Nigerian Research Journal of Chemical Sciences **(ISSN: 2682-6054)**
Volume 11, Issue 1, 2023

Comparative analyses of proximate and elemental compositions of chicken, duck, guinea fowl and turkey eggs obtained from Damaturu, Yobe State, Nigeria.

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ABSTRACT

This study aims at ascertaining the proximate and elemental compositions of chicken, duck, guinea fowl and turkey eggs. A total of sixty (60) fresh unfertilized eggs (15 each of chicken, duck, guinea fowl and turkey) were prepared for laboratory analyses. The elements were analysed using atomic absorption spectrophotometer (AAS). The proximate compositions were determined using AOAC methods. In the present study, the whole egg and egg yolk of chicken were found to be rich in protein and fat than other birds in addition to having higher crude fibre in the egg yolk. Egg white of duck was rich in protein, fat, moisture and crude fibre while that of turkey showed higher ash, crude fibre and NFE contents. Whole egg of duck was rich in calcium, copper and potassium while guinea fowl showed higher zinc and sodium. Copper, zinc and sodium contents of egg white of turkey were significantly higher than in other birds. Chicken egg yolk showed higher contents of zinc, sodium and potassium. The results obtained from this study showed that eggs of chicken, duck, guinea fowl and turkey are rich sources of protein, fat and a number of some essential minerals. Hence, the components of the eggs of all the birds can be homogenized as nutritive ingredients in the production of healthy food products.

Keywords: Nutritional contents, elemental composition, proximate analysis, eggs, birds.

INTRODUCTION

A balanced diet is required for proper growth and maintenance of human body. Aside the main nutrients which include carbohydrate, proteins, and vitamins, the body needs certain amount of essential elements to carry out some metabolic processes optimally. Eggs form a vital and integral component of human diet due to its high quality protein [1]. Poultry eggs serve as good source of income, means of livelihood as well as socio-economic well-being of

some individuals and they also find application in scientific research for production of vaccine [2].

Bird eggs have been valuable foodstuffs since prehistory in both hunting societies and more recent cultures where birds are kept domestically for different purposes. The eggs most consumed by humans are those of the hen, though duck eggs and the eggs of other birds are also commonly used as food [3]. Eggs have held a vital place in human nutrition; a study of how food affects the health, growth and survival of the human being. Humans require food for growth, reproduction and proper maintenance of good health. Without food, human bodies would not stay warm, build, repair tissues or maintain a heartbeat [4]. Eating the right food can help avoid certain diseases or recover faster when illness occurs and live a healthy lifestyle [5]. These and other important functions are triggered by chemical substances in food called nutrients. Nutrients are classified as carbohydrates, proteins, fats, vitamins, minerals and water.

The consumption of egg is greatly essential because it is one of the foods that contain most mineral elements needed [6, 7]. Of all the foods available to man, egg nearly approaches a perfect balance of all nutrients, serving as a good source of both major and trace elements. Mineral elements are essential to life and can be supplied to body through egg consumption.

Transporting eggs is difficult because they are fragile and perishable [8, 9]. Pulverized form of egg provides lasting solution to virtually all the problems mentioned. The modern technological methods of pulverized egg production include: washing, breaking, filtering and pasteurization of the egg liquid produced, then dried as whole egg or into various components of egg yolk and egg white. Other techniques involved in processing and preservation of eggs like spray drying, tray drying and freeze drying have been employed but have been observed to have effect on the quality of the products [10].

The minerals or nutrients needed by the body are usually in specified amount but few studies have documented the nutritional contents of the various egg components from different birds. Therefore, this study aims at assessing and comparing the mineral and proximate compositions of different components of egg and to determine the component that has suitable amount of nutrients needed by the body. Since mineral elements and nutrients are essential to life and can be supplied to body through egg consumption, the research work intends to recommend changes in people's habit towards egg consumption to meet nutritional requirements of some of the important dietary elements.

MATERIALS AND METHODS

Chemical and reagents

Conc. hydrochloric acid (HCl), hydrogen peroxide, conc. nitric acid (HNO_3), concentrated sulphuric acid (H_2SO_4), copper sulphate, Boric acid, selenium powder, sodium hydroxide, ethanol, diethyl ether, bromocresol green, and methylated spirit. The chemicals and reagents used in this study were analytical grade products of May and Baker, England.

Sample Collection

A total of sixty (60) fresh unfertilized eggs (15 each of chicken, duck, guinea fowl and turkey) were obtained from Damaturu Central Market, Damaturu Local Government Area, Yobe State in Nigeria.

Preparation of Samples

After washing the eggshell with distilled water, they were allowed to dry. The eggs were carefully cracked-open (de-shelled), collected and separated as egg white, egg yolk and whole egg liquid. The egg liquids were later homogenized with a metal stirrer and a drop of hydrogen peroxide was added to free products from viable *salmonella* microorganisms and also to prevent browning of the product [11]. The samples were later oven-dried at 44 °C for 12 hours and allowed to cool. The dried samples were pulverized and used for analyses.

Digestion of Sample

The finely ground sample (1 g) was weighed and transferred into porcelain crucibles which together with the sample were ignited in muffle furnace for 7 hours at 500 °C. It was cooled on top of asbestos sheet. To the left-over ash, 5 ml of 1 M nitric acid solution was added and evaporated to dryness on a hot plate. It was returned to the furnace and heated at 400 °C for 15 minutes until a perfect white ash was obtained. The sample was cooled on top of asbestos sheet, followed by the addition of 10 ml of 1 M hydrochloric acid to dissolve the ash. The solution was filtered into 50 ml volumetric flask and made to the mark with 0.1M hydrochloric acid solution. The filtrate was used for metal analysis [12].

Proximate analyses

The moisture content was determined using AOAC method [13]. Crude fibre content was determined using AOAC method [14], while furnace method was used to determine the ash content. The kjeldahl method was used to determine crude protein. Fat content was

determined using ether extraction by reflux soxhlet method, while the Nitrogen Free Extract (NFE) was calculated using the method described by Dastu *et al* [15]. The volatile matter and fixed carbon were determined as described by ASTM [16].

Elemental Analyses

The elements were analysed using Atomic Absorption Spectrophotometer machine (AA320n, Wincom Company LTD, China).

Statistical Analysis

The results were analysed using one-way ANOVA and mean differences were sorted out based on Turkey-Kramer's Multiple Comparisons Test using GraphPadInStat Software (2022).

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RESULTS AND DICUSSION

Proximate composition of whole egg of Chicken, Duck, Guinea fowl and Turkey

Egg has high biological value because it is a rich source of protein and the quality of protein found in egg is used as standard for measuring the quality of all other food proteins, Kusum *et al.*, [17]. On Table 1, the protein (13.19±0.17) and fat (12.53±0.47) contents of whole egg of chicken were observed to be significantly higher than protein content of duck (09.69±0.05), guinea fowl (10.21±0.01), turkey (10.21±0.01) and the fat content of duck (11.35±0.10), guinea fowl (11.11±0.20), turkey (09.21±0.02). This result is in agreement with the finding of Kabir *et al* [18], who also reported higher protein and fat in the whole egg of chicken than guinea fowl. Crude fibre was seen to be significantly higher in turkey (0.18+0.01) than in guinea fowl (0.13+0.02), duck (0.07±0.01) and chicken (0.05±0.02). This is not in agreement with the assertion of Kabir *et al* [18], which shows significantly higher moisture in whole egg of guinea fowl than chicken. Ash represents the amount of mineral in a given sample [19]. Ash was seen to be significantly higher in whole egg of guinea fowl (01.02±0.10) than chicken (00.98±0.03), duck (00.98±0.03) and turkey (00.98±0.03) which are statistically at par. A study [19] shows that there is no significant difference between the ash content of guinea fowl and that of chicken which is in discordance with the present study. The moisture content of a given sample simply means the water content of that sample, according to Forson *et al* [20]. Moisture content of duck (74.37±0.10) and turkey (74.37±0.10) are also statistically at par but significantly higher than that of chicken (72.13±0.13) and guinea fowl (73.85±0.12). The oil and water absorption properties of the

eggs also help to retain moisture and oil during baking and subsequent storage. It enhances both the physical and sensory qualities of their products [21]. The whole egg of turkey (5.05) shows higher value of nitrogen free extract (NFE) content compared to that of guinea fowl (3.68), duck (3.54) and chicken (1.12).

Table 1: Proximate composition of whole egg of Chicken, Duck, Guinea fowl and Turkey

(%)

Birds	Protein	Fat	Ash	Moisture	Crude fibre	NFE	VM	FC
Chicken	13.19±0.17^{a}	12.53±0.47^{a}	00.98±0.03^{b}	72.13±0.13^{c}	0.05±0.02^{d}	1.12	12.00	14.89
Duck	09.69±0.05^{c}	11.35±0.10^{b}	00.98±0.02^{b}	74.37±0.10^{a}	0.07±0.01^{c}	3.54	19.00	05.65
Guinea	10.21±0.01^{b}	11.11±0.20	^{c}01.02±0.10^{a}	73.85±0.12^{b}	0.13+0.02^{b}	3.68	16.00	09.13
Turkey	10.21±0.02^{b}	09.21±0.02^{d}	00.98±0.02^{b}	74.37±0.10^{a}	0.18+0.01^{a}	5.05	19.00	05.65

Values are expressed as mean±standard deviation of triplicate (n= 3) determination and values with different superscript on the same column are significantly different ($p<0.05$) while those with the same superscript are not significantly different ($p>0.05$). VM = Volatile Matter, FC = Fixed Carbon.

Proximate composition of egg yolk of Chicken, Duck, Guinea fowl and Turkey

Proteins are essential components of living cell required by human body for growth, maintenance and repair of body tissues, according to Zoubida *et al* [22]. Table 2 shows that the egg yolk of chicken (17.41±0.07) has significantly higher content of protein and fat (30.71±0.25) when compared to the egg yolk protein content of duck (15.62±0.01), guinea fowl (13.49±0.00), turkey (14.15±0.03) and also the fat content of duck (29.13±0.01), guinea fowl (29.14±0.02), turkey (30.43±0.01). High protein content in the egg yolk of chicken could be attributed to high fibre content of the feed that would reduce passage time and increase time for absorption of nutrients during digestion in the gut of chicken. According to Fakai *et al* [23], ash represents the amount of mineral in a given sample. Samples with high concentration of various mineral elements speed up metabolic processes, improve growth and development [24]. Ash has a significantly higher value in guinea fowl (01.91±0.01) and turkey (01.91±0.31) than chicken (01.85±0.15) and duck (01.87±0.17). The amount of water in food varies from low to high moisture levels in food [25]. Moisture was observed to be significantly higher and statistically at par in turkey (49.98±0.03) and duck (49.98±0.43) than

chicken (48.11±0.32) and guinea fowl (49.46±0.02). High water contents of food have been implicated for low shelf life due to microbial attack [26]. The egg yolks of all the birds show crude fibre values that are not significantly different from each other, chicken (0.12+0.03), duck (0.13+0.02), guinea fowl (0.12+0.03) and turkey (0.15+0.02). Guinea fowl (0.12+0.03) shows higher content of NFE in its egg yolk than in turkey (3.38), duck (3.27) and chicken (1.80).

Table 2: Proximate composition of egg yolk of Chicken, Duck, Guinea fowl and Turkey

(%)

Birds	Protein	Fat	Ash	Moisture	Crude Fibre	NFE	VM	FC
Chicken	17.41±0.07^{a}	30.71±0.25^{a}	01.85±0.15^{b}	48.11±0.32^{c}	0.12+0.03^{a}	1.80	14.00	36.04
Duck	15.62±0.01^{b}	29.13±0.01^{c}	01.87±0.17^{b}	49.98±0.43^{a}	0.13+0.02^{a}	3.27	26.00	22.15
Guinea	13.49±0.00^{d}	29.14±0.02^{c}	01.91±0.01^{a}	49.46±0.02^{b}	0.12+0.03^{a}	5.88	38.00	10.63
Turkey	14.15±0.03^{c}	30.43±0.01^{b}	01.91±0.31^{a}	49.98±0.03^{a}	0.15+0.02^{a}	3.38	22.00	26.11

Values are expressed as mean±standard deviation of triplicate (n= 3) determination and values with different superscript on the same column are significantly different ($p<0.05$) while those with the same superscript are not significantly different ($p>0.05$).VM = Volatile Matter, FC = Fixed Carbon.

Proximate composition of egg white of Chicken, Duck, Guinea fowl and Turkey

On Table 3, the egg white of duck (19.35±0.59) contains significantly higher protein when compared with the egg white protein content of guinea fowl (17.73±0.72), chicken (14.59±1.43), turkey (14.41±0.02). Fats are known to enhance the emulsification process in foods, they diminish their foaming potentials [27]. The foaming properties are particularly important in the stability of ice cream and in bread production [28, 29].

Fat content of egg white of guinea fowl (0.11±0.01) has been revealed to be significantly higher than chicken (0.08±0.01), turkey (0.06±0.02), duck (0.02±0.01). This agrees with the finding of Eridiong *et al* [30], on protein content but it is in disagreement with the fat content.

The ash content gives a measure of total amount of inorganic compounds like minerals present in a food. Ash was observed to be significantly higher and statistically at par in the egg white of turkey (0.62±0.02) and guinea fowl (0.61±0.01) than that of duck

(0.74±0.20) and chicken (0.95±0.07). This is an indication that egg white of turkey and guinea fowl will contain more minerals. This could be attributed to the variation in feed composition of the birds. The finding of Eridiong *et al* [30], shows higher content of ash in the egg white of turkey.

Moisture was observed to be significantly higher in the egg white of duck (78.74±0.10) than chicken (76.01±0.07), guinea fowl (76.96±0.02), turkey (77.51±0.04). The crude fibre content of all the egg components are all statistically at par, chicken (0.08±0.01), duck (0.05±0.02), guinea fowl (0.09±0.02), turkey (0.07±0.02).

The egg white of chicken (8.29) has shown higher value of NFE when compared with that of duck (1.10), guinea fowl (4.50) and turkey (7.33).

Table 3: Proximate composition of egg white of Chicken, Duck, Guinea fowl and Turkey

	(%)							
Birds	Protein	Fat	Ash	Moisture	Crude Fibre	NFE	VM	FC
Chicken	14.59±1.43^{c}	0.08±0.01^{c}	0.95±0.07^{c}	76.01±0.07^{d}	0.08±0.01^{a}	8.29	14.00	09.04
Duck	19.35±0.59^{a}	0.02±0.01^{a}	0.74±0.20^{b}	78.74±0.10^{a}	0.05±0.02^{a}	1.10	16.00	04.52
Guinea	17.73±0.72^{b}	0.11±0.01^{d}	0.61±0.01^{a}	76.96±0.02^{c}	0.09±0.02^{a}	4.50	06.00	16.43
Turkey	14.41±0.02^{d}	0.06±0.02^{b}	0.62±0.02^{a}	77.51±0.04^{b}	0.07±0.02^{a}	7.33	10.00	11.87

Values are expressed as mean±standard deviation of triplicate (n= 3) determination and values with different superscript on the same column are significantly different ($p<0.05$) while those with the same superscript are not significantly different ($p>0.05$).VM = Volatile Matter, FC = Fixed Carbon.

Elemental composition of whole egg of Chicken, Duck, Guinea fowl and Turkey

On Table 4, calcium deficiency has been associated with susceptibility to osteoporosis, kidney stones, colorectal cancer, hypertension and stroke, coronary artery disease, insulin resistance and obesity. Calcium helps in avoiding some forms of cancer, strengthens bone, increases bone mass and also inhibits heavy metal absorption [31]. This result as presented in Table 4, shows that the calcium content of whole egg of duck (11.53±0.05) is significantly higher than that of chicken (07.38±0.01), guinea fowl (09.17±0.01) and turkey (07.40±0.02). Copper at low level is necessary for good health but harmful at high level. Exposure to large

amount of copper can result to death [32]. The copper content of whole egg of duck (07.56±0.02) shows significantly higher value than guinea fowl (02.51±0.01), chicken (05.54±0.04) and turkey (05.52±0.02) which are both statistically at par.

Potassium and sodium are the predominant cations both within and outside the cells in the body. They both play vital role in the nervous system during nerve impulse transmission and osmotic pressure. Many enzymes require potassium in order to get activated and its deficiency can result to high blood pressure, arthritis, cancer, stroke, infertility and gastrointestinal disorders, Tunsaringkarn *et al* [33]. Potassium has been observed to be significantly higher in the whole egg of duck (06.17±0.56) when compared with the whole egg of chicken (06.01±0.43), guinea fowl (04.07±0.49) and turkey (05.16±0.47).

Zinc plays important role in maintaining good body health, though it can cause damage and toxicity when in excess Keshab *et al* [34]. Studies have shown that the use of phosphate and urea fertilizer in an improper manner is one of the major anthropogenic activities introducing most trace elements such as zinc in the environment Rauf *et al* [35]. Guinea fowl shows significantly higher value of zinc (08.01±0.04) in its whole egg when compared with zinc content of chicken (05.65±0.02), duck (07.97±0.01), turkey (05.57±0.03). The whole egg of guinea fowl (18.64±0.03) also contains significantly higher value of sodium than duck (10.01±0.01), chicken (17.66±0.02) and turkey (17.64±0.01) which are both statistically at par.

Table 4: Elemental composition of whole egg of Chicken, Duck, Guinea fowl and Turkey

	Concentration (mg/100g)				
Birds	Calcium	Copper	Zinc	Sodium	Potassium
Chicken	07.38 ± 0.01^{c}	05.54 ± 0.04^{b}	05.65 ± 0.02^{c}	17.66 ± 0.02^{b}	06.01 ± 0.43^{b}
Duck	11.53 ± 0.05^{a}	07.56 ± 0.02^{a}	07.97 ± 0.01^{b}	10.01 ± 0.01^{c}	06.17 ± 0.56^{a}
Guinea Fowl	09.17 ± 0.01^{b}	02.51 ± 0.01^{c}	08.01 ± 0.04^{a}	18.64 ± 0.03^{a}	04.07 ± 0.49^{d}
Turkey	07.40 ± 0.02^{c}	05.52 ± 0.02^{b}	05.57 ± 0.03^{d}	17.64 ± 0.01^{b}	05.16 ± 0.47^{c}

Values are expressed as mean±standard deviation of triplicate (n= 3) determination and values with different superscript on the same column are significantly different ($p<0.05$) while those with the same superscript are not significantly different ($p>0.05$).

Elemental composition of egg white of Chicken, Duck, Guinea fowl and Turkey

Calcium helps in the regulation of muscle contraction required by children, infants and foetus for bones and teeth development [36]. On Table 5, calcium can be observed to be significantly higher in the egg white of guinea fowl (04.38±0.15) when compared with chicken (02.21±0.01), duck (03.05±0.05), turkey (02.74±0.01). This implies that the egg white of guinea fowl is a good source of calcium and can contribute to dietary calcium. Turkey shows significantly higher value in copper (02.91±0.06) than in the egg white of chicken (02.75±0.09), duck (01.50±0.02), guinea fowl (01.51±0.01).

Zinc was observed to be higher in egg white of turkey (03.14±0.01) than in chicken (02.40±0.03), duck (02.42±0.02) and guinea fowl (03.14±0.01). Sodium was also observed to be significantly higher in turkey (07.74±0.10) when compared with that of chicken (05.53±0.01), duck (05.94±0.05) and guinea fowl (06.63±0.02). 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 [36]. This study revealed that the egg white of chicken has significantly higher value of potassium (03.35±0.17) than duck (02.98±0.06), guinea fowl (02.07±0.19) and turkey (03.00±0.04). This is not in concordance with the result obtained by Bashir *et al* [37].

Table 5: Elemental composition of egg white of Chicken, Duck, Guinea fowl and Turkey

	Concentration (mg/100g)				
Birds	Calcium	Copper	Zinc	Sodium	Potassium
Chicken	02.21±0.01^{d}	02.75±0.09^{b}	02.40±0.03^{b}	05.53±0.01^{d}	03.35±0.17^{a}
Duck	03.05±0.05^{b}	01.50±0.02^{c}	02.42±0.02^{b}	05.94±0.05^{c}	02.98±0.06^{b}
Guinea Fowl	04.38±0.15^{a}	01.51±0.01^{c}	02.32±0.01^{c}	06.63±0.02^{b}	02.07±0.19^{c}
Turkey	02.74±0.01^{c}	02.91±0.06^{a}	03.14±0.01^{a}	07.74±0.10^{a}	03.00±0.04^{b}

Values are expressed as mean±standard deviation of triplicate (n= 3) determination and values with different superscript on the same column are significantly different ($p<0.05$) while those with the same superscript are not significantly different ($p>0.05$).

Elemental composition of egg yolk of Chicken, Duck, Guinea fowl and Turkey

Table 6; has revealed that the egg yolk of duck has significantly higher content of calcium (07.59±0.01) than in the egg yolk of chicken (05.17±0.03), guinea fowl (06.37±0.02) and turkey (06.36±0.10). Copper was seen to be significantly higher in the egg yolk of turkey (07.97±0.02) when compared with chicken (07.71±0.03), duck (06.52±0.02) and guinea fowl (06.54±0.01). Chicken has shown significantly higher value of zinc (08.39±0.04) than duck (06.38±0.42), guinea fowl (03.48±0.12) and turkey (06.39±0.04). In the present study, the results of both copper and zinc agree with the findings of Salwa *et al* [38]. Sodium has been observed to be significantly higher in the egg yolk of chicken (12.14±0.01) than in that of duck (11.21±0.02), guinea fowl (10.64±0.02) and turkey (11.02±0.03). Potassium also shows a significantly higher value in chicken (07.21±0.12) when compared with duck (06.63±0.04), guinea fowl (05.17±0.12) and turkey (05.61±0.20). In this study, egg yolk of chicken was found to contain the highest concentration of potassium. The level of potassium in the egg yolks of chicken is a good indication that its consumption will enhance the maintenance of the osmotic pressure and acid-base equilibrium of the body [39]. The variation of the elemental composition observed in the egg yolk of the various birds can be attributed to the feeds used in feeding the birds.

Table 6: Elemental composition of egg yolk of Chicken, Duck, Guinea fowl and Turkey

	Concentration (mg/100g)				
Birds	Calcium	Copper	Zinc	Sodium	Potassium
Chicken	05.17±0.03^{c}	07.71±0.03^{b}	08.39±0.04^{a}	12.14±0.01^{a}	07.21±0.12^{a}
Duck	07.59±0.01^{a}	06.52±0.02^{c}	06.38±0.42^{b}	11.21±0.02^{b}	06.63±0.04^{b}
Guinea Fowl	06.37±0.02^{b}	06.54±0.01^{c}	03.48±0.12^{c}	10.64±0.02^{d}	05.17±0.12^{d}
Turkey	06.36±0.10^{b}	07.97±0.02^{a}	06.39±0.04^{b}	11.02±0.03^{c}	05.61±0.20^{c}

Values are expressed as mean±standard deviation of triplicate (n= 3) determination and values with different superscript on the same column are significantly different ($p<0.05$) while those with the same superscript are not significantly different ($p>0.05$).

CONCLUSION

In conclusion, this research intends to recommend changes in people's habit towards egg consumption to meet nutritional requirements of some of the important dietary elements. The findings of this study revealed that both the whole egg and egg yolk of chicken are rich sources of protein and fat than other birds in addition to high crude fibre content in the egg yolk. The egg yolk of chicken also showed higher contents of zinc, sodium and potassium. Egg white of duck was seen to be rich in protein, fat, moisture and crude fibre while that of turkey showed higher ash, crude fibre and NFE contents. Whole egg of duck was found to be rich in calcium, copper and potassium. Copper, zinc and sodium contents of egg white of turkey were seen to be significantly higher than in other birds. The results obtained from this study have shown that various components of egg (whole egg, egg white and egg yolk) of chicken, duck, guinea fowl and turkey are rich sources of protein, fat and quite a number of some essential mineral elements. Hence, all components of eggs of the four (4) birds which contain one important nutrient or the other can be homogenized as nutritive ingredients in the production of healthy food products. A study should be carried out on same birds been fed by a particular product of feed.

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