NUTRITIONAL DIVERSITY OF MEAT AND EGGS OF FIVE POULTRY SPECIES IN KENYA

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Abstract
Poultry production is a major source of livelihood to many Kenyans with a significant role in nutrition and food security. Wild birds have been harvested from forests and consumed for long because of health claims but the nutritional differences between domesticated and wild birds remain scientifically unexplored in Kenya. The study sought to highlight the nutritional diversity of indigenous chicken, commercial chicken, quail and guinea fowl meat and eggs by determining the proximate composition and mineral content. Samples were bought from Kiambu and Western Kenya and then transported to Department of Food Science laboratory, Jomo Kenyatta University of Agriculture And Technology for preparation and analysis with clearance from the relevant authorities. Proximate composition was determined according to Association of Analytical Chemists, (AOAC, 1995), mineral analysis by ashing followed by atomic absorption spectrophotometry for specific mineral. Indigenous chicken was the heaviest (1426g)and wild quail was the lightest (163g) while commercial chicken egg was the heaviest (60g) compared to the commercial quail egg (11g) which had the least weight. Results showed no significance difference in fat, moisture, protein and zinc among poultry types of egg samples. For meat samples, moisture, fat, ash, carbohydrates calcium and zinc varied among the poultry types significantly at $p \leq 0.05$. In conclusion, wild quail live weight was the least among all the poultry type but had high protein, ash, iron, zinc, there is need for consumer awareness on sustainable use. of wild birds.

Key words: Kenya, proximate, mineral content, nutritional diversity, meat and eggs

1.0 Introduction
Kenya has an estimate of 28 million birds comprising of 76% free range indigenous chicken, 22% commercial chicken (broilers and layers) and the remaining 2% is made up of the other species: ducks, turkey, pigeons, ostrich, guinea fowls and quails (Republic of Kenya, 2010) and these other species are increasingly becoming important. About 20 tonnes of poultry meat worth 3.5 billion and 1.3 billion eggs worth 9.7 billion are produced annually (Republic of Kenya, 2010).

There is legal framework and incentives for wildlife related enterprises provided by the Wildlife Policy and Act hence it has presented a huge potential for huge game farming including guinea fowls and quails (MOLD, 2013; Moreki, 2012: Republic of Kenya, 2010.) Guinea fowls are increasingly becoming common among our small scale farmers providing extra income and food to our households thus contributing to poverty alleviation, nutritional and food security (MOLD, 2013).

In Kenya, guinea fowls are domesticated with the permission of KWS, the red wattle helmeted type (Numida meleagris) being the most widely domesticated (MOLD, 2013). On the other hand, local quails have been kept and consumed in Western Kenya as a tradition for a long time. The birds are trapped from the forests and kept at home for breeding or consumed directly (Okello et al., 2010, Nyaga, 2007.) The wild quail birds are seasonally available in the market in Siaya County and their eggs were not available for this research.
Indigenous chicken are mostly kept by an estimate of 75% rural families who on average keep about 13 birds and contribute to about 71% of the total eggs and poultry (FAO, 2008). This therefore impacts rural trade, welfare, and food and nutrition security of the small holder farmers significantly (FAO, 2008). Commercial chicken on the other hand are kept in the urban and peri-urban areas where there's availability of ready market and this has led to the growth of hatcheries selling day old chicks (Omiti & Okuthe, 2010.) There have been several health and safety concerns about commercial chicken being reared on feed with antibiotics and

'promoters of growth' hence causing antibiotic resistance. This has created a shift in consumption to indigenous chicken and wild birds; quails and guinea fowls. This has led to growth of the venture to meet the increasing consumer demands for these poultry products which command higher prices (FAO, 2011). Consumption of these products have been associated with health and 'medicinal' claims which include being more nutritious than commercial chicken and being able to 'cure' diabetes and prevent cancer and cardiovascular diseases. The claims are associated with the known functions of macro and micronutrients hence the need to determine the nutritional composition of these products which remain scientifically unexplored in Kenya.

2.0 Materials and Methods

2.1 Ethical Clearance

Clearance from the department of Food Science and Technology, Jomo Kenyatta University of Agriculture and Technology, Kenya was obtained to undertake the research.
Research on the indigenous chicken and commercial chicken, domesticated guinea fowl and quail birds and eggs got no objection under permit number RES/POL/VOL.XXVII/162 while ethical clearance for wild quails was obtained from Kenya Wildlife Services under permit number: KWS/BRM/5001.

2.2 Experimental Design

The experiment was laid in random block design (RBD) with purposive sampling used to select the two blocks to collect the samples: Western Kenya and Nairobi. The two blocks were selected based on the high density of each poultry type.

2.3 Sample Collection

A tray of commercial chicken and domesticated quail eggs and respectively three live birds were bought from Wangige market in Kiambu County. Three live indigenous chickens and a tray of their eggs were bought from Busia. Likewise, three live domesticated helmeted guinea fowl and their eggs were bought from Mount Elgon region, Bungoma County. The samples were transported to Jomo Kenyatta University of Agriculture and Technology, Juja, Kenya for preparation and the analysis at the laboratory at the Food Science and Technology.

2.4 Evaluation of Physical Quality of Poultry Eggs

The eggs samples were washed to remove contaminants from the shells and dried with a towel then weighed. The yolk was separated from the albumen manually and the respective weights determined using (Shimadzu weighing scale). The shells were weighed after drying in an oven overnight and shell percentage proportion was calculated

2.5 Determination of Physical Characteristics of Poultry Birds

Several live indigenous chicken, commercial quail, wilds quail and wild guinea fowls birds were weighed and released to determine their live weigh. For chemical analysis, three live birds were weighed, slaughtered, bled for three minutes, defeathered, eviscerated, dissected, intestines and legs removed and then weighed. The carcass was then deboned manually. The meat and bones were weighed separately and meat to bone ratios calculated. The meat with skin was minced and mixed thoroughly for homogeneity, put in tree plastic bags, frozen immediately at -18^{0}C for further analysis. Prior to chemical tests, frozen meat samples were thawed overnight in a refrigerator (+4 ºC).

2.6 Chemical Analysis

Proximate composition (moisture, fat, ash, protein and carbohydrates content), mineral content (Zinc, Calcium, Iron) and fatty acid profiles of the samples were determined.

2.7 Determination of Proximate Composition Poultry Meat and Eggs

The proximate composition of meat and egg samples was determined according to the AOAC (1995) methods. Moisture content was determined by drying the samples at 105°C to constant weight. The crude protein content was determined by the Kjeldahl method and the crude fat content was determined by the Soxhlet method. The ash content was determined by charring followed by ashing the samples at 550°C to a white ash. The carbohydrate content was calculated by difference (total mass of moisture, total fat, ash and crude protein subtracted from the mass of the food).

2.8 Determination of Mineral Content of Meat and Eggs

The atomic absorption spectrophotometer method was used to determine zinc, iron and calcium content of AOAC (1995). The cooled ash from ash determination was dissolved in 15 ml of 1:1 HCl: water in a volumetric flask which then topped up to 100 ml mark with distilled water. It was then heated to 80- 90^{0}C for 5 minute on a hot plate then transferred to a 100ml volumetric flask, filled up to the mark with HCl, mixed well and filtered. Standard solution of zinc, iron and calcium at different concentrations was prepared and injected to spectrophotometer (model A- 6200, Shimadzu, Corp., Kyoto, Japan) using the respective cathode lamps. The individual mineral element composition was calculated from the AAS spectrophotometer readings obtained for both the blank and the test solution. Actual result = measurement – blank and then determined using the standard curve. All determinations were done in triplicate and reported in mg/100g sample.

3.0 Results and Discussion

3.1 Poultry Carcass Characteristics

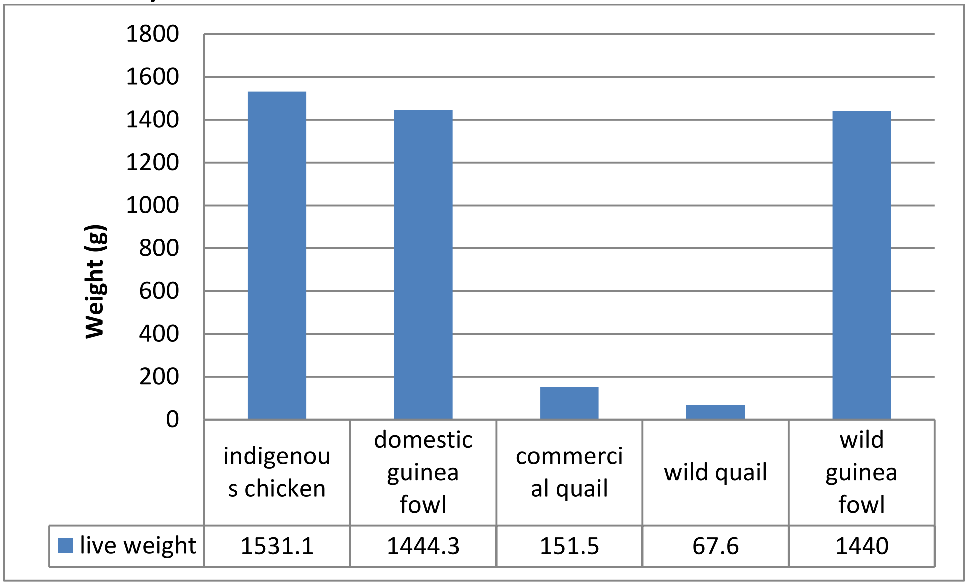

Figure 1: Live weight of poultry birds in Kenya in Grams

Indigenous chicken was about twenty times heavier than wild quail which had the least live weight. The weight of commercial quails was higher than to that reported by Bonos & Christaki, (2010) ,

Table 2: Carcass characteristic of poultry in Kenya (Grams)

Poultry type	Live bird	Meat weight	Bone weight	Meat: bone ratio
Indigenous chicken	1426.67±434.32	743.33±39.20	470.00±8.66	1.58±0.47
Commercial chicken	1100.68±213.05	670.56±42.02	323.45±10.40	1.44±0.19
Domestic guinea fowl	766.67±96.48	266.67±35.14	185±13.23	1.58±0.85
Commercial quail	163.33±21.99	72.15±4.02	50±6.73	1.45±0.14
Wild quail	57.86±2.68	20.57±3.07	9.14±1.07	2.30±0.30

Live indigenous chicken weighed more than the commercial chicken. Domestic guinea fowls were approximately half the weight of indigenous chicken while wild quail was the lightest. Similar results were observed in terms of meat weight. The meat/bone ratio (1.58) was highest in the case of indigenous chicken and domestic guinea fowl. Commercial chicken and quail had similar (1.45) but lower meat/bone ratio. Meat quality has been reported to be a function of interaction between genotype and environmental factors (Lokman et. al, 2011). Kokoszyński et. al, (2013) reported higher average live and carcass weight of commercial chicken. Commercial quail weight was similar to that reported by Song et. al, (2001) and Santos et.

al, (2011). Domestic guinea fowl weight is not influenced by dietary treatment significantly but by age, yet dietary composition influences the dressing percent (Moreki, 2012). Males have been reported to be heavier than females but the floor type has also been reported to affect the weight (Mareko et. al, 2012). There is no data on the meat: bone ratio of wild quails. Carcass characteristics of wild quails were similar to those reported by El-Dengawa and Nassar 2001) while the live weight was consistent with results by Chang et al., 2008.

3.2 Physical Quality of Poultry Eggs

Table 1: Physical quality of poultry eggs

Poultry type	Whole egg	Shell	Yolk	Albumen
Indigenous chicken	$46.01±1.72^{c}$	$15.27±0.63^{d}$	$5.84±0.27^{b}$	$24.90±3.81^{c}$
Commercial chicken	$60.31±1.91^{d}$	$6.05±0.21^{b}$	$15.01±0.42^{c}$	$39.25±1.58^{d}$
Domestic guinea fowl	$34.57±0.91^{b}$	$11.75±1.50^{c}$	$5.40±2.023^{b}$	$17.42±0.633^{d}$
Commercial quail	$11.35±0.23^{a}$	$3.88±0.26^{a}$	$1.05±0.06^{a}$	$6.42±0.32^{a}$

The results of physical characteristics of poultry eggs in Kenya are presented in Table1. The weights of whole eggs varied significantly at ($p<0.05$). Similar results were observed for egg shell, yolk and albumen which are consistent with the results by Haushi et. al, (2010). Commercial chicken egg had the heaviest whole egg followed by indigenous chicken; commercial chicken egg weight was approximately double that of a guinea fowl and six times that of commercial quail egg. This is consistent with Haushi et. al (2010) that native chicken eggs are smaller than improved chicken. Proportionately, the albumen makes the highest component of an egg. Commercial chicken had the highest percentage albumen content (65%) while the worst case was observed in guinea fowls (50.4). The egg shell was the second highest component of an egg in the case of indigenous chicken, domestic guinea fowl and commercial quail except for commercial chicken where it accounted for 10% of the total weight. Commercial chicken produced eggs with the highest yolk content. This implies that commercial chicken produce eggs that have more edible part than indigenous chicken, guinea fowl or quail. These results are similar to those obtained by Sahmad et. al. (2014) that the weight of whole quail eggs ranges between 11.66- 14.15g. In contrast, our results were slightly higher than those reported by Tunsaringkarn et.al, 2013. Physical characteristics of eggs have been shown to be influenced by genetics, age, feeding management and environmental factors as reported by (Haunshi, Doley, & Kadirvel, 2010).

3.3 Proximate Composition of Poultry Meat

Table 3: Proximate composition of poultry meat in Kenya (%)

Parameters	Indigenous chicken	Commercial chicken	Domestic guinea fowl	Commercial quail	wild quail
Moisture	$69.56±1.15^{b}$	$73.54±0.74^{a}$	$74.89±0.59^{a}$	$73.51±1.04^{a}$	$65.09±1.15^{c}$
Ash	$0.93±0.09^{ab}$	$0.68±0.06^{b}$	$1.00±0.07^{a}$	$0.94±0.14^{ab}$	$1.03±0.16^{a}$
Fat	$3.12±0.51^{a}$	$3.27±0.22^{a}$	$2.41±0.23^{a}$	$4.21±0.44^{a}$	$2.69±0.47^{a}$
Protein	$18.15±0.81^{a}$	$19.70±0.25^{a}$	$19.48±1.43^{a}$	$18.39±0.64^{a}$	$25.50±1.59^{b}$
Carbohydrates	$8.250±2.17^{a}$	$2.57±0.77^{b}$	$2.978±1.48^{b}$	$2.95±1.50^{b}$	$5.69±32.37^{ab}$

The proximate composition of poultry varied with the species (Table 3). Commercial quail meat had the highest moisture content (76%). The moisture content did not differ significantly ($p>0.05$) from that of commercial chicken and commercial quail. Wild quail meat had slightly lower moisture content (65.09%). The ash content was highest in wild quail meat and lowest in commercial chicken meat. The ash content in indigenous chicken and commercial quail meat showed no significant variation ($p>0.05$) but significantly differed from that of commercial chicken and guinea fowl meat. This implies that wild quail meat has the highest minerals content. The fat content of poultry was in the range of 2.4% for domesticated guinea fowl to 4.2% for commercial quail. The fat content of guinea fowl meat did not vary significantly from that of commercial chicken meat. All the poultry types had high protein content (≈18%). The protein content did not vary significantly with species at (p>0.05). The carbohydrate content of the meat samples was highest in indigenous chicken which significantly differed from guinea fowl meat, quail meat and commercial chicken (p<0.05).

Parameters	Indigenous chicken	Commercial chicken	Domestic guinea fowl	Commercial quail
Moisture	72.25 ± 0.37^{a}	75.55 ± 1.17^{a}	71.13 ± 2.30^{a}	70.99 ± 0.89^{a}
Ash	1.03 ± 0.03^{ab}	0.86 ± 0.12^{a}	1.03 ± 0.03^{ab}	1.09 ± 0.05^{b}
Fat	2.33 ± 0.45^{a}	2.34 ± 0.12^{a}	2.17 ± 0.08^{a}	2.63 ± 0.12^{a}
Protein	15.11 ± 0.22^{a}	15.44 ± 1.65^{a}	13.08 ± 1.03^{a}	16.25 ± 1.33^{a}
Carbohydrates	9.28 ± 0.30^{ab}	5.81 ± 1.11^{a}	12.60 ± 1.53^{b}	9.05 ± 0.41^{ab}

The nutritional content of poultry meat varies from one study to another and this can be attributed to variation in breed, feed, age at slaughter, system of production, sex, processing, and the part of the cut as suggested by (Haunshi et al., 2010). The results on moisture content of guinea fowl meat were consistent with those reported by (Moreki, 2012.) In contrast, Mohamed et. al (2012) reported higher moisture content of guinea fowl meat. The results on commercial chicken moisture content were in agreement with those reported by Baeza et. al (2012). The difference between indigenous and commercial chicken moisture content can be attributed to the age since commercial chicken are fast growing while indigenous chicken are slower and take longer. The results on moisture content of guinea fowl meat were similar to those reported by Moreki (2009). Ash in food determines largely the extent to which the dietary minerals would be available in a food and the rate at which food substances would make available the amount of energy locked in it (Ogunmola et. al, 2013). The feed type determines the ash content of the meat. Commercial chicken are fed on commercial feed which could be low in minerals. On the other hand, indigenous chicken and guinea fowls are usually left to scavenge with minimum mineral supplements. Our results were in agreement with those reported by (Tougan et al., 2013)on the indigenous chicken meat. Fats play an important role in building the membranes that surround our cells in helping blood to clot. Also, presence of fat in the right proportion in the body helps the body to absorb certain vitamins and also to prevent the body from extreme cold and heat (Ogunmola et. al, 2013)

Fat content of muscles have been reported to depend on energy value of feeds and age (Moreki, 2012). The results from this study were similar to those obtained by Thong (2008) but differed from the ones reported by Díaz et. al, (2010).

According to Tougan et. al, 2013 the protein content of indigenous chicken increases with age and the values are consistent with the results of this study. In contrast, (Díaz et al., 2010) concluded that protein content decreases with age . Surprisingly, there were no major proximate content differences between indigenous and commercial chicken yet the indigenous chicken fetch higher prices than commercial chicken despite the difference in production costs. This is in contrast to the report by Oluwatosin and others (2007). Results of wild quail meat on moisture and ash content were consistent with those reported by El-Dengawy and Nassar, 2001.

3.4 Proximate Composition of Poultry Eggs

The proximate composition of poultry eggs in Kenya are shown in Table 4. The moisture, fat and protein content of the egg samples were not significantly different with varying species (p>0.05). This is in contrast to the common belief that indigenous chicken are nutritionally superior to commercial chicken: low fat content and higher protein content making the indigenous chicken fetch higher prices. Commercial chicken egg had the lowest ash content while the highest was in commercial quail eggs. Domesticated guinea fowl egg had the highest carbohydrate content followed by indigenous chicken, quail and commercial chicken respectively. There was no significant difference in the carbohydrate content of indigenous chicken and commercial quail eggs (p>0.05). The results of this study are similar to those reported by Tunsaringkarn et. al (2013) on quail's egg ash and moisture content while the carbohydrate and protein content were higher.

3.5 Mineral Content of Poultry Meat

Table 5: Mineral content of poultry meat in Kenya

Poultry type	Calcium	Iron	Zinc
Indigenous chicken	149.10±1.88^{b}	2.06±0.34^{b}	1.28±0.43^{ab}
Commercial chicken	100.30±6.63^{c}	1.69±0.29^{b}	0.51±0.16^{b}
Domesticated guinea fowl	194.30±16.48^{a}	2.20±0.22^{b}	0.91±0.22^{ab}
Commercial quail	140.80±12.75^{b}	3.41±0.08^{a}	1.30±0.13^{ab}
Wild quail	63.57±1.46^{d}	2.64±0.56^{ab}	1.79±0.34^{a}

Mineral content of meat are presented in Table 5. The most abundant mineral in meat was calcium which is an essential mineral. Commercial chicken meat had the highest calcium content followed by wild quail, commercial quail and indigenous chicken meat respectively. Commercial and indigenous chicken showed no significance difference ($p>0.05$) while there was no significance difference ($p>0.05$) among wild and commercial quail meat.

Iron content did not vary significant among the indigenous chicken, commercial chicken, domestic guinea fowl and commercial quail meat at ($p>0.05$) with wild quail meat having the highest content while domestic guinea fowl had the least iron content. Iron, which is a trace mineral has many functions in the body hence very important in maintaining healthy immune system for blood to work efficiently and transports oxygen as haemoglobin. Deficiency of iron is manifested as fatigue especially among long distance athletes. According to Soetan et. al, 2010, severe deficiency of iron causes iron deficiency anaemia which affects many people globally especially pregnant women in developing countries. From our results consuming wild quail meat would be a better way to prevent anaemia.

Zinc content varied significantly among indigenous chicken, commercial chicken and commercial chicken meat at $p\leq0.05$ while domestic guinea fowl and wild quail meat did not vary significantly at $p\leq0.05$. Commercial quail meat had the lowest zinc content while indigenous chicken was the best source of zinc among all. Zinc is a trace element involved in many body reactions which help in construction and maintenance of DNA, formation, growth and repair of body tissues, hair, skin, bones, nails and teeth. (Yakoob et. al, 2011) It is also important in the reduction of pneumonia and diahorrea deaths among children under five years of age in developing countries. Zinc also plays a key role in immunity, chronic diseases and apoptosis according to Chasapsis et. al, 2012.

Results for zinc and iron content in both commercial chicken and domestic guinea fowl meat were similar to those reported by Lormbardi et. al, (2005). Results on commercial chicken meat calcium content were higher compared to Scholtz et. al, (2001) while zinc and iron content showed consistency. Results of this study on iron, calcium and zinc content of indigenous and commercial chicken meat were lower than those reported by Ogunmola et.al, 2013).

3.6 Mineral Content of Poultry Eggs

Table 6: Mineral content of poultry eggs in Kenya

Poultry type	Calcium	Iron	Zinc
Indigenous chicken	149.10±1.88^{b}	2.06±0.34^{b}	1.28±0.43^{ab}
Commercial chicken	100.30±6.63^{c}	1.69±0.29^{b}	0.51±0.16^{b}
Domesticated guinea fowl	194.30±16.48^{a}	2.20±0.22^{b}	0.91±0.22^{ab}
Commercial quail	140.80±12.75^{b}	3.41±0.08^{a}	1.30±0.13^{ab}
Wild quail	63.57±1.46^{d}	2.64±0.56^{ab}	1.79±0.34^{a}

The mineral content of poultry eggs in Kenya are presented in Table 5. Calcium content among indigenous chicken and commercial quail eggs no showed significant difference ($p \geq 0.05$) while they varied significantly with commercial chicken, domestic guinea fowl and wild quail eggs at ($p \leq 0.05$). Domestic guinea fowl eggs therefore would be recommended for children to ensure development of strong and healthy bones and teeth and the elderly because it had the highest calcium content.

Commercial chicken had the least zinc and iron content. This can be attributed to the fact that commercial chicken is fed on commercial feeds which could be less dense in minerals (Ca, Zn and Fe). According to Sidhu et. al, 2004, it is advisable to consume higher levels of zinc in the presence of antinutrients which is common in grains which constitutes a large proportion of commercial feeds ingredients. This can explain the low content of minerals in commercial chicken eggs and meat.

Iron content among indigenous chicken, commercial chicken and domestic guinea fowl eggs showed no significance difference at ($p \geq 0.05$) and they varied significantly with commercial quail eggs at $p \leq 0.05$. Commercial quail eggs were the richest in iron while commercial chicken had the least.

Domestic guinea fowl results on zinc and iron content were lower than those reported by (Adeyeye, 2010) but calcium content was higher.

4.0 Conclusion

Wild quail live weight and carcass weight was the least among all the poultry type but had high protein, ash, iron, zinc and low fat content making it the healthiest and therefore may be taken into consideration in diet to alleviate malnutrition in Kenya which is rampant among vulnerable groups. Among the eggs nutritional value of each egg varied. Commercial quail eggs are the richest source of ash hence minerals and protein while domestic guinea fowl healthier because of their low fat. With these results, there is need for consumer and farmer awareness on the sustainable use of indigenous and wild birds and the effects of feed on the nutritional value of their products respectively.

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