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Full Length Research Paper

Identification, characterisation and composition of scavengeable feed resources for rural poultry production in Central Tanzania

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A participatory study was carried out in four villages of central Tanzania to appraise existing and potential scavengeable feed resources available for rural poultry. In addition, proximate analysis of selected scavengeable feed resources including chicken crop and gizzards contents was carried out to quantify their feeding value. Results indicate that the most important scavengeable feed resources in the dry season were cereal grains and their by-products, oil seeds and oil seed cakes and in the wet season were forage leaves, flowers, seeds, garden vegetables, insects and worms. Changes in seasonal conditions, farming activities, land size available for scavenging and the flock size had a major influence on the feed availability. The mean dry matter (DM) of the feed resources was 888 ± 1.8 g per kg. Gross energy ranged from 17.1 to 29.3 MJ kgDM^{-1} and crude protein (CP) from 64.5 to 418 g kgDM^{-1}. Crude fibre (CF) ranged from 33.3 to 230 g kgDM^{-1} and ether extract (EE) ranged from 16.0 to 488 g kgDM^{-1}. The mineral composition ranged from 1.5 to 18.4 g kgDM^{-1} for calcium (Ca); 3.6 to 17.3 g kgDM^{-1} for phosphorus (P); 9.5 to 34.5 g kgDM^{-1} for potassium (K) and 0.2 to 8.5 g kgDM^{-1} for magnesium (Mg). Physical analysis of crop and gizzard contents indicated that the diets consumed by scavenging chickens consisted of cereals and cereal by-products (29.0%), vegetables and forage materials (1.8%), seeds and seed by-products (3.4%), insects and worms (0.2%), egg shells, feathers and bones (0.3%), unidentified feeds (41.5%), inert materials (0.8%) and sand/grit (23.0%). The diet consumed as determined from the crop/gizzard contents had DM of 479 ± 9.6 g per kg and metabolizable energy (ME) of 10.1 ± 0.5 MJ kgDM^{-1}. Nutrient composition in kgDM^{-1} of the crop and gizzard contents was: 80.4g CP; 70.7g EE; 45.7g CF; 234g Ash; 6.6g Ca; 6.5g P; 12.1g K and 2.6g Mg. The study showed that the nutrient concentrations of scavengeable feed resources consumed by rural poultry were below the recommended levels for optimum growth and egg production.

Key words: Central Tanzania, rural poultry, scavengeable feed resources, nutrient composition, crop and gizzard.

INTRODUCTION

The livestock industry in Tanzania contributes about 18% of the national GDP and about 30 % of the agricultural GDP, and provides food which is consumed in the form of meat, milk and eggs (URT, 2005). The livestock industry is divided into a traditional and commercial sector. Cattle and poultry are the major livestock species. The poultry sub-sector consists of traditional small-scale poultry production in the rural areas and commercial small to large-scale poultry production in peri-urban and urban areas. The traditional small-scale poultry production is the largest sub-sector and comprises various poultry species such as chickens, ducks, turkeys, geese, pigeons and

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guinea fowls. Most of these species are local ecotypes and account for about 90% of the total poultry population in Tanzania (MOAC, 1995). Due to their high degree of adaptation to a wide range of environments, rural poultry or village poultry are widely distributed throughout the country. Chickens are the most common poultry species in the country, and account for about 95% of total poultry in the traditional sector (MOAC, 1995). These rural poultry are owned by individual smallholder farmers that practise a wide range of management strategies, mainly characterized by hardly any or no inputs for housing, feeding and health care. Free-ranging is the dominant poultry production system practiced by most of the households in rural areas. In this system, poultry usually are allowed to scavenge their own food around home-steads and from the surrounding environments during the daytime. This low-input/low-output system has been a major component of the smallholder farming in the country for centuries. In spite of the social and econo-mical importance of the free-range system, few develop-ments have been undertaken in Tanzania to improve the overall productivity of rural poultry. For example, in the past, breeding programmes were introduced to the villages to improve the productivity of local birds by crossing with exotic cockerels (Goromela, 2000). Such programmes have also been reported in many other African countries (Tadele and Ogle, 1996; Kitalyi, 1998). However, these programmes placed more emphasis on rapid genetic improvement with the justification that improvement in feeding would be inefficient when animals of low genetic potential are raised (Sonaiya et al., 1999). As a result, the majority of these programmes failed due to lack of management skills that were needed for the crossbreds and the management changes that should be adopted by the rural people.

In recent years, there has been a growing awareness of the need to balance the rate of genetic improvement with improvement in feeding and in management (Kitalyi, 1998; Sonaiya et al., 1999; Minga et al., 2000). Moreover, there has been a renewed interest in rural poultry produc-tion and in the potential of rural poultry as efficient con-verters of locally available scavengeable feed resource base (SFRB) into eggs and meat (Kitalyi, 1998; Sonaiya et al., 1999; Minga et al., 2000). In the free-range system, rural poultry obtain their diets mainly from SFRB. However, the amounts and availability of SFRB are not constant throughout the year (Cummings, 1992). Such feed resources tend to vary with factors such as seasonal conditions, farming activities, life cycle of insects and other invertebrates (Roberts, 1995; Tadele, 1996; Sonaiya, 2004). If the supply of SFRB and the seasonal variations is known, efficient strategies for production of scavenging poultry can be developed (Gunaratne, 1999). Thus the objectives of this study were to appraise exist-ing and potential scavengeable feed resources available for rural poultry and quantify their feeding value. The second aim was to determine the constraints with regard to the availability of these feed resources for rural poultry in free-range systems in central Tanzania.

MATERIALS AND METHODS

The study area

This study was carried out in four villages of Bumila, Chitemo and Kisokwe in Mpwapwa district and Chamkoroma in Kongwa district in Dodoma region. Administratively, Central Tanzania comprises Dodoma and Singida regions with a total human population of 2.7 million. About 80% of this population depend on crop and livestock production as the major basis of their livelihoods. Central Tanzania is categorised as a semi-arid zone with a savannah climate charac-terized by a short rainy period of four months between December and May. The average annual rainfall is 450 mm. The average maximum temperature is 28°C and the minimum temperature is 17°C with an average relative humidity of 70%. The villages were selected essentially based on the farming systems being practiced. Bumila and Chamkoroma villages are located in the maize-beans-sunflower based farming system while Kisokwe and Chitemo villages are located in the sorghum-pearl millet-groundnut based farming system.

Identification of available scavengeable feed resources

A reconnaissance survey was carried out in November, 2005 to obtain background information of the above mentioned four villa-ges. A group of 20 - 30 key informants in each village was inter-viewed. Using this background information, the questionnaire for a formal survey was developed and pre-tested for consistency of questions. Then a formal survey was carried out in December, 2005 in the above mentioned villages and the questionnaire addressed feed resources and nutrients eaten by rural poultry in the villages at different times of the year; factors affecting quantity and quality of SFRB and interventions/strategies that should be used to improve feed resource availability. A total of 318 households from the four villages were interviewed with a sample size of 70 - 80 households per village. Most of the respondents were adult women who had responsibilities for the daily management of local birds as their main domain. In addition, a balanced sub-sample of 40 farmers involved in the formal survey from each village was used in group interviews to obtain qualitative information on seasonal availability of SFRB and constraints with regard to the availability of these feed resources. PRA tools such as pair-wise ranking; matrix scoring and direct observations were used. Samples of existing and potential feed resources were collected from interviewed farmers during the household survey. These samples were sorted out in the laboratory and pooled together based on types and varieties of the feed resources. The final feed samples were sub-sampled for the determination of chemical composition.

Characterization of scavengeable feed resource base

Characterization of scavengeable feed resources for rural poultry was carried out to assess the relative availability of each feedstuff separately during the wet and dry season. A relative qualitative scale was developed by farmers and ranged from abundantly available to scarcely available. In addition, a pairwise ranking method was used to rank the most important feedstuffs which had significant impact on the rural poultry production. Feed resources which had the highest scores and ranked from 1 to 6 were considered as the most important feedstuffs in each feed category. Moreover, the factors affecting quantity and quality of SFRB with respect to the variation of energy and protein sources were investigated using matrix scoring method. Using a total of 120 groundnut seeds, farmers assigned these seeds to each month of the year drawn on a flip-chart where 10 seeds per a particular month indicated maximum availability of the feed resources. The number of seeds assigned on each month was counted as scoresor percentage of the feed resources that were more likely to be available and the underlying factors were discussed.

Quantitative assessment of SFRB from chickens' crop and gizzard contents

A quantitative assessment of SFRB in the chickens' crop, proventriculus and gizzard contents was carried out between December 2005 and January 2006. A total of 141 scavenging chickens of both sexes with an average liveweight of 1.2 kg ± 0.3 were randomly purchased from farmers in the four villages for the analysis of crop and gizzard contents. The crop and gizzard contents were used to determine the amount and composition of the diets consumed by scavenging chickens. The chickens were collected directly from the farmers between 11.00 and at 16.00 h. Chickens were weighed before slaughtering using an electronic balance. The chickens were slaughtered according to normal practice on farms and the feathers were removed after dipping the body into hot water. The carcasses were eviscerated and the whole gastro-intestinal tracts were removed and packed in the cool boxes containing ice-packs. Samples of the gastro-intestinal tracts were taken to the laboratory where they were frozen at -30^o C. Later the frozen gastro-intestinal tracts were opened up after thawing in the air for a few hours and the crop, proventriculus and gizzard were eviscerated. The ingested feed materials from crop, proventriculus and gizzard were identified visually using magnifying lenses. Chyme of crop, proventriculus and gizzard was physically separated into different individual feed components. These individual feed components were weighed using electronic balance. In order to determine their proportions on dry weight basis the samples were partially dried at 60^{o}C in the laboratory using an oven.

Chemical analyses of scavengeable feed resources and chickens' crop/gizzard contents

Samples of scavengeable feed resources and samples of chickens' crop and gizzard contents were sub-sampled according to the villages from which they had been collected. All the samples were ground using laboratory mills to pass through a 2 mm screen in order to produce homogenous samples for the analysis of chemical composition. The homogenous samples of feed resources and crop/gizzard contents were analysed for dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF), Ash, calcium (Ca), phosphorus (P), potassium (K), and magnesium (Mg) according to the procedures of AOAC (1985). NFE was estimated from organic matter (OM) minus the sum of amounts of CP, EE and CF (g/kg DM). Gross energy (GE) was determined using a regression equation of the chemical composition of the feed resources as described by Wiseman (1987): GE (kcal/kgDM) = 57.2 CP% + 95.0 EE% + 47.9 CF% + 41.7 NFE%. The Metabolizable energy (ME) of the crop/gizzard contents was determined by calculating the True Metabolizable energy (TME) with the assumption that TME was 8% higher than the ME (Wiseman (1987).

Data analysis

All the data collected were coded and analysed for descriptive statistics for each variable investigated using SPSS programme version 11.0 for Windows 2003.

RESULTS

Scavengeable feed resources available for rural poultry in the villages

The scavengeable feed resources available for rural poultry in the 4 villages of Mpwapwa and Kongwa districts are presented in Tables 1 - 4. The results show that feed resources consisted of energy, protein and mineral/vitamin-rich feedstuffs. About 52.9% of the respondents in Kisokwe, 64.8% in Bumila, 61.6% in Chamkoroma and 46.7% in Chitemo reported that energy-rich feedstuffs were slightly available during the wet season while 80.79% of the respondents in Kisokwe, 82.28% in Bumila, 68.66% in Chamkoroma and 72.6% in Chitemo reported that these feedstuffs were abundantly available in the dry season. Regarding the availability of protein and mineral/vitamin-rich feedstuffs, 64.8% of the respondents in Kisokwe, 70.0% in Bumila, 68.1% in Chamkoroma and 55.7% in Chitemo reported that such feedstuffs were highly available in the wet season while 56.8% of the respondents in Kisokwe, 60.0% in Bumila, 50.7% in Chamkoroma, and 53.9% in Chitemo reported that these feedstuffs were slightly available in the dry season. The study revealed that both conventional and unconventional feedstuffs in all the four-villages were generally similar and abundantly available in certain periods despite the differences in farming systems and climatic conditions.

Characterization of scavengeable feed resources available for rural poultry

The relative availability of scavengeable feed resources during different seasons is shown in Tables 1 - 4. The results indicate that the availability of various SFRB between dry and wet seasons varied widely. Much of this variation is in amounts and in flora and fauna and origin of species available as food for the rural poultry. Most of the energy-rich feedstuffs and some protein-rich feedstuffs particularly sunflower seed cakes and groundnut seeds were abundantly available during the dry season. However, at the end of the dry season and during the wet season (January - April) the availability of these feed resources were relatively low. The protein-rich feedstuffs (insects and earthworms); and mineral/vitamin-rich feedstuffs were abundantly available during the wet season while in the dry season these feedstuffs were relatively low. Among the energy-rich feedstuffs: maize bran, maize brew wastes, maize thick porridge (ugali), maize grains and sorghum grains ranked highest in Bumila village and Chamkoroma village while in Kisokwe village and Chitemo village sorghum ugali, maize ugali, pearl-millet ugali, pearl millet brew wastes, sorghum brew wastes and maize brew wastes ranked highest. In Bumila village and Chamkoroma village the protein/mineral feedstuffs: forage leaves, forage flowers, garden vegetables, tree

Table 1. Relative availability of scavengeable feed resources for rural poultry during wet and dry season as assessed by farmers at Bumila village in Mpwapwa district

Categories of scavengeable feeds	Relative feed availability during wet season[1]						Relative feed availability during dry season[1]						Pair-wise ranking by farmers	
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Total scores	Rank
1. Cereal grains														
Maize	xx	xx	x	x	xx	xxx	xxx	xxx	xxx	xxx	xxx	xx	5	4
Sorghum	xx	xx	x	x	xx	xxx	xxx	xxx	xxx	xxx	xxx	xx	4	5
2. Cereal by-products														
Maize bran	xx	xx	x	x	xx	xxx	xxx	xxx	xxx	xxx	xxx	xx	8	1
Maize brew-waste	xx	x	x	x	xx	xxx	xxx	xxx	xxx	xxx	xxx	xx	7	2
Sorghum bran	xx	xx	x	x	xx	xxx	xxx	xxx	xxx	xxx	xxx	xx	2	7
Sorghum brew-waste	xx	x	x	x	xx	xxx	xxx	xxx	xxx	xxx	xxx	xx	0	9
3. Other cereal and tuber products														
Maize Ugali	xx	xx	xx	xx	xx	xxx	xxx	xxx	xxx	xxx	xxx	xx	6	3
Sorghum Ugali	xx	xx	xx	xx	xx	xxx	xxx	xxx	xxx	xxx	xxx	xx	1	8
Cassava	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	3	6
1. Crop and animal protein feeds														
Sunflower seed cake	x	x	⇩	⇩	⇩	⇩	x	xx	xxx	xxx	xxx	xx	*9*	5
Groundnuts seeds	x	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	8	6
Sesame seeds	⇩	⇩	⇩	⇩	⇩	⇩	x	x	⇩	⇩	⇩	⇩	0	14
Fish meal	x	xx	x	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	3	11
Meat meal	⇩	⇩	⇩	⇩	⇩	⇩	x	x	⇩	⇩	⇩	⇩	1	13
2. Insects and worms														
Earth worms	xxx	xx	xx	xxx	xxx	xx	x	⇩	⇩	⇩	⇩	⇩	4	10
Maggot larvae	xx	xxx	xx	xxx	xxx	xx	x	⇩	⇩	⇩	⇩	⇩	2	12
Termites	xx	xx	xxx	xxx	xxx	xx	xx	xx	xx	x	x	xx	7	7
Grasshopper	xx	xxx	xxx	xxx	xxx	xx	xx	xx	xx	xx	xx	xx	6	8
Cut worms	xxx	xxx	xxx	xxx	xxx	xx	x	⇩	⇩	⇩	⇩	⇩	5	9
3. Minerals and Vitamins														
Garden vegetables	xx	xxx	xxx	xxx	xxx	xxx	xx	xx	⇩	⇩	⇩	⇩	11	3
MTPs/forage leaves	xx	xxx	xxx	xxx	xxx	xxx	xx	xx	x	⇩	⇩	⇩	13	1
Forage flowers	x	xx	xxx	xxx	xxx	xxx	xx	⇩	⇩	⇩	⇩	⇩	12	2
Tree seeds	⇩	⇩	⇩	x	xx	xx	xxx	xxx	xxx	xx	x	⇩	10	4

[1]Relative scale: xxx= abundant, xx = average, x= low, and - = very low/none

Table 2. Relative availability of scavengeable feed resources for the rural poultry during wet and dry season as assessed by farmers at Chamkoroma village in Kongwa district

Categories of scavengeable feeds	Relative feed availability during wet season[1]						Relative feed availability during dry season[1]						Pair-wise ranking by farmers	
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Total scores	Rank
1. Cereal grains														
Maize	xxx	xx	x	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xxx	7	3
Sorghum	⇩	⇩	⇩	⇩	⇩	xx	xx	xxx	x	⇩	⇩	⇩	6	4
Rice	xx	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xx	xx	3	7
2. Cereal by-products														
Maize bran	xx	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	8	2
Maize brew-waste	xx	x	⇩	⇩	xx	xx	xxx	xxx	xxx	xxx	xxx	xx	5	5
Sorghum bran	⇩	⇩	⇩	⇩	⇩	xx	xx	xxx	xx	⇩	⇩	⇩	2	8
Sorghum brew-waste	⇩	⇩	⇩	⇩	⇩	xx	xx	xxx	x	⇩	⇩	⇩	1	9
Rice bran/polishings	xx	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xx	xx	0	10
3. Other cereal and tuber products														
Maize Ugali	xxx	xx	x	x	xx	xx	xxx	xxx	xxx	xxx	xxx	xx	9	1
Sorghum Ugali	xx	xx	xx	xx	xx	xxx	xxx	xxx	xxx	xxx	xxx	xx	4	6
1. Crop and animal protein feeds														
Sunflower seed cake	xx	x	⇩	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xx	8	4
Groundnuts seeds	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xxx xx	xxx xx	6	6
Fish meal	x	⇩	⇩	⇩	x	xx	xx	xx	xx	xx	xx	xx	2	10
2. Insects and worms														
Earth worms	xx	xxx	xx	xxx	xxx	xx	x	⇩	⇩	⇩	⇩	⇩	4	8
Maggot larvae	xx	xxx	xxx	xxx	xxx	xx	x	⇩	⇩	⇩	⇩	⇩	1	11
Termites	xx	xxx	xx	xxx	xxx	xxx	xxx	xx	x	x	x	x	7	5
Grasshopper	xx	xxx	xxx	xxx	xx	xx	x	x	x	x	x	x	3	9
Cut worms	xx	xxx	xxx	xxx	xxx	xx	xx	x	⇩	⇩	⇩	⇩	5	7
3. Minerals and Vitamins														
Garden vegetables	xx	xxx	xxx	xxx	xxx	xxx	xx	xx	x	⇩	⇩	⇩	11	1
MTPs/forage leaves	xx	xxx	xxx	xxx	xxx	xxx	xx	xx	x	x	⇩	⇩	10	2
Forage flowers	x	xx	xxx	xxx	xxx	xx	x	x	⇩	⇩	⇩	⇩	9	3
Tree seeds	x	⇩	⇩	x	x	x	xx	xxx	xxx	xxx	xxx	xx	0	12

[1] Relative scale: xxx= abundant, xx = average, x= low, and - = very low/none

Table 3. Relative availability of scavengeable feed resources for the rural poultry during wet and dry season as assessed by farmers at Kisokwe village in Mpwapwa district.

Categories of scavengeable feeds	Relative feed availability during wet season[1]						Relative feed availability during dry season[1]						Pair-wise ranking by farmers	
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Total scores	Rank
1. Cereal grains														
Maize	xx	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xx	xx	0	12
Sorghum	xx	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xx	xxx	3	9
Pearl-millet	xx	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	1	11
2. Cereal by-products														
Maize bran	xx	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	4	8
Maize brew-waste	x	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	6	6
Sorghum bran	xx	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	5	7
Sorghum brew-waste	x	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	7	5
Pearl millet bran	x	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	2	10
Pearl-millet brew waste	x	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	8	4
3. Other cereal and tuber products														
Maize Ugali	xx	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	10	2
Sorghum Ugali	xx	x				xx	xxx	xxx	xxx	xxx	xxx	xx	11	1
Pearl-millet Ugali	xx	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	9	3
1. Crop and animal protein feeds														
Sunflower seed cake	x	⇩	⇩	⇩	⇩	⇩	x	xx	xxx	xxx	xx	xx	0	12
Groundnuts seeds	x	⇩	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xx	xx	5	7
Fish meal	xx	x	x	x	⇩	⇩	⇩	x	xx	xx	xx	xx	1	11
2. Insects and worms														
Earth worms	xx	xxx	xx	xxx	xx	x	⇩	⇩	⇩	⇩	⇩	⇩	4	8
Maggot larvae	xxx	xxx	xxx	xxx	xx	xx	x	⇩	⇩	⇩	⇩	⇩	2	10
Termites	xxx	xxx	xxx	xxx	xxx	xx	x	x	x	x	x	x	7	5
Grasshopper	xx	xx	xxx	xxx	xxx	xx	xx	xx	x	x	x	x	6	6
Cut worms	xx	xxx	xxx	xxx	xxx	xx	x	x	⇩	⇩	⇩	⇩	3	9
3. Minerals and Vitamins														
Garden vegetables	xx	xxx	xxx	xxx	xxx	xx	xx	x	⇩	⇩	⇩	⇩	8	4
MTPs/forage leaves	xx	xxx	xxx	xxx	xxx	xx	xx	x	⇩	⇩	⇩	⇩	9	3
Forage flowers	xx	xx	xxx	xxx	xxx	xx	xx	x	⇩	⇩	⇩	⇩	11	1
Tree seeds	xx	⇩	⇩	⇩	⇩	⇩	x	xx	xx	xxx	xxx	xxx	10	2

[1]Relative scale: xxx= abundant, xx = average, x= low, and - = very low/none

Table 4. Relative availability of scavengeable feed resources for the rural poultry during wet and dry season as assessed by farmers at Chitemo village in Mpwapwa district

Categories of scavengeable feeds	Relative feed availability during wet season[1]						Relative feed availability during dry season[1]						Pair-wise ranking by farmers	
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Total scores	Rank
1. Cereal grains														
Maize	xx	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	1	12
Sorghum	xx	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	2	11
Rice	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	0	13
Pearl-millet	xx	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	4	9
2. Cereal by-products														
Maize bran	x	x	⇩	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xx	5	8
Maize brew-waste	x	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	7	6
Sorghum bran	xx	x	⇩	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xx	6	7
Sorghum brew-waste	x	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	8	5
Pearl millet bran	x	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	3	10
Pearl-millet brew waste	x	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	9	4
3. Other cereal and tuber products														
Maize Ugali	xx	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	11	2
Sorghum Ugali	xx	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	12	1
Pearl-millet Ugali	xx	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	10	3
1. Crop and animal protein feeds														
Groundnuts seeds	x	x	⇩	⇩	x	xx	xxx	xxx	xxx	xxx	xxx	xx	2	9
Fish-meal	x	x	x	x	x	x	x	x	x	x	x	x	4	7
Meat- meal	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	0	11
2. Insects and worms														
Earth worms	xx	xxx	xxx	xxx	xxx	x	⇩	⇩	⇩	⇩	⇩	⇩	7	4
Maggot larvae	xxx	xxx	xxx	xxx	xxx	xx	x	⇩	⇩	⇩	⇩	⇩	5	6
Termites	xxx	xxx	xxx	xxx	xxx	xx	x	⇩	⇩	⇩	⇩	⇩	10	1
Grasshopper	x	xx	xxx	xxx	xxx	xxx	xxx	xx	x	x	x	x	9	2
Cut worms	xx	xxx	xxx	xxx	xxx	xxx	xx	x	⇩	⇩	⇩	⇩	8	3
3. Minerals and Vitamins														
Garden vegetables	xxx	xxx	xxx	xxx	xxx	xx	x	x	⇩	⇩	⇩	⇩	6	5
MTPs/forage leaves	xxx	xxx	xxx	xxx	xxx	xx	xx	x	⇩	⇩	⇩	⇩	1	10
Forage flowers	xx	xxx	xxx	xxx	xxx	xx	xx	x	⇩	⇩	⇩	⇩	3	8

[1]Relative scale: xxx= abundant, xx = average, x= low, and - = very low/none

Table 5. Factors affecting availability of scavengeable feed resource base for rural poultry in the four villages of Mpwapwa and Kongwa districts.

Factors	% frequency of the factors affecting availability of SFRB				
	Kisokwe	Bumila	Chamkoroma	Chitemo	Pearson Chi Square (χ^2)
Season	24.5	26.1	25.2	24.2	χ^2 (4) =12.87, P<0.05
Land preparation	25.8	24.2	25.2	24.8	χ^2 (4) = 6.66, P>0.05
Harvesting	25.6	25.6	25.2	23.6	χ^2 (4) =14.59, P<0.05
Flock size	24.6	26.5	26.1	22.8	χ^2 (4) = 9.75, P<0.05
Feed management	20.6	28.1	28.1	23.1	χ^2 (4) =7.49, P>0.05
Land size for scavenging	22.4	27.0	28.2	22.4	χ^2 (4) =34.76, P<0.001

seeds, sunflower seed cakes and groundnuts ranked highest while in Kisokwe village and Chitemo village garden vegetables, termites, grasshopper, cutworms, earthworms and maggot larvae ranked highest.

Factors affecting availability of scavengeable feed resource base for rural poultry

Factors affecting availability of SFRB are presented in Table 5. Results indicate that season, harvesting of crops, poultry flock size and land size for scavenging had significant association (P<0.05) with the availability of SFRB while land preparation and management of feed resources at household level had no significant association (P>0.05). Further analysis of the data revealed that there was highly significant interaction effects (P<0.001) among the factors affecting availability of scavengeable feed resources. The effect of season and farming activities on the availability SFRB could evidently perceived by farmers as shown in Figures 1 - 4.

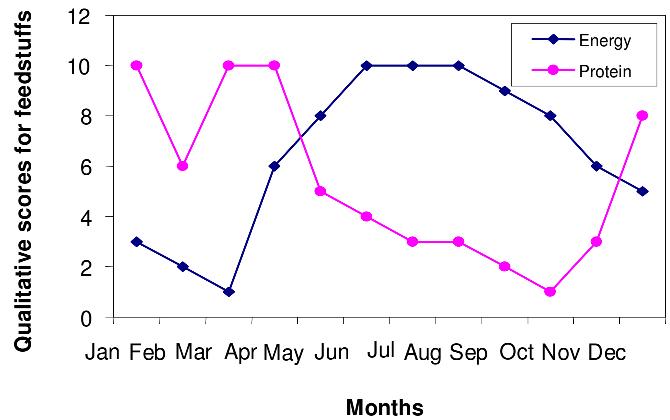

Figure 1. Effect of season and farming activities on the availability of scavengeable feed resource base at Kisokwe village.

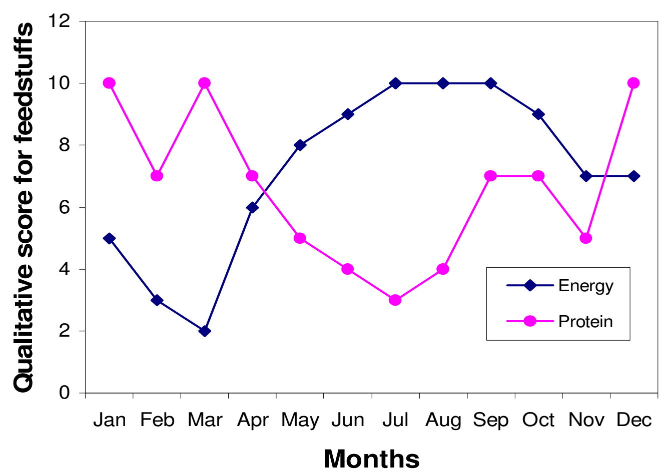

Figure 2. Effect of season and farming activities on the availability of scavengeable feed resource base at Chitemo village.

Chemical composition of scavengeable feed resources available for rural poultry

Results on the chemical composition of scavengeable feed resources are presented in Table 6. The results show that the chemical composition of scavengeable feed resources varied considerably. The DM contents of cereals, oil seeds and their by-products and fish-meal were higher than those of dried cassava chips. Gross energy (GE) ranged from 17.1 to 29.3 MJ kgDM^{-1}. Cereal grains and their by-products had low energy content compared to oil seeds and their by-products. Maize bran and pearl millet brewers' wastes had high crude fibre contents. Also sesame seeds, sunflower seeds and sunflower seed cakes had high crude fibre content owing to the presence of husks. Crude protein contents of cereal grains and cereal bran were similar. They ranged between 113.3 and 145 g CP kgDM^{-1} but cereal bran had higher values than grains. Rice grains and rice bran/polishings had the lowest protein values of 108 and 89 g CP kgDM^{-1} respectively. The oil seeds, their by-products and fish meal had higher protein contents than cereal grains and their by-products. Cereal grains and

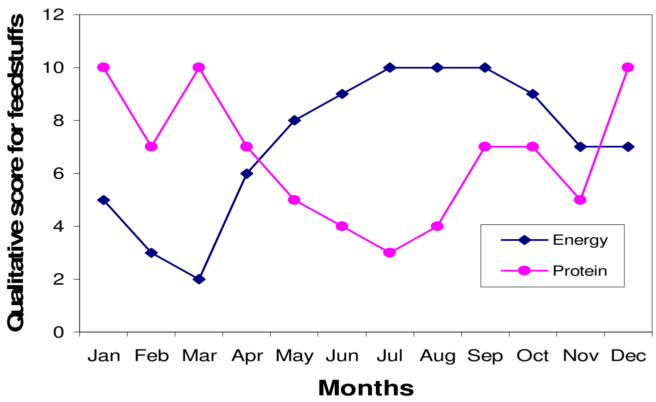

Figure 3. Effect of season and farming activities on the availability of scavengeable feed resource base at Bumila village

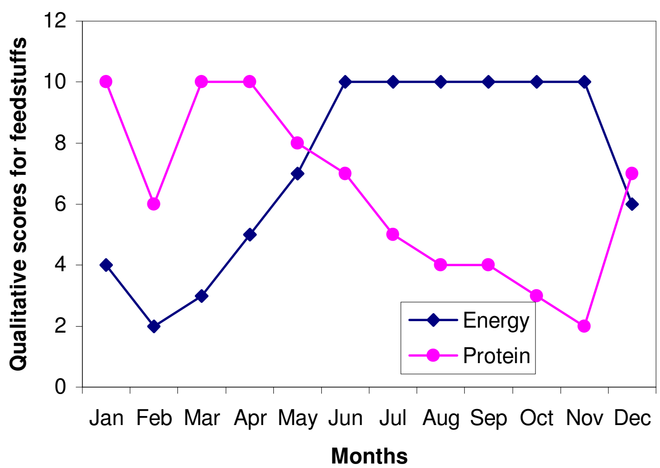

Figure 4. Effect of season and farming activities on the availability of scavengeable feed resource base at Chamkoroma village

their by-products had low crude fat contents (EE) compared to the oils seeds and their by-products. The Ash contents of scavengeable feed resources were fairly high except for grains of maize, red sorghum (improved variety) and rice polishings. The Nitrogen-free extract (NFE) content was high in all energy-rich feedstuffs than protein feedstuffs. The mineral contents of potential feed resources were generally low.

Physical composition of scavengeable feed resources found in chicken crop and gizzard

Results on physical composition of the individual feed components found in the crop, proventriculus and gizzard (Table 7) show that there was diversity in the composition of the diets consumed by scavenging chickens. The aggregate analysis of individual feed materials in the crop and gizzard consisted of: cereals and cereal by-products (29.0%), vegetables and forage materials (1.8%), seeds and seed by-products (3.4%), insects and worms (0.2%), egg shells and bones (0.3%), unidentified feeds (41.5%), inert materials (0.8%) and sand/grit (23.0%). Generally, the proportion of energy feedstuffs was higher than protein and mineral/vitamin-rich feedstuffs. Average dry weight of both crop and gizzard contents (g) did not vary very much between villages where in Bumila village was 22.1 ± 7.9, Chamkoroma village was 20.6 ± 11.0, Chitemo village was 24.8 ± 16.0 and Kisokwe village was 20.0 ± 13.4.

Chemical composition of scavengeable feed resources found in chickens' crop and gizzard

The results on chemical composition of scavengeable feed resources found in crop, proventriculus and gizzard of scavenging chickens are given in Table 8. The DM concentration of the crop and gizzard contents ranged from 472.3 to 493.7 g DM per kg and the mean DM was 478.7 ± 9.6 g per kg. The crude protein content of the crop and gizzard contents was generally low with an overall mean of 80.4 ± 2.3 CP g $kgDM^{-1}$. The crude fibre content varied among the villages and the overall mean was 70.7 ± 15.7 CF g $kgDM^{-1}$. Ether extract content was relatively low with an overall mean of 45.7 ± 21.3 EE g kg DM^{-1}. Kisokwe had the lowest value of 19.9 g $kgDM^{-1}$. The Ash content ranged from 210.2 to 258.0 g $kgDM^{-1}2$ and the overall mean was 234.2 ± 20.5 g $kgDM^{-1}$. The NFE content had high values and the overall mean was 555.0 ± 32.5 NFE g $kgDM^{-1}$. The mineral content was generally low but had constant values.

DISCUSSION

Scavengeable feed resources for rural poultry and the factors affecting their availability

Energy-rich feedstuffs such as grains of maize, sorghum, pearl-millet and their by-products appeared the most important scavengeable feed resources in all villages. The cereals are the most important crops grown for human consumption in the semi-arid areas of central Tanzania. Their availability is high during the dry season when they are harvested. These energy-rich feedstuffs are used mostly as basal feeds or as supplements to the diets scavenged by rural poultry in most of rural households in the villages. Supplementation with available feedstuffs is sometimes done by giving cereal grains and their by-products and household wastes generally in the morning or evening depending on their availability in the households. However, supplementation of these feedstuffs decreases and sometimes disappears during the wet season in most of the households due to their scarcity. Protein-rich feedstuffs such as sunflower seeds, groundnut seeds, sesame seeds, sunflower seed cakes are also the most important poultry feeds in the villages.

Table 6. Chemical composition of feed resources for rural poultry obtained from interviewed farmers in the four villages of Mpwapwa and Kongwa districts

	DM	Chemical composition (g kgDM^{-1})									GE
	g/kg	CP	CF	EE	ASH	NFE	Ca	P	K	Mg	(MJ/kg
1. Cereal grains											
Maize	877	113	52.1	41.8	14.5	779	1.5	5.0	11.0	1.0	19.0
Sorghum[1]	874	136	157	77.7	25.0	604	3.9	5.2	10.1	2.1	20.0
Sorghum[2]	875	121	136	48.1	33.3	662	3.2	5.4	11.7	1.3	19.1
Sorghum[3]	865	111	33.3	15.6	17.2	823	3.6	3.5	9.5	0.8	18.3
Pearl-millet[4]	875	123	37.0	51.3	69.0	720	3.4	5.8	11.4	1.4	18.3
Pear-millet[5]	869	130	63.8	140	76.6	590	3.8	6.5	15.4	2.2	20.2
Finger-millet	865	122	106	16.0	73.4	683	6.0	3.6	11.4	0.8	17.5
Rice grains	875	108	62.6	16.2	90.1	723	6.2	4.8	12.0	1.0	17.1
2. Cereal bran											
Maize[6]	897	145	229	92.8	53.4	480	2.6	7.7	17.1	3.6	20.1
Maize[7]	874	142	186	105	62.7	504	2.1	8.1	16.2	3.7	20.1
Sorghum[8]	871	137	62.3	51.5	53.6	696	3.9	6.7	16.2	2.4	18.8
Pearl-millet	875	122	72.8	52.2	84.1	669	2.6	5.8	11.4	1.6	17.7
Rice polishings	879	89.2	48.9	35.6	15.3	811	6.1	6.4	20.1	2.8	18.7
3. Cereal brewers waste											
Maize & P/millet	890	275	97.7	27.6	36.4	563	12.7	7.9	22.1	3.5	19.5
Sorghum[9]	875	287	70.7	140	53.6	449	12.6	9.4	21.8	4.5	19.8
Pearl millet	906	294	184	62.9	84.1	375	11.4	9.2	20.1	4.2	19.8
4. Other energy feeds											
Cassava chips[10]	856	64.5	74.7	68.1	64.0	729	3.5	2.6	9.9	0.2	19.5
5. Oil seeds & by-products											
Sunflower cakes	915	303	202	145	38.1	312	15.4	13.0	25.9	6.1	22.5
Sunflower seeds	912	284	230	399	35.4	51.6	8.8	17.1	26.0	8.3	28.1
Sesame seeds	900	328	146	279	67.2	180	10.3	17.3	30.0	8.5	24.9
Groundnut seeds	922	322	17.8	488	64.7	108	8.5	15.0	25.6	7.7	29.3
6. Animal protein feeds											
Fish meal	910	418	109	105	37.8	330	18.4	16.5	34.5	7.5	22.1

Note: [1]Red sorghum (local variety); [2]White sorghum (Pato variety); [3] Red sorghum (improved variety); [4]Pearl-millet local variety; [5]Pearl-millet improved variety; [6]Maize (hand processed); [7]Maize (machine processed); [8]Sorghum bran, [9]White sorghum local variety (Lugugu) and [10]Dried cassava chips, GE = Gross energy (MJ/kg DM).

Again, these are important oil seed crops found in the farming systems of semi-arid areas of central Tanzania. Like the energy feedstuffs, these feedstuffs are given to the birds as supplements. In some households, ground sunflower meals from screw pressed cakes are given to the poultry in combination with cereal by-products. Other protein-rich feedstuffs such as fish-meal and meat-meal are not commonly available in the villages. However in recent years, fish-meal has been gradually taking an important place in poultry feeding in Chamkoroma, Bumila, and Kisokwe and Chitemo villages.

Unconventional feedstuffs such as earthworms, maggot larvae, termites, and grasshopper and cut worms are another potential scavengeable feed resource in the study area. Availability of these feedstuffs is seasonal dependent. Higher quantities are available during the wet season and they are always obtained from the surrounding environments. Similar findings have been reported by Tadele (1996) in Ethiopia and Mwalusanya et al. (2002) in Tanzania. The study revealed that heaps of cattle dung in the kraal or bomas is used as media for earthworms, maggot larvae and cutworm production and they provide an excellent source of protein rich-diets for the rural poultry. In Africa: insects, maggot larvae and earthworms are the most important protein sources for scavenging chickens (Smith, 1990; Sonaiya, 1995). In Ghana, maggot larvae are produced by farmers from fermented mixture of blood, rumen contents and cattle dung (Smith, 1990). In Colombia a 100 kg of cattle manure could yield between 0.9 and 2.6 kg of earthworms (Beteta et al., 1996).

The study also showed that mineral and vitamin-rich feedstuffs particularly garden vegetables, forage leaves, flowers and forage seeds are also important feed

Table 7. Physical composition of SFRB in the dry season expressed as percentage of total dry weight of the chickens' crop and gizzard contents in the four villages of Mpwapwa and Kongwa districts

	Physical components of crop and gizzard contents (% dry basis)				
	Bumila (n = 35)	Chamkoroma (n = 30)	Chitemo (n = 41)	Kisokwe (n = 35)	Overall (n= 141)
1. Energy feedstuffs					
Maize grains	8.0	7.0	4.1	6.3	6.3
Maize bran	4.0	6.0	0.8	2.3	3.3
Sorghum grains	0.3	0.0	3.5	0.8	1.2
Sorghum bran	0.2	4.4	13.7	11.4	7.4
Pearl-millet grains	0.0	0.0	1.4	0.0	0.4
Pearl-millet bran	0.0	0.0	0.1	0.0	0.0
Local brew wastes	3.0	0.0	1.2	2.8	1.8
Cassava chips	0.0	0.1	0.0	0.9	0.2
Kitchen wastes	11.0	9.3	7.8	5.5	8.4
2. Protein feedstuffs					
Insects	0.1	0.3	0.4	0.1	0.2
Earthworms	0.0	0.0	0.0	0.1	0.0
Feathers	0.1	0.1	0.1	0.0	0.1
Sunflower cake	0.5	4.3	0.1	5.5	2.5
Watermelon seeds	0.0	0.0	0.0	0.2	0.1
Tree seeds	0.0	0.2	0.1	0.0	0.1
Ground nuts	0.1	2.2	0.3	0.7	0.7
3. Mineral/vitamin feedstuffs					
Grass leaves/stems	0.0	0.3	0.0	0.0	0.1
Fruits	0.0	0.7	0.0	0.4	0.4
Forage leaves	0.2	0.8	0.1	0.4	0.4
Onions	0.0	0.1	0.0	0.0	0.3
Egg shells	0.0	0.0	0.2	0.0	0.1
Tree flowers	0.0	0.6	0.0	0.2	0.2
Fibrous materials	0.7	0.9	0.2	0.1	0.5
Bones	0.1	0.2	0.2	0.0	0.1
4. Inert materials					
Metal materials	0.2	0.3	0.4	0.9	0.4
Trouser/shirt button	0.1	0.0	0.0	0.2	0.1
Shoes materials	0.1	0.0	0.0	0.0	0.0
Plastic materials	0.5	0.4	0.2	0.2	0.3
5. Other feed materials					
Sand/grits	24.1	28.7	17.3	22.2	23.0
Unidentified feeds	46.7	32.2	47.8	39.4	41.5

Table 8. Average chemical composition of crop and gizzard contents of scavenging chickens in the four villages of Mpwapwa and Kongwa districts

Village	DM	Chemical composition (g $KgDM^{-1}$)									ME
	g/kg	CP	CF	EE	ASH	NFE	Ca	P	K	Mg	(MJ/kg
Bumila	472	80.3	83.1	52.2	258	517	7.1	7.3	13.6	2.9	9.4
Chitemo	474	82.1	51.5	39.9	242	563	7.2	7.2	14.3	2.9	10.5
Kisokwe	494	77.3	64.2	19.9	227	594	7.2	6.8	13.2	2.4	9.9
Chamkoroma	479	82.1	83.8	70.7	210	545	7.8	8.0	13.3	3.3	10.5
Overall mean	479	80.4	70.7	45.7	234	555	7.3	7.3	13.6	2.9	10.1
	±9.6	±2.3	±15.7	±21.3	±20.5	±32.5	±0.3	±0.5	±0.5	±0.4	±0.5

resources for the rural poultry. Leaves, flowers and seeds from trees species such as *Leucaena leucocepahala*, *Caliandra colothyrus*, *Acacia tortilis* and *Citrus vulgaris* are collected by some farmers for their poultry. However their availability is limited by the seasonal nature as most of them are available during the wet season. This indicates that during the dry season, rural poultry can develop mineral and vitamin deficiencies because of the scarcity of the succulent forage materials on the range.

Apart from season, the study also revealed that availability of scavengeable feed resources for rural poultry was significantly associated wit the farming activities. In the study area, land preparation involves clearing and burning of crop-residues and natural weeds in the fields. These are the ecological niches for termites, grasshopper, reptiles and other invertebrates. Such invertebrates are usually destroyed by fire during land preparation and in some cases they migrate to bushy areas where they cannot be scavenged by poultry. In addition, during ploughing and planting, farmers use hand-hoes and animal drawn implements such as ox-drawn ploughs. As a result, some surface vegetation and crop-residues are incorporated into the soil and the soil borne insects are exposed to the surface where they become available to the rural poultry. Moreover, during planting some grains and oil seeds sown in the fields become available for scavenging poultry. As previously stated, crop harvesting and post harvest activities had also significant effect on the availability of SFRB. The study noted that there are substantial amounts of cereal grains, oil seeds and their by-products spilled on the ground during harvesting and threshing of these crops which are picked up by the rural poultry. Moreover, availability of SFRB is associated with the land size available for scavenging and the size of the flock biomass in the village. The study revealed that land size available for scavenging is directly related to the density of village houses. In all the four villages, housing density was relatively high and most of the family flocks had to mix with flocks from their neighbours when scavenging. Such situation in most cases could result into high competition for SFRB among the poultry and the chicks are more likely to suffer from this competition. Management of the feed resources at farm level is another factor reported to contribute to the availability of SFRB. It was noted that most of the household wastes discarded out by the family members could be available for other livestock species such as pigs, goats, pets and wild birds.

Nutritional composition of scavengeable feed resources for rural poultry in the villages

The high gross energy values in the cereal grains and their by-products indicate that these feedstuffs are good sources of digestible energy and metabolizable energy for poultry (McDonald et al., 2002). Despite the high energy content, most of the grains and their by-products had relatively low protein contents ranging from 8 - 12 CP g $kgDM^{-1}$. The low protein values in cereal grains and their by-products could have been associated with the high fibre content in these feedstuffs. High fibre content has been reported to have diluent effect on the grains as whole and reduces the energy and protein value proportionally (McDonald et al., 2002). As a result of this, most of the cereal grains and their- by-products have moderately to low content of lysine, tryptophan and threonine for monogastric animals and methionine for poultry (McDonald et al., 2002). Regarding the mineral contents, the results showed that scavengeable feed resources in the villages had very low mineral contents particularly calcium (Ca) and magnesium (Mg). Phosphorus (P) and potassium (K) contents seem to be comparatively high, although much of it was present in oil seeds and their by-products and fish meal than in cereal grains and their by-products. The low mineral contents in cereal grains could have been associated with the marginal soil fertility in the study area coupled with very low fertilization inputs and erratic rainfall pattern.

The high content of ether extract and crude protein in the oil seeds and their by-products shows that these feedstuffs can have a significant contribution to the energy and protein diets for rural poultry. However, in general oil seed proteins are deficient in essential amino acids in particular cystine, methionine and lysine and the feed materials have high fibre content (McDonald et al., 2002). Thus the high fibre content and the relative low levels of the essential amino acids in these feed materials is a constraint to their inclusion in poultry feeds because they cannot provide adequate supplementation of the cereal bran. Therefore they should be used in combination with other protein sources such as soya bean and fish meal.

Physical and chemical composition of chickens' crop and gizzard contents

Visual observations of the crop and gizzard contents revealed that the scavenged feed had a diversity of feed ingredients. The diversity in the composition of the diets consumed by scavenging birds showed that they can select from various feed ingredients available and compose their own diets. Thus a free-range system is of particular importance to small-scale poultry producers in developing countries such as Tanzania because it reduces substantially the costs of commercial feeds which most of the farmers can not afford to buy. Also the system offers an effective way to make use of locally available grains such as maize, sorghum and pearl millet, oilseeds and their by-products. However, as indicated in Table 8, most of the SFRB available for scavenging are not concentrated enough particularly in terms of protein. The crop and gizzard contents in the present study contain on average 80.4 g of CP per kgDM. The low crude protein in the scavenged feeds could be explained by the lower percentage of protein feedstuffs in the diets consumed by birds in the dry season. Similar results were obtained by Tadele (1996) and Rashid et al. (2005) who reported low CP content of 76 and 102 g per kgDM respectively, in the crop contents of scavenging hens in the dry season. However, Pousga et al. (2005) in Burkina Faso reported that the CP in the crop contents was higher in the dry season (115 g kgDM^{-1}) compared to the wet season (105g kgDM^{-1}) for both local and crossbred birds, resulting from higher consumption of green grass/leaves, larvae, insects and worms due to occasional showers occurred at the end of dry season. The metabolizable energy (ME) concentration of 10.1 MJ kgDM^{-1} in the crop and gizzard contents was approximately similar to the energy content of around 11.4 MJ kgDM^{-1} reported by Pousga et al. (2005) in Burkina Faso, Rashid et al. (2005) in Bangladesh and Tadelle (1996) in Ethiopia in the dry season. However these energy values were lower than the energy content of around 12.4 MJ kgDM^{-1} reported by the same authors during the rainy season. These results confirm the earlier findings that birds kept in the free-range system can certainly not find all the nutrients they need for optimum growth and egg production all the year round (Goromela et al., 2006). Supplementation with the energy and protein sources can complement what birds need for optimum growth and egg production in central Tanzania.

Conclusion

From the present study, it can be concluded that in central Tanzania cereal grains and their by-products, the oil seeds and their by-products are the most important scavengeable feed resources available for rural poultry. Unconventional scavengeable feed resources such as forage leaves and flowers; forage seeds, garden vegetables, insects and worms are also the most important protein and mineral-rich feedstuffs for rural poultry. However, their availability is seasonal in nature. Considerable amounts of cereal grains and their by-products and some of their by-products were available during the dry season while large amounts of protein and mineral/vitamin feedstuffs were available during the wet season. Thus any attempt to improve the diet of scavenging birds should take into consideration what the birds are essentially consuming depending on season and farming activities. The chemical composition of SFRB indicates that cereal grains and their by-products had high energy contents and low contents of crude protein and minerals particularly calcium and magnesium. The low protein and mineral/vitamins contents in these energy-rich feedstuffs require supplementation with locally available protein and minerals/vitamins sources. The high crude fibre levels of above 20% and the low content of amino acids in oil seeds and their by-products can potentially limit the inclusion of this feed material in poultry diets where the recommended maximum fibre level of inclusion rate is 10% of the diet for adult poultry. Thus they should be combined with other protein sources such as soya-bean and fish-meals when given to poultry. The low concentrations of energy, protein and minerals in the crop and gizzard contents indicates that diets consumed by birds could not meet optimum requirements of scavenging birds for growth and egg production. Supplementation of these nutrients would be necessary to attain reasonable growth and egg performance for rural poultry. However, the major part of the present study has evaluated the available SFRB and the nutrient contents which may not represent the actual diets and nutrients scavenged by rural poultry. Thus further studies should be undertaken to determine the physical and chemical composition of the crop and gizzard contents and thus feed consumed by scavenging birds in different seasons and farming systems of central Tanzania and investigate their interaction effects with poultry management practices on the productivity of rural poultry.

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