

The determined data were submitted to analysis of variance.

Results

In table 1 the values for AME of added fat and digestibility of fat and protein for soy bean oil and both frying fats are shown.

Table 1. Determined values for AME of added fat and digestibility of fat and protein.

Added dietary fats	determined values AME(MJ/kg)	digestibility of fat(%)	digestibility of protein(%)
FF1	32.2	77.6**	85.4
FF2	20.8	59.6**	85.4
soy bean oil	32.3	81.0	87.2

**Significantly ($P \leqslant 0.01$) different from values obtained for soy bean oil.

The results revealed a marked difference in feeding value of both frying fats. Although FF1 had the highest contents of polymers the feeding value was only slightly lower than obtained with pure soy bean oil. The digestibility of FF1 is just 3% lower than the value got for soy bean oil.

A very distinct reduction in AME of added fat and digestibility is found for FF2.

In this experiment polymeric glycerides combined with saturated fatty acids have a much more negative effect on the feeding value of the added fat than even higher polymer contents combined with a high content of unsaturated fatty acids.

The reason could be that different kinds of polymeric glycerides are formed dependent on the fatty acid composition of the fat.

A clear distinction can be made between so called non polar polymeric tri glycerides and the polar or oxy-polymers.

The non polar dimers/polymers are formed by thermal treatment without a reaction with oxygen.

If polar or oxy polymers are formed oxygen is incorporated in the polymerised molecules.

It is not yet known how different kinds of fatty acids in fats effect the formation of different kinds of polymeric tri glycerides.

Also more research has to be done to determine the effect of rancidity of the used fats on taste and smell of slaughterted broilers.

In table 2 the effect of adding emulsifiers to frying fats on digestibilities of fat and protein in the complete diets is shown. The results are compared with digestibilities got from diets with added pure soy bean oil.

Table 2. Digestibilities of fat and protein from diets without and with emulsifiers A and B.

Diets with	digestibility of fat (%)	digestibility of protein (%)
FF1	77.6**	85.4**
FF1 + A	79.4	85.2**
FF1 + B	75.3**	84.7**
soy bean oil	80.9	87.2
FF2	59.6**	85.4**
FF2 + A	59.2**	86.3*
FF2 + B	55.1**	83.9**

**Significantly ($P \leqslant 0.01$) different from the diet with soy bean oil

* Significantly ($P \leqslant 0.05$) different from the diet with soy bean oil

It is shown that adding emulsifier A to FF1 resulted in a digestibility of fat not significantly different from that of soy bean oil. FF1 without added emulsifier exhibited a reduced digestibility of fat compared to soy bean oil.

In diets with FF2 emulsifier A had no effect on fat digestibility but had a slight beneficial effect on protein digestibility.

No positive effect of emulsifier B on digestibility of fat and protein in diets with frying fats could be attained.

On the contrary this emulsifier seemed to have an extra reducing effect on digestibility of nutrients in diets with frying fats.

This may be due to interactions between polymers and this special emulsifier.

Conclusions

1. The content of polymeric glycerides of frying fat cannot be used as a reliable parameter.
2. Important interactions between origin of frying fat in relation to the content of unsaturated fatty acids and content of polymeric glycerides seem to be responsible for great differences in feeding value of frying fats.
   Also different kinds of polymers dependent on fatty acid composition of fats and on treatment of the fat could have different effects on feeding values of diets.
3. From the results of this experiment it can be concluded that polymers of FF1 were at least partly digested.
4. Emulsifiers used in veal calf milk replacers seem to have a beneficial effect on digestibility values of nutrients, if reduced by using frying fats.
   The other emulsifier tested in this experiment seemed to have a negative effect on digestibilities of nutrients in the diets with frying fats.

References

Billek and Rost, Kurzfristige Fütterungsversuche mit Methylestern dimerer Fettsäuren. F.S.A., 76, 436-439 (1974).

FEATHER MEAL PROTEIN AND AMINO ACID DIGESTIBILITY UNDER DIFFERENT PROCESSING CONDITIONS

M.C. Papadopoulos, A.R. El Boushy, A.E. Roodbeen and E.H. Ketelaars

Department of Animal Science, Agricultural University, Wageningen, The Netherlands

Introduction

The use of by-products in livestock and poultry nutrition is increasing. The feathers (waste at processing plants) must be hydrolyzed in order to be digestible by animals. However, this product will differ in quality because heat treatments have not only beneficial effects, but they can also reduce the nutritive value of feather meal protein.

Objectives

1. To investigate the relationship between methods of feather meal processing and amino acid digestibility, by the faecal analysis method.
2. To test if crude protein digestibility would reflect the amino acid digestibility.

Material and methods

Nine differently processed feather meal samples (hydrolyzed at 345 kPa pressure) have been used in this study. The test groups composed a factorial experiment including two factors, namely processing time (three levels: 30, 50 and 70 min) and way of treatment (three methods: no additives, chemically treated with 0.4% NaOH and enzymatically treated with 0.4% enzyme).

Sixty-three male broiler chicks (7 chicks per group) of 4 weeks old were first starved for 24 hrs. Chicks were force-fed 12 g (dry matter) of a test feather meal as a sole feed. An additional group of nine chicks received a nitrogen-free diet, in the same manner as the feather meal test-groups, to give an estimate of the metabolic faecal plus endogenous urinary excretion of amino acids. Quantitative excreta collection took place over a period of 36 hrs (4 times daily), after force-feeding.

Results

The data on the true amino acid digestibility values of the feather meals, are presented in figure 1. Comparison between crude protein and amino acid digestibilities are presented in figure 2.

Conclusions

1. There was a significantly negative time-linear effect on the true digestibility of all amino acids of the feather meals, with exception of leucine.
2. There are considerable variations between individual amino acids, with respect to their true digestibility values (range from 38% for aspartic acid to 85% for isoleucine).
3. The amino acid digestibility determinations revealed differences between the differently processed feather meals, which ar not detectable by the crude protein (N x 6.25) digestibility.

PRELIMINARY STUDY ON FEATHER MEAL LANTHIONINE EVALUATION

M.C. Papadopoulos, A.E. Roodbeen and L.J.G.M. Bongers[1]

Department of Animal Science, Agricultural University, Wageningen, The Netherlands

Introduction

Lanthionine is an unnatural amino acid formed by degradation of cystine, during thermal and/or alkali treatments of proteins. Balance trials for this amino acid in feather meals have not been made before.

Objectives

1. To study the total excreta-recovery of lanthionine (present in the differently processed feather meals) by balance trials.
2. To test if there is a relationship between feather meal lanthionine content and amino acid digestibilities.

Material and methods

The nine test feather meals and the faecal analysis technique used in this experiment have been described by the authors in a previous experiment presented in this 'session posters'. Lanthionine has been analyzed in pooled excreta (per test group).

Results

The data of this experiment are graphically demonstrated in figures 1 and 2.

Conclusions

1. The total recovery of lanthionine in poultry excreta is always inferior to 100%, suggesting that lanthionine is transformed by intestinal flora, or metabolized or retained in the organism.
2. The amino acid digestibility values of the processed feather meals are inversely proportional to the lanthionine content of the test feeds.

1. Dept. of Animal Physiology, Agricultural University, Wageningen, The Netherlands

A STUDY ON VARIATIONS IN FEEDING VALUE OF RENDERERS FAT WITH POULTRY

C.W. Scheele

Spelderholt Centre for Poultry Research and Extension
7361 DA Beekbergen, The Netherlands

Introduction

In the Netherlands nowadays renderers fat - a mixture of lard, tallow and poultry fat - is mixed up in poultry diets in increasing levels. Recently investigations have revealed that young chickens exhibit low digestibility values of animal fats in diets.

Scheele and ten Have,(1979) and Haertel (1980) showed that the feeding value of added fat was dependent on the dietary composition of the basal ration.

The objectives of the studies reported herein were to find how apparent metabolizable energy -AME- and digestibility of renderers fat was effected by the following factors:

1. The age of chickens
2. Different levels of added fat to the basal diet
3. Different levels of crude fibre in the basal diet
4. Exchanging one feedstuff in the basal diet by another one

Feedstuffs studied were: Wheat bran, Sunflower meal and Alfalfa meal. Obtained data were compared between adult cocks and chickens at different ages.

Methods

Six basal diets were obtained by mixing respectively wheat bran, sunflower meal and alfalfa meal as sources of crude fibre in two levels with soy bean meal and maize.

These basal diets with two levels of crude fibre were mixed with respectively 6 and 12% animal fat.

All diets were fed to four groups of male ckickens different in age (2, 4, 6 and 8 weeks of age) and to adult cocks.

Per treatment 4 groups of 10 chickens of each age and 3 adult cocks were used. Total excreta were collected during 4 days.

Standard AME and fat digestibility values were determined. AME was corrected for nitrogen equilibrium. Fat was extracted after hydrolyzing with hydrochloric acid.

The determined data were submitted to analysis of variance.

Results

In table 2 the mean values of AME and digestibility of renderers fat obtained in the experiment are shown. Chickens till five weeks of age demonstrate low digestibility values of fat for both fat levels in the diets.

After five weeks the digestibility values of fat increase distinctly but are still much lower than values obtained by adult cocks.

Doubling the fat content in diets from six to twelve percent caused a relative small decrease of the digestibility of added fat. A small positive effect of a higher crude fibre level in diets on feeding value of added fat was obtained. The reason could be that fat is better devided in diets when it can attach to fibre particles.

Feedstuffs with high fibre contents normally are poorly digestible. The fat of these feedstuffs also can have a low digestibility value. This can explain that higher crude fibre levels accompagnied with higher contents of poorly digested feedstuffs did not result in a positive effect on digestibility of the total amount of fat in the diet. Only added fat was effected by crude fibre.

More wheat bran in diets than sunflower meal or alfalfa meal is needed to reach the same crude fibre levels. Therefore the effect of crude fibre cannot be disconnected from the effect of dietary composition. In this experiment this could be the reason for a significant ($P \leq 0{,}001$) interaction between crude fibre and feedstuff as a source of crude fibre.

Table 1. Composition of six basal diets without fat in g/kg.

Ingredients	Basal diets 1	2	3	4	5	6
Soy bean meal	235	235	235	235	235	235
Maize	470	-	639	479	639	479
Wheat bran	235	705	-	-	-	-
Sunflower meal	-	-	66	226	-	-
Alfalfa meal	-	-	-	-	66	226
Vit. Min. mixture	60	60	60	60	60	60

Conclusions

1. A clear and important effect of age was shown on AME and digestibility of animal fat. Values determined with adult cocks were higher compared with chickens.
2. An increased level of added fat resulted in a significant decrease of AME of fat.

Table 2. AME and digestibility of renderers fat.

Experimental factors (results of factors 2, 3 and 4 are given only for chickens and not for cocks)	Determinations	
	AME added fat MJ/kg	Digestibility total fat in diets (%)
1. Age week 2	27.96	62.5
week 4	29.02	66.9
week 6	32.39	72.0
week 8	33.19	73.4
adult cocks	36.47	85.0
S.of the Effect *:	P≤0.001	P≤0.001
2. Added fat 6%	31.26	71.0
Added fat 12%	30.02	69.4
S.of the Effect	P≤0.001	N.S.
3. Crude fibre 4%	30.33	69.3
Crude fibre 8%	30.96	68.1
S.of the Effect	P≤0.001	N.S.
4. Feedstuffs in basal diets		
- wheat bran	29.43	62.4
- sunflower meal	31.21	71.6
- alfalfa meal	31.29	72.0
S.of the Effect	P≤0.001	P≤0.001

* Significance of the Effect.

3. An important effect of wheat bran compared with sunflower meal and alfalfa meal was found on AME and digestibility of fat.
4. A slight positive effect of crude fibre on AME of fat was shown.
5. A significant interaction between crude fibre and feedstuff as source of crude fibre was found.
   Fibre of wheat bran had a negative effect
   Fibre of sunflower meal and alfalfa meal produced a positive effect.
   ME additivity for poultry feedstuffs determined with adult cocks seems not valid for young growing birds.

References

Härtel, H., 1980. Proceedings 6th European Poultry Conference. Hamburg. World's Poultry Science Association German Branch (Fed).

Scheele, C.W. & H.G.M. ten Have, 1979. Proceedings 2nd European Symposium on Poultry Nutrition. Beekbergen, The Netherlands.

Discussion session 3: Wastes of animal processing.

Chairman: S. Boer Iwema

Discussion summarized by P. ten Have

Mr. Hopwood (United Kingdom) elucidated his own poster, about the lignosulfonate process which is an alternative flocculation-flotation process for slaughterhouse waste water treatment. Precipitation is caused by the addition of lignosulfonate and sulfuric acid. The sludge is treated with lime, dewatered and dried. There are 21 plants of this type in operation throughout the world so it is a well tested process. He showed results of feeding trials in which up to 9% lignosulfonate precipitate in the ration of chickens was used as a replacement for soymeal and meatmeal. The precipitate originated from a beef packing abattoir in the U.S.A. No significant change in weight gain was observed. Other feeding experiments with chickens and pigs were carried out. In experiments with pigs at the Veterinary College in Oslo the diet contained 30-60% sludge dry matter (3-6% lignosulfonates). There was no effect on weight gain and no adverse effect on the carcass. It was also established that up to 50% of the soybean meal could be replaced by the lignosulfonate meal (dried sludge obtained by precipitation with lignosulfonate). Comparing the lignosulfonate process with the process which uses ferric chloride as a precipitant, he saw some advantages in the process first mentioned:

- Lignosulfonate is an approved additive, both under the EEC and the FDA regulations. It is a traditional additive to animal feedstuffs.
- Lignosulfonate is more successful than $FeCl_3$ in the removal of blood from wastewater.
- The sludge is somewhat easier to dewater.
- The ash content of the sludge is not increased by the addition of an inorganic salt.

Slides of a lignosulfonate plant at a beef abattoir in Colorado, U.S.A., were showed. Most plants produce dry material. In a few occasions wet sludge, preserved with formic acid, was fed to pigs. This was successful, but the tests were not carried out on a scientific basis. At a plant, which his company recently installed, sludge is dewatered together with blood from the abattoir. This product is then mixed with pressed paunch contents and screenings.

The whole mixture is rendered together and fed to cattle and sheep. These animals accept it, gain weight normally and their carcasses show no change.

Mr. Mentink (Netherlands) asked mr. Scheele (Netherlands), on behalf of his poster on renderers fat, if he could explain the influence of age on the digestibility of fat. Mr. Scheele replied that young chickens lack bile salts in their digestive tract. Especially the saturated fatty acids, like stearic acid, are then poorly digested. When they grow older they produce enough bile salts to digest the fats. A second question, put forward by mr. Mentink, was: Can you explain the influence of crude fibre on the digestibility of the added fat?

In response, mr. Scheele, supposed that crude fibre has a surface enlargening and emulsifying effect on the fat in the feed.

Mr. Steg (Netherlands), when studying the data presented in Scheeles short paper, had observed a very significant positive effect of crude fibre on the apparent metabolisable energy (AME) of added fat, but on the other hand s slightly negative effect on the digestibility of that fat. He asked mr. Scheele for an explanation. Mr. Scheele replied that metabolisable energy is easier determined than digestibility. Their figures on digestibility showed a large variation. In his opinion the apparent negative effect on digestibility was just an random effect.

Nobody expressed a wish to comment on the other posters. Mr. Boer Iwema then gave the opportunity for a discussion of the lectures.

As a comment on the lecture of Mr. Edel, Mr. Shih (U.S.A.) brought forward that he had published, about 4-5 years ago, about a new process for the purification of poultry processing waste water. He called it "Membrane ultra filtration" process. This membrane removes all the macromolecules in the waste water, mainly consisting of protein and polymerized fats. The effluent is very clean; the COD concentration is better than the standard set by North Carolina regulations for discharge to open water. The concentrate removed consists for 60-70% of protein. Feeding trials with chickens showed that the soybean meal could be completely replaced by the removed material. He estimated the investment costs for a treatment plant for the waste water from the processing of 100.000 birds per day to be about 0,5 to 1 million U.S. dollars. The capital costs of such an investment were prohibitive. He had three questions for Mr. Edel.

- Where do the heavy metals come from.
- Are the chemicals ferric chloride and polyelectrolyte pure enough.
- Can you give information about the costs of the flocculation-flotation process you described.

Mr. Edel said, in reply to the first question, that Cu, Mn and Zn are added to the diet of pigs and are, therefore, relatively high in concentration. Trace elements like Cd and Pb are environmental contaminants which generally occur in low levels. They can accumulate, however, but this is not always so.
From many analyses on organs of animals it is obvious that the level of Hg is going down, because it is no longer used as a pesticide. Feed used by animals show low levels of these trace elements. They are passed on via the slaughterhouse to the flotation sludge, but the levels observed are no threat to the health of man or animal. Replying the second question. Dr. Edel said that only chemicals with a good quality, which means low levels of unwanted components, are to be used. He asked mr. ten Have (Netherlands) to answer the third question.

Mr. ten Have showed some sheets about the costs of flocculation-flotation with ferric chloride and polyelectrolyte. The value of dried poultry sludge was estimated at ƒ 65/100 kg at the end of 1982. A year later a shadow price of about ƒ 95/100 kg was calculated, mainly due to the a sharp rise of the price protein and fat on the world market. The value of sludge from slaughterhouses for pigs and cattle is about 20% lower. A graph was presented showing the relation between the capacity of slaughterhouse and the net costs or returns of various ways of sludge disposal sludge value minus processing costs. Direct feeding to pigs, after pasteurisation and preservation, showed a net profit in most situations; Indirect feeding (via dewatering and rendering) a net loss. The last sheet showed the total annual costs of waste water treatment and discharge versus the plant capacity. When compared with an annual levy of ƒ 45.- per population equivalent, taxed by river authorities for sewer discharge, a flocculation-flotation plant is profitable at capacities at and above about 5.000 population equivalents; the biggest savings for a treatment plant at a poultry processing plant where the sludge is directly fed to the pigs at a nearby farm after pasteurisation and preservation with acid.

Mr. van den Bosch (Netherlands) asked if there was anybody who had compared the costs of the use of lignosulfonate with those of the use of ferric chloride. Mr. Smits (Netherlands) replied that the Dutch group which did research on the use of flotation sludge as a feed ingredient had not made such a comparison of the chemical costs of both systems. He had the opinion that sludge originating from the lignosulfonate process would have a fairly high level of Ca due to the addition of lime. That could cause a depression in the fat digestibility. Moreover, the addition of minerals would not increase feeding value of the sludge, on the contrary. He asked Mr. Hopwood to comment on these aspects. In reply, Mr. Hopwood said that some years ago a laboratory comparison was made between ferric chloride and lignosulfonate precipitation and dewatering of the sludge. The general impression was that lignosulfonate was preferable for the reasons he had uplined a little earlier: The dewatering is somewhat easier and the removal percentage of soluble (blood) proteins is higher.

There is not a great deal of difference, however, in a waste water where most of the protein is in particulate form. They were also concerned, quite a few years ago, about the various regulations. It was clear that lignosulfonate was more acceptable in the sense that the regulations specifically named lignosulfonate as an acceptable additive and it had traditionally been used in animal feed. It was for these reasons that they promoted the lignosulfonate process. They had not been in the position to make comparisons between full scale plants, although they had installed full scale ferric plants as well as full scale lignosulfonate plants. None of the ferric plants which they had installed used their sludge for animal feedstuff, so they had not been in a position to make a direct comparison. He certainly thought that there is plenty of room for more work to be done, but he would like to stress that it is very much a question of the situation. In some countries lignosulfonate is relatively cheaper than ferric salts and in other countries it is more expensive and this must have a big effect on the choice of process. Most of the lime used in the lignosulfonate process is used for the neutralisation of the effluent and it doesn't find its way to the sludge. A certain amount of lime is used to neutralise the sludge before dewatering. He believed that it is necessary to neutralise any sludge before dewatering, so the lime may get in anyway. They had never found any adverse effects of calcium in any of the feeding trials they had done.

Mr. Steg gave comment on the question of Mr. van den Bosch. The reason they had done work on $FeCl_3$ alone was that no other precipitating chemical was used in the Netherlands. Although he had no correct idea of the prices the two systems, he thought that economic consideration was the cause of the absence of lignosulfonate plants in his country.

Mr. van den Bosch asked Mr. Edel if he considered it a safe procedure to heat sludge to not more than 70 °C when there is a possibility of the presence of sporeformers. He himself was confronted with this question at his work in the industry. He also wanted to know what people from other countries thought about this question. Mr. Edel replied that he considered sterilisation the safest treatment but sterilisation is more expensive than pasteurisation. The costs benefits ratio should not be forgotten. Heating up to not more than 70 °C is not without risk because the sporeforming bacteria are resistent. On the other hand, there were not many cases of illness when animals were fed with pasteurised sludge. Besides, poultry is only fed with dried (sterilised) sludge.

One must be certain that infectious agents are not recirculated.
Although he had not seen severe illnesses in the pig trials, there might have been a build-up of these agents. That was not well investigated. Maybe more attention should be paid to this matter. It is calculation of the risks.
Mr. Alderman (U.K.) explained the current situation in the U.K. After long cogitation they had a so-called "protein processing order" which doesn't attempt to specify the processing conditions because what is written down is very often not what is done.
His veterinary colleagues had opted for a system of monitoring the product from the plants under the requirement that those products should be free of the organisms of concern, particularly the Salmonella. This is because there is both an animal and a human health problem which historically has been associated with Salmonella getting into animal feed. The conditions how to run the the plant are not specified: they should be adjusted until the product is safe to enter into the food chain.

Mr. Newman (U.K.) wanted to go back to the relative costs of the ferric chloride and the lignosuldonate systems. From the data mr. ten Have had presented, he understood that in most of the occasions the sludge treatment costs were higher than the value. Mr. Hopwood had pointed out that the costs of chemicals vary from country to country. He had the impression that the lignosulfonate system, being more complicated, would be more capital intensive. He asked mr. Hopwood if there were any circumstances when the lignosulfonate process was as profitable or even more profitable as the ferric chloride system.

Mr. Hopwood replied that they had conducted an economic evaluation before they installed a plant recently at a poultry factory in the U.K. They found that the operating costs were virtually identical between the ferric and the lignosulfonate process. He didn't know enough about the capital costs of his competitors plants but he believed they are simular for both systems. Looking at it in a broader perspective he thought that the economic for this sort of process depend very much on the amount of money which the factory is paying towards its pollution control costs. They had never sold an effluent treatment plant where there is not an effluent treatment problem. Therefore the costs of effluent treatment must be taken together with the costs and values of protein recovery in making an economic evaluation.

Mr. Hof (NL) was interested in the effect of the addition of lime to flotation sludge. Mr. Smits had mentioned before that he considered that a disadvantage of the lignosulfonate process. When ferric chloride was added, the animals were loaded with a high amount of chloride. He wanted to know if, by adding ferric chloride, the acid-base balance in the animals was disturbed and if there was compensated for.
Mr. Smits replied that the addition of calcium will decrease the fat digestibility and therefore also the feeding value of the sludge. The sludge produced in the ferric chloride process contains only small amounts of chloride cons. These give no problems. He agreed with mr. Hof that when an in organic acid like HCl or H_2SO4 is added one has to be aware of the possibility of disturbance of the acidbase belance. In such a situation $CaCO_3$ has to be added to the diet. He intended to carry out some experiments with sludge, preserved with H_2SO4 instead of formic acid, next

year.
So maybe in a year time he would be able to give a good answer to Mr. Hof's question.

The chairman, mr. Boer Iwema, after establishing that there were no further questions, thanked the lecturers and the participants in the discussion. From this mornings discussion he concluded that the feeding of sludge to animals is not without risk. There is hope, however, that the problems can be solved. The solution of a pollution problem combined with the production of animal feed depends very much on the costs of the process. He hoped this application would not be obligatory. After this the chairman closed the morning session.

★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★

AQUATIC BIOCONVERSION OF EXCREMENTS IN PONDS

Carl J. Soeder

Institut für Biotechnologie, Kernforschungsanlage Jülich GmbH, D-5170 Jülich, FRG

Summary

Aquatic bioconversion of excrements is predominantly indirect. Primary productivity as increased by plant nutrient input, may boost fish productivity in ponds. This scheme is of special economic importance in tropical and subtropical countries. It represents a nutrient recycling potential which is only partially exploited until now. To make better use of aquatic recycling of excrements, not only regional training and information programs are required but also further investigations, and operations research.

Introduction

The most important conventional way of disposing of human or livestock excrements in a useful manner is to spread ecologically adequate amounts of liquid or solid manure onto the agricultural land. There, complete remineralization takes place, before the nutrients are taken up again by plants to render new food and feed materials. More or less analogous to this practice is the fertilization of fish ponds and other aquacultural systems by cow manure, piggery wastes, primary sewage or night soil, etc. Also fermented cow manure is effective (Barash & Schroeder, 1984). The principal crop is then fish (e.g. Edwards, 1980) but in marine aquaculture the final product may also consist in mussels or shrimp (Kinne, 1977).

Both in agricultural or aquacultural practices where excrements are applied as outlined above, almost all of the residual energy content of the excrements is lost in the course of immediate remineralization. Bioconversion of a significant part of the residual energy of organic wastes into methane by anaerobic digestion (Sahm, 1984) does not lower the fertilizer value of the fermented material (for fish ponds cf. Barash & Schroeder, 1984).

Be it on agricultural land or in aerobic ponds, without or subsequent to anaerobic digestion, a gain in hygienic safety and in aesthetic inoffensiveness goes always along with aerobic remineralization of excrements.

Advocating an intensified utilization of excrements, Kromann (1980) outlined in general terms a number of conceivable strategies for direct nutritional recycling of the fecal matter, in order to conserve residual energy this way. Since the relevant examples for agricultural practices of that kind are sufficiently covered in other contributions to this volume, the present article has been restricted to excrement bioconversion and nutrient recycling in managed freshwater systems. It should also be made clear at this point that the author, filling unexpectedly in for a leading expert (P. Edwards), is specialized on algal ponds and not on fishponds. Although quite aware of the deficiencies in his knowledge of the latter subject, the author takes advantage of the chance to plead for increased efforts to employ ponds or pond systems in the bioconversion of excrements.

From China where the feeding of human feces to hogs has been common at least in the past, originated apparently the boosting of fish production in ponds by application of excrements or manure. What has been apostrophed a "circumvention of biodegradation by biogradation" consists in the fact that part of the fecal matter administered may be eaten directly by carp or other kinds of cultivated fish. Most of the fish production in sewage ponds seems, however, to rely on aquatic food chains based on vigorous growth of microalgae and bacteria (Edwards, 1980). How productive sewage fishponds can be, may be illustrated by a figure from Manila (10 tons of live fish per hectare and year). The corresponding highest value from Germany (0.5 t/ha x yr) shows the strong dependence of productivity on climate.

Aquatic recycling and/or utilization of excrements is of particular importance in Southeast Asia. A wellknown example for that region is the production of milkfish (Chanos chanos) in very shallow ponds in Indonesia and the Philippines (Hickling, 1971). Like Tilapia, the milkfish is a herbivorous filter feeder, i.e. capable of eating suspended microalgae directly. It grazes also on filamentous algae on the pond bottom. The fact that this means a reduction of the foodchain to its minimal length, explains the success of milkfish farming which belongs moreover to the simplest technologies in pisciculture.

Before elaborating more on productivity and usefulness of sewage-based pisciculture, the significance of pond systems for nutrient recycling shall be discussed with regard to algal productivity.

Algal Ponds

Today the treatment of urban sewage in pond systems appears to be the most economic treatment technology in warmer climates whereever sufficient areas of comparatively low value are available (Arthur 1982; Table 1). The usefulness of pond systems for temperate climates is not as clear yet and deserves further investigation. Obviously the particular advantage of the pond systems relates to the production of fish and, if water is in short supply, of irrigation water as added values.

With respect to the economics Taiganides (1982) states: "The three resources which can be recovered from organic wastes such as pig wastes and wastewaters are: water, energy and nutrients. However, the recovery of these resources cannot be justified on economic terms but must be carried out in conjunction with pollution control or sanitation operations. Wastewater treatment to meet strict environmental pollution standards is sufficiently expensive to justify employing purification processes which yield useful products."

It should be emphasized that none of the pond systems mentioned in Table 1 under positions 2 and 4 can be considered to be optimized yet. The same appears to hold for the fishpond management and the selection of fish species.

The physiological backbone of algal pond technology is the cooperation of suspended bacteria (responsible for eventual aerobic degradation of excrement organics) and microalgae photosynthesizing according to light energy input. When utilizing the metabolic end products of bacteria (carbon dioxide, ammonium etc.), the algae supply the bacteria with the oxygen required for full breakdown of degradable organics.

For this kind of algal-bacterial interaction the term "photosynthetic wastewater treatment" was coined , also referred to as "algal symbiosis (with bacteria) in ponds" (Gotaas & Oswald, 1951). When testing algal-bacterial interaction in the light under defined conditions, we found the metabolism of the microalgae to be strictly photoautotrophic despite a continuous input of dissolved organics, as long as the bacteria were not strongly oxygen limited (Fingerhut & Soeder, 1984). This is important to state, because photosynthetic oxygen production can now be calculated from light energy input, temperature and optical density of the suspension according to the model by Grobbelaar et al. (1984) at least for high-rate algal ponds also permissable areal loading (kg BOD_5/m^2 x day), required residence times etc.

Table 1. Cost comparison of various technologies for treating the sewage of a city of 250,000 inhabitants at ambient temperatures of 15 - 30 ^oC. Land value: 5 US $\$/m^2$. From Arthur (1982) and for high-rate algal ponds (= HRAP) after Berend et al. (1980) multiplying their numbers by 1.33 and restricting the mixing time to 8 h/day. Cost values in 1000 US $ per capita and year. For HRAP economics cf. also Shelef et al. (1980b).

		Total Cost
1. Activated sludge (incl. sludge handling and disposal)		10
2. Waste stabilization pond system		
Capital cost (including land)	+ 5.68	
Operational cost	+ 0.21	
Income from irrigation water	- 0.43	
Income from pisciculture	- 0.30	5.16
3. Oxidation ditch system		
Capital cost (including land)	+ 4.80	
Operational cost	+ 1.49	
Income from irrigation water	- 0.43	5.86
4. HRAP system without anaerobic step		
Capital cost (including land)	+ 6.30	
Operational cost	+ 4.24	
Income from irrigation water	- 0.43	
Income from ALBAZOD sales	- 5.80	4.31

In conventional stagnant ponds, anaerobic digestion of sedimented microbial biomass and/ or inanimate particulate organics (including zooplankton feces) at the pond bottom plays an important role. This holds to a much lesser extent for the HRAP, i.e. an artificially agitated algal pond which is characterized by much lower residence times than typical for static algal ponds (Oswald, 1970; Shelef et al., 1980a; Table 2).

Provided that suspended matter be removed efficiently from the pond effluent, full treatment in terms of BOD removal can be accomplished either by static algal ponds or by HRAPs. One saves, however, pond area and residence time by employing ponds in a series in which the organic load is stripped stepwise from the wastewater (Arthur, 1982; Table 3).

Table 2. Characteristics of the most important types of ponds employed in the treatment of domestic liquid wastes or manure. Data from Metcalf & Eddy (1972; facultative pond), Arthur (1982) and Groeneweg (1984; HRAPs and sewage fishponds). Values are based on 335 mg/l of BOD_5 in influent and temperatures between 15 and 30 °C. SFP = sewage fish pond.

Pond type	Permissable load (kg BOD_5/ha x d)	Typical depth (m)	Recommended residence time (d)	BOD_5 removal (in %)	Sludge accumulation
Anaerobic	4000 - 16,000	2.5 - 4	2	30 - 90	++
Facultative	30 - 120	1.0 - 1.8	7 - 20	80 - 98	-
Maturation	15 - 50	0.6 - 1.5	5	30 - 70	-
HRAP	100 - 450	0.4 - 0.6	1.5 - 5	95 - 98	-
SFP	10 - 30	0.5 - 1.5	2 - 3	70 - 75	+

Table 3. Pond area (in hectares) required and total detention time (in days; values in parentheses) for different pond systems and a town of 50,000 inhabitants. Sewage per capita per day: 0.12 m^3, i.e. Q = 6000 m^3/d. BOD_5 = 335 mg/l. Temperatures as air temperature. From Arthur (1982) and Berend et al. (1980).

Pond system	Pond area (total detention time) Temperature 12 °C	20 °C	25 °C	Electric energy input (kWh/d)
Anaerobic + facultative + maturation	19.7(29.7)	7.7(18.8)	5.1(13.0)	-/-/-
Facultative + maturation	18.5(48.9)	9.4(25.4)	6.8(17.6)	-/-/-
Aerated lagoon + maturation	12.3(34.0)	8.4(21.0)	6.3(16.8)	about 3000
HRAP	6.7(5)	4.3(3.2)	2.0(1.5)	2500/1600/750

Except for the anaerobic pond, the other pond types in Table 2 can be called less specifically "algal ponds". The gain in efficiency in space and time by using anaerobic ponds as the first in a pond series is obvious at all temperatures considered here.

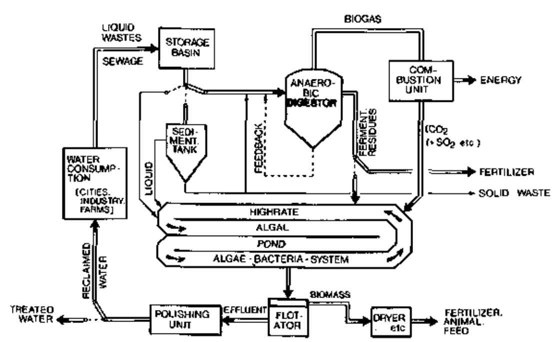
Anaerobic ponds rely exclusively on bacterial metabolism, and in the facultative ponds (= facultatively anaerobic ponds) the organic load is still so high that algal photosynthesis turns the water aerobic only during part of the day. The fully aerobic maturation ponds bring about the final "polishing" of the effluent. From serial ponds effluents of very good quality may be obtained by proper management (Shelef et al., 1980a). How HRAPs would be fitted best into a series of ponds is not quite clear yet because of a lack of systematic research at the semitechnical scale. Operations research is required, too.

Only when operating HRAPs, microbial biomass can be obtained in the form of ALBAZOD as a protein-rich byproduct (Fig. 1).

ALBAZOD: Biomass from HRAPs

The term ALBAZOD is introduced to indicate that the particulate matter which can be recovered from HRAPs consists of algae (i.e. microalgae), bacteria, zooplankton and detritus. Thus, unprecise expressions such as "algal biomass", "algal-bacterial matter" etc. are avoided.

Fig. 1: Schematic flowchart of the treatment of sewage or other liquid wastes with mixed populations of microalgae and bacteria. The treatment in the highrate oxidation ponds is accomplished either after removal of particulate matter or after anaerobic digestion yielding biogas (double arrows in upper part).



The coarse chemical composition of one type of ALBAZOD is compared in Table 4 with that of pure microalgal biomass. There are no obvious differences, and the two types of single cell protein coincide in containing about 55 % of crude protein in the dry matter. Like Scenedesmus meal, roller dried ALBAZOD was found to be a good protein source for rats (Mokady et al. 1978), freshwater fish (carp and Tilapia; Sandbank & Hepher, 1980), even if most of the protein in the diet came from ALBAZOD. In chicken some loss in growth performance was noted, especially during the first weeks after batching, if more than 50 % of the protein was from ALBAZOD (Mokady et al. 1980; Lipstein and Hurwitz,1980). As to pigs the positive results of testing a diet containing 10 % ALBAZOD (Hintz et al., 1966) and those of Taiganides (1982; 50 % protein from ALBAZOD) shall be mentioned.

Table 4. General chemical composition of ALBAZOD (Lipstein and Hurwitz, 1980) and of pure Scenedesmus obliquus (Soeder, 1980). In both cases roller-dried material was analysed. Values in per cent of dry matter. Protein absorption was determined in rates in percent of a casein + 5 % methionine standard (Lipstein and Hurwitz, 1980; Pabst, 1978).

Constituent	ALBAZOD	Scenedesmus obliquus
Crude protein	57	50 - 60
Total lipids	7	12 - 14
Crude fibre	2	3 - 10
Phosphorus	1.2	1.7
Calcium	0.2	3.5
Metabolizable energy (kJ/kg x 10^3)	11.62	?
Protein absorption	80.7 %	73 - 77 %

The feeding of ALBAZOD from urban sewage to carp or chicken did not result in the accumulation of nonpermissible or hazardous amounts of heavy metals or xenobiotics in meat, liver and bone. Chicken meat produced on an ALBAZOD containing diet appeared to be innoxious when subjected to a secondary toxicity test with rats (Yannai et al. 1980). Although these stimulating findings can certainly not be generalized, because urban sewage is in certain cases too heavily polluted, there is a large potential for producing toxicologically safe ALBAZOD in HRAPs, and it should be borne in mind that milkfish, carp and Tilapia harvested, marketed and consumed in terms of hundred thousands of annual tons in Southeast Asia, are produced from manure, night soil or domestic wastewater.

Recovery of proteinaceous microbial biomass fom HRAPs was regarded as a special merit of this pond technology from the beginning (Oswald et al. 1965). Until now the utilization of ALBAZOD in animal husbandry is neither practised at the industrial scale in California, where several large HRAP systems are in operation since many years, nor in Israel where ALBAZOD harvesting, processing and testing has been an integral component of a large Israeli-German project (Shelef et al. 1980).

A remarkable breakthrough seems to have been achieved in Singapore. Here HRAPs are now required by law for the treatment of piggery wastes with or without precedent methanization (Taiganides 1982). An essential part of the progress made in HRAP technology in Singapore consisted in the development of an improved technology for separating ALBAZOD from treated water by microstraining. But flocculation with alum and subsequent flotation is also an effective separation technique (Shelef et al. 1980 b) involving, however, the use of chemicals which can only partially be recycled themselves.

Features of aquatic nutrient recycling

The preference given to pond systems for wastewater treatment in less developed countries in the tropics and subtropics is not only for economic reasons (Table 1) but also because of the much greater simplicity as compared to the active sludge process. Not being bound to operation at the industrial scale, pond systems can be scaled down to the farm level. Hence, the existence of sewerage or well-organized night soil transportation is not a prerequisite for the application of pond systems in water reclamation and nutrient recycling from liquid wastes.

With regard to the operational cost, algal pond systems may be yielding fish and, given the demand, irrigation water of high quality. The significance of these added values (Table 1) obviously depends on the value of the land which will be inversely proportional to the relative advantage of pond systems, and the value of the fish and of the reclaimed water. It is by no means everywhere that both types of byproducts help to reduce overall costs.

Pisciculture in maturation ponds (Arthur, 1982) is probably the most natural method of nutrient recycling in sewage ponds. Although this type of "biological harvesting of ALBAZOD" may be much less efficient (e.g. with respect to nitrogen recovery) as compared to the feeding of pelletized ALBAZOD (Meske & Pfeffer, 1978; Sandbank & Hepher, 1980), it involves almost no additional investment and no special technologies.

Production of fish is certainly not the only final objective of aquatic recycling of excrements. Groeneweg and Schlüter (1981) paved the way for mass production of rotifers valuable e.g. for aquacultural purposes on HRAP effluent in which the zooplankton organisms act as miniharvesters of ALBAZOD. An actually established technique is the use of algal pond effluent as the drinking water for cattle in the Southern Soviet Union. It is claimed that the comparatively small amounts of microplankton thereby supplied to the cattle exert a beneficial effect on meat and milk production (Ganovski et al., 1975).

Recycling by ponds concerns mainly water, metabolizable energy (as restored by photosynthetic bioconversion of solar energy), carbon and nitrogen. If we base a rough estimate on the Israeli case study by Shelef et al. (1978), the annual ALBAZOD crop from the wastewater of 250,000 people amounts to 2600 t containing about 200 t of N. This compares to 580 t N in the influent and 175 t N in the final effluent. Hence the nitrogen incorporated into ALBAZOD and effluent nitrogen amount to 35 and 30 % of N input, respectively. The remaining 45 % can mostly be attributed to ammonia loss to the atmosphere which can be reduced, if desired (Groeneweg, 1984). As demonstrated by the same case study, the ratio of ALBAZOD recovered to BOD_5 input is in the order of unity.

The conversion of ALBAZOD protein to fish protein is fairly efficient. Taking the data by Sandbank and Hepher (1980) who fed pellets containing ALBAZOD, cereals and other ingredients (total protein content of feed: 25 %) to carp (assumed total protein content: 9 %), the feed conversion coefficient was about 2.0. This means that 180 g of fish protein were synthesized from 250 g of feed protein. This gives a net protein utilization of 71 %, i.e. about 30 % of the fed N must have been excreted again which coincides with the 26 - 30 % nitrogen loss quoted in Watanabe et al. (1983), also for filter- feeding fish like Tilapia (Sandbank & Hepher, 1980).

For pisciculture in maturation ponds the efficiency of nitrogen bioconversion can be expected to be higher because of nutritional short circuits whereby fish excrements are again converted into secondary ALBAZOD. Effluent of more intensively managed fish ponds will contain excess nutrients which can be utilized for the production of cereals as shown by Edwards et al. (1981). In principle, fish pond effluents could be refed to algal ponds, increasing the yield in ALBAZOD which for optimal utilization requires another input of cereals etc. The eventual and necessary outlet for excess nitrogen may consist in ammonia volatilization from algal ponds or in crop irrigation.

An important open question to be mentioned in this context is the fate of environmental pollutants (cf. Yannai et al., 1980) in continued recycling of nutrients.

Summing up one of the most complete studies on aquatic bioconversion of excrements in ponds, Edwards et al. (1981) still maintain that fish produced from sewage in such schemes should not be used for human consumption but rather as a feed for high-value carnivorous fish. Accordingly, Arthur (1982) assigns a value of only US $ 0.1 to the "trash fish" produced in maturation ponds. Although this appears to be the present state of the art, it is ecologically wasteful, and the author expects further research to lead to safe and simple ways of utilizing the ALBAZOD eating fish directly. Substantial improvements are also expected in HRAP technology which has not yet been exploited to its full potential.

Until now some of the largest cities in the world like many industries dispose of their sewage by ocean outfalls. We have learnt that this means in most cases the spoiling of natural waters by eutrophication and other types of environmental pollution. This ever escalating damage to nature could only be counteracted by biological and advanced treatment. Conventional processes available for this purpose are costly and are used to the effect that organic matter is broken down as completely as possible to CO_2, water, molecular nitrogen (after nitrification and denitrification), phosphate sludge etc. and yet one is faced with the problems of sewage sludge. This means a waste of energy in duplicate, because we are wasting energy to bring energy-containing substances (e.g. NH_4^+) to a state of minimal energy content. While it would already be utopic to demand such a perfection of waste treatment for all excrements produced in industrial countries, how could one sincerely hope for the better in the less developed countries?

Despite the attractiveness of aquatic bioconversion of excrements in ponds and the significant potential role of inland aquaculture in global protein supply strategies (UNO, 1967), research efforts in this area have not been sufficient up to now. Consequently, mature technologies for aquatic nutrient recycling cannot be offered yet, and there are no satisfying answers to some rather basic questions concerning pond performance, hygienic aspects etc. However, the merits of pond systems are already such that it would be certainly advantageous to establish regional demonstration plants and regular training programs, in order to disseminate the available knowledge for improved management of our natural resources.

References

Arthur, J.P., 1982. Notes on the design and operation of waste stabilization ponds in warm climates of developing countries. World Bank, Urban Development Department, Technical Paper 6.

Barash, H. & G.L. Schroeder, 1984. Use of fermented cow manure as a feed substrate for fish polyculture in stagnant water ponds. Aquaculture 36: 127 - 140.

Berend, J., E. Simovitch & A. Ollian, 1980. Economic aspects of algal animal food production. In: G. Shelef & C.J. Soeder (Ed.). p. 799 - 818.

Edwards, P., 1980. The production of microalgae on human wastes and their harvest by herbivorous fish. In: G. Shelef & C.J. Soeder (Ed.). p. 191 - 204.

Edwards, P., O.-A. Sinchumpasak, V.K. Labhsetwar & M. Tabucanon, 1981. The harvest of microalgae from the effluent of a sewage fed high rate stabilization pond by Tilapia nilotica. Part 3: Maize cultivation experiment, bacteriological studies, and economic assessment. Aquaculture 23: 149 - 170.

Fingerhut, U. & C.J. Soeder, 1984. Growth and acetate utilization of Scenedesmus falcatus and Pseudomonas aeruginosa in axenic and mixed continuous cultures. Ergebn. Limnol. 15: (in press).

Ganovski, H., K. Usonova, G. Karabashev & N. Cherkesov, 1975. Influence of Scenedesmus acutus microalgae on the digestability of fattening calves ration and on some blood indexes. Zhivortnovd. Nauki 12: 77 - 83.

Gotaas, H.B. & W.J. Oswald, 1951. Algal symbiosis in oxydation ponds. 2nd Progr. Report, Institute of Engineering, University of California, Berkeley. Ser. No. 3: 1 - 58.

Grobbelaar, J.U., C.J. Soeder & E. Stengel,, 1984. Modelling algal growth in large outdoor cultures. J. theoret. Biol. (submitted).

Groeneweg, J., 1984. Personal communication.

Groeneweg, J. & M. Schlüter, 1981. Mass production of freshwater rotifers on liquid wastes. II. Mass production of Brachionus rubens Ehrenberg 1838 in the effluent of high-rate algal ponds used for the treatment of piggery waste. Aquaculture 25: 25 - 33.

Hickling, C.F., 1971. Fish culture. Faber and Faber, London. p. 317.

Hintz, H.F., H. Heitmann, W.C. Weir, D.T. Torell & J.H. Meyer, 1966. Nutritive value of algae grown on sewage. J. Animal Sci. 25: 675 - 681.

Kinne, O., 1977. Marine Ecology. Part 2. Cultivation of animals. John Wiley & Sons, London, New York, Sydney, Toronto.

Kromann, R.P., 1980. A nutritional ecosystem model to conserve nutrients for man. In: G. Shelef & C.J. Soeder (Ed.). p. 745 - 756.

Lipstein, B. & S. Hurwitz, 1980. The nutritional and economic value of algae for poultry. In: G. Shelef & C.J. Soeder (Ed.). p. 667 - 686.

Meske, C. & E. Pfeffer, 1978. Growth experiments with carp and grass carp. Ergebn. Limnol. 11: 98 - 107.

Metcalf & Eddy, Inc., 1972. Wastewater Engineering. McGraw-Hill Book Company, New York.

Mokady, S., S. Yannai, P. Einav & Z. Berk, 1978. Nutritional value of the protein of several algae species for broilers. Arch. Hydrobiol. Beih. 11: 89 - 97.

Mokady, S., S. Yannai, P. Einav & Z. Berk, 1980. Protein nutritive value of several microalgae species for young chickens and rats. In: G. Shelef & C.J. Soeder (Ed.). p. 655 - 660.

Oron, G. & G. Shelef, 1980. An optimization model for high-rate algae ponds. In: G. Shelef & C.J. Soeder (Ed.). p. 497 - 504.

Oswald, W.J., 1970. Growth characteristics of microalgae cultured in domestic sewage: environmental effects on productivity. In: Prediction and Measurement of Photosynthetic Productivity, Wageningen, p. 473 - 487.

Oswald, W.J., C.G. Golueke & G. Shelef, 1965. Closed ecological systems. Proc. Amer. Soc. Civil Engrs. 91: 23.

Pabst, W., 1978. Nutritional evaluation of nonsewage microalgae by the rat balance method. Ergebn. Limnol. 11: 65 - 70.

Sahm, H., 1984. Anaerobic wastewater treatment. Adv. Biochem. Engin./Biotechnol. 29, 83 - 115.

Sandbank, E. & B. Hepher, 1980. Microalgae grown in wastewater as an ingredient in the diet of warmwater fish. In: G. Shelef & C.J. Soeder (Ed.). p. 697 - 706.

Shelef, G., W.J. Oswald & C.G. Golueke, 1969. The continuous culture of algal biomass on wastes. In: I. Malek (Ed.): Continuous cultivation of microorganisms. Academia, Prague. p. 601 - 629.

Shelef, G., R. Moraine & G. Oron, 1978. Photosynthetic biomass production for sewage. Ergebn. Limnol. 11: 3 - 13.

Shelef, G., Y. Azov, R. Moraine & G. Oron, 1980a. Algal mass production as an integral part of a wastewater treatment and reclamation system. In: G. Shelef & C.J. Soeder (Ed.). p. 163 - 190.

Shelef, G. & C.J. Soeder, 1980b. Algae Biomass: Production and use. Elsevier/North Holland Biomedical Press, Amsterdam, 852 pp.

Soeder, C.J., 1980. Massive cultivation of microalgae: results and prospects. Hydrobiologia 72: 197 - 209.
Taiganides, E.P., 1982. Biomass from the treatment of pig wastes. Wissenschaft u. Umwelt 4/1982: 256 - 267.
UNO, 1967. Economic and Social Council of the United Nations. Increasing the production and use of edible protein. 43rd Session. UN-Report No. 67, Document No. 13072.
Watanabe, T., C. Kitajima & S. Fujita, 1983. Nutritional values of live organisms used in Japan for mass propagation of fish: a review. Aquaculture 34: 115 - 144.
Yannai, S., S. Mokady, K. Sachs, B. Kantorowitz & Z. Berk, 1980. Certain contaminants in algae and in animals fed algae-containing diets, and secondary toxicity of the algae. In: G. Shelef & C.J. Soeder (Ed.). p. 757 - 766.

Acknowledgement

The author thanks Dr. H.J. Fallowfield (Belfast, Northern Ireland) for valuable informations and comments.

RESIDUAL SLUDGE FROM BREWERY WATER TREATMENT PLANTS AS RUMINANT FEED[1]

R. Parra, R. M. Dixon, A. Escobar, O. Parra, J. Cabrera y N. Román

Instituto de Producción Animal, Facultad de Agronomía, U.C.V. Maracay, Venezuela

Introduction

The residual sludge (RSB) derived from aerobic treatment of brewery waste waters is produced in substantial quantity (2-9 kg DM/1000 l beer), and there may be an appreciable cost associated with its disposal in a manner appropiate to avoid pollution of the environment. Therefore the possibility of its incorporation into animal diets is of interest. Similar sewage sludges have been used, in general without ill effect, as dietary components for growing chicks (3), laying hens (4), turkeys (7), swine (1), sheep (5, 6) and cattle (2).

This study evaluates the RSB produced at a brewery in Venezuela from a nutritional point of view, and explores its potential as a ruminant feed.

In the process of producing RSB, the activated sludge is partly dried by filter-pressing. Previous to filtering, spent diatomaceous earth, and lime + ferric chloride (as floculants) are added to the sludge.

Materials and methods

Ten samples of RSB were obtained over a 12 month period, dried at 70°C and analyzed for nitrogen (Kjeldahl) neutral detergent (NDR), ash, silica, in vitro organic matter digestibility (IVOMD) and mineral elements.

In Exp 1 West African sheep were given a control ration consisting of 40% dried brewers grains, 40% ground *Cynodon* spp hay, 18% maize flour residue, 1% urea and 1% dicalcium phosphate, or one of three diets where RSB replaced the brewers grains to constitute 4%, 8% or 12% of the diet. Voluntary intake was measured for 31 d, a total collection of faeces was made during the last 7 d to determine digestibility, and the sheep were weighed weekly to determine liveweight change. In Expt 2 the same sheep were given for 23 d a similar group of diets where the hay was not included in the diet, and the levels of RSB were 0%, 8%, 16% and 24% of the total ration. Digestibility was determined during the last 7 d. In Expt 3 similar sheep were given a control diet containing 47% dried brewers grains, 47% NaOH treated (5%) ground maize cobs, 4% molasses, 1% urea, 1% dicalcium phosphate and 0.1% elemental sulphur, or two experimental rations where the brewers grains and maize cobs were replaced by 10% RSB prepared without diatomaceous earth, or the equivalent quantity of ash derived from RSB. Voluntary intake was measured for 43 d, and a total collection of faeces was made during the last 7 d. In Expt 4 the effects on intake and digestibility of incorporation of diatomaceous earth in the RSB, and of drying the brewers grains-RSB mixture were examined in a 28 d trial utilizing a 2 x 2 factorial design. In Expt 5 four fistulated sheep were used to measure rumen VFA, pH and $N-NH_3$ levels, when fed two diets based on ground hay (40%), maize flour residue (18%), urea (1%), mineral mix (1%) and brewers grains (40%), without or with RSB (0% and 8%).

Results and discussion

Table 1 shows the average composition of RSB over the sampling period.

Table 1. Chemical composition[a] of RSB from San Joaquin brewery (POLAR), Venezuela.

Dry matter, %	29.0	(25.4 - 32.8)
Ash, %	51.9	(43.8 - 66.5)
Silica, %	13.9	(9,8 - 16.3)
Nitrogen, %	3.12	(2.49 - 3.49)
NDR, %	25.0	(11.4 - 38.6)
IVOMD, %	52.6	(32.3 - 58.9)
Ca, %	13.49	(10.20-17.58)
P, %	0.64	(0.46 - 0.74)
Na, %	0.11	(0.05 - 0.23)
Fe, ppm	20903	(19000-22500)
Cu, ppm	92	(85 - 96)
Zn, ppm	113	(95 - 145)

a Mean and range values; all values expressed on dry matter basis

Incorporation of sludge containing diatomaceous earth up to the level of 12% of dietary DM increased ($P < 0.05$) OM intake in Expt 1, while levels of 16% and 24% in Expt 2 appeared ($P < 0.05$) to be associated with a lesser increase in OM intake than that observed in the same experiment for the 8% level of dietary incorporation. In Expts 1 and 2 there was a decrease ($P < 0.05$) in OM digestibility, and linear regression indi-

1. Project financially supported by Fundación POLAR, Caracas, Venezuela

cated that OM digestibility was depressed by 0.2% for each % unit of incorporation of sludge in the diet. Liveweight gains were not different($P < 0.05$) within Expt 1, but in accord with the increased intake of digestible OM, liveweight gain was increased ($P < 0.05$) at the 8% level of dietary sludge in Expt 2.

Table 2. Effects on intake and growth of West African sheep of incorporating various levels and forms of sludge into the diet (N = 5 for each treatment).

	Level of sludge (%)	Intake OM (% LW)	Dig OM (%)	Gain (g/d)	FC
Expt 1	0	3.0^a	56^a	37^a	15.6
31 d	4(+DiaE)	3.5^{ab}	49^b	44^a	15.4
	8(+DiaE)	3.7^b	52^{ab}	51^a	13.9
	12(+DiaE)	3.7^b	52^{ab}	26^b	26.8
Expt 2	0	2.7^b	65^a	57^a	8.4
23 d	8(+DiaE)	4.5^a	64^{ab}	146^b	6.1
	16(+DiaE)	3.7^{ab}	61^b	59^a	11.7
	24(+DiaE)	3.2^b	61^b	37^a	17.4
Expt 3	0	3.8^a	75^a	151^a	7.1
43 d	10(-DiaE)	4.2^a	62^b	138^a	9.2
	A-10(-DiaE)	3.8^a	62^b	157^a	6.8
Expt 4	D-16(+DiaE)	3.1^a	60^a	40^a	19.1
23 d	D-16(-DiaE)	3.5^a	68^b	58^a	12.7
	W-16(+DiaE)	2.1^b	62^a	-58^b	-
	W-16(-DiaE)	2.5^b	66^b	-70^b	-

Initial LW: Expt 1:16.3 kg; Expt 2:1.17 kg; Expt 3:20.6 kg and Expt 4:19.5 kg.
OM: organic matter; LW: liveweight; Dig: Digestibility; FC: feed conversion, kg feed DM/kg liveweight gain; +DiaE or -DiaE: sludge containing or not containing diatomaceous earth respectively; A-10: ash derived from this proportion of sludge; D: diet fed dried; W: diet fed fresh.
Letters indicate differences between means within each experiment.

Expt 3 was intended to determine if the increased intake of digestible OM due to sludge incorporation in the diet was due to the organic or inorganic components of the sludge. However, in this experiment OM intake was not affected by the incorporation of the sludge in the diet, and there were no differences due to the incorporation of entire sludge or only the ash derived from the sludge in the diet. There was however a 13% depression ($P < 0.05$) in OM digestibility. In Expt 4 the effects of drying the mixtures of brewers grains and sludge, and of using sludge with or without diatomaceous earth were examined. Intake of OM tended to be greater ($P < 0.05$) and intake of digestible OM was significantly greater ($P < 0.05$) when diatomaceous earth was not incorporated in the sludge. There was a large and significant ($P < 0.05$) increase in OM intake due to drying the brewers grains-sludge mixture, due probably to de rapid fermentation and putrification of the wet mixtures resulting in an unpalatable ration for the sheep.

The results of Expt 5 are shown in Table 3. There were no differences in pH, total VFA concentration and molar proportions of acetic propionic and butyric, between diets. Rumen $N\text{-}NH_3$, through a 24 hour cycle, showed consistently higher values for the diet which included RSB.

Solubilities of total nitrogen in 0.15 M NaCl and phosphate buffer (pH 7.0) were 21.0% and 18% respectively.

Table 3. Average rumen values of pH, VFA and $N\text{-}NH_3$.

Measurements	Diet Without RSB	With RSB
pH	6.5	6.4
Total VFA, m mol/l	90.2	86.9
Acetic, %	68.8	68.3
Propionic, %	19.4	18.8
Butyric, %	8.9	9.2
Higher VFA, %	3.0	3.8
$N\text{-}NH_3$, mg N/l	204	344

Conclusions

The work carried out so far indicates that RSB is a resource of low energy (high ash), medium nitrogen and high calcium content. It is possible to use it as a feedstuff for ruminants. It appears important to consider processing of RSB to avoid putrification, while elimination of diatomaceous earth is desirable. Incorporation of up to 10% of the ration did not affect, or in some experiments increased, intake of digestible OM and weight gain.

References

(1) Beaudouin, J., Shirley, R. L. & Hammell, D. L., J. Anim. Sci. 50:572, 1980.
(2) Bertrand, J. E., Lutick, M. C., Breland, H. L. & West, R. L., J. Anim. Sci. 50: 35, 1980.
(3) Goto, I., Masuda, Y. & Senuki, M., Sci. Bull. Fac. Agric. Kyushu Univ. 28:115, 1974.
(4) Goto, I. & Masuda, U., Sci. Bull. Fac. Agric. Kyushu Univ. 28:151, 1974.
(5) Hackler, L. R., Neumann, A. L. & Jhonson, B. C., J. Anim. Sci. 16:125, 1957.
(6) Hallford, D. M., Hudgens, R. E., Morrical D. G., Shoenemann, H. M., Kiesling, H. E. & Smith, G. S., J. Anim. Sci. 54: 922, 1982.
(7) Kienholz, E. W. & Moreng, R. F. Poultry Sci. 60:1879, 1981.

EARTHWORMS AS CONVERTERS OF ORGANIC WASTE

Ir. H.C. Reijntjes
Vermico, co-operative association of earthworm farmers
Stadsweg 88, 9793 PD Winneweer (Gr.), Holland

Summary

Some species of earthworms can be used on a profitable base in the management of organic waste. On small scale this is done by Verm ico. Organic waste of domestic origin is decomposed by earthworms (Eisenia foetida e.o.) and microbes into stabilized humus, vermicompost. Both earthworms and vermicompost are marketed. Earthworms are appreciated for the ir high protein content and can be used as fish-bait and in the diets of fish and poultry.Vermicompost is willingly used by market-gardeners (biological) and growers of potplants e.o. for its good effect on plant growth.
The author believes that in the future vermicomposing could be come suitable for mass-production.

Introduction

In nature earthworms are important converters of raw organic waste into stabilized humus. Their activities increas the soil fertility and consequently improve plant growth. Their tunnels and castings ameliorate the soilstructure and enhance the microbial activity. Their castings are an important source of nutrients which aren't susceptable to leaching.
Some species of earthworms, the so-called manure - or compost-earthworms, to which Eisenia foetida belongs, are by their enormous reproduction capacity, profitable as production animals. In the U.S.A. but also in Canada, England, Italy, Japan, Thailand, Taiwan and many other countries earthworms are propagated as fish-bait and/orfor conversion of organic waste. In the U.S A and Japan earthworms, especially Eisenia foetida, are succesfully used for sludge-stabilisation in sewage-processing. The products of earthworm farming, earthworms and castings (vermicompost) have both good qualities. Earthworms have a high protein-content (ca. 23% of dry matter of which ca. 58% proteins) and can be used in deits of poultry and fish e.o.. Vermicompost has a very good effect on plant growth. The exact reason of this is not yet known (the buffering and nourishing humuscomplex, the enhanced microbial activity or(?) growth-inducers ?). The chemical analyse of vermicompost doesn't explain this effect good enough.
On account of its good results vermicompost is used by market-gardeners (biological), growers of pot-plants, for the maintenance of indoor-plants, lawns and sports-grounds and after desinfectation of hothouses.

Research on earthworms , especially for waste management, is being done in the U S A and England. Research on vermicompost is still, to our knowledge, almost a barren field.

The co-operative association "Vermico"

Vermico is a co-operative association of earthworm farmers whose object it isto market the products of its members, to increase the knowledge conserning the propagation of earthworms and the production of vermicompost, to distribute this knowledge under its members, to controle the quality of the products and other activities which can be of benefit to the associated farmers. Our young and fast growing association is convinced that, by its activities, it can contribute to resolve the problems concerning the management of organic waste of municipalities. Earthworm farming, as propagated by us, also could crea te employment for many.

The proces of production

Our farmers are mainly using organic waste of domestic origin and horse- ór cow-manure as the basic materials for the propagation of earthworms. Commenly Eisenia foetida is used as earthworm specie but it is also possible to use Lumbricus rubelles, Dendroaena subrubicunda or Eudrilus eugeniae.
The organic waste is collected by a s.c. "peel-collector". Municipalities are normaly very willing to support our projects as they could diminish their expences for garbadge collection. After the collection the organic waste is preselected, chopped and mixed. This raw compost can be directly used. It is set up in long ridges and inocculated with adult earthworms. Under optimale conditions, humidity, pH, salinity and temperature (20 - 25° C. which is obtained through heating) these earthworms are reproducing very fast so that after 6 weeks already enough biomass is obtained to decompose, with the aid of a very active microbe population, the raw organic matter into stabilized humus, vermi--compost. Nearly all the organic matter is than once eaten by earthworms and turned over into earthworm castings.
This proces of decomposition takes about 4 months, the time necessary for young worms to grow up to adults. At this point the earthworms are seperated from the vermicompost and prepared for marketing. The vermicompost itself has to ripen and dry. Depending on its destination the vermicompost may be sieved, cleaned of insects, mixed with other composts and packed.
On the market "Oorsprong" vermicompost is for sale in ½ l. boxes and shortly also in 5 and 50 l. bags and as potting-earth in 5 and 20 l. bags. "Oorsprong" vermicompost is also to be sold in bulk.

In the future it should be possible to produce and

sell earthworms and vermicompost as mass-products. At the moment our method of production is still rather labour- and space-intensive but this can for sure be improved. The basic materials, at this moment waste, are readily available. It is even possible to ferment the organic waste (especially the surplus of manure) to obtain biogas. The residual sludge afterwards can be vermicomposed.
Vermiprotein as mass-product is of interest to industrial processing by food- and farmaceutic-industries. Vermicompost can, as mass-product partly replace chemical fertilizers.

References

Edwards,C.E. and Lofty,J.R ,1977, Biology of earthworm s, 2 ed.- chapman and Hall, Londen.

Hoogerkamp,M. et al.,1982, Effects of earthworms on grassland in recently reclaimed polder soils in the Netherlands, Wageningen.

Knieriemen,D.,1982, Zur Bedeutung von Regenwürmern für Umsetzung und Bodenverbesserung. Zeitschrift für Vegetationstechniek 5 W-Germany.

Loehr,R.C., Neuhauser,E. et al. 1982, Waste management using earthworms- engineering and scientific relationships. Dep. of Agr. Eng. Cornell Un. ,Ithaca , New York, U.S.A..

Mekada,H.,Hayashi,N. et al. 1979, Performance of growing and laying chickens fed diets containing earthworms (Eisenia foetida), Japanese Poultry Science 16, Japan.

Schulz,E.,Graff,O.,1977, Zur Bewertung von Regenwürmmehl aus Eisenia foetida als Eiweissfuttermittel. Landbauforschung Volkenrode, 27 Jhrg. Heft 3, W-Germany.

Lunt,H.A., Jacobson,H.G M.,1944, The chemical composition of earthworm casts. Soil Science 1944.

Mackay, A.D., Syers,J.K. et al. 1982, Plant availability of phosphorus in superphoshate and a phosphate rock as influenced by earthworms. Soil Biol. Biochem. Vol14, 1982, Great-Britain.

Prominent research institutes are:
Department of Agricultural Engineering,
Cornell University , Ithaca, New York, U.S.A..
Rothamsted Experimental Station, Herts, England.

MANURE-LOADED FISH PONDS: SOME INSIGHTS GAINED BY STABLE-ISOTOPE ANALYSES

Gerald L. Schroeder

Department of Animal Sciences, Agricultural Research Organization
Bet Dagan, Israel

The high fiber, ash and NPN content of manures make them poor direct feeds. Modification is necessary. In ruminant husbandry, the microbial activity of the rumen can perform this function. Fish ponds acting as a sort of sun-lit, facultative rumen, host the necessary organisms, autotrophic and heterotrophic, to convert manures into effective foods for target aquatic animals, grown the ponds. The efficiency of the fish pond in performing this function is surprising. In earthen, stagnant, freshwater ponds, with stocking densities at 1 to 2 fish/m^2 of pond area, fish yields are 20 to 30 kg/ha/day, averaged over the entire grow-out period. When grass-eating carps are included in the polyculture and grass added as well as manure, or when ducks are fed directly over the pond, yields reach 40 kg/ha/day. Substituting fish meal enriched feed pellets (25% protein; 15% fish meal; 70% sorghum; 15% soybean oil meal) for the manure, the fish yield rises only by 20% to 30%, yet the cost of the pellets is 10 times the cost of the manure delivered to the pond. The efficiency of conversion of manures into fish growth is similar to that of feed pellets. Typically 2 to 3 kg of feed pellets are required to produce 1 kg fish growth. With manure, 2 to 4 kg of manure organic matter (ash-free dry weight) are required. For the manure (an indirect feed) to function as efficiently as the feed pellets, the food web converting the manure into a feed must be short. From our studies of cellulose digestion in manured fish ponds, the conversion of manure crude fiber into microbial slimes occurs primarily at the sediment-water interface. The crude protein content of the slime plus fiber substrate reaches 15 to 20% within 3 to 5 days residence at the pond bottom. Ciliate activity at times looks very much like that observed in a rumen. For the pond to be efficient, the entire range of natural foods must be harvested by the fish. Stable isotopes have let us learn which fish species are active in harvesting the several trophic levels of the natural food supply.

Common carp carbon isotopes match closely the organic carbon of the ponds bottom. This carbon has its origin 1/2 from manure and 1/2 from precipitated microalgae. Tilapia carbon matches the algal growth abundantly found on rock surfaces submerged on the banks. Silver carp carbon matches 100% the microalgae unless fresh manures that flocculate in the pond water are added. Then SC match this fresh manure plus algae. This is also true for Big head carp (both SC and BH are filter feeders). The grass eating Wuchang fish carbon shows 2/3 manure, 1/3 grass.

BIOGAS AND SOLID BY-PRODUCT FROM A POULTRY WASTE DIGESTER

Jason C. H. Shih

Department of Poultry Science, North Carolina State University, Raleigh, N. C. 27695, U.S.A.

Poultry Waste Digestion

The caged layer waste was demonstrated to have a high potential for biogas production in the laboratory (Huang & Shih, 1981; Huang et al., 1982). A high rate of gas produced at 4.5 v/v/day (methane 3.0 v/v/day) can be reached at 50°C, 4-day retention time (RT) and 6% volatile solid (VS) concentration. If this potential can be obtained on a poultry farm, the process of anaerobic digestion for waste treatment and energy production would be economically attractive.

A simple and low-cost poultry waste digester (PWD) system was designed and constructed on the NCSU research farm (Steinsberger & Shih, 1984a). The digester, attached to a 4,000-hen house, was made of two plastic bags with insulation, a heating system, a hot water tank, and other metering equipment. In two years' operation, the gas can be produced consistently at a rate of 4.0 v/v/day (methane 2.2 v/v/day) with 4-day RT and 3% VS. At this optimal operation, the gas rate reached 90% of the laboratory operation. It was considered as a success of translating laboratory findings to a farm operation. However, a higher loading with 6% VS concentration was not reached as in the laboratory. This might be due to the reduction of the digester volume by the solid accumulation in the digester bag.

Solid by-product

Using the biogas heat, the sludge out of the PWD was dried to produce a solid by-product (SBP). SBP was chemically and biologically evaluated for its nutritional value (Steinsberger & Shih, 1984b). The product was analyzed to contain 3%N, 3.9%P 18.5%Ca, 8.6%K, 1.3%Mg, 10% true protein, and some water-soluble vitamins. The availability of P in SBP for growing broiler chicks was determined by a slope ratio method by comparing with graded levels of $CaHPO_4$ and SBP in experimental diets. After three weeks of feeding, it was demonstrated that SBP had no toxicity and supported animal growth by providing P with an availability of 90%. Evaluations of other nutrients in SBP are also being investigated.

The anaerobic digestion of poultry waste is a process which offers options for the generation of biogas energy and the production of a feed supplement by using the energy for drying. It would be interesting to compare this process with the process of ensiling and refeeding to ruminants. The comparison is made in the following table.

	Ensiling-Refeeding	Thermophilic Anaerobic Digestion
Process	batch	continuous
Rate	slow	fast
Cost	low	high to medium
Water use	low	high
Energy	in feed	in biogas
Nitrogen	recycled	recycled
Minerals	recycled	recycled
Vitamins	?	synthesized
SBP	?	synthesized
End waste	ruminant waste	removed
Pathogens	reduced	totally destroyed
Other products	none	possible

Perspectives

Although we had some initial success in experimenting a new PWD system, more research is needed to make the process technically and economically feasible. The acceptability and practicality will be based on several important criteria. First, the gas production rate must be high enough to guarantee a net gain of energy. From our PWD system, a surplus of 51% was gained after substrating the input of operational energy. When the rate is high, a shorter retention time can be reached and consequently a smaller digester is needed for a given amount of waste to be treated. For instance, a 4-day RT was used in our system which means the digester volume is only one-third of a digester volume when operated at a 12-day RT. A smaller digester will critically reduce the capital cost for construction.

The new technology has to be appropriate which means low in cost and simple in operation. The price of the system has to be affordable by the farmer. The process must be so simple that it can be easily learned and managed by the farmer.

The last and probably the most important influence on the economics of the system is an efficient utilization of all the products from the system. Three types of products are generated: gas (biogas), liquid (effluent), and solids (solid sludge). Several studies in my laboratory have indicated promises. Biogas is a readily useful energy source for heating and generating electricity. But it is more economical to use the energy on site. A biogas fueled hot-water drying bed was constructed for drying crops or solid sludge. It had a heating efficiency of 60% (Jiang et al., unpublished). the liquid effluent was added to a fish pond. Because of the nutrient content in the pond, the fish grew bigger than in the control pond without the effluent (Shih, unpublished). The solid sludge was dried to produce the solid by-product (SBP) which was used as a feed supplement for minerals, protein, and some vitamins (Steinsberger & Shih, 1984b).

In conclusion, caged layer manure can be treated by the process of thermophilic anaerobic digestion at a high rate and with a low-cost digester. The system produced a surplus of biogas energy on the farm. This energy could be used to dry the solid sludge from the digester to generate a solid by-product which has nutritional value for feed supplement.

References

Huang, J. J. H. & J. C. H. Shih, 1981. The potential of biological methane generation from chicken manure. Biotech. Bioeng. 23:2307-2314.

Huang, J. J. H., J. C. H. Shih & S. C. Steinsberger, 1982. Poultry waste digester: from the laboratory to the farm. In: F. Vogt (Ed.): Energy conservation and use of renewable energies in bio-industries, 2. Pergamon Press, Oxford, p. 376-383.

Steinsberger, S. C. & J. C. H. Shih, 1984a. Construction and operation of a simple and low-cost poultry waste digester. Biotech. Bioeng. (in press).

Steinsberger, S. C. & J. C. H. Shih, 1984b. Availability of phosphorus in solid by-product from the poultry waste digester. Poultry Sci. (submitted).

DISCUSSION OF SESSION 4, MICROBIAL PRODUCTS FROM WASTE

Dr.Ir. E.J. van Weerden
Research Institute in Animal Nutrition and Toxicology, Wageningen, The Netherlands

Discussion summarized by E.J. van Weerden

Short communications of Dr. J. Shih (North Carolina State University, Raleigh, U.S.A.) on: biogas production from poultry manure

Dr. Shih mentioned first the 3 stages of the development of an anaerobic, thermophylic poultry waste digester:

- laboratory scale work to define the potential of poultry waste for biogas production. This potential proved to be very satisfactory.
- semi-practical scale studies to check stage 1 proved that under these conditions approximately 90% of the potential found in stage 1 could be attained.
- practical scale to test the economical feasibility of the system. Criteria are:
  - high gas production. 49% of the gas produced in this digester is used to maintain the system and 51% is surplus, that can be used for other purposes (heating, drying, electricity).
  - stable gas production. The variation with time in this system was 5-10%.
  - simple, low-cost set-up in order to keep costs as low as possible.
  - all products produced must be utilisable, i.e. gas, effluent and solid biomass as biogas production alone cannot justify this operation (under U.S.A.-conditions). Effluent may be used in fishproduction. Solid biomass (dried by the biogas) may be fed to animals (Ca and P contents high and high P-availability (90%)).

In the discussion of this short communication, Prof. Vandepopuliere (U.S.A.) put forward some questions regarding the energy cost of drying the fermentation sludge and the feasibility of not drying the sludge, but directly feeding it to fish or animals.

Dr. Shih replied that the total surplus of biogas produced (i.e. 50% of total) is needed to dry the sludge, so in that case the energy balance of the whole system is zero. No data are available on the energetic efficiency of the system when the sludge or the total methane digesta is directly fed to fish or animals.

A second short communication was given by Mr. A.C. Reijntjes (Vermico, The Netherlands) on the use of earthworms as waste converters. Mr. Reijntjes stressed the evidence that earthworms, though not being microbes, can convert on a profitable base organic waste materials into protein. A rough calculation indicates that earthworms can produce anually around 100 tonnes of biomass, equivalent to 15 tonnes of protein per ha.

1. Discussion on the paper of Dr. Söder

- A question of Dr. W. Edel (The Netherlands) concerned the possible effects of feeding fish with animal manure or human excreta on the microbiological status of the fish or their intestinal tract.

  Dr. Söder answers that no carry-over of pathogenic bacteria has been shown, however, the situation with respect to viruses is not so clear. An important point is here, that before consuming the fish an adequate heat treatment (frying or cooking) takes place. Experience over long times in Indonesia and India has learned, that under the conditions in these countries no major problems were met.

- Dr. E.J. van Weerden (The Netherlands) asked for comment on the possibilities to apply economic, low-key technology in order to pasteurize/sterilize human excreta before this material is used as a feedstuff for fish.
  Dr. Söder replied that steam-sterilization is nearly always too expensive, but solar-heat pasteurization might offer a solution.
- Prof.Dr. E.H. Ketelaars (The Netherlands) asked for comment on the feasability of the integrated systems of fish ponds-animal production units and the problems to be solved.
  Dr. Söder mentioned experiences in Israel, where these integrated farming systems were not successful because on practical farms these technologies are too difficult to apply in a small-scale set-up; it is possible that in a semi-industrial set-up the conditions are better, but more expertise is needed.

2. Discussion on the paper of Dr. Zadrazil

- Ir. N.M. van Wageningen (The Netherlands) put forward a question regarding the figures presented on the digestibility of straw treated with different fungi: is the loss of organic matter compensated by the improvement of digestibility and how was performance of the animals eating the straws.
  Dr. Zadrazil replied that it is in all these processes a balance between loss of organic matter and increase of digestibility. The aim is a specific degradation of lignine and not a degradation of cellulose and/or hemicellulose. Digestibility was determined in vitro and, in some cases, also in vivo. In vivo digestibility was, in one experiment, lower than in vitro digestibility, so more research is needed in this field.
  Dr. G. Hof (The Netherlands) mentioned in this respect the experience that animals did not eat the fungal material at all, only after drying feedconsumption was no longer a problem, but this is an expensive way. Acceptability of these materials must always be carefully checked.
  Dr. E.J. van Weerden (The Netherlands) came back to the question of losses of organic matter, i.e. lignine, cellulose/hemicellulose, caused by fungal growth on straw: the Chilean white rot fungus on wood produces a material with 80% cellulose and 1% lignine, but what are the losses of cellulose before this stage is reached?
  Dr. Zadrazil commented that this result of fungal activity was only found under the specific climatic conditions in Chili (low temperature and very much rain). Brown-rot fungi behave quite differently, their activity results in an increase of lignine content and a decrease of cellulose/hemicellulose content of the wood.
  Dr. N. Lang Mathiesen (Denmark) asked about the effect of the lower soluble-sugar content in fungal-treated straw on the activity of rumen microörganisms.
  Dr. Zadrazil commented that only in the first,colonisation stage of fungal growth soluble-sugars are decreasing; afterwards, fungi produce extracellular cellulases and content of soluble sugars in the substrate gradually increases.
  Ir. G. Montsma (The Netherlands) draws

attention to the process used in Western Europe when liberating the flax-fibres by a brief rotting process; can this type of fungal activity not be used for pre-digesting straw?

Dr. Zadrazil assumes that in the flax-rotting process no delignification of the fibres takes place, but it is mainly a decomposition of the parenchymal hemicelluloses.

Dr. J. Shih (U.S.A.) asked which end-products arise from the fungal delignification of straw or wood, are these possibly phenolic compounds and could these compounds be toxic?

Dr. Zadrazil confirmed that some phenolic compounds may be formed during lignine decomposition, but no specific data on amounts nor on toxicity of these compounds are available.

The chairman amplified that this discussion shows once more the need for a multi-disciplinary study of the many aspects of these fermentation processes and including in these studies also the toxicological assessments.

LIST OF PARTICIPANTS

International Symposium 'Animals as Waste-Converters'

BELGIUM

Borloo
Laboratory for nutrition and hygiene
Proefgroevestraat 10
9230 Melle-Gent

C. Boucque,
National Institute for Animal Nutrition
Scheldeweg 68
B-9231 Melle-Gontrode

D.J. Roele
Kemin Europa N.V.
Industrie Zone "Wolfstee"
2410 Herentals

R. de Wilde
Laboratorium voor Diervoedingsleer
Heidestraat 19
B-9220 Merelbeke

CAMEROON

H.N.L. Endeley
National Adv. School of Agriculture
BP 138 Yaounde

CANADA

J.D. Summers
Department of Animal and Poultry Science
University of Guelph
Guelph Ontario N1G 2W1

DENMARK

H. Mathiesen
N.L. Mathiesen APS.
Alf. Christensensv. 9A
DK 2850 Naerum

N. Mathiesen
N.L. Mathiesen APS.
Alf. Christensensv. 9A
DK 2850 Naerum

EGYPT

M.A. El-Ashry
Faculty of Agriculture
Ainshams University
Shoubra el Kheima
Cairo

M.K. Hathout
Animal Production Research Institute
Ministry of Agriculture
Nadi el Seid Street
Dokki-Giya

INDIA

G.Krishna
Department of Animal Nutrition
College of Animal Sciences
Haryana Agricultural University
Hissar (125004)
Haryana

INDONESIA

Koentjoko
Department of Animal Nutrition
Faculty of Animal Husbandry
Brawijaya University
Malang

I. Soebagio
Faculty Peternakan
University Brawijaya
Malang

KUWAIT

M.A. Razzaque
Kuwait Institute for Scientific Research
P.O. Box 24885
Safat

MEXICO

M.G. Ortega
Departement de Produccion Animal
Institucion Nacionale de la Nutricion
"Sal Zub"
Calle Vasco de Quiroga no. 15
Col. Tlalpan del.Tlalpan 14000

NETHERLANDS

J.H. Aalberts
International Agricultural Centre
P.O. Box 88
6700 AB Wageningen

F.P.W. Aarts
International Education Barneveld College
International Training Centre on Animal
Husbandry and Milling Technology
P.O. Box 64
3770 AB Barneveld

P.W.M. van Adrichem
Department of Animal Physiology
Agricultural University
Haarweg 10
6709 PJ Wageningen

V. Ast
Agricultural College KNBTB
BadenPowellstraat 1
5212 BW 's Hertogenbosch

A. Baas
Drogerij Marknesse B.V.
Dronterweg 29
8251 PA Dronten

H. Bakker
Department of Tropical Animal Husbandry
Agricultural University
Marijkeweg 40
6709 PG Wageningen

A. Bentum
Agricultural University
Marijkeweg 40
6709 PG Wageningen

H. Beumer
Institute for Cereals, Flour and Bread, T.N.O.
P.O. Box 15
6700 AA Wageningen

H.J.M. van Binsbergen
Euroconsult
P.O. Box 441
6800 AK Arnhem

S. Boer Iwema
Department of Animal Nutrition
Agricultural University
Haagsteeg 4
6708 PM Wageningen

F. de Boer
Institute for Livestock Feeding and Nutrition Research
Runderweg 2
P.O. Box 160
8200 AD Lelystad

H. Boer
Department of Animal Nutrition
Agricultural University
Haagsteeg 4
6708 PM Wageningen

N.M. Bolder
Centre for Research and Information for Poultry Husbandry "Het Spelderholt"
Spelderholt 9
7361 DA Beekbergen

M. Boon
Department of Tropical Animal Husbandry
Agricultural University
Marijkeweg 40
6709 PG Wageningen

G. van den Bosch
Cooperatief Centraal Laboratorium CEHAVE NV
NCB-laan 52
Veghel

ten Brinke
International Education Barneveld College
International Training Centre on Animal Husbandry and Milling Technology
P.O. Box 64
3770 AB Barneveld

J. van Bruchem
Department of Animal Physiology
Agricultural University
Haarweg 10
6709 PJ Wageningen

W. Brunekreef
Hendrix' Voeders B.V.
P.O. Box 1
5830 MA Boxmeer

W. Davids
Ministry of Agriculture
Bezuidenhoutseweg 73
2594 AC 's Gravenhage

G.Y. v.d. Dries
Department of Microbiology
Agricultural University
P.O. Box 8033
6700 EJ Wageningen

W. Edel
Ministerie van Welzijn, Volksgezondheid en Cultuur
P.O. Box 439
2260 AK Leidschendam

Emmens
Agricultural College
Prof. H.C. van Hallstraat 1
9726 AG Groningen

R.M. van Engelen
Department of Animal Husbandry
Agricultural University
Marijkeweg 40
6709 PG Wageningen

A. van Es
Institute for Livestock Feeding and Nutrition Research
Runderweg 2
P.O. Box 160
8200 AD Lelystad

T. Gebrehiwet
Department of Animal Breeding
Agricultural University
Marijkeweg 40
6709 PG Wageningen

C.P. Gootjes
International Agricultural Centre
P.O. Box 88
6700 AB Wageningen

J. Haaksma
I.R.S., Nutritional Department
P.O. Box 32
4600 AA Bergen op Zoom

L.A. den Hartog
Department of Animal Nutrition
Agricultural University
Haagsteeg 4
6708 PM Wageningen

P.J.W. ten Have
Rijks Agrarische Afvalwaterdienst
Kemperbergerweg 67
6816 RM Arnhem

Heinrich
Ministry of Agriculture and Fisheries
Bezuidenhoutseweg 73
P.O.Box 20401
2500 EK Den Haag

G.P.A. Henderikx
Gist-Brocades, Materialendienst
P.O. Box 1
2600 MA Delft

T. Hermans
Centre for World Food Studies
Bornsesteeg 65
6708 PD Wageningen

G.den Hertog
Agricultural College
Brinkgreverweg 69
7413 AB Deventer

J. de Heus
De Heus Veevoeder N.V.
Langstraat 96
3771 BJ Barneveld

W. Heye
Agricultural University
Marijkeweg 40
6709 PG Wageningen

K.W. van der Hoek
Rijks Agrarische Afvalwaterdienst
Kemperbergerweg 67
6816 RM Arnhem

J. Hoekstra
Department of Tropical Animal Husbandry
Agricultural University
Marijkeweg 40
6709 PG Wageningen

G. Hof
Department of Animal Nutrition
Agricultural University
Haagsteeg 4
6708 PM Wageningen

T. Hovers
Windmill Holland B.V.
P.O.Box 58
3130 AB Vlaardingen

E. Jaarsma
Bokkumer Wal 4-5
8494 NP Nes (Akkrum)

A.J.M. Janssen
Salveriastraat 11
5462 AP Veghel

R. de Jong
Directoraat Generaal Internationale Samenwerking
Ministery of Foreign Affairs
Breehoven 19
6721 SP Bennekom

A.A. Jongebreur
Centre for Research and Information for
Poultry Husbandry "Het Spelderholt"
Spelderholt 9
7361 DA Beekbergen

G. Kaasschieter
Department of Tropical Animal Husbandry
Agricultural University
Marijkeweg 40
6709 PG Wageningen

G.J.M. van Kempen
Hendrix' Voeders B.V.
P.O. Box 1
5830 MA Boxmeer

J.J.M.H. Ketelaars
Centre for Agrobiological Research
P.O. Box 14
6700 AA Wageningen

E.H. Ketelaars
Department of Animal Breeding
Agricultural University
Marijkeweg 40
6709 PG Wageningen

G.J. Kremers
Ministerie van Welzijn, Volksgezondheid
en Cultuur
P.O. Box 439
2260 AK Den Haag

B. Krijger
Department of Tropical Animal Husbandry
Agricultural University
Marijkeweg 40
6709 PG Wageningen

H.J.M. Kruydenberg
Projectbureau Energie Onderzoek
P.O. Box 342
7300 AH Apeldoorn

L.Chr.N. de La Lande Cremer
Institute for Soil Fertility
Oosterweg 92
P.O. Box 30003
9750 RA Haren (Gr)

A. Land
Ansinghlaan
3431 GT Nieuwegein

H.J. Leutscher
Institute for Research on Storage and Processing of Agricultural Produce
Bornsesteeg 59
P.O. Box 18
6700 AA Wageningen

A.C.M. Mentink
Marijkeweg 28 - E1
6709 PG Wageningen

J.Middeljans
Ned.Th.Ch.Fabriek
Damsingel 30
9262 NC Suameer

J. Miedema
Agricultural College
Brinkgreverweg 69
7413 AB Deventer

A. Moen
HVA-Holland Agro Industries B.V.
29, Leidseplein
1017 PS Amsterdam

G. Montsma
Department of Tropical Animal Husbandry
Agricultural University
Marijkeweg 40
6709 PG Wageningen

van Muilwijk
Cebeco Handelsraad
Blaak 31
3011 GA Rotterdam

R.W.A.W. Mulder
Centre for Research and Information for Poultry Husbandry "Het Spelderholt"
Spelderholt 9
7361 DA Beekbergen

P.J.G. Oostenbach
Department of Animal Science
Agricultural University
Marijkeweg 40
6709 PG Wageningen

J. Oosterom
Rijksinstituut voor de Volksgezondheid
P.O. Box 1
3720 BA Bilthoven

A. Osinga
Research and Advisory Station for Cattle Husbandry
Runderweg 6
8219 PK Lelystad

M.C. Papadopoulos
Department of Animal Science
Agricultural University
Marijkeweg 40
6709 PG Wageningen

Van der Ploeg
UT Delfia Mengvoeder B.V.
Maarssenbroeksedijk 4
3606 AN Maarssen

Van Ree
K. de Vries en Zn
Industrieweg 12
3771 MD Barneveld

H.C. Reijntjes
Lieverseweg 22
9321 XN Peize

C.W. Scheele
Centre for Research and Information for Poultry Husbandry "Het Spelderholt"
Spelderholt 9
7361 DA Beekbergen

L.M. Schoonhoven
Department of Animal Physiology
Agricultural University
Haarweg 10
6709 PJ Wageningen

G. Schouten
Schouten Giessen B.V.
Postbus 1
Giessen

J.B. Schutte
Foundation ILOB, Institute for Animal Nutrition Research
Haarweg 8
P.O. Box 9
6700 AA Wageningen

B. Smits
Institute for Livestock Feeding and Nutrition Research
Runderweg 2
P.O. Box 160
8200 AD Lelystad

G. Snoek
De Buurt 2
1606 AG Venhuizen

S.F. Spoelstra
Institute for Livestock Feeding and Nutrition Research
Runderweg 2
P.O. Box 160
8200 AD Lelystad

Spreeuwenberg
Cooperatief Centraal Laboratorium CEHAVE NV
NCB-laan 52
5462 GE Veghel

Staps
Instituut voor Afvalstoffenonderzoek
Natriumweg 7
P.O. Box 184
3800 AD Amersfoort

A. Steg
Institute for Livestock Feeding and Nutrition Research
Runderweg 2
P.O. Box 160
8200 AD Lelystad

L. Tjoonk
Institute for Livestock Feeding and Nutrition Research
Runderweg 2
P.O. Box 160
8200 AD Lelystad

J.H. Veenbaas
Institute for Research on Storage and Processing of Agricultural Produce
Bornsesteeg 59
P.O. Box 18
6700 AA Wageningen

H.H. Veldman
Ansjovisweg 5
8251 RW Dronten

H. Vertregt
Department of Animal Husbandry
Agricultural University
Marijkeweg 40
6709 PG Wageningen

N.M. van Wageningen
Department of Tropical Animal Husbandry
Agricultural University
Marijkeweg 40
6709 PG Wageningen

P. van der Wal
Foundation ILOB
Institute for Animal Nutrition Research
Haarweg 8
P.O. Box 9
6700 AA Wageningen

E.J. van Weerden
Foundation ILOB
Institute for Animal Nutrition Research
Haarweg 8
P.O. Box 9
6700 AA Wageningen

F.M. van Werven
Van Werven Consulting B.V.
Churchilllaan 1
5242 BD Rosmalen

G. Zemmelink
Department of Tropical Animal Husbandry
Agricultural University
Marijkeweg 40
6709 PG Wageningen

A.J. van der Zijpp
Department of Animal Husbandry
Agricultural University
Marijkeweg 40
6709 PG Wageningen

NEW ZEALAND

A.F. Niederer
The Meat Research Institute of New Zealand
P.O. Box 617
Hamilton

SAUDI-ARABIA

M.J. Head
The Arab Investment Company S.A.A.
P.O. Box 4009
Riyadh

SWEDEN

B. Frank
Department of Animal Husbandry
Swedish University of Agricultural Science
P.O. Box 59
S-230 53 Alnarp

SWITZERLAND

A. Schurch
Borglernstrasze 69
8700 Kusnacht-ZH

UNITED KINGDOM

G. Alderman
Ministry of Agriculture, Fisheries and Food
Great Westminster House
Horseferry Road
London SW1P 2AE

G.D. Barber
Agricultural Chemical Division
The West of Scotland Agricultural College
Auchincruive, Ayr
KA6 5HW Scotland

Ch.L. Benham
Ministry of Agriculture, Fisheries and Food
Government Buildings, Colly Park
RG1 6DT Reading

A.P. Hopwood
Alwatech UK Limited
33A Park Parade, Hazlemere
High Wycombe, Buckinghamshire

D.H. Machin
Industrial Development Department
Overseas Development Administration
Tropical Development and Research Institute
Culham/Abingdon
Oxfordshire OX14 3DA

P.B. Newman
Meat Research Institute
Agricultural Research Council
Langford
Bristol BS18 7DY

J.C.H. Shih
Biotechnology
University College
Newport Road
Cardiff CF2 1TA

U.S.A.

J.P. Fontenot
Department of Animal Science
Virginia Polytechnic Institute and State
University
Blacksburg
Virginia 24061

J.M. Vandepopuliere
Poultry Science Department
College of Agriculture
University of Missouri-Columbia
65211 Missouri

VENEZUELA

R. Parra
Fac. de Agronomica
Universidad Central de Venezuela
Institute de Produccion Animal
El Limon - Maracay

WESTERN GERMANY

C.J. Söder
Kernforschungsanlage
Institut für Biotechnologie
Postfach 1913
5170 Julich

F. Zadrazil
Institut für Bodenbiologie
Bundesallee 50
3300 Braunschweig

AUTHOR INDEX

Al-Awadi, A.
Alderman, G.
Al-Nasser, A.
Benham, C.L.
Boer, F. de
Boer Iwema, S.
Bolder, N.M.
Bongers, L.J.G.M
Boucque, Ch. V.
Buysse, F.X.
Carera, J.
Cottyn, B.G.
Dixon, R.M.
Edel, W.
El-Ashry, M.A.
El-Boushy, A.R.
El-Mawla, A.
El-Serafy, A.M.
Endeley, H.N.L.
Es, A.J.H. van
Escobar, A.
Fiems, L.O.
Fontenot, J.P.
Have, P. ten
Hector, D.A.
Holsheimer, J.P.
Hopwood, A.P.
Janssen, W.M.M.A.
Jayasuriya, M.C.N.
Kaasschieter, G.A.
Ketelaars, E.H.
Khattab, H.
Krishna, G.
Machin, D.H.
Meyer, H.
Mulder, R.W.A.W.
Newman, P.J.
Oostenbach, P.J.G.
Oostendorp, D.
Ortega, M.E.
Papadopoulos, M.C.
Parr, W.H.
Parra, R.
Parra, O. de
Perdok, H.B.
Perez-Gil, F.
Pone Kamden, D.
Razzaque, M.A.
Reijntjes, H.C.
Rojas, O.
Roman, N.
Roodbeen, A.E.
Salman, A.J.
Scheele, C.W.
Schoonhoven, L.
Seliman, H.
Shih, J.C.H.
Smits, B.
Söder, C.J.
Spoelstra, S.F.
Steg, A.
Swan, A.
Tchouken, M.D.
Tchoumboue, J.
Tiwari, S.P.
Tjoonk, L.
Vandepopuliere, J.M.
Vries, A.W. de
Wageningen, N.M. van
Wal, P. van de
Walker, G.
Weerden, J.E. van
Zadrazil, F.
Zemmelink, G.