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Comparison of phenotypic traits and chemical composition of egg from chicken (*Gallus gallus*) and Guinea fowl (*Numida meleagris*)

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ABSTRACT: Due to the rapid increase in the global population, there is a corresponding increase in the demand for daily protein and mineral requirements, thus, emphasizing the need for cost-effective and readily available protein sources. The study evaluates the phenotypic traits (shell weight, shell thickness, yolk weight, and albumen weight) and chemical composition (yolk moisture, yolk protein, yolk fat, albumen moisture, albumen protein, albumen fat, crude fibre, crude protein, moisture, oil, ash, Ca, K, Mg, Fe, Zn, and P) of poultry eggs (*Gallus gallus* and *Numida meleagris* eggs) procured from DMJ Etukudo Poultry Farm and Resources in Ukanafun Local Government Area of Akwa Ibom State, Nigeria. The eggs were weighed and cooked, thereafter, the shells were removed and, the yolks and the whites (albumen) were separated, sliced, weighed and oven-dried at 75ºC to a constant weight. The egg shells were boiled for 10 to 15 minutes in a 5% Sodium Hydroxide Solution to remove the proteinaceous membrane. The egg shells' thickness was measured using a Venier calliper after rinsing in water and oven-dried. Proximate analyses, mineral composition and correlation analyses were conducted. Significant differences ($p<0.01$) were observed in proximate and mineral compositions among the egg powders of the two poultry egg types studied. Proximate analysis revealed high protein, oil and, low fibre contents among the two poultry egg types. Mineral analysis indicated high levels of Ca, P, Mg, K, Zn and Fe, across all poultry types. There was a negative and lower correlation significant ($p<0.05$) level between albumen moisture (ALM) and yolk protein (YKP) of *Gallus gallus*, with the coefficient correlation of -0.5131, all other parameters measured were negatively and non-significantly ($P > 0.05$) correlated. The high protein and low fat and fiber contents suggest that *Gallus gallus* and *Numida meleagris* egg powder could be used as additives for food fortification to meet the global demand for protein.

Keywords: Chemical, composition, egg, evaluation, phenotypic, *Gallus gallus, Numida Meleagris,* traits.

INTRODUCTION

Domestic guinea fowl (*Numida meleagris*) and domestic chicken (*Gallus gallus*) are species of poultry which are raised for meat and egg production, respectively (Soara *et al*., 2020). They belong to the kingdom Animalia, phylum Chordata, and class Aves (Blench *et al*., 1999). Guinea fowls are seasonal egg producers under extensive management and commercial production. They can produce excess eggs during their production season, but demand for their eggs is low compared to chicken eggs with high demand by the populace (Lannotti *et al*., 2014). Whole eggs are highly demanded and consumed worldwide due to their nutritional value (Lannotti *et al*., 2014). Eggs are essential animal protein needed by both children and adults due to their efficacy in contributing to food and nutritional security globally (Lannotti *et al*., 2014).

More so, poultry eggs have a high concentration of animal protein, essential fatty acids, vitamins, minerals, phospholipids, sphingomyelin, lutein, zeaxanthin, various bioactive components, antioxidants, and choline (Iskender and Kanbay, 2014; Zdrojewicz *et al*., 2016; Park *et al*., 2018). Chicken eggs, provide essential nutrients that are less expensive, and also acceptable to the populace (Asghar and Abbas, 2012). Froning (2008) reported that breast milk from mothers contains high concentrations and quality of protein, followed by poultry eggs. Many important products have been derived from eggs which include hard-cooked, chopped eggs, precooked, scrambled eggs or omelettes, quiches, precooked egg patties, scrambled mixes, crapes, and egg powder (Jay, 2000).

Egg powder are made by spray drying the eggs just like the same way powdered milk is manufactured and they are fully dehydrated (Asghar and Abbas, 2012). There is a reduced weight per volume of whole egg equivalent accompanied by shelf life in powdered eggs, making it more essential than fresh eggs (Ndife, 2010). Egg powder are preferred by food producers because it is less expensive couple with their storage properties and easy to handle (Sharif *et al*., 2018). Powdered, dried eggs can be stored for a year or longer under optimum temperatures and proper storage conditions (Asghar and Abbas, 2012).

Poultry (chicken and guinea fowl) management and production which is tantamount to egg production can help in protein production which is highly needed by the populace as well as reducing poverty and unemployment in Nigeria. Thus, this research seeks to evaluate the phenotypic and chemical content of G*allus gallus* and *Numida meleagris* eggs which can serve as baseline information for improvement of other species of poultry.

MATERIALS AND METHODS

Study area

The study was conducted at the Biological Laboratory in the Department of Biological Sciences, Topfaith University, Mkpatak, Akwa Ibom State, Nigeria.

Experimental animals and eggs

Eighty (80) fleshly laid eggs consisting of forty (40) each of *Gallus gallus* and *Numida meleagris* were procured from DMJ Etukudo Poultry Farm and Resources in Ukanafun Local Government Area of Akwa Ibom State.

Experimental procedures

The eggs were weighed and cooked, thereafter, the shells were removed, remaining only the yolks and the white (albumen) which were later separated and sliced. Each component was weighed and oven-dried at 75°C to a constant weight. The egg shells were boiled according to Christensen *et al.* (1982) for 10 to 15 minutes in a 5% Sodium Hydroxide Solution to remove the proteinaceous membrane. The thickness of the egg shells was measured using the Venier calliper after rinsing in water and oven-dried.

Egg powder production

A dehydrator was used and it involved neatly unshelling 40 pieces of guinea fowl eggs and whisking them up thoroughly with the aid of a blender to enhance homogeneity (Olugbemi *et al*., 2023). Thereafter, the egg slurry was poured onto a fruit-roll sheet (a tiny non-stick layer attached to the dehydrator) and then, the temperature of the dehydrator was set at 62.8°C. The whole egg slurry was allowed to dry for about 19 hours until completely in brittle form. The dried brittle guinea fowl eggs were packed and poured into a dry blender and blended until a fine powder was obtained. The whole egg powder was bagged in a Ziploc bag and stored for further studies. The same procedure was adopted for the chicken egg powder however 40 pieces of chicken eggs were used.

Proximate analyses (moisture, crude protein, crude fibre, oil, and ash) were carried out on the guinea fowl and chicken egg powder samples according to AOAC (2023) procedure. The minerals (Ca, K, Mg, Fe, P, and Zn) were analyzed using the Atomic Absorption Spectrophotometer (Model 721, Medifriend, England) as described in AOAC (2023).

Statistical analysis

Data collected were subjected to statistical analysis using a statistical package for social sciences version 18 statistical package (SPSS, Inc. USA). Analysis of Variance (ANOVA) was done to determine significant differences at ($p<0.01$). The means were separated using the Least Significant Difference (LSD). Correlations between pairs of egg traits were done using Pearson's correlation test of SPSS (SPSS, 2014).

RESULTS AND DISCUSSION

Proximate composition of *Gallus gallus* and *Numida meleagris* egg powder

The proximate composition of the egg powders derived from two poultry eggs is detailed in Table 1. Significant variations ($p<0.01$) were recorded in the proximate

Table 1. Proximate composition of *Gallus gallus* and *Numida meleagris* eggs powder.

Parameters	*Gallus gallus* egg powder	*Numida meleagris* egg powder
Moisture (%)	7.30±0.03[a]	3.10±0.08[b]
Crude Protein (%)	45.50±0.06[a]	41.30±0.02[b]
Crude Fibre (%)	0.00	0.00
Oil (%)	30.10±0.01[b]	36.20±0.09[a]
Ash (%)	4.10±0.04[b]	6.20±0.07[a]

[ab]Means on the same row with different superscripts are significantly different at p<0.01.

contents among the poultry eggs studied, which may be attributed to differences in species, genetic constitution and temperature. High moisture content (7.30%) was recorded for eggs of *Gallus gallus* against 3.10% moisture content recorded for *Numida meleagris* eggs, respectively. This result was slightly higher than the values of 2.10 and 6.20% recorded for guinea fowl and chicken eggs, respectively, by Olugbemi *et al*. (2023). The crude protein recorded in this study was higher (45.50%) in *Gallus gallus* eggs than in *Numida meleagris* eggs (41.30%). Protein serves as an essential component and source of amino acids in our foods, helping in the growth, development and maintenance of the living system (Sivasankar, 2011; Ufot *et al*., 2018; Etukudo *et al*., 2024). The high concentration of protein obtained in this study from poultry eggs indicated that they could be used for the fortification of carbohydrate-based foods, which will potentially be tailored towards addressing the issue of protein-energy malnutrition among our populace.

The ash concentration in the result of this study was significantly (p<0.01) higher in the two poultry eggs type, however, the *Numida meleagris* eggs recorded 6.20% ash against 4.10% ash for *Gallus gallus* eggs as indicated in Table 2. The result obtained in this study was slightly higher than the one obtained by Olugbemi *et al*. (2023), whose values for ash were 5.50 and 3.75%, respectively, for guinea fowl and chicken eggs. The ash serves as an essential indicator of the nutritional value and processing of food items. Higher ash content is typically connected to processed foods compared to natural foods with lower ash content. However, ash content provides insight into the inorganic concentration of a sample and the origin of mineral elements. The high ash content in the egg powder obtained from the two poultry eggs in this study suggests a high concentration of mineral elements, indicative of processed foods.

Low crude fibre (0.00%) was recorded in this study for both egg types. This value recorded for crude fibre was in tandem with the findings of Olugbemi *et al*. (2023) and Abdullahi (2016), where they obtained the same value of 0.00% for guinea fowl and chicken eggs. This is an indication that the two egg types are suitable for food supplementation.

High significant (p<0.01) oil content was observed in this study for *Numida meleagris* eggs (36.20%) and 30.10% for *Gallus gallus* eggs. The result in the present study was in tandem with values (35.90% and 29.90%) recorded for guinea fowl and chicken eggs respectively reported by Olugbemi *et al*. (2023). Oil supplies calories and essential fats that help the body absorb fat-soluble vitamins such as A, D, E and K. The type of fat is just as important for health as the total amount of fat consumed (Abdullahi, 2016).

The differences in the nutritional composition as shown in the proximate analysis could be due to nutritional and genetic differences as reported by Krockel *et al*. (2005).

Mineral composition of *Gallus gallus* and *Numida meleagris* egg powder

All the mineral composition values obtained in this study for *Gallus gallus* eggs were higher than that of *Numida meleagris* eggs except for phosphorus which recorded a lower value of 8061 mg/100g against 8962 mg/100g obtained for the eggs of *Numida Meleagris* (Table 2). There was a great disparity between the mineral values obtained that led to significant (p<0.01) differences between the two egg types. The high concentration of phosphorus in *Numida meleagris* eggs obtained in this study is in line with the report of Olugbemi *et al*. (2023), where they reported high content of phosphorus in the whole guinea fowl eggs to be 8853 mg/100g against 7959 mg/100g value for chicken. Phosphorus which was the highest of all the minerals studied is an important component of teeth and bones, similar to calcium, with approximately 85% of phosphorus found in bones (Davies and Jamabo, 2016). The phosphorus composition in milk, liver, and beef was reported by Ihekoronye and Ngoddy (1985) to be 95, 313 and 156 mg/100g, respectively. Comparing the results obtained in this study for phosphorus shows that poultry eggs are a good source of phosphorus.

The high content of calcium obtained in this study, though it was high in *Gallus gallus* egg 986.30 mg/100g than the value 812.61 mg/100g obtained for *Numida meleagris*, showed that Ca is important for the development of bones and teeth during infancy and childhood, therefore, it is recommended that powdered

Table 2 Mineral composition of *Gallus gallus* and *Numida meleagris* eggs powder (Mg/100g).

Parameters	*Gallus gallus* egg powder	*Numida meleagris* egg powder
Ca	986.30±0.04[a]	812.61±0.08[b]
K	74.00±0.08[a]	71.10±0.05[b]
Mg	970.41±0.12[a]	781.78±0.10[b]
Fe	38.10±0.09[a]	34.40±0.23[b]
Zn	61.20±0.04[a]	44.31±0.33[b]
P	8061±0.06[b]	8962±0.08[a]

[ab]Means on the same row with different superscripts are significantly different at p<0.01.

eggs of *Gallus gallus* be incorporated in the diets for infants, as it can contribute to their calcium intake significantly. Calcium and phosphorus are crucial for bone formation during childhood and developmental stages, while zinc and iron are essential for disease prevention, growth, and fundamental cellular activities, respectively (Cruz and Tsang, 1992).

The iron (Fe) concentration was higher in *Gallus gallus* eggs (38.10 mg/100g) compared to *Numida meleagris* eggs (34.40 mg/100g) in this study. This result was closely in agreement with the report of Olugbemi *et al*. (2023) where they observed iron concentration for guinea fowl eggs to be (32.00 mg/100g) and chicken eggs to be 35.00 mg/100g. Iron is an essential mineral for the formation of the *heme* molecule in haemoglobin, which carries oxygen in the bloodstream to different parts of the body. Enough iron intake in the diet is important for reducing the incidence of iron deficiency, especially in young children. Based on the observations from this study, it is therefore recommended to include poultry eggs in the diet of children due to their high concentration of iron.

Magnesium was the next that is higher in concentration (970.41 and 781.78 mg/100g) for *Gallus gallus* and *Numida meleagris* eggs, respectively, after calcium among the poultry eggs studied (Table 2). Magnesium is a mineral that is important for maintaining healthy bones, muscles, nerves, and blood sugar levels. Deficiency of magnesium over a long period may result in a higher risk of health problems such as heart attack, stroke, diabetes or osteoporosis (Nkansah *et al*., 2021).

Potassium values recorded in this study were 74.00 and 71.10 mg/100g for *Gallus gallus* and *Numida Meleagris* eggs, respectively (Table 2). This result was nearly in tandem with the report of Olugbemi *et al*. (2023), where they observed values of 70.00 and 72.00mg/100g for guinea fowl and chicken eggs, respectively. Potassium is important in the sense that it permits the nerves to respond to stimulation and muscles to contract, including those in the heart. Also, it reduces the effect of sodium (present in table salt) on blood pressure and helps to move nutrients into cells and waste products out of cells (Nkansah *et al*., 2021).

Zinc was found in significant amounts in all the egg powders studied, *Gallus gallus* eggs powder recorded the value of 61.20 mg/100g against 44.31 mg/100g recorded for *Numida meleagris* eggs powder (Table 2). This result was slightly higher than the values of 59.00 and 40.00 mg/100g respectively obtained by Olugbemi *et al*. (2023) for guinea fowl and chicken eggs. Zinc plays a crucial role in dark adaptation and night vision in the human system (Burton and Foster, 1988). It is also important for the production of DNA, RNA, proteins, insulin hormones and the proper functioning of the immune system and enzyme activation (Lilly *et al*., 2017).

Phenotypic traits and chemical parameters of *Gallus gallus* and *Numida Meleagris* eggs

The results of the phenotypic traits and chemical parameters measured between *Gallus gallus* and *Numida meleagris* eggs were presented as mean ± standard error of the mean for each phenotypic and chemical measurement (Table 3). The eggs of *Gallus gallus* had higher values for all the phenotypic traits and chemical parameters measured except for shell thickness, whose value of 0.36 mm was lower than that of *Numida meleagris* which recorded 0.51 mm. On the other hand, the values obtained for shell weight (5.32 g), yolk weight (12.40 g/100g), albumen weight (18.50 g/100g) and moisture (84.27%) of the eggs of *Numida meleagris* were all lower than that of *Gallus gallus* eggs (Table 3). There were disparities between the eggs of the two poultry that resulted in significant differences (p<0.01) between the mean shell weights of 6.60 g for *Gallus gallus* and 5.32 g for *Numida meleagris* (Table 3). More so, most of the phenotypic and chemical traits measured for *Gallus gallus eggs* were bigger and higher than *Numida meleagris* eggs. The results indicated that *Gallus gallus* eggs are bigger, larger and heavier than *Numida meleagris* eggs. The results obtained in this study are in line with the results obtained by Okon *et al*. (1989) that the shell weights, albumen moisture, albumen weight, albumen protein, yolk weight, yolk protein and yolk fat of domestic fowl eggs were all higher than that of guinea fowl eggs. This indicated that the *Gallus gallus* eggs are bigger than the eggs of *Numida meleagris*.

Table 3. Phenotypic traits and chemical parameters of *Gallus gallus* and *Numida meleagris* eggs.

Parameters	*Gallus gallus* egg	*Numida meleagris* egg
Shell weight (g)	6.60±0.05[a]	5.32±0.34[b]
Shell thickness (mm)	0.36±0.57[b]	0.51±0.06[a]
Yolk moisture (%)	49.10±0.04[a]	49.42±0.09[a]
Yolk weight (g/100g)	17.20±0.56[a]	12.40±0.60[b]
Yolk protein (g/100g)	16.30±0.06[a]	16.10±0.07[a]
Yolk fat (g/100g)	26.46±0.34[a]	26.23±0.03[a]
Albumen moisture (%)	87.34±0.09[a]	84.27±0.34[b]
Albumen weight (g/100g)	39.10±0.02[a]	18.50±0.07[b]
Albumen protein (g/100g)	10.00±0.53[a]	9.98±0.45[a]
Albumen fat (g/100g)	1.10±0.00[a]	1.12±0.01[a]

[ab]Means on the same row with different superscripts are significantly different at p<0.01.

Table 4 Coefficient of correlations (r_p) of chemical traits between *Gallus gallus* and *Numida meleagris* eggs.

Egg traits	ALM	ALW	ALP	YKM	YKW	YKP	YKF
ALM	1	0.1643[NS]	0.1809[NS]	0.0420[NS]	0.0297[NS]	-0.5131*	-0.1609[NS]
ALW	0.0600[NS]	1	-0.0364[NS]	0.2852[NS]	0.4567[NS]	-0.3584[NS]	-0.1699[NS]
ALP	0.0460[NS]	0.0481[NS]	1	0.3389[NS]	0.3298[NS]	0.1346[NS]	0.0578[NS]
YKM	-0.0658[NS]	-0.325[NS]	-0.0936[NS]	1	0.3122[NS]	0.2327[NS]	0.2327[NS]
YKW	-0.1520[NS]	-0.0563[NS]	-0.1898[NS]	0.1646[NS]	1	0.0092[NS]	-0.0587[NS]
YKP	0.1950[NS]	0.0901[NS]	-0.0721[NS]	0.2551[NS]	0.4124[NS]	1	0.1786[NS]
YKF	0.0108[NS]	-0.2670[NS]	-0.2637[NS]	-0.0018[NS]	-0.1768[NS]	-0.0781[NS]	1

Abbreviations: ALM **=** Albumen moisture, ALW = Albumen weight, ALP = Albumen protein, YKM = Yolk moisture, YKW = Yolk weight, YKP = Yolk protein, YKF = Yolk fat. NS = P>0.05 (Non- significant level), * = P<0.05 (Lower significant level).

Coefficient of correlations (r_p) of chemical traits between *Gallus gallus* and *Numida meleagris* eggs

The results obtained for chemical correlations among chemical traits in this study for the two poultry eggs types studied (Table 4) indicated negative, weak, low and non-significant (p>0.05) correlation coefficient (r_p) between albumen moisture and most of the chemical traits studied for *Gallus gallus* and *Numida meleagris* eggs. The only strong, negative and lower significant (p<0.05) correlation coefficient of r = -0.5131 was obtained between albumen moisture (ALM) and yolk protein (YKP) for the *Numida meleagris* egg traits. All other coefficients of correlations of the chemical traits between *Gallus gallus* and *Numida meleagris* eggs were non-significant (p>0.05) between the measured traits. On the other hand, these results of negative, low, non-significant chemical correlations between albumen moisture and most of the measured chemical traits of the eggs studied were in agreement with Okon *et al.* (1989). This signifies that the pairs of chemical traits of the eggs used have an indirect association or relationship and they are controlled by different genes in different directions, thus selection for one trait will lead to non-improvement of the other traits. The differences in correlation coefficients could be due to species effect, age, the size variation of the eggs used and weight range.

Conclusion

The study revealed significant variations in minerals, proximate compositions and correlations among the egg powders derived from the two types of poultry (*Gallus gallus* and *Numida meleagris*). These poultry eggs exhibited high protein, oil, calcium, magnesium, iron, and phosphorus but were low in fat, ash and fibre contents. There was a negative and lower correlation significant (p<0.05) level between albumen moisture (ALM) and yolk protein (YKP) of *Gallus gallus*, with the coefficient correlation of -0.5131, all other parameters measured were negatively and non-significantly (p>0.05) correlated. Given the low crude fibre, fat and high protein concentrations in the egg powders of the two poultry eggs, they can serve as valuable dietary supplements. Additionally, the low-fat concentration suggests their potential use as additives in diets for individuals with hypertension and other fat-related disorders. Strategically incorporating these egg powders into diet fortifications, formulations and development efforts can effectively leverage these affordable, nutritious, and natural sources of egg protein. However, the eggs can be processed into powered eggs to reduce the losses encountered during production seasons. The chemical correlations obtained in this study among chemical traits of the eggs of the two poultry types showed that species type, size differences of the eggs used and the weight of the eggs, have high and pronounced effects on the phenotypic traits, chemical traits and correlation coefficient of the eggs.

COMPETING INTERESTS

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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