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Digestibility for veal calves of fish protein concentrates

I Prepared on a pilot scale; the absorption of iron

II Prepared on a commercial scale

With separate summaries

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Abstract

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Half or three-quarters of the milk protein was replaced by one of several fish proteins in balance trials lasting 6 or 3 days with 2 or 3 Dutch Black Pied bull calves each.

The digestibility coefficients for the fish proteins varied from 85 to 92% between the types of fish protein concentrates and with the proportion in the diet.

Iron absorption coefficient was usually 20% or more, but did not exceed 48%. Some of the rations with fish protein concentrates obviously contained substances or factors that caused a remarked decrease in the haemoglobin concentration in the calves' blood.

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Contents

I Digestibility for veal calves of fish protein concentrates prepared on a pilot scale, and the absorption of iron from such concentrates

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1 INTRODUCTION

The artificial milk products so far customarily used for veal calves are composed mainly (approx. 70%) of skim-milk powder and whey powder.

The mixtures also contain approximately 20% of vegetable and/ or animal fat, and 6% to 10% of easily convertible carbohydrates, together with vitamins, minerals, an antibiotic and an emulsifier.

The protein content varies from 20% to 25% and is obtained almost entirely from the dried milk products.

The Fe content in such mixtures is usually below 20 mg of Fe per kg of the products (ppm) (Boeve, 1971).

According to van Kraaykamp (1969), the average daily growth achieved under commercial conditions with these mixtures is 950 g. The meat has the white colour popular with consumers.

Van Kraaykamp's research also shows that feed costs have a very marked effect on the profitability of calf-fattening.

Feed costs are determined by: (1) the cost of the feed and (2) the feed conversion (= kg of feed per kg of growth). Improvement of one of these factors will have a favourable effect on the profitability of calf fattening.

The cost of the feed can be reduced by replacing the skim-milk powder contained in the usual mixtures by cheaper raw materials such as starch, fat, and vegetable or animal protein. One of the possibilities is replacement of the milk protein by fish protein.

Wendlandt et al. (1968) calculated a maximum digestion coefficient of 70% from the results of trials with a specific kind of fish protein (approx. 83% crude protein (cp) and 10% to 13% ash).

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On the other hand, Huber & Slade (1967) give digestion coefficients of approx. 80%. According to Gropp (1972, quoting van Hellemond) digestion coefficients of approx. 88% were obtained using a Swedish product (Prot-Animal), for veal calves. Gropp also states that the digestion coefficients of the protein obtained from the fish product NFPC are about 84% (1972, quoting van Weerden). One of the main themes of this research was the obtaining of fish proteins that could be easily digested by veal calves (digestion coefficient > 90%).

Replacement of a large proportion of the milk protein in milk-substitute mixtures for veal calves by fish protein increases the Fe content of the mixtures, the amount of the increase depending, of course, on the Fe content of the fish protein concentrate and the replacement percentage. Continuous feeding of veal calves over a long period with rations fairly rich in iron impairs the colour of the meat (Charpentier, 1966, and Orth et al., 1966).

Research on iron absorption and on the iron-binding capacity of chelate-forming substances therefore plays an important role in the use of protein products as substitutes for milk protein, as they usually contain a relatively large quantity of iron. One of the aims of the research described was to determine the degree of iron absorption when feeding veal calves with mixtures containing fish protein products.

Each of the fish products prepared on a pilot scale that were involved in the research contained a quantity of trimethylamine oxide (TMAO). According to Ender & Helgebostad (1968) this substance, which is present in certain species of fish, causes anaemia in mink if they are fed on raw fish. Animals fed on cooked fish showed no symptoms of anaemia, whereas the addition of 0.6 to 0.8 grams of TMAO per day to the cooked fish did cause anaemia.

Since the fish products examined contained TMAO, the Hb content of the blood was examined during the trials.

The fish products were in part prepared and made available on the recommendation of Mr P.Nieboer of Den Boer's Handelsonderneming B.V., Schiedam. The technological processes undergone by the products examined were carried out by Mr J.Bon of the TNO Institute for Fishery Products in Ymuiden.

2 THE TRIALS

2.1 Products

Digestion, N-balance and Fe-balance trials were carried out with four fish products, viz.:

product B = freeze-dried whitefish meal from deboned fish
product D = spray-dried herring meal
product E = spray-dried whitefish meal
product F = steam-dried whitefish meal from mechanically deboned fish.

The chemical composition of the four products is given in Table 1.

2.2 Method of preparing the fishmeal for testing

Product B Eviscerated whiting and haddock, deep-frozen at sea, was thawed in running tap-water. The fish was mechanically deboned in a Baader-694 bone separator, yielding 78% deboned fish pulp. The pulp was spread in thin layers in a blast air freezer and frozen to -40°C and then stored at -25°C. After the frozen fish pulp had been reduced in a mincing machine, the temperature meanwhile rising to -7°C, the test material was once again cooled down to -25°C and transferred in insulated containers to an Atlas type commercial drying cabinet. The drying time was 20 hours and the plate temperature 50°C. The maximum time spent by the dried pulp in the cabinet at 50°C was estimated to be about five hours. The dried fishmeal was packed in plastic bags in hermetically sealed tins in a nitrogen atmosphere and stored at room temperature.

Table 1. Chemical composition of the fish products B, D, E and F.

Product	Dry matter (%)	Crude protein (%)	Crude fat (%)	Ash (%)	Fe (mg/kg)	TMAO (mg/kg)
B	94.29	87.07	3.57	7.21	± 50	5000
D	93.97	43.20	32.20	4.02	± 30	5000
E	93.41	64.04	2.57	5.90	± 70	5000
F	97.56	92.28	4.35	3.72	± 100	3750

Product D Herrings, deep-frozen at sea, were thawed in air at a temperature of 18°C. The fish were gutted in a BTC (Steen type) filleting and eviscerating machine, a yield of 91% being obtained. They were then mechanically deboned in a Baader-694 bone separator, a yield of 84% of the deep-frozen weight being recorded. The fish pulp from the bone separator was mixed with water and lactose and finely ground in a Fryma toothed disc mill. The suspension was pumped at a temperature of 40°C into the drying chamber of a Stork-Volma spray-drier with an air temperature of 140°C at the inlet and 100°C at the outlet. During spray-drying, crust formation took place, resulting in a low yield of dry powder.

Product E Eviscerated lean fish (haddock, whiting and codling), deep-frozen at sea, was thawed in still air and deboned in the Baader-694 bone separator. The deboned fish was then mixed with water and lactose and finely ground in the Fryma mill. The mixture was dried in the Stork-Volma spray-drier, losses due to crust formation occurring once again.

Product F Eviscerated cod, coalfish and whiting, deep-frozen at sea, were thawed in air at a temperature of 18°C. The heads were cut off and the fish then deboned in the Baader-694 bone separator. The deboned fish was acidified with hydrochloric acid to a pH of approx. 6.0, cooked, pressed and dried in a continuous CRO fishmeal plant (capacity 100 kg/h). The cooking temperature was approx. 107°C. The pressed fish cake was dried first by indirect heating with steam of 3 atm to approx. 30% moisture content, and then with steam of 2 atm to the final moisture content. The stickwater released during pressing was not recovered.

2.3 Programme for the trials

In digestion trials with veal calves the principle is often adopted of replacing one of the feed constituents of the control (i.e. basal) mixture by the feed to be tested. As with other species of animals, the aim in digestion trials with veal calves is to replace the maximum quantity possible. In this way any adverse effects of the replacement product on digestion can be quickly and effectively demonstrated.

In digestion trials with veal calves, too, the feed regime is generous (approx. 1.8% of body weight); the animals therefore show reasonable growth during the trials, enabling a comparison to be made with farm conditions.

The following was the programme chosen for this series of digestion trials: three days transitional period, four days preliminary period and two main periods of six days each.

The KV 87 and KV 88 trials consisted of only one main period of six days, subdivided into two periods of three days. In the case of these trials the regimes were also reversed but this procedure was later abandoned in view of the results of another investigation in Hoorn (Smits et al., second part of this report).

Table 2 shows the general scheme of the digestion trials.

The chemical and the percentage composition of the mixtures tested and the composition of the premix used are given in Tables 3, 4 and 5, respectively.

Table 3 also shows the substitution percentage, a figure that indicates what percentage of the protein used in the mixture came from the substitute fish protein.

The daily quantities of feed were weighed out per animal on one day before the commencement of a trial, a representative sample of the feed being taken at the same time. For the purpose of the iron balance determinations a sample of the water was also taken daily, to enable the intake of iron from drinking water to be ascertained. The faeces produced by each animal in each main period was collected and stored at 4°C. To prevent changes taking

Table 2. Arrangement of the trials.

Trial No.	Animal No.	Mixture
KV 87	22	control
87	21	B
88	22	B
88	21	control
89	23	B
89	24	B
90	25	D
90	26	D
93	29	E
93	30	E
94	31	F
94	32	F

Table 3. Chemical composition of the mixtures and the replacement percentage of the milk protein.

Mixture	Dry matter (%)	Crude protein (%)	Crude fat (%)	Ash (%)	Fe (mg/kg)	% Replacement
Control	96.16	26.58	18.96	7.14	12	-
B	96.89	26.82	19.41	4.75	19	65
D	95.78	24.83	19.32	5.53	17	51
E	95.87	25.71	19.60	4.82	25	72
F	97.15	26.03	19.39	3.84	49	75

Table 4. Composition of the mixtures (%).

	Control	B	D	E	F
Skim-milk powder	70.00	22.50	34.00	20.00	18.75
Fish protein	-	20.00	29.10	28.75	21.25
Lactose	-	27.50	15.50	21.25	30.00
Maize glucose	4.00	4.00	4.00	4.00	4.00
Maize starch	6.00	6.00	6.00	6.00	6.00
Tix-o-sil (free flowing agent)	1.00	1.00	1.00	1.00	1.00
Palm kernel fat	8.50	8.50	4.20	8.50	8.50
Lard	8.50	8.50	4.20	8.50	8.50
Lecithin	1.00	1.00	1.00	1.00	1.00
Glycerol monostearate	0.30	0.30	0.30	0.30	0.30
Premix	0.853	0.853	0.853	0.853	0.853

Table 5. Premix components in the feed mixture (%).

Iodized salt	0.100
Ca hydrophosphate	0.300
Mg oxide	0.120
Cu oxide	0.003
Vitamin A	0.005
Nicotinamide	0.006
Vitamin C	0.010
Vitamin D_3	0.001
Vitamin E	0.008
Terramycin preparation	0.300
Total	0.853

place in it, 4 ml of formalin was added to the faeces produced each day. A percentage sample was taken daily of the urine produced. To prevent N losses, a sufficient quantity of sulphuric acid was put in the bucket in which the urine was collected to ensure that the environment into which it was admitted was strongly acid. The calves were housed in fully galvanised iron boxes. As an extra safeguard against accidental intake of iron important parts of the boxes were insulated still further with hardboard sheets and hard plastic pipes. Synthetic materials were used for tethering and feeding the calves. The minimum weight of the ten Dutch Black Pied calves used in these trials was 55 kg. Van Weerden et al. (1970) and Smits et al. (this publication, p.28) state that young calves (weighing approx. 50 kg) have a lower digestive capacity than older calves (weighing approx. 85 kg). Moreover, during the first weeks of their lives diarrhoea and intake problems often have to be contended with.

A blood sample was taken from each calf at the beginning and end of a digestion trial, to gain an idea of changes in the haemoglobin content

2.4 Progress of the trial

Owing to illness and diarrhoea, calf No. 21 had to be removed from trial KV 88.

The digestion trials with Products E and F progressed undisturbed. The feed intake was good and the consistency of the faeces normal.

In the trials with the mixture containing Product B, one animal was found to have slight diarrhoea. There was no intake problem.

An intake problem was, however, encountered in the trial with Product D. At first the substitution percentage was approx. 75%, but owing to intake difficulties it had to be cut down to about 50%. Although this reduced the intake problems, calf No. 25 continued to have intake difficulties.

3 RESULTS

The Hb content of the blood of the calves used in this series of digestion trials is recorded in Table 6.

The table shows a marked reduction in the Hb content for the various products.

Table 6. Survey of the Hb content of the blood, g Hb per 100 ml blood.

Trial No.	Animal No.	Feed	Hb(start)	Hb(end)	Decrease per week
KV 87	22	control	-	-	-
87	21	B	-	-	-
88	22	B	-	-	-
88	21	control	-	-	-
89	23	B	15.0	10.9	1.0[1]
89	24	B	13.4	12.3	0.3[1]
90	25	D	11.1	8.6	0.8
90	26	D	10.8	7.4	1.1
93	29	E	9.3	7.9	0.5
93	30	E	10.0	8.3	0.6
94	31	F	11.9	10.4	0.5
94	32	F	11.0	9.5	0.5

[1]With these animals the Hb content was determined about 1 week before the start of the trial.

Table 7. Average digestion coefficients of the mixtures and variation coefficients.

Mixture	Digestion coefficients					Variation coefficients				
	Dry matter	Crude protein	Organic matter	Ash	Crude fat + Nfe[1]	Dry matter	Crude protein	Organic matter	Ash	Crude fat + Nfe[1]
Control	95.5	94.9	96.8	78.6	-	0.6[2]	0.3[2]	-	-	-
B	95.7	93.3	96.5	74.9	97.8	1.3	2.2	1.1	6.3	0.8
D	94.5	90.8	95.3	81.3	97.0	0.8	1.3	0.7	3.3	0.5
E	96.2	92.9	97.0	80.8	98.6	0.8	1.4	0.6	4.8	0.4
F	95.2	92.1	96.3	68.7	97.9	0.3	0.3	0.4	2.6	0.4

[1]Nitrogen-free extract.

[2]Variation within the trials.

Table 8. Average digestion coefficients and variation coefficients of the protein from the fish products B, D, E and F and from the control mixture.

	B	D	E	F	Control
Average	92.4	86.9	92.0	91.1	94.9
Variation coefficient	3.2	2.9	1.9	0.4	-

Table 9. Average protein deposition (g/day) and variation coefficients.

Mixture	Protein deposition	Variation coefficient
Control	160	6.6
B	163	16.3
D	160	14.9
E	154	8.4
F	163	2.7
Average	160	
Variation coefficient 2.3		

The average digestion and variation coefficients of the mixtures are stated in Table 7. There are only slight differences in digestibility between the mixtures. That containing Product D shows the lowest digestion coefficients.

The average digestion coefficients of the protein from Products B, D, E and F are given in Table 8. It will be seen that there are only very slight differences in the digestibility of the proteins in Products B, E and F. Moreover, in view of the digestion coefficients of 91% to 93%, the protein in these products must be of very good quality.

The protein in Product D has a lower digestibility, viz. about 87%.

The average protein deposition in grams per day is given in Table 9, which shows that there is no difference in protein deposition per day between the various mixtures. The average protein deposition is about 160 g per day.

Table 10. Average weight of the animals, in kg, and protein deposition, in g per day.

Trial No.	Animal No.	Protein deposition	Approximate average weight
KV 87	22	160	70
87	21	138	70
88	22	154	90
89	23	176	60
89	24	184	65
90	25	141	75
90	26	178	80
93	29	152	60
93	30	156	60
94	31	162	60
94	32	164	70
Average		160	70
Variation coefficient		9.1	

Table 11. Results of the iron balance determinations.

Trial No.	Calf No.	Ration	Experimental period	Fe-content of the ration (mg/kg)	Fe-intake in 6 days (mg)	Dry matter in faeces (g)	Fe excreted in faeces in 6 days (mg)	Apparently absorbed Fe in 6 days (mg)	Apparently absorbed Fe (% total Fe-intake)
87	21	B	1	21	164	231	86	78	48
87	22	control	1	13	98	350	77	21	21
88	22	B	1	20	173	506	137	36	21
89	23	B	1	20	103[1]	250	77[1]	26	25
89	23	B	2	20	90[2]	179	67[2]	23	26
89	24	B	1	20	125	355	135	-10	- 8
89	24	B	2	20	137	206	103	34	25
90	25	D	1	18	102	336	71	31	30
90	25	D	2	18	109	309	79	30	28
90	26	D	1	18	116	379	102	14	12
90	26	D	2	18	124	499	140	-16	-13
93	29	E	1	26	164	300	147	17	10
93	29	E	2	26	180	315	169	11	6
93	30	E	1	26	164	202	109	55	34
93	30	E	2	26	180	237	142	38	21
94	31	F	1	50	322	318	238	84	26
94	31	F	2	50	353	364	290	63	18
94	32	F	1	50	322	329	259	63	20
94	32	F	2	50	353	318	322	31	9

[1]In 5 days.

[2]In 4 days.

Table 10 summarizes the protein deposition per animal per trial. It also contains the average weights of the calves.

The results of the different iron balance determinations are given in Table 11.

Most of them show positive iron balances, i.e. the total iron intake was larger than the faecal iron output. Only in two cases (KV 89-24-B-1 and KV 90-26-D-2) was more iron excreted than was taken up with the feed. If the differences in iron absorption between main periods 1 and 2 in the same test calf are examined, it is found that in trials KV 89-23 and KV 90-25 these differences are slight, viz. 3 mg and 1 mg of iron, respectively. The greatest difference occurs in trial KV 89-24, where 44 mg more iron was absorbed in main period 2 than in main period 1. In all other cases the differences between the two successive main periods lie between the aforementioned limits, more iron always being absorbed, however, in main period 1 than in main period 2.

There are also considerable differences in iron absorption between calves of the same trial and main period. The biggest difference (46 mg) occurs in trial KV 90 between calf No. 25 and calf No. 26 in main period 2. The difference is smallest (11 mg) in trial KV 89, this being between calves No. 23 and No. 24 in main period 2. The remaining differences lie between these limits. The greatest absolute quantity of absorbed iron (84 mg in 6 days) was found in trial KV 94-31-F-1. Finally it should be noted that the iron absorption coefficient (in roughly 2/3rds of the total number of balances) is 20% or more (max. 48% in KV 87-21) and that there are no significant differences between the 4 types of rations as regards this percentage.

4 DISCUSSION

Method of preparation

The herring meal (D) has a very high fat content, because during its preparation no oil is removed. The fat content of filleted herring varies between 3% and 20%, the highest content occurring in July and the lowest in April (Lovern & Wood, 1937). The meal had a rancid smell, which was perceptible immediately after drying. The high fat content was a contributory factor in the rancidity. Tests showed that the herring oil had already oxidised during thawing. Determination of the thiobarbituric acid content as an indicator of the occurrence of rancidity in frozen and thawed herring showed an increase of more than 200% after thawing in air, and of only 25% after thawing in brine. An increase of approx. 100% would have led to a degree of rancidity perceptible to humans.

On average, marine fish contains between 0.1% and 1.0% of trimethylamine oxide (TMAO) (Shewan, 1951; Dyer, 1952 and Hughes, 1959). During storage at temperatures above freezing point, TMAO is converted into trimethylamine (TMA) by the enzymatic action of bacteria. Mutatis mutandis, the TMAO content of fishmeal could be used as a measure of the freshness of the raw material if the method of preparation were known, since during the cooking and drying of fish TMAO is gradually converted into TMA or may be lost with the stickwater. It can be concluded from the analytical data that in all probability freeze-drying and spray-drying do not affect the TMAO content.

TMAO is proof against enzymatic reduction at pH values of 6 or lower (Castell & Snow, 1949).

Be this as it may, it can be inferred from a high TMAO content in fishmeal (e.g. of 0.5%) that the raw material from which the meal was prepared must have been of good quality and the processing conditions unexceptionable.

Hb content

In this series of digestion trials the Hb content of the blood showed an unmistakable decrease, as can be seen from Table 6. The average weekly decreases for Products B, D, E and F were approx. 0.6, 0.9, 0.6 and 0.5, respectively. Although these figures relate only to a relatively small number of observations, a marked decrease in the Hb content can be clearly observed.

Smits et al. (report not yet published), when feeding with a control mixture containing approx. 15 mg/kg Fe, arrive at an average weekly decrease of 0.3 to 0.4 g of Hb per 100 ml of blood. A decrease of the same order of magnitude can also be calculated from data published by van Hellemond (1970).

The approx. 0.6 g% per week decrease observed in the digestion trials with fish proteins could indicate the presence of a certain causative substance or combination of substances and/or factors in the mixtures tested.

Ender & Helgebostad (1968), in the trials they performed, came to the conclusion that TMAO has an anemogenic effect.

Digestion coefficients

In contrast to the paucity of information available on protein from fish products, various data have been published on the digestibility of milk protein.

Van Weerden et al. (1970) state the amounts of milk protein digested by calves weighing approx. 50 kg, 85 kg and 105 kg to be 93.5%, 95% and 94%, respectively.

In the trials with fish proteins, the digestibility of the milk protein was 94.9%, which tallies with the published figures. The digestion coefficients of the protein in fish products B, E and F are remarkably high, viz. 92.4%, 92.0% and 91.1% respectively. These figures are markedly higher than those found in literature on the subject.

The conclusion can be drawn from the figures now obtained that it is possible by using technological processes to manufacture a fish protein that can be easily digested by veal calves.

The digestibility of Product D is somewhat lower, viz. 86.9%, while a slight negative effect can likewise be observed on the digestibility of the fraction crude fat + N-free extract of the mixture in which fish Product D is used (see Table 7). Possibly the high fat content in fish product D is partly responsible for this.

Protein deposition in g per day

Tables 9 and 10 show that the average daily protein deposition at an average weight of approx. 70 kg is 160 g. No difference in protein deposition between the mixtures could be demonstrated. Van Weerden et al. (1970) also arrive at a protein deposition of approx. 160 g a day for a weight of approx. 70 kg.

Iron absorption

Because the fish protein products investigated contain an excess of a natural iron-binding substance, the generally high iron balances obtained (20% ore more) are somewhat surprising. It was, however, ascertained that the decrease in the haemoglobin content was more than normally pronounced. From this it was concluded that the iron-binding substance inhibits the assimilation of iron in haemoglobin rather than the absorption of iron as such.

The results obtained in these trials relate only to the digestibility of the products tested. Problems regarding growth, feed conversion, long-term intake, meat quality, whiteness of the meat, etc., cannot be solved by means of digestion trials and N-balance trials of short duration. Such matters have to be dealt with by carrying out feeding trials with larger numbers of animals.

SUMMARY

- The digestibility of the protein from four fish products was determined in a series of digestion trials with veal calves. 65% to 75% of the total protein ration came from fish products B, E and F, and 50% from Product D. N-balance trials were also carried out to determine the daily protein deposition.
- The research also included iron balance determinations to ascertain the iron absorption.

In addition, the Hb content of the blood was ascertained at the beginning and end of the trials.
- The trials went smoothly, except that in the case of the mixture containing fish product D the substitution percentage had to be lowered to about 50 in order to obtain a good intake. Product D contained at least 30% of herring oil, which was slightly rancid.
- The high TMAO content of fish products B, D, E and F showed that the raw material used in their preparation was of good quality and the processing conditions were unexceptionable.
- The digestion coefficients of the protein from fish products B, E and F were 92.4%, 92.0% and 91.1%, respectively. That for the protein from Product D was found to be 86.9%. The results obtained justify the conclusion that by using technological processes it is possible to make a fish protein that can be very easily digested by veal calves. This is even the case with high substitution percentages.
- The average daily protein deposition was 160 g for an average animal weight of approx. 70 kg. Practically no differences were observed between the mixtures.
- The iron absorption coefficient is in most cases 20% or higher,

but does not exceed 48%.

- The fairly high figures obtained are somewhat surprising, since the fish protein products tested contain trimethylamine oxide. The decrease in the haemoglobin content was, on the other hand, greater than normal.
- From the marked decrease in the Hb content the conclusion can be drawn that the mixtures used contain one or more substances and/or factors that caused this decrease.
- More research is required if an answer is to be found to the question whether and to what extent TMAO is responsible for the decrease in the Hb content.

LITERATURE

Boeve,J., 1971. Vervanging van melkeiwit door plantaardig en/of dierlijk eiwit in kunstmelk. Landbouwk. Tijdschr. 83: 360-365.

Castell,C.H. & J.M.Snow, 1949. The effect of pH on the enzymatic reduction of TMAO. J.Fish. Res. Bd Can. 7: 561-562.

Charpentier,J., 1966. Pigmentation musculair du veau de Boucherie. Annls Zootech. 15: 361-366.

Dyer,W.J., 1952. Amines in fish muscle. IV. TMAO content of fish in marine invertabrates. J.Fish. Res. Bd Can. 8: 314-324.

Ender,F. & A.Helgebostad, 1968. Studies on the anemiogenic properties of trimethylamine oxide, an etiological factor in fish-induced anemia in mink. Acta vet. Scand. 9: 174-176.

Gropp,J., 1972. Auf dem Weg zum Milchproteinersatz. Kraftfutter 55: 294-298.

Hellemond,K.K.van, 1970. Over het hemoglobine-gehalte van het bloed en de vleeskleur van mestkalveren. Landbouwk. Tijdschr. 82: 139-142.

Huber,J.T. & L.M.Slade, 1967. Fish flour as a protein source in Calf Milk Replacers. J.Dairy Sci. 50: 1296-1300.

Hughes,R.B., 1959. Chemical studies on the herring (Clupea harengus) .1. Trimethylamine Oxide and Volatile Amines in Fresh, Spoiling and Cooked Herring Flesh. J. Sci. Fd Agric. 10: 431-436.

Kraaykamp,E.C.van, 1969. De kalvermesterij in Nederland. Public No. 35, Proefstation voor de Akker- en Weidebouw, Wageningen.

Lovern,J.A. & H.Wood, 1937. The variation in the chemical composition of herring. J. Mar. biol. Ass. U.K. 22: 281-293.
Orth,A. & R.Diews, 1966. Versuche über den Einflusz von Eisen im Futter auf die Fleischfarbe von Schnellmastkälbern. Wirtschaftseigene Futter 12: 35-42.
Shewan,J.M., 1951. The biochemistry of fish. Biochem. Soc. Symp. No. 6, University Press, Cambridge, p. 28-48.
Smits,B., K.Vreman, J.Boeve, J.Bon & P.Nieboer, 1974. Digestibility for veal calves of fish protein concentrates. II. Digestibility for veal calves of fish protein concentrates prepared on a commercial scale. Agric. Res. Rep. 819, Pudoc, Wageningen, p. 00-00.
Weerden, E.J.van, A.J.H.van Es & K.K.van Hellemond, 1970. Eiwit- en vetaanzet van mestkalveren bij verschillende rantsoenen. Landbouwk. Tijdschr. 82: 115-120.
Wendlandt,R.M., K.E.Harshbarger & R.D.Genskow, 1968. Growth response of calves fed milk replacers containing fish protein concentrate. Mimo University of Illinois.

II Digestibility for veal calves of fish protein concentrates prepared on a commercial scale

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1 INTRODUCTORY REMARKS

In the first part of this publication, Smits et al. showed that by technological processes fish protein concentrates can be manufactured that are very easily digestible by veal calves. The products tested had, however, been prepared on a pilot scale.

As a continuation of this research, we carried out trials with fish protein concentrates that had undergone no special technological processing. The results of these trials will be discussed in the following report.

Our thanks are due to Mr P.Nieboer of Den Boer's Handelsonderneming B.V., Schiedam, who supplied the various consignments of fish protein concentrates.

2 THE TRIALS

2.1 Products

The products examined in these trials were:

CPSP : hydrolysed fishmeal of French origin; fish oil largely removed by centrifuging
Pescamino : extracted fishmeal from Norway
Product A : extracted fishmeal from Norway
Product C : extracted anchovy meal
Product G : steam-dried whitefish meal with reduced ash content
Product H : steam-dried whitefish meal with increased ash content.

CPSP, Pescamino and Product C are available commercially. Product A is a somewhat modified version of Pescamino.

Products G and H originate from the same raw material. The difference in ash content was achieved by partially sieving out the bones from part of the consignment, resulting in a product with a reduced ash content. These bones were then added to the remainder of the original material, giving a product with an increased ash content.

Products G and H can be manufactured on a large scale as an economically sound proposition.

The chemical composition of the six fish products is given in Table 1.

2.2 Programme

The digestion trials with the six products referred to can be divided into two groups, viz.:

1. the trials with CPSP and Pescamino, and
2. the trials with Products A, C, G and H.

The reason for this distinction is that the programmes, duration etc. of the trials very quite considerably.

Pescamino and CPSP In order to get a proper appreciation of the digestibility of the fish products tested, each was subjected to three digestion trials involving the replacement of 50%, 75% and 100% of the milk protein by the products concerned.

This series of digestion trials included reverse trials, i.e. the animal that had been given Mixture A in the first trial received Mixture B in the second, while the other calf was given the feeds in the reverse order. Table 2 shows the general scheme of the trials.

All the digestion trials in this series were carried out with two male calves of the Dutch Black Pied breed, the animals weighing approx. 50 kg at the commencement of the trials.

Table 1. Chemical compositon (%) of the fish products Pescamino, CPSP, A, C, G and H.

Product	Dry matter	Crude protein	Crude fat	Ash
CPSP	98.0	84.2	9.9	6.0
Pescamino	95.3	83.6	2.1	9.8
A	94.5	85.2	1.6	9.8
C	92.5	72.8	1.9	17.0
G	94.9	79.4	4.8	10.8
H	94.8	69.0	4.2	21.4

Table 2. Survey of the trials. In brackets percentage replacement of the control mixture.

Trial No.	Animal No.	Mixture
KV 60	3	control I
60	4	control I
62	3	CPSP (50%)
6	4	Pescamino (50%)
64	3	Pescamino (50%)
64	4	CPSP (50%)
66	3	control II
66	4	control II
68	3	CPSP (75%)
68	4	Pescamino (75%)
69	3	Pescamino (75%)
69	4	CPSP (75%)
71	3	control III
71	4	control III
72	3	CPSP (50%)
72	4	Pescamino (50%)
73	4	Pescamino (100%)
87	22	control IV
91	27	A
91	28	A
92	27	A
92	28	A
100	37	C
100	38	C
101	37	C
101	38	C
103	41	G
103	42	G
103	43	G
104	44	H
104	45	H
104	46	H

As the feed level was high (approx. 1.8% of body weight), the animals showed reasonable growth during the trials, making comparison possible with the circumstances normally found in practice.
Before the commencement of a trial the feed for the entire trial period was weighed out and samples were taken.

The faeces are collected during a main period on a quantity basis and stored in a refrigerator at 4°C; then, at the end of the two main periods, it was homogenized and samples were taken. To prevent changes taking place in the faeces, 3 ml of formalin was added to the faeces produced each day.

The following programme was chosen for this series of digestion trials:
three days transitional period, four days preliminary period and two main periods of three days each.

The chemical and percentage composition of the mixtures examined is stated in Tables 3 and 4, while the percentage composition of the premix used is given in Table 5.

Fish products A, C, G and H When carrying out the digestion trials with these products, the aim was to replace as much as

possible of the milk protein by the products being tested.
For Products A and C the substitution percentage was approx. 75%, and for Products G and H approx. 50%. Unlike the trials with CPSP and Pescamino, those with Products A, C, G and H were not carried out in reverse. Table 2 shows the general scheme of the digestion trials.

The digestion trials with Products A and C were all carried out on two male Dutch Black Pied calves, and those with Products G and H on three calves. The minimum weight of the calves was 65 kg, since it had been found in the trials with CPSP and Pescamino that calves whose body weight was approx. 50 kg were unable to digest the protein of the control feed very well (VC cp < 90%).
These figures agree with the results of trials carried out by Van Weerden et al. (1970).

The feed level in the trials with Products A, C, G and H was approx. 1.8% of the body weight. The weighing out of the feed and the handling and processing of the faeces was done in the same way as for the trials with CPSP and Pescamino.

The programme for the trials with Products A, C, G and H was as follows: three days transitional period, four days preliminary period and two main periods of six days each.

The chemical and percentage composition of the mixture tested is given in Tables 3 and 4 respectively. Table 5 shows the percentage composition of the premix.

Table 3. Chemical composition of the mixtures (%) and replacement percentage of the milk protein by fish protein.

Product	Dry matter	Crude protein	Crude fat	Ash	% Replacement
Control I	96.09	24.74	19.49	6.92	-
Control II	95.90	25.14	19.33	6.94	-
Control III	95.26	24.76	18.72	6.90	-
Control IV	96.16	26.58	18.96	7.14	-
CPSP (50%)	95.46	24.13	20.05	4.95	49
CPSP (75%)	96.60	24.25	20.59	4.18	69
Pescamino (50%)	95.43	24.97	18.72	5.61	50
Pescamino (75%)	95.80	25.62	19.07	5.06	72
Pescamino (100%)	96.75	26.76	19.61	4.58	100
A	96.71	26.42	18.88	5.30	73
C	96.20	23.10	18.87	7.31	75
G	95.68	26.88	[1]	6.09	50
H	95.38	26.93	[1]	8.15	50

[1]Not determined

Table 4. Composition of the mixtures (%). In brackets percentage replacement of the control mixture.

Feedstuffs	Controls	CPSP		Pescamino			A	C	G	H
		(50%)	(75%)	(50%)	(75%)	(100%)				
Skim-milk powder	70.00	35.00	20.00	35.00	20.00	- -	20.00	17.50	36.00	36.00
Fish protein	-	14.00	20.00	15.00	22.00	29.00	22.50	23.75	17.00	19.60
Lactose	-	21.00	30.00	20.00	28.00	33.50	27.50	28.75	15.00	12.40
Maize glucose	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Maize starch	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	7.00	7.00
Tix-o-sil (free flowing agent)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Palm kernel fat	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50	9.00	9.00
Lard	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50	9.00	9.00
Lecithin	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Glycerol mono-stearate	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Premix	0.853	0.853	0.853	0.853	0.853	0.853	0.853	0.853	0.853	0.853

Table 5. Premix components in the feed mixture (%).

Iodized salt	0.100
Ca hydrophosphate	0.300
Mg oxide	0.120
Cu oxide	0.003
Vitamin A	0.005
Nicotinamide	0.006
Vitamin C	0.010
Vitamin D	0.001
Vitamin E[3]	0.008
Terramycin preparation	0.300
Total	0.853

2.3 Progress of the trials

In the series of digestion trials with CPSP and Pescamino, difficulties repeatedly arose as regards intake and faeces consistency when changing over from one product to the other. In trials KV 62 and KV 73, calf No. 3 had to be removed from the trials owing to illness and diarrhoea. Occasionally this calf also had difficulty in taking up the ration.

No difficulties were observed, however, with calf No. 4 in the trials with CPSP and Pescamino.

In KV 91 and KV 92 the mixture containing Product A was not taken up at all readily by calf No. 28, whereas no difficulty was experienced by calf No. 27.

Intake of the mixture containing Product C presented no problems. Calf No. 38 had to miss one main period of KV 101 owing to diarrhoea.

The digestion trials with Products G and H went off smoothly.

3 RESULTS

The average digestion and variation coefficients of the mixtures are given in Table 6. There are quite big differences

Table 6. Average digestion coefficients of the mixtures and variation coefficients.

Mixture	Digestion coefficients					Variation coefficients	
	Dry matter	Crude protein	Organic matter	Crude fat	N-free extract	Crude protein	Organic matter
Control I	92.3	88.6	94.3	87.2	100.5	4.4	2.9
Control II	96.6	95.7	97.6	95.4	99.6	0.7	0.5
Control III	95.6	95.1	96.7	91.3	99.1	1.2	0.7
Control IV	95.5	94.9	96.8	96.8[1]		0.3	-
CPSP (50%)	94.4	89.9	95.4	92.1	99.7	2.0	1.1
CPSP (75%)	94.7	89.6	95.9	93.6	100.1	3.0	1.0
Pescamino (50%)	94.4	91.4	95.7	91.7	99.7	1.6	0.8
Pescamino (75%)	93.6	88.4	95.0	91.4	100.1	3.8	1.4
Pescamino (100%)	87.6	76.8	89.4	80.6	100.5	4.3	1.3
A	93.2	87.5	94.5	97.4[1]		6.5	2.9
C	91.5	83.5	93.5	97.0[1]		1.7	0.8
G	93.5	91.9	95.0	96.3[1]		1.8	1.3
H	94.3	92.9	96.5	98.1[1]		1.8	0.8

[1]Crude fat + N-free extract.

between the figures from the trials with the control feed, particularly as regards the digestion of crude protein and crude fat. The trial with control feed I is clearly at a lower level than the other three trials with control feed, viz. 89% as against 95%.

Digestibility proved markedly lower in trial KV 69 as in trial KV 68. This is clearly shown, as far as protein digestibility is concerned, by the following:

Calf No. 3	KV 68, CPSP	(75%)	91.8%
	KV 69, Pescamino	(75%)	85.9%
	difference	d_1	5.9%
Calf No. 4	KV 68, Pescamino	(75%)	90.9%
	KV 69, CPSP	(75%)	87.5%
	difference	d_2	3.4%

$d_1 \neq d_2$

The same phenomenon can be observed in the case of dry-matter, ash and fat digestibility.

The figures from the trials with CPSP show that the digestibility of the protein in the mixture does not decrease as the substitution percentage increases, whereas with Pescamino it does, particularly when there is 100% substitution.

There are fairly big differences between the digestion coefficients of the crude protein (cp) in the mixtures containing Products A, C, G and H. The cp-fraction in the mixtures containing Products G and H is more readily digested than that in the mixtures with Products A and C. The digestion coefficients are 92%, 93%, 88% and 84%, respectively.

The variation coefficient of the digestion coefficient of the cp-fraction in the mixture containing product A is 6.5%, whereas in the case of Products C, G and H it is approx. 1.8%.

The digestion coefficients of the protein from the various fish products are given in Table 7. It can be seen from these figures that there are only slight differences in the digestibility of the cp-fraction between CPSP (with approx. 50% and approx. 75% substitution), Pescamino (with 75% substitution) and Product A. The digestibility of the protein is 86.8%, 87.2%, 85.7% and 84.7%, respectively.
The digestibility of the protein from Pescamino (with approx. 50% substitution), from Product G and Product H is somewhat greater, being 89.6%, 88.9% respectively, whereas the digestibility of Product C is 79.5%.

4 DISCUSSION

The digestibility of control feed I (digestion coefficient cp = approx. 89%) differs markedly from that of control feeds II, III and IV (digestion coefficient cp = approx. 95%). The trial with control feed I was carried out with very young calves (body weight approx. 50 kg). Van Weerden et al. (1970) likewise observed low digestibility for veal calves with a body weight of approx. 50 kg. The digestibility of the protein in the trials with control feeds II, III and IV is at the same level as that stated in the literature.

The digestibility of the protein from CPSP is not affected in these trials by the level of the substitution percentage; it is approx. 87%. The digestibility of the protein from Pescamino decreases from approx. 90% via approx. 86% to 77% for

Table 7. Average digestion coefficients and variation coefficients of the protein from the products CPSP, Pescamino, A, C, G and H.
In brackets percentage replacement of the control mixture.

	CPSP		Pescamino			A	C	G	H
	(50%)	(75%)	(50%)	(75%)	(100%)				
Average	86.8	87.2	89.6	85.7	76.8	84.7	79.5	88.9	90.9
Variation coefficient	8.1	4.4	3.4	5.7	4.3	9.2	2.4	3.6	3.6

substitutions of 50%, 75% and 100%, respectively.

The digestibility of the protein of Product A is virtually identical to that of Pescamino at approx. 75% substitution, being approx. 85%. In the trials with Product A the substitution percentage was also approx. 75%.

The digestibility of the protein from Pescamino (with approx. 50% substitution) and from Products G and H is approx. 90%. These proteins can be readily digested by veal calves. The substitution percentage in the trials with Products G and H was not affected by the ash content.

To sum up, it is possible without drastic and costly technological processing to make fish products that can be readily digested by veal calves, even with high substitution percentages.

SUMMARY

- In a series of digestion trials with veal calves the digestibility of the protein from six fish products was determined. The products were:

CPSP : hydrolyzed fishmeal, France, fish oil removed by centrifuging
Pescamino : extracted fishmeal, Norway
Product A : extracted fishmeal, Norway
Product C : extracted anchovy meal
Product G : steam-dried whitefish meal with reduced ash content
Product H : steam-dried whitefish meal with increased ash content.

In the case of CPSP and Pescamino, three substitution percentages were used, viz. 50%, 75% and 100% (i.e. 50%, 75% and 100% of the protein of the ration consisted of the fish protein in question). In the case of Products A and C a substitution of approx. 75% was used, and in that of products G and H the substitution percentage was approx. 50%.

- The intake of Product A left something to be desired, as did that of Product C, albeit to lesser extent.
- The average protein digestion coefficients were:

CPSP	(50% substitution)	87%	Product A	85%
idem	(75% substitution)	87%	Product C	80%
Pescamino	(50% substitution)	90%	Product G	89%
idem	(75% substitution)	86%	Product H	91%
idem	(100% substitution)	77%		

- From these figures the conclusion can be drawn that the products tested can be readily digested by veal calves, even with substitution percentages of 50% or more.

LITERATURE

Weerden, E.J. van, A.J.H. van Es & K.K. van Hellemond, 1970. Eiwit- en vetaanzet van mestkalveren bij verschillende rantsoenen. Landbouwk. Tijdschr. 82: 115-120.