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Nutritional Quality of Quail Feeds Used in Urban and Peri-Urban Areas of Uganda: Chemical and Energy Composition

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Abstract
Quail production is steadily gaining importance in developing countries like Uganda, particularly in urban and peri-urban areas. However, inappropriate feeding practices such as using the same feed classes across different growth stages or beyond the recommended growth stages have been reported among quail farmers. This study evaluated the nutritional properties of quail diets used in urban and peri-urban areas of Uganda. Samples of three classes of quail feeds (starter, grower, and layer diets) were collected from quail farmers and poultry feed suppliers in Mukono, Kampala, and Wakiso districts. The samples were analyzed for crude protein (CP), ether extract, crude fiber (CF), ash, calcium, phosphorus, and gross energy contents and then metabolizable energy (ME) contents of the samples were calculated. The data were compared with the minimum dietary specifications recommended for quails in the tropics. Results revealed a high variation in the nutritional quality and that the diets did not conform to the recommended specifications. The average CP contents of starter and grower diets from farmers (17% and 15.9%, respectively) and feed suppliers (15.7% and 16.8%, respectively) were far lower ($P < 0.05$) than the minimum specifications for low-protein diets (24% and 20%, respectively). The average ME contents for all the feed classes were also lower ($P < 0.05$) than the minimum specifications. The diets were characterized by high ash and CF contents (averages ranged between 17.1-20.2% for ash and 5.5-6.3% for CF). The chemical and energy values obtained were in the range reported for chicken diets (in Uganda), which points to the use of diets formulated for chickens in quail feeding. In conclusion, it is necessary to train and sensitize quail farmers and feed suppliers about the benefits of using quail diets with adequate protein content, preferably produced based on protein sources that attract less or no competition from humans. Future research should identify such protein sources, their nutritional properties, and their potential use in quail diets.

Introduction
The quail (*Coturnix japonica*) is a game bird species with growing acceptance in the poultry industry worldwide. Quails possess the unique characteristics of fast growth (they can be sold at five weeks of age as table birds), early sexual maturity (they lay their first egg at ~40 days of age), high rate of egg production (up to 250 eggs a year) and shorter incubation period (16-17 days) (Kaur *et al.*, 2008; Poynter *et al.*, 2009; Parvin *et al.*,

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2010; Ayasan, 2013; Priti and Satish, 2014). Additionally, due to their small body size (230-250 g and 250-300 g for adult male and females, respectively), quails require less housing space and feed (Haruna *et al*., 1997; Padmakumar *et al*., 2000). These characteristics make quails suitable for resource-constrained livestock production systems such as in urban and peri-urban production. However, for the fast growth and high egg production performances to be realized, quails must be provided with optimum management conditions, particularly nutrition and feeding. One of the most important nutrients for quails is high quality protein with adequate amino acid balance (Leeson and Summers, 2005; Kaur *et al*. 2008) as high dietary crude protein (CP) is necessary for its fast growth.

The National Research Council (NRC, 1994) recommends dietary CP levels of 24% (with ME level of 2,900 Kcal/kg) up to 6 weeks of age as well as 20% (ME 2,700 Kcal/kg) for the production period (beyond 6 weeks). However, various reports have recommended varying nutrient levels for different environments (Altine *et al*., 2016). Leeson and Summers (2005) recommended CP levels of 28%, 18%, and 20% for quails in the starting (ME 2,900 Kcal/kg), growing (ME 2,900 Kcal/kg) and laying (ME 2,950 Kcal/kg) periods, respectively. Prabakaran (2003) has shown that quails can be profitably raised in the tropics on starter (0-2 weeks), grower (3-5 weeks), and production (6 weeks and beyond) diets containing CP levels of 24% (ME 2,750 Kcal/kg), 20% (ME 2,700 Kcal/kg), and 19% (ME 2,650 Kcal/kg), respectively.

In Uganda, the early 2010s witnessed increased interest in quail farming in many urban areas, particularly for quail eggs, which were claimed to have better health benefits compared to chicken eggs (Tobiko, 2015). These claims stimulated consumer demand for quail eggs to the extent that the market price of quail eggs was about 70% higher than the price of chicken eggs. However, despite the importance of optimum nutrition and feeding to profitable quail production, inappropriate feeding practices have been reported among quail farmers in Uganda (Nasaka *et al*., 2017). Such practices include the use of the same class of feed across different growth sages or beyond the recommended growth stages. Such inappropriate feeding practices are likely to subject quails to nutritionally inadequate diets. Until now, information on the nutritional qualities of feeds used in quails in Uganda has been limited. Therefore, this study was conducted to evaluate the nutritional properties of quail diets used in Uganda.

Materials and Methods

The study was conducted in three urban districts of Uganda: Wakiso, Mukono, and Kampala. The districts were selected based on the existence of domesticated quail production activities.

Source and collection of samples

Samples of three classes of quail feeds (starter, grower, and layer feeds) were collected randomly from a list of known quail farmers and poultry feed suppliers in Mukono, Kampala, and Wakiso districts. The samples were collected over a period of 6 months (January to June 2017). With the consent of the farmers, a representative sample of about 250 g was taken from the feed intended for each of the starter, grower, and layer stage. From quail farmers, we collected 10 samples from Mukono, 12 from Wakiso, and 16 from Kampala. This resulted in a total of 38 samples (12 starter, 12 grower and 14 layer feed).

The poultry feed suppliers included feed manufacturers, wholesalers, and retail poultry feed outlets. To obtain feed samples from poultry feed suppliers, 1 kg of the marketed quail feed was purchased for each of the respective development stages and then a sample of about 250 g was taken. Twelve samples were collected from Mukono, 10 from Wakiso, and 14 from Kampala. This resulted in a total of 36 samples (12 starter, 12 grower, and 12 layer feeds).

Chemical analysis

The feed samples were oven dried (forced air oven) at 60°C for over 48 hrs until constant readings were obtained. The samples were then ground through a 1 mm sieve and analyzed for dry matter (DM), CP, ether extract (EE), CF, calcium (Ca), phosphorous (P), and total ash according to protocols from AOAC (1990). Gross energy (GE) content was determined using a bomb calorimeter (Gallenkamp auto bomb, UK). Metabolizable energy (ME) was calculated as Apparent Metabolizable energy corrected for nitrogen (AME_n) using the equation by Carré and Rozon (1990): $AME_n = 0.913GE - 18.5CP - 109.5CF$; where GE is in Kcal/kg, CP and CF in percent.

Statistical analysis

All data were analyzed using SAS version 9.3

statistical software (SAS, 2002). Using a one-sample t-test procedure, the chemical composition and calculated ME content of the quail feeds were compared with the minimum dietary specifications recommended for quails in the tropics (Prabakaran, 2003). Comparisons between sources of samples from quail farmers and poultry feed suppliers were conducted using the two-sample t-test procedure of SAS.

Results

Chemical and energy composition

The chemical and energy compositions of quail diets are summarized in Tables 1 and 2. The diets were characterized by both high ash and CF contents. The average ash content ranged from 17.1% to 20.2% (with a tendency towards higher ash content for layer diets), while average CF content ranged from 5.5% to 6.3%. On average, the layer diets had consistently higher CP contents (19% and 16.8% for diets from farmers and feed suppliers, respectively) than the starter and grower diets. However, there was no consistent trend observed in the calculated ME content. For diets from poultry feed suppliers, the starter diets had the highest calculated ME (2,389 Kcal/kg), while for diets from quail farmers, the layer diets had the highest calculated ME content (2,478 Kcal/kg).

There were high coefficients of variation (CV) for all the chemical and energy composition measurements across diets from quail farmers and feed suppliers (averages ranged from 15.6% to 55.9%). Generally, the chemical and energy composition of samples collected from quail farmers and feed suppliers was similar (Table 2), apart from the CP content of layer diets from quail farmers (19%) being significantly higher (*P* < 0.05) than that from feed suppliers (16.8%).

Table 1. Chemical and energy composition of quail diets in urban and peri-urban areas of Uganda

		Starter diets			Grower diets			Layer diets		
	As-fed basis	Mean	SD	CV%	Mean	SD	CV%	Mean	SD	CV%
Farmers' feeds	DM (%)	91.7	2.3	2.5	91.5	1.5	1.7	92.3	2.2	2.4
	CP (%)	17.0	4.2	24.6	15.9	4.7	29.4	19.0	5.6	29.7
	CF (%)	6.0	1.4	23.4	5.5	1.1	19.4	6.0	1.7	28.9
	EE (%)	6.6	2.7	40.5	7.1	1.7	23.3	6.4	1.2	19.1
	Ca (%)	1.3	0.5	39.8	1.5	0.5	34.4	1.9	0.6	29.0
	P (%)	1.2	0.6	53.7	0.8	0.2	23.3	0.9	0.4	55.9
	Ash (%)	17.5	5.6	31.7	18.3	5.8	31.9	20.2	4.1	20.2
	GE (Kcal/kg)	3,658	722	19.7	3,197	924	28.9	3,817	597	15.6
	*ME (Kcal/kg)	2,364	693	29.6	2,304	860	37.4	2,478	502	20.3
Suppliers' feeds	DM (%)	91.9	1.8	1.9	91.7	2.1	2.3	92.5	1.9	2.1
	CP (%)	15.7	3.9	24.5	16.8	5.2	31.2	16.8	4.8	27.9
	CF (%)	6.1	1.6	26.7	6.0	1.4	26.4	6.3	1.3	21.3
	EE (%)	7.1	2.5	35.0	7.7	2.9	37.6	6.5	2.1	31.8
	Ca (%)	1.5	0.6	43.5	1.7	0.7	39.9	1.6	0.8	46.3
	P (%)	0.9	0.5	49.7	0.8	0.2	20.1	0.8	0.3	43.2
	Ash (%)	19.2	5.6	29.1	17.1	4.4	25.5	19.5	5.8	29.8
	GE (Kcal/kg)	3,666	665	18.1	3,515	836	23.8	3,439	803	23.3
	*ME(Kcal/kg)	2,389	573	24.2	2,304	740	32.1	2,135	693	32.6

*ME calculated from $AME_n = 0.913GE - 18.5CP - 109.5CF$; where GE is in kilocalorie per kilogram, CP and CF are in percentages (Carré and Rozon, 1990).

Chemical and energy compositions compared with recommended dietary specifications

The average CP values obtained in starter diets were lower (*P* < 0.05) than the minimum specification (24%) by 29% and 35% for farmers' feeds and suppliers' feeds, respectively (Table 3). Similarly, the average CP values obtained in grower diets were lower (*P* < 0.05) than the minimum specification (20%) by 21% and 16% for farmers' feeds and suppliers' feeds, respectively. For layer diets, the average CP content in farmers' feeds met the minimum specification (19%), but suppliers' feeds were lower (*P* < 0.05) by 13%. The average calculated ME contents for starter diets were lower (*P* < 0.05) by 14% and 13% than the minimum specification (2,750 Kcal/kg) for farmers' feeds and suppliers' feeds, respectively. Similarly, the average calculated ME values obtained for grower diets were also lower (*P* < 0.05) than the minimum specification (2,700 Kcal/kg) by 25% and 15% for farmers' feeds and suppliers' feeds, respectively. The average CF contents of starter, grower and layer diets were higher ($P < 0.05$) than the maximum specifications (≤ 4%, ≤ 4.5%, and ≤ 5.0%, respectively). The average Ca content (1.9%) of the layer diets was lower ($P < 0.05$) than the recommended specification (≥3.0%).

Table 2. Chemical and energy composition (As-fed basis) of quail diets from farmers compared with quail diets from feed suppliers

	Farmers' feed	Suppliers' feed	t-value	*P*-value
Starter diets (n)	12	12		
CP (%)	17.0	15.7	1.2	0.2417
CF (%)	6.0	6.1	- 0.1	0.9423
Ca (%)	1.3	1.5	0.1	0.9492
P (%)	1.2	0.9	- 0.1	0.9517
ME (Kcal/kg)	2,364	2389	- 0.09	0.9307
Grower diets (n)	12	12		
CP (%)	15.9	16.8	- 0.5	0.5923
CF (%)	5.5	6.0	0.2	0.8909
Ca (%)	1.5	1.7	- 0.8	0.4236
P (%)	0.8	0.8	1.3	0.1985
ME (Kcal/kg)	2,304	2,304	- 1.1	0.2958
Layer diets (n)	14	12		
CP (%)	19.0	16.8	2.3	0.01550
CF (%)	6.0	6.3	- 0.7	0.4868
Ca (%)	1.9	1.6	1.8	0.0796
P (%)	0.9	0.8	0.63	0.5320
ME (Kcal/kg)	2,478	2,135	1.83	0.0732

*ME calculated from AME_n = 0.913GE – 18.5CP – 109.5CF; where GE is in kilocalorie per kilogram, CP and CF are in percentages (Carré and Rozon, 1990).

Table 3. Chemical and energy composition (As-fed basis) of quail diets from farmers compared with recommended specifications

	Mean	95% CI	Recommended	t-value	*P*-value	AME_n/CP
Starter (n = 12)						
CP (%)	17.0	16.1-22.7	≥24	-9.1	<0.0001	
CF (%)	6.0	4.6-6.4	≤4	7.9	<0.0001	
Ca (%)	1.3	0.6-1.4	≥0.8	5.6	<0.0001	
P (%)	1.2	0.7-1.4	≥0.3	7.6	<0.0001	
*ME(Kcal/kg)	2,364	654-3,397	≥2750	-3.0	0.0053	139
Grower (n = 12)						
CP (%)	15.9	12.1-16.8	≥20	-3.8	0.0016	
CF (%)	5.5	4.7-6.9	≤4.5	3.9	0.0010	
Ca (%)	1.5	0.7-1.6	≥0.6	7.4	<0.0001	
P (%)	0.8	0.2-5.8	≥0.3	12.8	<0.0001	
*ME(Kcal/kg)	2,304	887-3,413	≥2700	-3.4	0.0034	145
Layer (n = 14)						
CP (%)	19	17.5-23.1	≥19	0.003	0.9791	
CF (%)	6.0	5.5-7.3	≤5.0	2.9	0.0060	
Ca (%)	1.9	1.5-1.9	≥3.0	-10.2	<0.0001	
P (%)	0.9	0.6-0.8	≥0.45	3.9	0.0007	
*ME(Kcal/kg)	2,478	1,547-3,394	≥2650	-1.9	0.0710	130

*ME calculated from AME_n = 0.913GE – 18.5CP – 109.5CF; where GE is in kilocalorie per kilogram, CP and CF are in percentages (Carré and Rozon, 1990).

In diets from poultry feed suppliers, the average CP contents of the starter (15.7%; ranging from 13.7% to 17.9%), grower (16.8%; ranging from 14.8% to 24.2%) and layer diets (16.5%; ranging from 14.8% to 18.4%) were significantly lower than ($P < 0.05$) than the recommended minimum specifications (24%, 20%, and 19%, respectively) (Table 4). A similar trend of chemical composition values being lower than the recommended was also observed for the average calculated ME contents of the starter, grower, and layer diets. The average CF contents of the starter (6.1%; ranging from 5.5% to 6.9%), grower (6.0%; ranging from 5.5% to 6.3%), and layer diets (6.3%; ranging from 5.9% to 7.1%) were higher (P < 0.05) than the recommended minimum specifications. The average Ca content of the layer diets (1.6%; ranging from 1.3% to 1.7%) was significantly lower (P < 0.05) than the recommended minimum specification (≥3.0%).

Table 4. Chemical and energy composition (As-fed basis) of quail diets from feed suppliers compared with recommended specifications

	Mean	95% CI	Recommended	t-value	P-value	AME_n/CP
Starter (n = 12)						
CP (%)	15.7	13.7-17.9	≥24	-10.5	<0.0001	
CF (%)	6.1	5.5-6.9	≤4	6.3	<0.0001	
Ca (%)	1.5	0.9-1.4	≥0.8	5.2	<0.0001	
P (%)	0.9	0.2-5.5	≥0.3	3.6	0.0015	
*ME(Kcal/kg)	2,389	812-3,397	≥2750	-3.0	0.0006	152
Grower (n = 12)						
CP (%)	16.8	14.8-24.2	≥20	-2.6	0.0174	
CF (%)	6.0	5.5-6.3	≤4.5	2.8	0.0135	
Ca (%)	1.7	0.7-1.6	≥0.6	6.8	<0.0001	
P (%)	0.8	0.6-0.8	≥0.3	11.5	<0.0001	
*ME(Kcal/kg)	2,304	890-3,420	≥2700	-2.3	0.0365	137
Layer (n = 12)						
CP (%)	16.5	14.8-18.4	≥19	-2.9	0.0135	
CF (%)	6.3	5.9-7.1	≤5.0	5.0	<0.0001	
Ca (%)	1.6	1.3-1.7	≥3.0	-9.9	<0.0001	
P (%)	0.8	0.6-10	≥0.45	5.1	<0.0001	
*ME(Kcal/kg)	2,135	296-2,895	≥2650	-3.9	<0.0005	129

*ME calculated from AME_n = 0.913GE – 18.5CP – 109.5CF; where GE is in kilocalorie per kilogram, CP and CF are in percentages (Carré and Rozon, 1990).

Discussion

Chemical and energy composition

The average ash and CF contents of all three classes of quail diets were very high (5.5- 6.3%) compared to their recommended maximum specifications (≤4%, ≤4.5%, and ≤5.0%, for starter, grower and layer diets, respectively) (Prabakaran, 2003). This observation is consistent with previous reports (Carew *et al.,* 2005; Nalwanga *et al.,* 2009; Kasule *et al.,* 2014) on the nutritional value of poultry feeds in developing countries, like Uganda and Nigeria. The high CF content is attributed to high inclusion of feed ingredients that contain relatively high fibre contents (such as cotton seed cake, sunflower cake, etc.). The high ash content is indicative of contamination or even adulteration with inorganic materials (particularly sand and soil particles). Adulteration with sand is a deliberate action by unscrupulous feed suppliers to exploit farmers (Nabukeera, 2011; UNBS, 2012; Kasule *et al.,* 2014). The consistent trend we observed of higher CP contents in layer diets compared to the starter and grower diets was surprising. The genetic makeup of quails, which allows them to grow and reach sexual maturity quickly, makes the quail chicks' protein requirements higher than that of laying quails. Offering inadequate levels of nutrients, particularly protein, reduces growth performance in quails (Gheisari *et al.,* 2011; Tuleun *et al.,* 2013), thereby significantly affecting the profitability and long-term economic feasibility of the enterprise.

The high variation in chemical and energy composition observed in this study reflects the unpredictability and inconsistency of nutritional quality among the feeds. This variation at the feed-supplier level could be largely explained by the absence of quality control inspection by government agencies (NLP, 2008; Katongole *et al.,* 2012; UNBS, 2012). At the farm level, the variability could be partially minimized by training and sensitization campaigns to maintain the wholesomeness of feeds. It is common practice among poultry farmers in urban and peri-urban areas of Uganda to purchase commercially compounded feeds, and dilute them with cheap and/or locally available feed ingredients as a cost-saving strategy (Katongole *et al.,* 2012).

Chemical and energy composition compared with recommended dietary specifications

When the chemical and energy compositions of the quail diets were compared with the recommended specifications under tropical conditions (Prabakaran, 2003), the nutritional quality generally did not conform to their specifications. These chemical and energy composition values observed in this study were within the range of values reported for diets used in the feeding of chickens in Uganda (Magala *et al.*, 2012; Kasule *et al.*, 2014; Nakkazi *et al.*, 2015). This observation was not surprising, because it points to the use of diets formulated for chickens in quail feeding, which has been widely reported in developing countries (Prabakaran, 2003; Bawa *et al.*, 2011; Tuleun *et al.*, 2013). Although the dietary CP requirement for laying quail birds is within the range of the requirement for laying chickens, the same is not true for starting and growing quails. Owing to their fast growth, quail have a much higher requirement for dietary protein than chickens (Prabakaran, 2003; Gheisari *et al.*, 2011; Altine *et al.*, 2016).

The ME:CP ratios of the diets tended to decrease with advancing stages of growth (146, 141, and 130 for starter, grower, and layer diets, respectively), likely because of higher CP contents in the starter through layer diets (while maintaining the ME level at 2,300 Kcal/kg to 2,400 Kcal/kg). However, previous studies (Sehu *et al.*, 2005; Tarasewicz *et al.*, 2006; Kamran *et al.*, 2008) have indicated that increasing the ME:CP ratios from the starter through the laying period can translate into more efficient utilization of low-protein diets by poultry, thereby increasing profitability. The decreasing ME:CP ratios from starter to the laying period that we observed in this study may compromise the performance of quails, thus affecting the profitability of the quail enterprise. The use of protein sources that attract less or no competition from humans may be an option for ensuring adequate dietary protein supply to quails, particularly during the starting and growing periods.

Conclusions

Results of this study revealed a high variation in the chemical and energy composition of diets used for feeding quails in urban and peri-urban areas of Uganda. The diets did not conform to the recommended specifications for tropical conditions. Starter and grower diets contained far lower CP and energy contents than the minimum specifications. The layer diets were generally higher in CP content than starter and grower diets. The chemical and energy values were wihin the range of values reported for chicken feeds, which points to the use of chicken feeds in quail feeding. Therefore, there is need to train and sensitize quail farmers and feed suppliers about the benefits of using quail diets with adequate protein content, preferably produced based on protein sources that attract less or no competition from humans. However, further research is needed to identify such protein sources, evaluate their nutritional properties, and explore the possibility of including them in quail diets.

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