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Keywords : amino acids profiles, whole eggs, duck, francolin, turkey.

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Strictly as per the compliance and regulations of :

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I. Introduction

The egg is the astonishing and unintentional gift from birds to human beings, the acme offood packaging, and a prime resource of occidental and oriental cooks alike. It is also the ultimate measure of ignorance and incompetence in the kitchen; 'he/she can't even boil an egg', she/he will say, whether fondly or recentfully (Davidson, 1999).

A reference to 'an egg', with no qualification is assumed almost everywhere to mean a hen's egg, which is what, forms the first part of this introduction. The hen's egg is usually the one which carries symbolic significance (the renewal of life, e.g. in spring festivals and EASTER FOODS). Symbolic meanings and folklore and associated topics are admirably dealt with by Newall (1971).

The egg proteins are what make an egg so important a source of nutritional and such a versatile ingredient for the cook. Consider the composition of an egg as follows, white: 87.77 % (water), 10.00 % (protein), 0.05 % (fat), 0.82 % (ash); yolk: 49.00 % (water), 16.70 % (protein), 31.90 % (fat), 1.90 (ash). It will be apparent that the white, apart from its large water content, is almost pure protein; and that the yolk contains proportionately less water, more protein, and much more fat. White and yolk can therefore be expected to, and do, behave differently when cooked. Moreover, the proteins in the yolk are not the same as those in the white, and coagulate at distinctly higher temperature (Davidson, 1999).

(Many books refer to egg white as 'albumen,' which has the same meaning. However, this term can be confusing because there is also the word 'albumin' which refers to a class of proteins, all soluble in water, which includes albumen and others too.)(Davidson, 1999).

The protein in egg whites starts to coagulate in temperature range 55-60 °C (131-140 °F)and definitely coagulates at 65 °C (150 °F) or a little less. Those of egg yolks begin to thicken at 65 °C (150°F) and coagulate at just over 70 °C (158 °F). Thus the yolk always sets after the white, whether an egg is being boiled (when this would be bound to happen anyway because the heat reaches the yolk later than white) or being fried (Davidson, 1999).

Poultry eggs are eaten in most areas of the world with fewer social taboos associated with them than with pigs and cattle. In Asia ducks are sole source of livelihood of a considerable number of people who may own large flock for meat and egg production. Of the world duck population of 52.8 million, 90 % is found in Asia.

However, in Nigeria, more emphasis is laid on domestic fowl to the neglect of other classes of poultry. As a result domestic fowl dominated the poultry industry. Of the 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. The population of ducks in Nigeria had been put as 1.21 million as against 133.5 million local/exotic chicken. According to a report (Federal Government of Nigeria, 1988), 69 % of total meat, and 12 % of total eggs were supplied by domestic fowl in 1987.

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Despite abundant water, pasture land and the fact that 10 % of Nigerian households keep duck (Adenowo *et al*., 1999), consumption of its meat and especially eggs, was still low. A survey (Adenowo*et al.*, 1999) showed that ducks were neither raised for egg production nor for consumption. Thus duck eggs were seldom eaten or sold. The reason obtained by the survey, basically on taboo, partially explains why duck eggs have not found favour with consumers.

The double-spurred francolin, *Francolin-usbicalcaratus*, is a game bird in the pheasant family Phasianidae of the order Galliformes, gallinaceous birds. Like most francolins, it is restricted to Africa. It is a resident breeder in tropical West Africa, but there is a small and declining isolated population in Morocco. This bird is found in open habitats with trees. It nests in a lined ground scrape laying 5-7 eggs. Double-spurred francolin takes a wide variety of plant and insect food.

The male is mainly brown, with black and whiteflank streaking. The face is pale, and the head features a chestnut crown and white supercilium. It has a chestnut neck colour, white cheek patches and brown wings. The male has two spurs on each leg. The female is similar, apart from the double spurs, but slightly smaller, and the young birds are drabber versions of the adult. This is a very unobtrusive species, best seen in spring when the male sings a mechanical *krak-krak-krak* from a mound. It has a pheasant's explosive flight, but prefers to creep away unseen. (Retrievedfromhttp://en.-wikipedia.org/wiki/Double-spurred_Francolin)

The domesticated turkey is a large poultry bird raised for food. The modern domesticated turkey descends from the wild turkey (*Meleagrisgallopavo*). The turkey is reared throughout the temperate parts of the world, and is a popular form of poultry, partially because industrialized farming has made it very cheap for the amount of meat it produces. The female domesticated turkey is referred to as a *hen* and the chick as *poult*. In the United States, the male is referred to as a *tom*, whilst in Europe, the male is a stag [http://en.wikipedia.org/wiki/Turkey-(domesticated)]. In Nigeria, turkey meat is becoming a delicacy particularly at Christmas.

A comparative study on the characteristics of egg shells of some bird species had been carried out. The total egg weight for each of the birds was (g): francolin, 25.2 (23.5-27.1); duck, 74.9 (62.3-76.8) and turkey, 70.9 (62.3-79.5) and the edible portion was francolin, 19.9 (18.3-21.6); duck, 64.6 (54.0-67.3) and turkey, 62.7 (54.0-71.4) (Adeyeye, 2009).

There are no reports on the comparative study on the amino acids profiles of duck (*Cairinamoschata*, Linnaeus 1758), francolin (*Francolin bicalcaratus* Linnaeus 1766)and turkey (*Meleagrisgallopavo*, Linnaeus 1758) eggs. Due to the emphasis placed on the nutritive value of food by consumers a great need exists for information on nutritional composition of these eggs. The present study was therefore undertaken in an attempt to gain some information on the amino acids profiles and their comparison with other eggs like those from guinea fowl (*Numidameleagris*) and domestic fowl to evaluate their nutritional qualities.

II. Resources and Techniques

a) *Materials*

The francolin eggs were collected in the month of November in the bush (it is a taboo to rear the bird at home) while the eggs of local duck and white plumage turkey were directly obtained from poultry keepers. Five eggs were involved in each study and they were collected at once.

The edible portion was removed; oven dried, milled into flour and kept in a laboratory freezer pending analysis.

The amino acid profile in the known samples was determined using methods described by Spackman *et al* (1958). The known sample was dried to constant weight, defatted, hydrolysed, evaporated in a rotary evaporator and loaded into the Technicon Sequential Multi-sample Amino Acid Analyzer (TSM).

b) *Defatting of Sample*

A known weight of dried sample was weighed into extraction thimble and the fat was extracted with chloroform/methanol (2:1 v/v) using Soxhlet extraction apparatus as described by AOAC (2005). The extraction lasted for 15 hours.

c) *Hydrolysis of the Sample*

A known weight of the defatted sample was weighed into glass ample. 7 ml of 6 MHCl was added and oxygen was expelled by passing nitrogen into the ampoule. (This is to avoid possible oxidation of some amino acids during hydrolysis.) The glass ample was then sealed with Bunsen burner flame and put in an oven preset at 105 °C±5 °C for 22 h. The ampoule was allowed to cool before broken opened at the tip and the content was filtered to remove the humins. The filtrate was then evaporated to dryness at 40 °C under vacuum in a rotary evaporator. The residue was dissolved with 5 ml of acetate buffer (pH 2.0) and stored in plastic specimen bottles, which were kept in the freezer.

d) *Loading of the Hydrolysate into the TSM Analyser*

The amount of sample loaded was between 5-10 micro litre. This was dispensed into the cartridge of the analyser. The TSM analyser is designed to separate and analyse free, acidic, neutral and basic amino acids of the hydrolysate. The period of analysis lasted for 76 minutes.

e) *Method of Calculating Amino Acid Values from Chromatogram Peaks*

The net height of each peak produced by the chart recorder of TSM (each representing an amino acid) was measured. The half-height of the peak on the chart was found and the width of the peak on the half-height was accurately measured and recorded. Approximate area of each peak was then obtained by multiplying the height with the width at half-height.

The norleucine equivalent (NE) for each amino acid in the standard mixture was calculated using the formula:

NE = Area of norleucine peak/Area of each amino acid (Norleucine was the internal standard.) A constant S was calculated for each amino acid in the standard mixture:

Sstd = NEstd x Mol. weight x μMAAstd

Finally the amount of each amino acid present in the sample was calculated in g/16N or g/100 g protein using the following formula:

Concentration (g/100 g protein) = NH x W@ NH/2 x Sstd x C

Where : C = Dilution x 16/Samplewt(g)xN % x 10 vol.loaded ÷ NH x W (nleu)

Where: NH = Net height

W = Width @ half height

Nleu = Norleucine

f) *Estimation of Isoelectric Point (PI)*

The theoretical estimation of isoelectric point (pI) was determined using the equation of Olaofe and Akintayo (2000) and information provided by Finar (1975).

$$IPM = \Sigma IPiXi$$
$$i=1$$

WhereIPm is the isoelectric point of the i^{th} amino acid in the mixture and Xi is the mass or mole fraction of i^{th} amino acid in the mixture.

g) *Estimation of Dietary Protein Quality*

The predicted protein efficiency ratio (P-PER) was estimated by using the equation given by Alsmeyer*et al.* (1974).

P-PER = -0.468 + 0.454 (Leu) - 0.105 (Tyr).

h) *Estimation of Dietary Protein*

The amino acid scores were calculated quality in three different procedures:

- The total amino acid scores were calculated based on the whole hen's egg amino acid profiles (Paul and Southgate, 1976).
- The essential amino acids scores were calculated using the formula (provisional amino acid scoring pattern) (FAO/WHO, 1973):

Amino acid score = Amount of amino acid per test protein [mg/g] / Amount of amino acid per protein in reference [mg/g].

- The essential amino acids scores (including His) based on pre-school childsuggested requirement (FAO/WHO/UNU, 1985).

i) *Essential Amino Acid Index [EAAI]*

The essential amino acid index (EAAI) was calculated by using the ratio of test protein to the reference protein for each eight essential amino acids plus histidine in the equation (Steinke *et al.*, 1980):

$$\text{Essential amino acid index} = \sqrt[9]{\frac{\text{mgLysine in 1 g test protein}}{\text{mgLysine in 1 g reference protein}} \times \text{etc for all essential amino acid + His}}$$

j) *Leu/isoleucine Ratio*

The leucine/isoleucine ratios, their differences and their percentage differences were also calculated.

k) *Calculation of other Protein Quality Parameters*

Determination of the ratio of total essential amino acids (TEAA) to the total amino acids (TAA), i.e. (TEAA/TAA), total sulphur amino acids (TSAA), percentage cystine in TSAA (% Cys/TSAA), total aromatic amino acids (TArAA), total neutral amino acids (TNAA), total acidic amino acids (TAAA) and total basic amino acids (TBAA) were estimated from the results obtained for amino acids profiles.

l) *Statistical Analysis*

Statistical analysis (Oloyo, 2001) was carried out to determine the mean, standard deviation and coefficient of variation in per cent, a summary of the amino acids profiles into factors A and B was also carried out.

III. Results

a) *General Amino Acids Profiles*

In Table 1, the general amino acids profiles were shown. The most concentrated amino acid was Glu (12.1-13.1 g/100 g) with a trend of turkey < francolin < duck. Next to Glu was another acidic amino acid, Asp in all the samples with values of 8.93-10.2 g/100 g. The highest concentrated essential amino acid (EAA) was Lys (duck, 6.65 g/100 g), Leu (francolin, 6.45 g/100 g) and Lys (turkey, 6.24 g/100 g). The protein levels were duck (67.9 g/100 g) < turkey (77.6 g/100 g) < francolin (80.1 g/100 g). An observation in Asp/Glu showed that the level of Asp appeared to affect the level of Glu and vice versa: the lower the Asp, the much higher the Glu and the much higher Asp, the less higher the Glu; for examples the Asp/Glu in the samples were (g/100 g): duck, 8.93/13.1; francolin, 9.01/13.0 and turkey, 10.2/12.1. The coefficient of variation per cent (CV %) values were generally low ranging between 1.58-27.4 showing that the samples were close in values for all the parameters determined.

In Table 2 were shown the various calculated values derived from Table 1. The total amino acids were (g/100 g crude protein, cp): duck (82.4) > francolin (80.8) > turkey (79.9). The EAA (with His) were duck (39.5 g/100 g, 47.9 %); francolin (36.0 g/100 g cp, 44.6 %) and turkey (37.0 g/100 g cp, 46.4 %). Total neutral amino acid levels were duck (45.5 g/100 cp, 55.3 %); francolin (45.1 g/100 g cp, 55.8 %) and turkey (43.6 g/100 g cp, 54.6 %). Total aromatic amino acids ranged from 9.26-10.2 g/100 g cp (or 11.6-12.4 %); the total sulphur amino acid (TSAA) levels were low at 3.56-5.30 g/100 g cp (or 4.46-6.44 %). The protein efficiency ratio (P-PER) were better in duck (2.01) and francolin (2.14) but low in turkey (1.92). The isoelectric point (pI) was at acid range with values of 4.59-4.76 and the essential amino acid index ranged from 1.12-1.22. All CV % values were low.

In Table 3, the scores of the samples relative to whole hen's egg (Paul and Southgate, 1976) were shown .In the duck, the following amino acids had scores greater than 1.0: Lys (1.07), Glu (1.09), Gly (1.30) and Met (1.26); for francolin: Glu (1.08), Pro (1.04), Gly (1.40) andAla (1.07) whereas in turkey they were Lys (1.01) and Gly (1.54). The limiting amino acid here for each egg sample was Ser: duck (0.48), francolin (0.38) and turkey (0.37). The CV % levels were also low.

In Table 4, amino acid scores of the samples in relation to pre-school children requirements were depicted. In the duck, all the EAA values were better than the pre-school children requirements (scores > 1.0) except in Leu (score of 0.99); similar observation holds for turkey except in Leu (0.90) and in francolin, only scores for Lys (0.95) and Leu (0.98) were less than 1.0.

In Table 5, the sample amino acid scores relative to the provisional amino acid scoring pattern were shown. Valine was the limiting amino acid in the three different samples; in duck score was 0.80, in francolin score was 0.77 and in turkey it was 0.83. The summary of the essential and non-essential amino acids is shown in Table 6into Factors A and B means; both columns ended at 40.5. In Table 7 was shown the comparative compositions of the amino acids values (g/100 g) of duck, francolin, turkey, guinea fowl and domestic fowl.

IV. Discussion

a) *General Amino Acids Profiles*

Table 1 presents the amino acid composition of the samples. Virtually all the amino acids were high in value. Glu was the most concentrated amino acid (AA) in all the three samples with values of 13.1 g/100 g crude protein (cp) in the duck, 13.0 g/100 g cp in francolin and 12.1 g/100 g cp in turkey. A look at Table 1 will show that AA of the duck was most concentrated (on pair wise comparison) in 8/17 or 47.1 % of the AA; francolin was most concentrated in 4/17 or 23.5 % and in turkey it is 5/17 or 29.4 % best. Of these series, 5.8 (62.5 %) of the most concentrated AA in the duck were essential AA; it was ¼ (25.0 %) in francolin and 3/5 (60.0 %) turkey. The Asp was the second largest AA in the three samples. The most concentrated essential AA (EAA) in the samples was Lys (6.65 g/100 g) in the duck, Leu (6.49 g/100 g) in francolin and Lys (6.24 g/100 g) in turkey. The coefficient of variation per cent (CV %) ranged between 1.58-27.4 in the AA, with Arg having the least CV % and Cys the highest CV %. The calculations above would be an indication that the duck egg would be better in quality and quantity than francolin (in that order). So, whilst the AA levels (and quality) had this trend: duck > turkey > francolin; protein levels had opposite trend: francolin (80.1 g/100 g) > turkey (77.6 g/100 g) > duck (67.9 g/100 g). The Glu and Asp appeared to have opposite character levels in each sample; from Table 1, the much higher the Glu, the less higher is the Asp. For example: values of Glu/Asp (g/100 g cp) were : duck (13.1/8.93), francolin (13.0/9.01) and turkey (12.1/10.2). In the samples, highest Glu (13.1) was in duck and lowest Asp (8.93) was in Asp; second highest of 13.0 (Glu) was observed in francolin and second highest of 9.01 (Asp); in turkey third highest Glu (12.1) was observed and highest level of Asp (10.2) was observed. This type of observation had been noted for guinea fowl (Glu/Asp = 1.60/8.99 g/100 g) (Paul and Southgate, 1976).

Aspartic acid was first discovered in 1827 by deriving it from asparagine, which in turn had been isolated from asparagus juice about 20 years earlier. Aspartic acid was eventually understood to be an amino acid. Like all amino acids, Asp is a chiral molecule. The L-isomer is one of the 20 AA or building blocks of protein-based structures in human beings. Muscle tissue, skin, hair, fingernails and enzymes are all made from amino acids. L-aspartic acid is found in food, but it can also be made in the body, which makes it a non-essential AA. While L-Asp is widely used in the body as a building block, the biological role of its counterpart or enantiomer, D-Asp, is much more limited. D-aspartic acid is known to accumulate in the pituitary gland, pineal gland and testes, and is involved in hormone production. More specifically, it stimulates the release of sex hormones from the pituitary gland and testosterone from the testes. Consequently, D-Asp has become a popular supplement among body builders, other serious athletes and elderly men who have low-circulating levels of testosterone. Both forms of Asp are found in food, exceptional animal-based sources of Asp include beef, wild game, salmon, shrimp and eggs. Good vegetable sources include sprouting seeds, legumes, most nuts, avocados and asparagus (Kliegman*et al.*, 2007).

L-glutamic acid and L-glutamine have similar structures and play important roles in your body's functions. They are both amino acids that are constantly assembled and broken down again to form different proteins and enzymes. These amino acids are needed to form muscle and provide energy to the cells in the body small intestine. L-Glu is made from a number of amino acids, including omithine and arginine.

Glu is a non-essential amino acid, a component of folic acid and a precursor to glutathione, a powerful antioxidant. The acid is also referred to as glutamate, which is its salt form. Glu is involved in the metabolism of sugar and FAs, and works as a neurotransmitter in the brain, transporting potassium and detoxifying ammonia. L- glutamine can be synthesized, or made, from Glu. Glutamine is the most abundant free amino acid in the body, with most of it in skeletal muscle cells. It is metabolized in the small intestine, where it is broken down and used as the main source of cellular fuel, making it important in the regulation of the body GI tract. The study also states that glutamine is needed to fuel the cells of your immune system, and at times the kidney utilizes glutamine as well. It can be converted into glucose, or sugar when the body requires it, and it also helps to maintain the acid/alkaline balance in the body. Glutamic acid and glutamine are interconvertible, meaning that they can each make the other. Both compounds have a similar base chain while glutamic acid has a hydroxyl group attached to its chain (Kasper *et al.*, 2004).

b) Amino Acids Quality

Table 2 presents parameters on the quality of the protein of the samples. Total AA ranged as 82.4 g/100 g (duck) > 80.8 g/100 g (francolin) > 79.9 g/100 g (turkey). The EAA ranged between 36.0-39.5 g/100 g cp with a variation of 4.80 %. The values were lower than the value of 56.6 g/100 g cp of the egg reference protein (Paul and Southgate, 1980). The total sulphur amino acid (TSAA) of the samples were 5.30 g/100 g (duck), 3.63 g/100 g (francolin) and 3.56 g/100 g (turkey). The value of 5.30 g/100 g was close to the value of 5.80 g/100 g cp while values of 3.63-3.56 g/100 g cp formed more than one-half recommended for infants (FAO/WHO/UNU, 1985). The aromatic AA (ArAA) range suggested for ideal infant protein (6.8-11.8 g/100 g cp) (FAO/WHO/UNU, 1985) was very favourably comparable with the current report of 9.26-10.2 g/100 g cp showing that the samples protein could be used to supplement cereal flour. The percentage ratio of EAA to the total AA (TAA) in the samples ranged between 44.6-47.9 %. These values were well above the 39 % considered adequate for ideal protein food for infants, 26 % for children and 11 % for adults (FAO/WHO/UNU, 1985). The percentage of EAA/TAA for the samples could be favourably compared with other animal protein sources – 48.6 % in guinea fowl (Adeyeye, 2010), 51.1 % in domestic fowl (Paul and Southgate, 1976), 48.6-53.2 % in African giant pouch rat (muscle, skin) (Adeyeye and Falemu, 2012), 46.2 % in *Zonocerusvariegatus* (Adeyeye, 2005a), 43.7 % in *Macrotermes bellicosus* (Adeyeye, 2005b), 54.8 % in *Gymnarchus niloticus* (Trunk fish) (Adeyeye and Adamu, 2005), egg (50 %) (FAO/WHO, 1990). The TEAA in these results were close to the value of 44.4 g/100 g cp in soya bean (Altschul, 1958). The percentage of total neutral AA (TNAA) ranged from 54.6-55.8, indicating that these formed the bulk of the AA; total acid AA (TAAA) ranged from 26.8-27.8 which was lower than % TNAA, whilst the percentage range in total basic AA (TBAA) was 13.7-14.8 which made them the third largest group among the samples.

The predicted protein efficiency ratio (P-PER) was 2.16 (duck), 2.14 (francolin) and 1.92 (turkey). These results can be compared to these literature results: 2.25 (muscle) and 1.81 (skin) of guinea fowl (Adeyeye, 2011); 2.27 (skin) and 1.93 (muscle) of turkey hen (Adeyeye and Ayejuyo, 2007); 2.22 (*Clarias anguillaris*, 1.92 (*Oreochromis niloticus*) and 1.98 (*Cynoglossus senegalensis*) (Adeyeye, 2008a); 3.4 (whole body), 3.1 (flesh) and 2.6 (exoskeleton) of fresh water female crab (Adeyeye, 2008b); fresh water male crab: 2.9 (whole body), 2.8 (flesh), 2.4 (exoskeleton) (Adeyeye and Kenni, 2008); 4.06 (corn *ogi*) and reference casein with PER of 2.50 (Oyarekua and Eleyinmi, 2004). Some other literature values were 1.21 (cowpea) and 1.82 (pigeon pea) (Salunkhe and Kadam, 1989). 1.62 (millet *ogi*) and 0.27 (sorghum *ogi*) (Oyarekua and Eleyinmi, 2004); 3.21 in guinea fowl egg (Adeyeye, 2010) and domestic fowl (Paul and Southgate, 1976).The Leu/Ile ratio was low at 1.61-2.09, this is much less than in turkey hen (2.09-3.33) (Adeyeye and Ayejuyo, 2007) but close to the muscle and skin of guinea fowl at 1.191-1.98 (Adeyeye, 2011), hence no concentration antagonism might be experienced in the three samples. The essential AA index (EAAI) ranged from 1.12-1.22 as compared to the guinea fowl egg of 1.54 and domestic fowl of 1.55 (Adeyeye, 2010). The EAAI is useful as a rapid tool to evaluate food formulations for protein quality, although it does not account for differences in protein quality due to various reactions (Nielsen, 2002). It should be noted that Leu/Ile ratio in guinea fowl was 1.64 (Adeyeye, 2010) and 1.48 in domestic fowl (Paul and Southgate, 1976). The isoelectricpoints (pI) were acidic in values for all the results with range of 4.59-4.76 but higher in guinea fowl (5.93) (Adeyeye, 2010) and domestic fowl (5.93) (Paul and Southgate, 1976). The calculation of pI from AA would assist in the production of the protein isolate of an organic product.

Most animal proteins are low in Cys, for examples (Cys/TSAA) %: 36.3 % in *M. bellicossus* (Adeyeye, 2005a); 25.6 % in *Z. variegatus* (Adeyeye, 2005b); 35.5 % in *Archachatinamarginata,* 38.8 % in *Archatinaarchatina* and 21.0 % in *Limicolaria* sp. respectively (Adeyeye and Afolabi, 2004); 27.3 %-32.8 % in female fresh water crab body parts (Adeyeye, 2008b); 23.8 %-30.1 % in three different Nigeria fishes (Adeyeye, 2008a); 13.3 %-15.9 % in male fresh water crab body parts (Adeyeye and Kenni, 2008); 26.0-26.5 % in turkey hen meat (Adeyeye and Ayejuyo, 2007); 14.0 % in guinea fowl (Adeyeye, 2010) and 44 % in domestic fowl (Paul and Southgate, 1976); 26.2-30.3 % in the muscle and skin of guinea fowl (Adeyeye, 2011). The present results of 19.8-31.2 % corroborated these literature observations. In contrast, many vegetable proteins contain substantially more Cys than Met, examples: 62.9 % in coconut endosperm (Adeyeye, 2004) and in *Anacardiumoccidentale* it is 50.5 % (Adeyeye *et al*., 2007); however, in bambara groundnut seeds, the following were observed: testa (55.3 %), dehulled (46.1 %) and whole (44.5 %) (Adeyeye and Olaleye, 2012). Thus for animal protein diets, or mixed diets containing animal protein, Cys is unlikely to contribute up to 50 % of the TSAA (FAO/WHO, 1991). The percentage of Cys in TSAA had been set at 50 % in rat, chick and pig diets (FAO/WHO, 1991). Cys has positive effects on mineral absorption particularly zinc (Mendoza, 2002; Sandstrom *et al*., 1989).

c) Amino Acid Scores

Table 3 contains the AA scores (AAS) of the samples based on the whole hen's egg profile (Paul and Southgate, 1976). The scores had values greater than 1.0 in Lys (1.07), Glu (1.09), Gly (1.30) and Met (1.26) in the duck egg; in francolin egg, they were Glu (1.08), Pro (1.04), Gly (1.40) and Ala (1.07) whereas it was 1.00 in His; in turkey, the followings were observed: Lys (1.01), Gly (1.54) whereas it was 1.00 in Glu. Gly had the highest score in duck (1.30), in francolin (1.40) and in turkey (1.54). Gly score in guinea fowl under this standard was 2.23 (Adeyeye, 2010); the least score was Ser: 0.48 (duck), 0.38 (francolin) and 0.37 (turkey). The eggs under discussion showed very good comparison with the AA profile of the whole hen's egg. The CV % between AA levels for the scores in the eggs ranged between 1.60-25.8. Table 4 shows the essential AA scores (EAAS) based on the suggested requirement of the EAA of a pre-school child (FAO/WHO/UNU, 1985). It is interesting to note that all the EAAS in duck were greater than 1.0 (except Leu, 0.99); all in francolin except Lys (0.95) and Leu (0.98); all in turkey (except Leu, 0.90). Under this comparison, Met +Cys had the best score in duck (2.12), in francolin (1.45), in turkey (1.42). The limiting AA (LAA) in duck was Leu (0.99), in francolin it was Lys (0.95) and in turkey it was Leu (0.90). To correct for the LAA: in duck it is 100/99 or 1.01 x protein of duck; in francolin it is 100/95 or 1.05 x protein of francolin; in turkey it is 100/90 or 1.11 x protein of turkey. The CV % values were close at 4.40-23.8. Table 5 shows the EAAS based on the provisional essential amino acid scoring pattern (FAO/WHO, 1973). EAAS greater than 1.0 in duck were Lys, Met +Cys, Phe + Tyr and total EAA; in francolin, scores greater 1.0 or equal to 1.0 were Lys, Met + Cys and Phe + Tyr; in turkey, EAAS greater or equal to 1.0 were Lys, Thr, Met + Cys, Phe + Tyr and total EAA. The LAA in duck was Val (0.80), in francolin it was Val (0.77) and in turkey it was Val (0.83); all the corrections follow the trend as done for Table 4. The highest EAAS was Met + Cys (1.51) in duck; it was Phe + Tyr (1.26) in francolin and it was Phe + Tyr (1.20) in turkey.

The following values would show the position of the quality of egg samples protein; the EAA requirements across the samples were (values with His) (g/100 g protein): infant (46.0), pre-school (2-5 years) (33.9), school child (10-12 years) (24.1) and adult (12.7) and without His: infant (43.4), pre-school (32.0), school child (22.2) and adult (11.1) (FAO/WHO/UNU, 1985). From the present results based on these standards, we have: 39.5 g/100 g protein (with His) and 37.2 g/100 g (no His) protein in the duck; 36.0 g/100 g protein (with His) and 33.6 g/100 g protein (no His) in the francolin; 37. 0 g/100 g protein (with His) and 35.0 g/100 g protein (no His) in the turkey.

d) Summary of the Amino Acids Profiles

Table 6 gives a brief summary of the AA profiles in the three samples. Column under Factor B means showed that the values there were close with a range of 37.5-43.5; similar observation could be made in Factor A column with AA profile range of 39.9-41.2. it should however be noted that both columns A and B means terminated at 40.5.

e) Comparison of Amino Acid Profiles of Many Eggs

Table 7 contains the whole egg amino acids profiles of duck, francolin, turkey (from present study), guinea fowl and domestic fowl (from literature). It is only meant for easy reference on quality variation among the eggs.

V. Conclusion

The findings of this study showed that the samples demonstrated amino acid profiles of three different whole eggs being different from each other. The eggs are virtually adequate for pre-school children because they were all having scores greater than 1.0 in the principal limiting amino acids of Lys (first limiting, 0.95-1.15), Met + Cys (second limiting, 1.42-2.12), Thr (third limiting, 1.03-1.23), Try (fourth limiting, not determined). This means, all these eggs should be encouraged and taken (any of them) as choice eggs.

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Table 1 : The amino acid composition (g/100g crude protein edible portion) of duck, francolin and turkey eggs (dry weight)

Amino acid	Duck	Francolin	Turkey	Mean	SD	CV%
Lysine (Lys)*	6.65	5.49	6.24	6.13	0.59	9.60
Histidine (His)*	2.24	2.41	2.08	2.24	0.17	7.36
Arginine (Arg)*	5.89	5.83	5.71	5.81	0.09	1.58
Aspartic acid (Asp)	8.93	9.01	10.2	9.38	0.71	7.58
Threonine (Thr)*	3.55	3.50	4.18	3.74	0.38	10.1
Serine (Ser)	3.80	3.01	2.91	3.24	0.49	15.0
Glutamic acid (Glu)	13.1	13.0	12.1	12.7	0.55	4.33
Proline (Pro)	3.02	3.94	3.39	3.45	0.46	13.4
Glycine (Gly)	3.91	4.21	4.61	4.24	0.35	8.28
Alanine (Ala)	4.21	5.79	4.01	4.67	0.98	20.9
Cystine (Cys)	1.27	0.72	1.11	1.03	0.28	27.4
Valine (Val)*	4.02	3.83	4.16	4.00	0.17	4.14
Methionine (Met)*	4.03	2.91	2.45	3.13	0.81	26.0
Isoleucine (Ile)*	3.24	3.11	3.69	3.35	0.30	9.09
Leucine (Leu)*	6.51	6.49	5.95	6.32	0.32	5.03
Tyrosine (Tyr)	3.09	3.25	3.00	3.11	0.13	4.07
Phenylalanine (Phe)*	4.88	4.30	4.18	4.45	0.37	8.41
Tryptophan (Try)*	-	-	-	-	-	-
Protein[a]	67.9	80.1	77.6	75.2	6.44	8.57

** Essential amino acid; [a] Dry weight and fat free basis.*

Table 2 : Essential, non-essential, acidic, neutral, sulphur, aromatic (g/100g crude protein edible portion) of duck, francolin and turkey eggs (dry weight)

Amino acid	Duck	Francolin	Turkey	Mean	SD	CV%
TAA	82.4	80.8	79.9	81.0	1.27	1.56
TNEAA	42.9	44.8	42.8	43.5	1.13	2.59
% TNEAA	52.1	55.4	53.6	53.7	1.65	3.08
TEAA – with His	39.5	36.0	37.0	37.5	1.80	4.81
– no His	37.2	33.6	35.0	35.3	1.81	5.15
% TEAA – with His	47.9	44.6	46.4	46.3	1.65	3.57
-no His	45.2	41.6	43.8	43.5	1.81	4.17
TNAA	45.5	45.1	43.6	44.7	1.00	2.24
% TNAA	55.3	55.8	54.6	55.2	0.60	1.09
TAAA	22.0	22.0	22.2	22.1	0.12	0.52
% TAAA	26.8	27.2	27.8	27.3	0.50	1.85
TBAA	14.8	13.7	14.0	14.2	0.57	4.01
% TBAA	17.9	17.0	17.6	17.5	0.46	2.62
TSAA	5.30	3.63	3.56	4.16	0.99	23.7
% TSAA	6.44	4.49	4.46	5.13	1.13	22.1
% Cys/TSAA	24.0	19.8	31.2	25.0	5.77	23.1
TArAA	10.2	9.96	9.26	9.81	0.49	4.98
% TArAA	12.4	12.3	11.6	12.1	0.44	3.60
P-PER[a]	2.16	2.14	1.92	2.07	0.13	6.42
Leu/Ile	2.01	2.09	1.61	1.90	0.26	13.5

% Leu-Ile (diff)	50.2	52.1	38.0	46.8	7.65	16.4
pI[b]	4.76	4.65	4.59	4.67	0.09	1.85
EAAI[c]	1.22	1.12	1.16	1.17	0.05	4.31

[a]P-PER = predicted protein efficiency ratio; [b]pI =isoelectric point; [c]EAAI = essential amino acid index.

Table 3 : Amino acids scores of the samples with respect to whole hen's egg (amino acids values were in g/100g)

Amino acid	Duck	Francolin	Turkey	Mean	SD	CV%
Lys	1.07	0.89	1.01	0.99	0.09	9.26
His	0.93	1.00	0.87	0.93	0.07	6.97
Arg	0.97	0.96	0.94	0.96	0.02	1.60
Asp	0.83	0.84	0.95	0.87	0.07	7.62
Thr	0.70	0.69	0.82	0.74	0.07	9.82
Ser	0.48	0.38	0.37	0.41	0.06	14.8
Glu	1.09	1.08	1.00	1.06	0.05	4.67
Pro	0.79	1.04	0.89	0.91	0.13	13.9
Gly	1.30	1.40	1.54	1.41	0.12	8.53
Ala	0.78	1.07	0.74	0.86	0.18	20.9
Cys	0.71	0.40	0.62	0.58	0.16	27.7
Val	0.54	0.51	0.55	0.53	0.02	3.90
Met	1.26	0.91	0.77	0.98	0.25	25.8
Ile	0.58	0.56	0.66	0.60	0.05	8.82
Leu	0.78	0.78	0.72	0.76	0.03	4.56
Tyr	0.77	0.81	0.75	0.78	0.03	3.93
Phe	0.96	0.84	0.82	0.87	0.08	8.67
Total	0.84	0.82	0.81	0.82	0.02	1.86

Table 4 : Amino acids scores of the samples with respect to pre-schoolchildren requirements (amino acids value were in g/100g)

Amino acid	Duck	Francolin	Turkey	Mean	SD	CV%
Lys	1.15	0.95	1.08	1.06	0.10	9.57
His	1.18	1.27	1.09	1.18	0.09	7.63
Thr	1.04	1.03	1.23	1.10	0.11	10.2
Met + Cys	2.12	1.45	1.42	1.66	0.40	23.8
Val	1.15	1.09	1.19	1.14	0.05	4.40
Ile	1.16	1.11	1.32	1.20	0.11	9.17
Leu	0.99	0.98	0.90	0.96	0.05	5.16
Phe +Tyr	1.27	1.20	1.14	1.20	0.07	5.41
Total	1.20	1.06	1.09	1.12	0.07	6.60

Table 5 : Amino acids scores of the samples with respect to provisional amino acid scoring pattern (amino acids values were in g/100g)

Amino acid	Duck	Francolin	Turkey	Mean	SD	CV%
Lys	1.21	1.00	1.13	1.11	0.11	9.52
Thr	0.89	0.88	1.05	0.94	0.10	10.1
Met + Cys	1.51	1.04	1.02	1.19	0.28	23.3
Val	0.80	0.77	0.83	0.80	0.03	3.75
Ile	0.81	0.78	0.92	0.84	0.07	8.81
Leu	0.93	0.93	0.85	0.90	0.05	5.11
Phe +Tyr	1.33	1.26	1.20	1.26	0.07	5.15
Total	1.06	0.96	1.00	1.01	0.05	5.00

Table 6 : Summary of the amino acids profiles into factors A and B

Amino acid composition(Factor B)	Samples(Factor A)			Factor B means
	Duck	Francolin	Turkey	
Total essential amino acid	39.5	36.0	37.0	37.5
Total non-essential amino acid	42.9	44.8	42.8	43.5
Factor A means	41.2	40.4	39.9	40.5

Table 7 : Whole egg amino acid compositions of duck, francolin and turkey compared with those of whole egg amino acid compositions of guinea fowl and domestic fowl (g/100g crude protei

Amino acid	Duck	Francolin	Turkey	Guinea fowl[a]	Domestic fowl[b]
Lys	6.65	5.49	6.24	6.91	6.2
His	2.24	2.41	2.08	2.62	2.4
Arg	5.89	5.83	5.71	6.55	6.1
Asp	8.93	9.01	10.2	8.99	10.7
Thr	3.55	3.50	4.18	5.20	5.1
Ser	3.80	3.01	2.91	3.80	7.9
Glu	13.1	13.0	12.1	1.60	12.0
Pro	3.02	3.94	3.39	5.08	3.8
Gly	3.91	4.21	4.61	6.68	3.0
Ala	4.21	5.79	4.01	5.77	5.4
Cys	1.27	0.72	1.11	0.55	1.8
Val	4.02	3.83	4.16	6.58	7.5
Met	4.03	2.91	2.45	3.39	3.2
Ile	3.24	3.11	3.69	5.55	5.6
Leu	6.51	6.49	5.95	9.10	8.3
Tyr	3.09	3.25	3.00	4.29	4.0
Phe	4.88	4.30	4.18	5.70	5.1
Try	-	-	-	-	1.8