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RESEARCH ARTICLE

Low nutritive quality of own-mixed chicken rations in Kampala City, Uganda

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Abstract Chicken production is popular in Kampala City, Uganda. Indeed about 70 % of all poultry products consumed in Kampala are produced locally. However, the high cost of feed is a major limiting factor. As a consequence, chicken farmers are formulating and mixing their own feeds. However, these own-mixed feeds may not meet recommended nutrient levels. We therefore studied five classes of own-mixed chicken feeds: broiler starter, broiler finisher, chick mash, grower mash, and layer mash. Samples of the chicken feeds were collected from farmers in and around Kampala City. We analyzed crude protein, ether extract, crude fiber, total starch, ash, calcium, phosphorus, and gross energy contents of the feeds. The apparent metabolizable energy content was calculated. We compared data with dietary requirements recommended for chickens in the tropics. Results show that own-mixed rations contained 21.9–36.3 % less protein than minimum recommendations. Broiler rations contained 16.2–20 % less metabolizable energy than minimum recommendations, and their crude fiber content was 37.5–50 % higher than the maximum recommendation. Layer mash contained 66.7 % less calcium and 17.5 % less metabolizable energy than minimum recommendations. All the five classes of own-mixed chicken rations were very high in ash content, ranging from 17.0 to 21.2 %. We conclude that own-mixed chicken rations do not conform to the dietary recommendations. There is therefore a need to give chicken farmers training on feed formulation and mixing.

Keywords Chicken feeding · Nutritional adequacy · Own-mixed rations · Urban and peri-urban

1 Introduction

Livestock production in urban and peri-urban areas of Kampala has been increasing over the years. Its growth has been attributed to the increasing demand for livestock products due to the rapid human population growth and urbanization (Ishagi et al. 2003). Several livestock species are kept, of which chickens are the most common (Katongole et al. 2011). The predominance of chickens is attributed to the readily available market for eggs and chicken meat, quick returns to investment, less space requirement, no cultural/religious taboos, and less social tensions compared to the rearing of other livestock species (Ishagi et al. 2003; Katongole et al. 2011). However, high cost of feed is limiting chicken production in urban and peri-urban areas of Kampala (Katongole et al. 2012).

Feed cost has often been reported as the major element in the total cost of rearing chickens compared to the rearing of other livestock species. According to Walker and Gordon (2003), feed cost alone accounts for over 70 % of the total variable costs of poultry production. Consequently, this has led to many chicken farmers in urban and peri-urban areas of Kampala to adopt feed cost-saving mechanisms, particularly own-feed formulation and mixing (Katongole et al. 2012). Own-mixed feeds (Fig. 1) cost less than the commercially mixed feeds, because feed manufacturers raise the prices of their feeds to be able to pay wages, maintain their machinery, and also make a profit (Apantaku et al. 2006). Additionally, the variable operating expenses involved (electricity and fuels,

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Fig. 1 Farmers purchase feed ingredients (already milled) from feed suppliers and mix them from their farms. This practice is offering urban/peri-urban chicken farmers in Uganda an innovative way of reducing feed cost. The information concerning how much of each ingredient to add (feed formulation) is primarily obtained from fellow farmers and feed suppliers

handling, packaging, storage, etc.) in producing commercially mixed-feeds also lead to higher prices, which is not the case when farmers mix their own feeds. Nevertheless, economical poultry production necessitates that the diets used are adequate in essential nutrients (NRC 1994). However, information on the nutritional qualities of own-mixed chicken feeds is limited. Therefore, this study was conducted to evaluate the nutritional properties of own-mixed chicken rations/diets in urban and peri-urban areas of Kampala.

2 Materials and methods

2.1 Feed sampling

Eight samples of each of the five commonly used classes of chicken feeds (broiler starter, broiler finisher, chick mash, grower mash, and layer mash) were collected from several chicken farmers in four divisions of Kampala City (Kawempe, Rubaga, Nakawa, and Makindye) on various days. This resulted into a total of 40 feed samples. As samples were being collected, farmers were asked to disclose the feedstuffs used in their own-mixed chicken feeds.

2.2 Chemical analysis

The feed samples collected were analyzed for crude protein (CP), ether extract (EE), crude fiber (CF), calcium (Ca), phosphorous (P), and ash content according to the official methods of analysis by the Association of Analytical Chemists (AOAC 1990). Total starch content in the feed samples was determined by the amyloglucosidase-α-amylase method as described by McCleary et al. (1997). Gross energy (GE) content was determined using a bomb calorimeter (Parr 6300 Oxygen Bomb Calorimeter, Illinois, USA). Apparent metabolizable energy corrected for nitrogen (AME_n) was calculated by the equation used by Carre' and Rozo (1990): $AME_n = 0.913GE - 18.5CP - 109.5CF$; where GE is in kilocalorie per kilogram, CP in percent and CF in percent. A factor 4.185 was used to transform the AME_n values from kilocalorie to kilojoules.

2.3 Statistical analysis

The chemical and energy compositions of own-mixed chicken rations were subjected to the one-sample *t*-test procedure of SAS (2003) for comparison with the recommended dietary nutrient requirements of chickens in the tropics reported by Smith (2001) and Luis and Batungbacal (2010).

3 Results and discussion

3.1 Feed ingredients used in own-mixed chicken rations

All samples (100 %) of own-mixed chicken rations collected contained maize bran, fish meal (*Rastrineobola argentea* locally known as *Mukene*), common salt, lake shells, and vitamin–mineral premix. Around 70 % of the feed samples analyzed contained cottonseed cake and around 30 % contained sunflower seed cake. Only 10 % of the samples contained wheat bran; while none contained whole maize. Maize bran is extensively used in poultry feeds in Uganda (MAAIF 2005). The high demand of maize for human consumption has made it expensive, and hence, not feasible to use in animal feeds. However, maize bran based diets contain lower dietary energy compared to maize-based diets. The observed low use of wheat bran in chicken feeds is attributed to unavailability. Cottonseed cake is extensively used in poultry feeds in Uganda (MAAIF 2005). It is now being used to completely replace soya bean meal, which has become increasingly scarce and expensive. Fish meal is the only animal source of protein added, and it is usually added in small quantities owing to its high cost.

Samples of the three major feedstuffs used in own-mixed chicken rations (cottonseed cake, fish meal, and maize bran) were collected over the same time scale and locations as the samples for the own mixed rations and analyzed for CP, CF, and total ash. The average CP composition was 26.9, 18.3, and 9.7 % (air-dry) for cottonseed cake, fish meal, and maize bran, respectively. The average CF composition was 18.7, 1.5, and 4.4 %, while average total ash composition was 8.2, 29.2, and 5.3 % (air-dry), for cottonseed cake, fish meal, and maize bran, respectively. The chemical composition (CP, CF, and ash) of maize bran reported in this study was comparable to earlier studies from Uganda (Katongole et al. 2009; Lapenga et al. 2009) and those from neighboring countries (Ondiek et al. 1999; Munguti et al. 2012). However, for fish meal and cottonseed cake, the chemical composition reported in this study was different from other studies (Bille and Shemkai 2006; Munguti et al. 2012) in the region. The CP and ash compositions of fish meal reported by Munguti et al. (2012) were 67 % higher and 38 % lower (respectively) than what was reported in this study. For cottonseed cake, the CP and ash compositions reported by Munguti et al. (2012) were 31 % higher and 30 % lower (respectively) than what was reported in this study. The considerably lower CP composition is attributed to the high ash content. The high ash is indicative of the presence of adulterants, particularly sand and soil particles. Shirley and Parsons (2001) indicated that increased ash content has a negative effect on the concentrations of energy and protein as well as all the other essential nutrients in the diet, hence reducing the feed quality.

3.2 Chemical composition of own-mixed chicken rations

The average chemical composition of own-mixed chicken rations is summarized in Table 1. The ash content of all the five own-mixed chicken rations was notably very high (content ranged between 17.0 and 21.2 % air-dry). Chemical composition values were within the same range across all the five classes of chicken feeds (broiler starter, broiler finisher, chick mash, grower mash, and layer mash). The uniformity in chemical composition across all the five classes of chicken feeds suggests that farmers use more or less the same feed formula for the different classes of chickens. This is detrimental, because nutrient requirements of chickens change according to purpose for which the birds were developed (egg production or meat type), phase of growth (starting and growing, pre-egg laying, egg production, and molting phase), and activity (laying or breeding) (NRC 1994).

3.3 Nutrient composition of own-mixed chicken rations compared with recommended dietary requirements

The CP content of the two own-mixed broiler chicken rations was considerably lower ($P<0.05$) than the minimum dietary recommendations for broiler starter and broiler finisher (Table 2). The average CP content was 13.6 % air-dry (95 % confidence interval 12.1 to 15.1) and 12.1 % air-dry (95 % confidence interval 10.2 to 14.1) for broiler starter and broiler finisher, respectively. The CF content of the two rations was far in excess ($P<0.05$) of the maximum dietary recommendation. The average CF content was 5.5 % air-dry (95 % confidence interval 4.9 to 6.0) and 6.0 % air-dry (95 % confidence interval 5.8 to 6.2) for broiler starter and broiler finisher, respectively. Apparent metabolizable energy was lower ($P<0.05$) than the minimum dietary recommendation. The average apparent metabolizable energy content was 10.9 MJ/kg air-dry (95 % confidence interval 9.8 to 11.9) and 10.4 MJ/kg air-dry (95 % confidence interval 9.7 to 11.2) for broiler starter and broiler finisher, respectively. Calcium and phosphorus contents of the two own-mixed broiler chicken rations were within ($P>0.05$) the recommended dietary allowances.

The CP content of all the three own-mixed layer chicken rations was considerably lower ($P<0.05$) than the minimum dietary recommendations (Table 3). The average CP content was 13.0 % air-dry (95 % confidence interval 10.7 to 15.3), 12.5 % air-dry (95 % confidence interval 10.2 to 14.8), and 11.8 % air-dry (95 % confidence interval 11.1 to 12.4) for chick mash, grower mash, and layer mash, respectively. The CF content of the three own-mixed layer chicken rations was in conformity ($P>0.05$) with the maximum dietary recommendations. The apparent metabolizable energy content of

Table 1 Chemical composition of own-mixed chicken rations, means, and SD

Ration type					
Component	Broiler starter	Broiler finisher	Chick mash	Grower mash	Layer mash
n	8	8	8	8	8
% (air-dry)					
Crude protein	13.6 (1.6)	12.1 (2.1)	13.0 (2.2)	12.5 (2.7)	11.8 (0.8)
Ether extract	7.3 (2.7)	5.4 (1.8)	6.8 (2.1)	6.3 (1.6)	6.0 (2.4)
Crude fiber	5.5 (0.6)	6.0 (0.2)	5.9 (0.9)	6.3 (0.9)	6.6 (1.1)
Total starch	32.8 (5.1)	29.8 (3.4)	30.2 (0.8)	31.0 (4.6)	26.8 (3.6)
Calcium	0.98 (0.71)	1.08 (0.68)	1.07 (0.69)	1.30 (0.52)	1.00 (0.31)
Phosphorus	0.85 (0.18)	0.72 (0.16)	0.85 (0.11)	0.86 (0.48)	0.70 (0.15)
Ash	19.0 (5.8)	18.9 (4.0)	19.7 (5.3)	17.0 (3.0)	21.2 (5.1)
MJ/kg (air-dry)					
Gross energy	15.8 (1.4)	15.5 (0.7)	15.4 (1.5)	16.1 (1.0)	15.2 (0.9)
AME_n	10.9 (1.2)	10.4 (0.8)	10.4 (1.1)	10.8 (1.0)	9.9 (0.9)

SD standard deviation, *n* sample size

AME_n apparent metabolizable energy corrected for nitrogen was calculated as $AME_n = 0.913GE - 18.5CP - 109.5CF$; where GE is in kcal/kg, CP in percent and CF in percent (Carre' and Rozo 1990); where GE is gross energy, CP is crude protein, and CF is crude fiber

Table 2 Nutrient composition of own-mixed broiler chicken rations compared with recommended dietary requirements (air-dry)

	CP (%)	CF (%)	Ca (%)	P (%)	AME_n (MJ/kg)
Broiler starter					
Mean	13.6	5.5	0.98	0.85	10.9
Recommended level[a]	≥21.0	≤4.0	≥0.7 and ≤1.3	≥0.4 and ≤1.1	≥13.0
t-value	−12.3	6.75	−0.07	1.62	−4.86
Significance level	***	***	NS	NS	**
95 % confidence interval					
Lower limit	12.1	4.9	0.39	0.70	9.8
Upper limit	15.1	6.0	1.58	1.00	11.9
Broiler finisher					
Mean	12.1	6.0	1.08	0.72	10.4
Recommended level[a]	≥19.0	≤4.0	≥0.7 and ≤1.3	≥0.4 and ≤1.1	≥13.0
t-value	−8.72	23.5	0.32	−0.52	−8.03
Significance level	***	***	NS	NS	***
95 % confidence interval					
Lower limit	10.2	5.8	0.51	0.59	9.7
Upper limit	14.1	6.2	1.64	0.85	11.2

Nutrient composition is indicated using the following abbreviations: *CP* crude protein, *CF* crude fiber, *Ca* Calcium, *P* total phosphorus and AME_n apparent metabolizable energy corrected for nitrogen

*Indicates statistical significance at the 5 % level

**Indicates statistical significance at the 1 % level

***Indicates statistical significance at the 0.1 % level. *NS* indicates not significant

[a] Source: Smith (2001)

layer mash was lower ($P<0.05$) than the minimum dietary recommendation. The average apparent metabolizable energy content was 9.9 MJ/kg air-dry (95 % confidence interval 8.9 to 10.9). The calcium content of layer mash was by far below ($P<0.05$) the recommended dietary allowance. The average calcium content was 1.0 % air-dry (95 % confidence interval 0.74 to 1.26). For the chick mash and grower mash rations, apparent metabolizable energy and calcium contents were

Table 3 Nutrient composition of own-mixed layer chicken rations compared with recommended dietary requirements (air-dry)

	CP (%)	CF (%)	Ca (%)	P (%)	AME_n (MJ/kg)
Chick mash					
Mean	13.0	5.9	1.07	0.85	10.4
Recommended level[a]	≥18.0	≤6.0	≥0.7 and ≤1.3	≥0.4 and ≤1.1	≥11.0
t-value	−5.53	−0.29	0.25	2.25	−1.39
Significance level	**	NS	NS	NS	NS
95 % confidence interval					
Lower limit	10.7	5.1	0.42	0.74	9.2
Upper limit	15.3	6.7	1.71	0.95	11.5
Grower mash					
Mean	12.5	6.3	1.30	0.86	10.8
Recommended level[a]	≥16.0	≤6.0	≥0.7 and ≤1.3	≥0.4 and ≤1.1	≥11.5
t-value	−3.62	0.85	1.65	0.65	−1.85
Significance level	**	NS	NS	NS	NS
95 % confidence interval					
Lower limit	10.2	5.5	0.87	0.46	10.0
Upper limit	14.8	7.1	1.73	1.26	11.7
Layer mash					
Mean	11.8	6.6	1.00	0.70	9.9
Recommended level[a]	≥16.5	≤7.0	≥3.0 and ≤3.5	≥0.5 and ≤1.0	≥12.0
t-value	−17.5	−1.08	−20.4	−0.98	−5.50
Significance level	***	NS	***	NS	**
95 % confidence interval					
Lower limit	11.1	5.6	0.74	0.57	8.9
Upper limit	12.4	7.5	1.26	0.82	10.9

Nutrient composition is indicated using the following abbreviations: *CP* crude protein, *CF* crude fiber, *Ca* calcium, *P* total phosphorus and AME_n apparent metabolizable energy corrected for nitrogen

*Indicates statistical significance at the 5 % level

**Indicates statistical significance at the 1 % level

***Indicates statistical significance at the 0.1 % level. *NS* indicates not significant

[a] Source: Smith (2001) and Luis and Batungbacal (2010)

within (P>0.05) the recommended dietary allowances. Phosphorus content of the three own-mixed layer chicken rations was within (P>0.05) the recommended dietary allowances.

In general, own-mixed chicken rations did not conform to the recommended dietary allowances. This is likely caused by a combination of improper feed formulae and use of low quality feedstuffs. Feed adulteration is deliberately done by dishonest feed suppliers to exploit the final consumer (farmers). Pure feedstuffs (particularly expensive ones) are deliberately mixed with adulterants to increase weight. According to Byarugaba (2012) and UNBS (2012), common adulterants added include burnt tyres, sawdust, rice husks, maize cobs, white mica, limestone, stones, sand, soil particles, and water. Besides deliberate addition of adulterants, the low quality of feedstuffs is blamed on contamination as a result of haphazard handling and processing (Masette 2009). The challenge of poor and/or varying animal feed quality is increasingly becoming widespread in Uganda. Katongole et al. (2012) attributed this increase to the lack of the necessary legislative support. Much as the National Animal Feeds Policy exists, which aims at ensuring quality animal feeds on the market (MAAIF, 2005), it has never been implemented. The Animal Feeds Bill, which is supposed to operationalize the policy, has never been passed by the parliament.

The average CP values for broiler starter and broiler finisher rations were 35 and 36 % (respectively) lower than the minimum dietary value recommended by Smith (2001) for broiler chickens in the tropics. The average values for chick mash, grower mash and layer mash were 28, 22, and 28 %, respectively lower than the minimum dietary value recommended. The lower CP composition is attributed to the use of low quality feedstuffs (particularly fish meal). The CP composition (18.3 % air-dry) of fish meal reported in this study was 67 % lower than what was reported by Munguti et al. (2012) for pure fish meal. Studies by Masette (2009) indicated that adulteration of fish (*Rastrineobola argentea*) with extraneous material like livestock dung, plant materials, stones, and sand/soil was a principal constraint among poultry farmers within the Lake Victoria basin. The study indicated that the ash content of the low quality fish was four times higher than in pure fish, and the protein content was two to four times less. Lowering the protein content of chicken diets may reduce feed cost per se and decrease nitrogen excretion and ammonia emission to the environment (Keshavarz and Austic 2004; Roberts et al. 2007a). However, low protein levels in chicken diets have been reported to cause inferior growth performance and carcass quality in broiler chickens (Bregendahl et al. 2002; Widyaratne and Drew 2011), thereby resulting into suboptimal production efficiency. Maximum breast yield requires a high-protein diet (Widyaratne and Drew 2011), while feeding low protein diets causes increased body fat content (Bregendahl et al. 2002). In laying hens, a lower CP content in the diet than normal leads to lower egg production, egg mass, and feed utilization (Roberts et al. 2007b).

The average CF values for broiler starter and broiler finisher rations were 38 and 50 %, respectively higher than the maximum dietary value recommended by Smith (2001) for broiler chickens in the tropics. The higher CF content is attributed to the use of improper feed formulae. Owing to improper feed formulae, feedstuffs containing relatively high concentrations of CF (particularly cottonseed cake and sunflower seed cake) end up being included at higher levels than optimal. This translates into rations with high CF content. Increasing the content of fiber in the diets of poultry and pigs is known to reduce the digestibility of nutrients and energy (Högberg and Lindberg 2004; Rama Rao et al. 2006), resulting into a decreased production efficiency. High levels of CF have also been reported to reduce the concentration of energy (Carew et al. 2005). However, according to Rama Rao et al. (2006), the sensitivity to high fiber levels is reduced with increasing age of the birds. Rama Rao et al. (2006) indicated that replacing soybean meal completely with sunflower seed meal in commercial broiler chicken diets resulted in a higher growth depression during the early phase of growth than during the finisher phase. The growth depression was attributed to reduced food intake due to the high level of dietary fiber.

The average calcium content (1.0 %) of the own-mixed ration for laying chickens (layer mash) was 67 % lower than the minimum dietary level (3.0 %) recommended by Smith (2001). Satisfying the dietary requirement for calcium in laying hens is important for egg production and egg quality, particularly for hens approaching the end of their laying cycle. According to Safaa et al. (2008), increasing the level of calcium in the diet of hens in their late phase of egg production from 3.5 to 4.0 % significantly improved egg production, egg mass, and feed conversion. Shell quality characteristics (weight, thickness, and density) were also significantly improved, which led to a reduced percentage of broken and shell-less eggs.

4 Conclusion

Own-mixed chicken rations in urban and peri-urban areas of Uganda are nutritionally inadequate. They contain considerably lower protein, metabolizable energy, and calcium than the minimum dietary recommendations. On the contrary, the rations are excessively high in ash and CF. The chemical composition of the five classes of chicken feeds (broiler starter, broiler finisher, chick mash, grower mash, and layer mash) is within the same range, which implies that farmers use more or less the same feed formula across all the five classes of the chicken feeds. There is a critical need to give farmers training on how to source feed ingredients of right quality as well as feed formulation and mixing. Using feeds with adequate nutrient concentrations is a key prerequisite to ensuring profitable and sustainable chicken production.

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