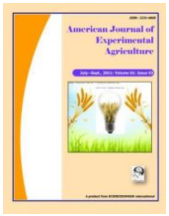

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Comparison of the Nutritional Value of Egg Yolk and Egg Albumin from Domestic Chicken, Guinea Fowl and Hybrid Chicken

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Authors' contributions

This work was carried out in collaboration between all authors. Author LB designed the study, carried out the laboratory work and performed the statistical analysis. He equally wrote the first draft of the manuscript and undertook the final editing of the paper. Authors PCO and OKS took part in the laboratory work, part of the draft and undertook in the initial editing of the paper. Authors ANA and TC carried out most of the literature searches and participated in designing the experiment. All authors read and approved the final manuscript.

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ABSTRACT

The present study was conducted to compare the nutritional and physical quality of egg yolk and egg white of birds from three different genotypes (domestic chicken, hybrid chicken and guinea fowl). The egg yolk and white from each of the bird were separated and analyzed for proximate, vitamins and minerals using standard analytical methods. The eggs of the 3 bird species showed similar conical shape, however, weight of whole egg, egg white and yolk of hybrid chicken was much higher than that of domestic and guinea fowl. The moisture (60.45±0.14%) and vitamin C (121.50±0.14mg/100g) contents of egg yolk were significantly higher in hybrid chicken than in domestic chicken and guinea fowl while the protein (5.47±0.88%), ash (1.32±0.03%) and vitamin C (68.50±0.70mg/100g) contents of egg white was higher in hybrid chicken than domestic chicken and guinea fowl. However, moisture contents (87.45±0.71%) of egg white from guinea fowl was

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significantly ($p<0.05$) higher than hybrid chicken. All elements considered in this study had higher concentrations (mg/100g) in egg yolk than white except for Na whose concentrations were higher in egg white than yolk. The concentration of K^+ (321.50±7.62 and 119.50±2.6.2), Fe^{2+} (12.45±0.09 and 4.45±0.0.8) and Ca^{2+} (26.60±0.63 and 9.23±0.22) for egg yolk and white respectively was significantly ($p<0.05$) higher in guinea fowl than domestic and hybrid chicken. However, Na contents in hybrid chicken (850.00±22.40 and 975.00±09.00) for egg yolk and white respectively was significantly ($p<0.05$) higher than that of guinea fowl and domestic chicken. It is concluded that egg yolk and white of hybrid chicken were riches in moisture, protein, ash, vitamin C and sodium than guinea fowl and domestic chicken. While egg yolk and white of guinea fowl were rich in K^+, Fe^{2+} and Ca^{2+} than the eggs of domestic and hybrid chicken.

Keywords: Proximate; minerals; vitamin; egg yolk; egg white.

1. INTRODUCTION

A balanced diet is essential for normal growth, health and preservation of the human body. Eggs have constituted an important part of human diets for centuries because of its high quality protein [1]. They are known to supply the best proteins besides milk [2]. It is also rich in amino-acids, carbohydrates, easily digestible fats and minerals, as well as valuable vitamins [3]. The yolk and white components are all of high biological value and are readily digested [4].

Eggs play important culinary roles and are therefore prepared into different dishes. There are many types of poultry species' eggs consumable as a protein and amino acid supplement [5]. Nigeria has the highest number of poultry farm in Africa. Nigeria presently produces about 300,000 tons of poultry meat per annum officially and 650,000 tons of eggs [6]. A parallel record from Poultry Association of Nigeria (PAN), indicates that Nigeria produces presently above 1.25million tons of egg per year. South Africa is the second producer of eggs in Africa [7]. The question arises whether there are interspecies differences in poultry eggs quality which may affect the nutritive value and quality as human food.

In Nigeria, domestic fowl dominated the poultry industry. Out of 150 million poultry population, 120 million (80%) were indigenous. Domestic fowl constituted 91% of this while guinea fowl, duck, turkey and others were 4%, 3% and 2% respectively [8]. Chicken eggs are the most commonly consumed eggs; they are also an inexpensive single-food source of protein. The yolk and albumin values from literature showed 33.04% (chicken yolk), 32.68% (guinea-fowl yolk); 57.10% (chicken albumin), 50.3% (guinea-fowl albumin) [8].

The guinea fowl is a bird native to the African continent [9]. It derives its name from the Coast of Guinea where it is believed to have originated. The indigenous guinea fowl (*Numida meleagris*) is widely distributed in Africa where it has distinct popularity among small holder farmers. It is believed that guinea fowls were taken to Europe and America by the Portuguese but in these regions the guinea fowls have been scientifically improved resulting in faster growth rate, bigger body size and enhanced egg laying capacity [10]. Guinea fowl breeding hens produce thicker shelled eggs in comparison to that of a regular chicken [11]. However there is paucity of information on the nutritional qualities of eggs from domestic fowl in comparison with eggs from other poultry species.

In this report, we evaluated the nutritional levels of the proximate, vitamins and minerals composition in egg yolks and egg albumin collected from different bird's species.

2. MATERIALS AND METHODS

2.1 Source of Materials

Freshly-laid egg samples from birds of three (3) different genotypes (domestic chicken, guinea fowl and hybrid chicken) were obtained between 21 and 22 September 2014 from a poultry keeper in Minna, Nigeria. The eggs were analyzed for nutritional compositions between 23 and 26 September 2014. At laying time the domestic fowl were approximately 28 weeks, guinea fowl were approximately 52 weeks and the hybrid chicken were approximately 26 weeks old. The birds' genotype was Hy-Line Brown (hybrid chicken), Pearl (guinea fowl) and normal feathered (domestic chicken). The domestic chicken and guinea fowl had outdoor access all the year round Fed with cereal, hay, clover, vegetables and green crop, according to the

season of year. The hybrid chicken ate balanced biocomplete cereal-based mixed fodder with several additives daily.

2.2 Sample Preparation

The egg samples were thoroughly washed with distilled water in the laboratory federal university of technology, Minna. Nigeria. The yolk and albumin were separated by breaking a small part of the egg shell at one end and separating the egg albumin from the yolk.

2.3 Evaluation of Physical Quality of Egg

Egg weight was measured with electronic weighing balance. Subsequently, yolk was separated from the white and weighed separately. The weight of shell was calculated by subtracting the weights of yolk and white from the weight of whole egg.

2.4 Proximate Analysis

Moisture and crude fat content were determined according to the standard methods of A.O.A.C [12]. Ash content was determined at 550ºC [13]. Crude nitrogen was determined by Kjeldahl method [13] and crude protein determined by using the formula Crude protein = Crude nitrogen × 6.25 [14]. All the analysis was performed in triplicate.

2.5 Mineral Analysis

The method of A.O.A.C [12] was employed for the determination of mineral content.

2.6 Vitamin Analysis

Vitamin C and Vitamin A composition of each of the sample, were determined by the method of A.O.A.C [12].

2.7 Ethical Clearance

Ethical clearance was given by Federal University of Technology, Minna/Nigeria ethical review board (CUERB) in accordance with international standard on the care and use of experimental animals.

2.8 Statistical Analysis

The data obtained were subjected to Analysis of Variance (ANOVA) using SAS statistical package. Means were separated using Duncan's Multiple Range Test (DMRT). Significance was accepted at $P<0.05$.

3. RESULTS

3.1 Physical Properties

The eggs of domestic chicken, hybrid chicken and guinea fowl showed similar conical shape with blunt and pointed ends; however, weight of whole egg, egg white and yolk of hybrid chicken was much higher than that of guinea fowl and domestic chicken respectively (Table 1).

3.2 Proximate

The proximate compositions of domestic chicken (*Gallus domesticus*), guinea fowl (*Numida meleagris*) and hybrid chicken are shown in Table 2. The moisture and crude protein content was significantly higher in egg white than yolk while the crude fat and ash content was significantly higher in yolk than in egg white for the three (3) eggs sample. For the egg yolk the moisture and the ash contents was significantly higher in hybrid chicken than in domestic chicken and guinea fowl. The egg yolk from the 3 birds species show no significant difference in there protein and fat content while egg white of the hybrid chicken is significantly lowered in moisture ($75.50\pm0.14\%$) but higher in ash (1.32 ± 0.03) content as compared with the guinea fowl and domestic chicken. The protein content was significantly ($p<0.05$) lowered in domestic chicken (3.48 ± 0.91) as compared with guinea fowl (5.81 ± 0.62) and hybrid chicken (5.47 ± 0.88).

3.3 Minerals

Table 3 presents the results of mineral analysis of domestic chicken (*Gallus domesticus*), guinea fowl (*Numida meleagris*) and hybrid chicken. All elements considered in this study had higher concentrations in egg yolk than in the white except for Na whose concentrations were higher in the egg white than in the yolk for all the species considered.

3.4 Vitamins

Table 4 presents the results of vitamins A and C contents of egg yolk and white from domestic chicken (*Gallus domesticus*), Guinea fowl (*Numida meleagris*) and hybrid chicken. Vitamin C content of egg yolk is higher in hybrid chicken (121.50 ± 0.14) and lowest in domestic chicken (97.50 ± 0.71) for the egg albumin the highest concentration of vitamin C was recorded for hybrid chicken (68.50 ± 0.70) and least was recorded for domestic chicken (47.00 ± 2.11).

Table 1. Physical properties of eggs collected from domestic chicken (*Gallus domesticus*), Guinea fowl (*Numida meleagris*) and hybrid chicken

	Weight (g)			
Sample	**Whole egg**	**Egg yolk**	**Egg white**	**Shell**
Hybrid chicken	72.45±2.41^{c}	21.40±1.34^{c}	37.13+2.10^{a}	13.92+1.01^{c}
Guinea fowl	41.34±1.71^{b}	13.56±1.08^{a}	22.76+1.99^{a}	5.02+0.98^{b}
Domestic chicken	34.48±1.20^{a}	11.87±0.99^{a}	20.54+2.90^{a}	2.07+0.33^{a}

Values follow by the same superscript are not differ significantly at p<0.05, values are Mean ± SEM of triplicate determination

Table 2. Proximate compositions of egg yolks and egg white collected from domestic chicken (*Gallus domesticus*), guinea fowl (*Numida meleagris*) and hybrid chicken

	Proximate (%)			
Sample	**Moisture**	**Protein**	**Crude fat**	**Ash**
		Egg yolk		
Hybrid chicken	60.45±0.14^{b}	3.43±0.88^{a}	27.65±0.70^{a}	3.42±0.23^{b}
Domestic chicken	55.60±0.16^{a}	3.85±0.91^{a}	30.41+0.22^{a}	1.50+0.11^{a}
Guinea fowl	50.50.±0.71^{a}	4.30±0.62^{a}	31.49+0.41^{a}	2.15+0.25^{ab}
		Egg white		
Hybrid chicken	75.50±0.14^{a}	5.47±0.88^{b}	2.00+0.03^{a}	1.32±0.03^{b}
Domestic chicken	86.90±0.16^{b}	3.48±0.91^{a}	1.09+0.30^{a}	0.99±0.21^{a}
Guinea fowl	87.45±0.71^{b}	5.81±0.62^{b}	1.21+0.10^{a}	0.70+0.12^{a}

Values follow by the same superscript are not differ significantly at p<0.05, values are Mean ± SEM of triplicate determination

Table 3. Minerals composition of egg yolks and egg white collected from domestic chicken, guinea fowl and hybrid chicken

	Minerals (mg/100g)			
Sample	**Sodium**	**Potassium**	**Iron**	**Calcium**
		Egg yolk		
Hybrid chicken	850.00±22.4^{b}	162.00±5.88^{a}	3.50±0.70^{a}	2.90±0.23^{a}
Domestic chicken	150.50±7.16^{a}	197.50±3.91^{a}	7.10±0.11^{b}	14.80±0.91^{b}
Guinea fowl	191.00±6.71^{a}	321.50±7.62^{b}	12.45.±0.09^{c}	26.60±0.63^{c}
		Egg white		
Hybrid chicken	975.00±09.0^{b}	82.00±0.88^{ab}	0.90±0.21^{a}	0.56.50±0.21^{a}
Domestic chicken	172.50±2.16^{a}	32.50±0.91^{a}	2.10±0.01^{ab}	5.80±0.09^{ab}
Guinea fowl	199.00±6.71^{a}	119.50±2.62^{b}	4.45.±0.08^{b}	9.23.±0.22^{b}

Values follow by the same superscript are not differ significantly at p<0.05, values are Mean ± SEM of triplicate determination

Table 4. Vitamins composition of egg yolks and egg white collected from domestic chicken, guinea fowl and hybrid chicken

Sample	**Egg yolks (mg/100g)**		**Egg yolks (mg/100g)**	
	Vitamin C	**Vitamin A**	**Vitamin C**	**Vitamin A**
Hybrid chicken	121.50±0.14^{b}	0.33±0.88^{a}	68.50±0.70^{b}	0.23±0.23^{a}
Domestic chicken	110.50±0.16^{ab}	0.21±0.91^{a}	47.00±2.11^{a}	0.11±0.91^{a}
Guinea fowl	97.50±0.71^{a}	0.31±0.62^{a}	52.00±4.09^{a}	0.78±0.63^{a}

Values follow by the same superscript are not differ significantly at p<0.05, values are Mean ± SEM of triplicate determination

However, no significant differences between the egg yolk and white of the 3 bird's species were found in the content of vitamin A.

4. DISCUSION

4.1 Physical Properties

Generally eggs of birds have oval shape with small differences among species. Despite its

small differences, egg shape is considered as an important factor in characterizing bird species. In this study the eggs of domestic chicken, hybrid chicken and guinea fowl showed similar conical shape with blunt and pointed ends, however eggs of domestic chicken is more pointed than the two bird species. Similar findings have been reported for egg shapes of quail and guinea fowl [15]. The significantly higher weight of whole egg, egg white and yolk observed in hybrid chicken as compared to domestic and guinea fowl was obviously due to vast difference in the size of these three bird species. This difference could be attributed to the various feed additives, antibiotics or production stimulants fed to the hybrid chicken but deprived domestic and guinea fowl. The weight of hybrid chicken reported in this study (72.45±2.41) (Table 1) was higher compared to 56.41g reported for naked neck chicken and 40.5g for full feathered chicken [16].

4.2 Proximate Composition

Protein is an essential component of human diet which is needed for the replacement of tissue and supply of energy. Protein deficiency cause growth retardation, muscle wasting, oedema, abnormal swelling of the body and collection of fluid in the body of children [17]. This study revealed low protein contents in three poultry egg species and the little amount presents are more abundant in the egg white, however contrary findings have been reported by [15], who reported more protein contents in egg yolk than white from Quai and guinea fowl. Also in this study no significant difference in the protein content of egg yolk from the three poultry egg species, however the egg white from hybrid and guinea fowl chicken contain more protein than egg white of domestic chicken (Table 2).

Dietary fat functions in the increase of palatability of food by absorbing and retaining flavours. This study also revealed that the eggs yolk and white are good and poor source of lipids respectively. Although no significantly difference in fat contents of egg white from the 3 bird species (Table 2), the low fat contents of egg white is an important consideration for people who suffer from elevated cholesterol level, and can also be recommend as part of weight reducing diets. The lipids contents of egg yolk for the three poultry egg species is high (Table 2), a diet providing 1-2% of its caloric of energy as fat is said to be sufficient to human beings as excess fat consumption is implicated in certain cardiovascular disorders such as cancer and aging [18]. The fat contents of albumin from domestic chicken and guinea fowl in this study is comparable with that reported for chicken and guinea fowl egg [19].

The ash content gives a measure of total amount of inorganic compounds like minerals present in a food. This study revealed that the egg yolk and white of hybrid chicken contain more ash than domestic chicken and guinea fowl (Table 2). This is an indication that the hybrid chicken will contain more minerals. This finding could be attributed to the variation in feed composition fed the birds. Similarly, low ash content has been previously reported for egg from Quai and guinea fowl [15], and chicken egg (0.91±0.03) [20].

This study revealed that egg white contain more moisture content than the egg yolk, also the egg yolk of hybrid chicken contain more water than those found in guinea fowl and domestic chicken. (Table 2) However high water contents of food have been implicated for low shelf life due to microbial attacked [21].

4.3 Minerals

Calcium helps in the regulation of muscle contraction required by children, infants and fetuses for bones and teeth development [22]. The recommended dietary allowance value of calcium is 600-1400mg/kg [23]. The present study show that both egg yolk and white of guinea fowl contain high amount of calcium as compared to the hybrid and domestic chicken. Considering the importance of calcium, its concentration in egg yolk implies that this can contribute to the amount of dietary calcium. However the level of calcium observed in this study was lower than 38.2mg/100g reported for a whole chicken egg [20]. The recommended daily value for sodium is 1100- 3300mg/kg for adults [22]. Hybrid chicken contains high sodium concentration than the guinea fowl and domestic chicken. However, the concentration of sodium in egg yolk and albumin for all the three bird species observed in this study was lower than 134±20 reported for a whole chicken egg [20].

The enrichment of iron in egg would provide improving the nutrition status of people especially in the risk of iron deficiency or anemia group especially infant, children, pregnant women and socioeconomic groups [24]. The recommended daily requirement of iron for man is 6-40 mg/kg [23]. The egg yolk and white was found to contain iron in concentration within the

recommended daily requirement. However, the egg yolk contain more iron than the white, contrary findings have been reported by [25], who reported more iron contents in egg white than egg yolk from snail-eating turtle eggs. Also hybrid chicken was found to have the highest concentration of Iron, this poultry egg species from the result obtained can be used in improving the anaemic condition in iron deficient diabetic patients. Potassium is responsible for nerve action and is very important in the regulation of water, electrolyte and acid – base balance in the blood and tissues [26]. In this study, egg yolk of guinea fowl was found to contain the highest concentration of potassium. The level of potassium in this poultry eggs especially the egg yolksis a good indication that its consumption will enhance the maintenance of the osmotic pressure and acid-base equilibrium of the body [27].

4.4 Vitamins

The Recommended Dietary Allowances (RDAs) for vitamins reflect how much of each vitamin most people should get each day. Results of the present study revealed that the 3 poultry egg species studied contain considerable amount of vitamin A and C (Table 4). However, vitamin C content of egg yolk and white is higher in hybrid chicken compare to domestic and guinea fowl. Vitamins A and C have been reported to have antioxidant properties and may protect body against some forms of cancer [28].

The concentration of vitamins is influenced by genetics, rate of egg production and it varies with the composition of the hen's diet [29]. As the concentration of fat-soluble vitamins in the feed increases, so does the content of vitamins in the egg yolk [30]. However, according to [31] for some vitamins, such as vitamin A, the liver acts as a reservoir so that the concentration in the yolk is buffered against large changes in the diet. This finding is supported by the results of the present study as no significant differences between the egg yolk and white of the 3 bird's species were found in the content of vitamin A (Table 4).

5. CONCLUSIONS

The findings of this study showed that eggs of guinea fowl, domestic and hybrid chicken are rich source of protein, vitamins and appreciable number of some essential minerals. However, from the tested parameters, egg yolk and white of hybrid chicken were rich in proximate, vitamin C and sodium than eggs of guinea fowl and domestic chicken. While egg yolk and white of guinea fowl were rich in K^{+}, Fe^{2+} and Ca^{2+} than the other two studied birds.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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