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Comparative Quality of Amino Acid Profiles of the Girth and Skin of the Breast of Domestic Duck (Anas platyrhynchos)

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Abstract

Amino acid profiles of girth and skin of female domestic duck consumed in Nigeria were determined. The %N ranged as 13.06 (girth) - 13.29 (skin) with respective total amino acid in g.100g-1 as 88.73 and 89.67. The amino acids were more concentrated in the skin than in the girth. Protein efficiency ratios 1 and 2 were 2.52 (girth) - 2.32 (skin) and 2.46 (girth) - 2.32 (skin) respectively. Essential amino acid index and biological value results for girth and skin respectively were 88.24 - 88.36 and 84.45 - 84.58. In the various amino acids scores calculated, Thr was limiting in girth and Ser in skin in chicken egg comparison; whilst Val was limiting in provisional amino acid scoring pattern for skin, Thr was limiting in girth; in pre-school essential amino acid requirement comparison, Thr was limiting in girth but no limiting amino acid in skin. Out of 19 amino acid related parameters determined, 10 (10/19 = 52.6%) parameters in skin were more concentrated; also in the eight essential amino acids determined, six (75.0%) of them were more concentrated in skin. Overall results showed that the skin of domestic duck breast was nutritionally better than the girth.

Keywords: *Anas platyrhynchos; Breast Girth; Skin; Amino Acid*

Abbreviations

AA: Amino Acid; TAA: Total Amino Acid; EAA: Essential Amino Acid; TEAA: Total Essential Amino Acid; TNEAA: Total Non-Essential Amino Acid; TNAA: Total Neutral Amino Acid; TAAA: Total Acidic Amino Acid; TBAA: Total Basic Amino Acid; TSAA: Total Sulphur Amino Acid; TArAA: Total Aromatic Amino Acid; TEArAA: Total Essential Aromatic Amino Acid; AAS: Amino Acid Score; P-PER: Pre¬dicted Protein Efficiency Ratio; pI: Isoelectric Point; EAAI: Essential Amino Acid Index; IFE: Index of Forecasting Efficiency; C_A: Coefficient of Alienation; CV: Coefficient of Variation; SD: Standard Deviation; IEC: Ion Exchange Chromatography; TSM: Technicon Sequential Multisample; BV: Biological Value; r_T: Table Value; rxy: Correlation Coefficient; rxy^2: Variance; Rxy: Regression Coefficient; SFA: Saturated Fatty Acid

Introduction

Wikipedia [1] defined poultry as domestic fowls including chickens, turkeys, geese and ducks that are raised for the production of meat or eggs or their feathers. The word is also used for the flesh of these birds used as food.

From ancient times domestic ducks have served as a source of food and income for people in many parts of the world. Ducks serve as sources of meat, eggs and down-feathers (for making bedding and warm jackets). Duck meat and its eggs are good dietary sources of high quality protein, energy and several vitamins and mineral [2,3].

Domestic ducks fall into three major genetic classifications [4]. First classification contains the common ducks. Most domestic ducks fall into this group. They are believed to have originated from the Mallard (*Anas platyrhynchos*). Some other members of common ducks include the Pekin, Asylesbury, Rouen, Call, Indian Runner, Khaki Campbell, Cayuga, Albio, Maya and Tsaiya. Common ducks are known to interbreed and produce fertile offspring. Eggs from common ducks require about 28 days to hatch. Second in the classification are the Muscovy ducks. The Muscovy (*Cairina moschata*). This breed is believed to have originated in South America, although ancient records of this or a similar breed have been found in Egypt; they are also of both coloured and white feathered varieties. Muscovy eggs require about 35 days to hatch. Whilst Muscovies can be crossed with common ducks, their offsprings are sterile. Third in the classification are the Sterile Hybrid Ducks. The offsprings of the hybrids formed when Muscovies and common ducks are allowed to mate, or Muscovies undergo artificial insemination, are always sterile. Hence, these hybrids are usually raised for their meat, or in some cases, for their liver (foic gras), which is a delicacy sold in famous restaurants.

Lean meats are meats with a relatively low fat content. Skinless chicken and turkey and red meat, such as pork chops, with the fat trimmed are examples of lean meat. The fat on a pork chop accounts for about two thirds of its fat content and the skin on chicken can account for 80 percent of its fat content [5]. Duck is a poultry, so it is expected to produce lean meat. Duck is well known for being higher in saturated fatty acid (SFA) and cholesterol than other poultry such as chicken and turkey. However, duck contains pretty much the same level of cholesterol (< 0.1%) as chicken, most of which is in the meat (girth) and not the skin, contrary to popular belief [6]. This is also the case with other lipids in the duck.

Literature information is available on the amino acid profiles of the yolk and albumen of domestic duck eggs consumed in Nigeria [2]. Also available is the literature on the amino acid profiles of the domestic duck visceral organs [3]. There is scarcity of information on the amino acid profiles on the meat (girth) and skin of the domestic duck either together or separately. This work was set out to evaluate on comparative basis, the amino acid profiles of the breast of the domestic duck for the girth and skin. The results were set out to achieve two major aims: (i) to provide information to improve the information on food composition Tables and (ii) to weigh the "loss" nutritionally when the skin of the domestic duck breast is removed from the meat and discarded.

Materials and Methods

Sample Collection and Treatment

The matured female domestic ducks used were purchased at the Iworoko market (about one and a half kilometers from the University campus). Before butchering, the ducks were not fed in order to ensure that the digestive system was empty. To kill the ducks, the head was held on the stump and the duck head was removed with an axe. After bleeding, the duck was plucked, anus was rinsed to remove any residue. A knife was then used to open the viscera. The duck was then cleaned with distilled water and dissected; both the skin and muscle of the breast sliced, rinsed and dried in the oven to constant weight; milled into flour and kept in freezer in McCartney bottles pending analysis.

Preparation of Fat-free Nitrogen and Amino Acid Analysis Samples

The micro-Kjeldahl method as described by Pearson [7] was used to determine the fat-free crude nitrogen. The fat was extracted with a chloroform/methanol (2:1 v/v) mixture using Soxhlet extraction apparatus [8]. Between 30mg and 35mg of defatted samples were weighed into glass ampoule. Then, 7ml of 6M HCl was added and oxygen was expelled by passing nitrogen gas into the ampoule. The glass ampoules were sealed with flame and put in an oven preset at 105 ± 5°C for 22h. The ampoules were cooled, opened and the contents filtered. The filtrate was evaporated to dryness at 40°C under vacuum. The residue was dissolved with 5ml acetate buffer (pH 2.0) and stored in the freezer pending analysis.

Amino Acid Analysis

Amino acid analysis was by ion-exchange chromatography [9] using a Technicon Sequential Multisample Amino Acid Analyzer (TSM) (Technicon Instruments Corporation, New York, USA) [10]. The TSM is designed to separate free acidic, neutral and basic acids of the hydrolysate. The amount loaded for each sample was 5 - 10 µl. The period of analysis was 76 minutes, with a gas flow rate of 0.50 $ml.min^{-1}$ at 60°C, the reproducibility was ± 3%. Tryptophan was not determined. The amino acid values were the average of two determinations. Norleucine was used as the internal standard. The amount of each amino acid present in the sample was calculated in $g.16^{-1}N$ or $g.100g^{-1}$ protein.

Some calculations from the analytical results

Estimation of isoelectric point (pI)

Estimation of isoelectric point (pI) for a mixture of amino acids can be carried out using the equation of the form [11]:

$$IPm = \sum_{i=1}^{n} IPiXi \quad (1)$$

where IP_m is the isoelectric point of the mixture of amino acids, IPi is the isoelectric point of the i^{th} amino acid in the mixture and Xi is the mass or mole fraction of the i^{th} amino acid in the mixture.

Estimation of predicted protein efficiency ratio (P-PER)

Computation of protein efficiency ratio (C-PER or P-PER) was carried out using the equations suggested by Alsmeyer., *et al.* [12]:

P-PER1 = -0.468 + 0.454 (Leu) - 0.105 (Tyr) (2a)

P-PER2 = -0.684 + 0.456 (Leu) - 0.047 (Pro) (2b)

Leucine/Isoleucine ratio (Leu/Ile)

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

Estimation of essential amino acid index (EAAI)

The method of EAAI calculation due to Oser [13] using the egg protein amino acids as the standard.

Estimation of biological value (BV)

Computation of biological value (BV) was done following the equation of Oser [13] as follows:

BV = 1.09 (EAAI) - 11.73 (3)

Computation of the differences in the anatomical parts

Differences in the amino acid profiles between girth and skin were calculated.

Computation of amino acid scores

The amino acid scores were computed using three different procedures:

- Scores based on amino acid values compared with whole chicken's egg amino acid profile [14].
- Scores based on essential amino acid scoring pattern [15].
- Scores based on essential amino acid suggested pattern of requirements for pre-school children [16].

Statistical evaluation

Data results from tables 1, 4, 6 and 8 were subjected to statistical analysis of linear correlation coefficient (r_{xy}), coefficient of determination or variance (r_{xy}^2), regression coefficient (R_{xy}), coefficient of alienation (C_A) and index of forecasting efficiency (IFE). The r_{xy} was converted to critical table value to see if significant differences existed among the sample results at $r_{=0.05}$ [17].

Results and Discussion

Amino Acid Composition of the Breast of Domestic Duck

The amino acid profiles of the girth and skin of female (matured) domestic duck can be seen in table 1. The most concentrated amino acids in the girth were Glu (14.89 g/100g) and Asp (11.26 g/100g), both are acidic amino acids; in the skin, the most concentrated amino acid was Asp (9.25 g/100g). On pairwise comparisons, the skin was better concentrated in the following amino acids (AA): Lys, His, Thr, Ala, Met, Ile, Tyr and Phe as well as in %N (fat free) and total AA. This meant that of the 19 amino acid related parameters determined, 10 or 10/19 (52.6%) parameters in the skin were more concentrated than the girth. Also, in the eight essential amino acids determined, six (6/8 or 75.0%) of them were more concentrated in the skin. The differences in the amino acid profiles between the girth and the skin were depicted also in table 1. The amino acid values were mostly very close as shown by the low levels of coefficient of variation per cent (CV%), 16 out of 19 (84.2%) parameters had their CV% values between 0.745 - 17.6; whereas only three (15.8%) CV% values ranged between 27.1 - 69.2. Whilst total amino acid values had the least CV% (0.745), Glu had the highest CV% of 69.2.

Amino acid	Girth	Skin	Mean	SD[b]	CV%	Differences	
						Girth - Skin	% Difference
Lys[a]	5.71	6.30	6.01	0.417	6.95	-0.59	-10.3
His[a]	2.20	2.50	2.35	0.212	9.03	-0.30	-13.6
Arg	7.15	6.85	7.00	0.212	3.03	+0.30	+4.20
Asp	11.26	9.25	10.26	1.42	13.9	+2.01	+17.9
Thr[a]	1.85	4.11	2.98	1.60	53.6	-2.26	-122
Ser	3.46	3.30	3.38	0.113	3.27	+0.16	+4.62
Glu	14.89	5.11	10.0	6.92	69.2	+9.78	+65.7
Pro	4.15	3.71	3.93	0.311	7.92	+0.44	+10.6
Gly	5.79	4.59	5.19	0.849	14.7	+1.20	+20.7
Ala	3.26	4.51	3.89	0.884	27.1	-1.25	-38.3
Cys	1.42	1.30	1.36	0.085	5.98	+0.10	+7.04
Val[a]	5.56	4.25	4.91	0.926	16.7	+1.31	+23.6
Met[a]	4.05	4.35	4.20	0.212	5.24	-0.30	-7.41
Ile[a]	3.44	3.80	3.62	0.255	7.40	-0.36	-10.5
Leu[a]	7.33	6.97	7.15	0.255	3.56	+0.36	+4.91
Tyr	3.19	3.61	3.40	0.297	9.31	-0.42	-13.2
Phe[a]	4.02	5.16	4.59	0.806	17.6	-1.14	-28.4
%N (fat free)	13.06	13.29	13.18	0.163	1.23	-0.23	-1.76
Total amino acid	88.73	89.67	89.2	0.665	0.745	-0.94	-1.06

Table 1: *Amino acid composition [g/100g protein] of the breast of domestic duck (dry weight)*
a: Essential amino acid; b: Standard deviation; c: Coefficient of variation percent; d: Minus sign means skin > girth value and vice-versa

The total amino acid value was 88.73 g/100g in the girth whereas it was 89.67 g/100g in the skin. Both the girth total AA and the skin AA were correspondingly more than the report in turkey where the girth was 81.16 g/100g and the skin was 76.42 g/100g [18]. In guinea fowl (*Numida meleagris*), the total AA in girth was 87.5 g/100g and the skin had 59.4 g/100g [19]; both values were correspondingly lower than the domestic duck. In the African giant pouch rat (*Cricetomys gambianus*), the muscle total AA was 84.8 g/100g and the skin was 56.0 g/100g [20], again both values being lower than in the domestic duck. However, in the case of the AA values in the greater cane rat (*Thryonomys swinderianus*), the trend changed [21]. In *T. swiderianus*, total AA in the muscle was 89.1 g/100g (compared to 88.73 g/100g in duck girth) whereas the *T. swiderianus* skin had total AA of 73.6 g/100g (still lower than in the skin of duck which was 89.67 g/100g). Hence, in the four comparisons made in the total AA, the duck girth was better than in turkey, guinea fowl and pouch rat whereas the duck skin was better than in the skin of turkey, guinea fowl, pouch rat and greater cane rat; in addition duck skin was better than the muscle of turkey, guinea fowl and pouch rat. The amino acid composition (g/100g) of different ostrich muscles was also available for comparison [22]. The muscles and the values were: *Iliofibularis* (90.95), *Femorotibialis medius* (88.41) and *Gastrocnemius pars interna* (87.58). Only the *Iliofibularis* value was higher than in the girth and skin of duck. Both Glu and Asp were the first and second most concentrated AA in the following samples (g/100g) as Glu (Asp): turkey muscle: 13.71 (10.02), turkey skin: 12.22 (8.79); guinea fowl muscle: 13.3 (9.96), guinea fowl skin: 8.60 (6.05); pouch rat muscle: 13.0 (10.2), pouch rat skin: 7.95 (7.25); greater cane rat muscle: 15.0 (8.11), greater cane rat skin: 14.0 (7.17); ostrich muscles: *Iliofibularis*: 16.1 (9.99), *F. medius*: 16.1 (8.78) and *G. pars interna*: 15.5 (9.67). On the other hand, whilst Glu and Asp were the first and second most concentrated AA in the girth of domestic duck with respective values of (g/100g) 14.89 and 11.26, Asp was the first most concentrated AA in the duck skin with a value of 9.25 g/100g whereas Leu (6.97 g/100g) was the second most concentrated AA in the duck skin. In the samples under discussion, Leu was the highest concentrated essential AA in both girth (7.33

g/100g) and skin (6.97 g/100g); from literature, this trend was observed in the muscle (7.04 g/100g) and skin (5.70 g/100g) in pouch rat; 7.22 g/100g (muscle) and 6.90 g/100g (skin) in greater cane rat; in ostrich muscles we have (g/100g Leu): 9.11 (*Iliofibularis*), 8.78 (*F. medius*) and 8.43 (*G. pars interna*); however, Lys was the most concentrated essential AA (EAA) in turkey with values of (g/100g): 7.01 (muscle) but Leu in skin (6.85); in guinea fowl, it was Lys (7.23) in the muscle but Leu (5.24) in the skin. The energy density due to duck girth was 327 kcal/100g (1388 kJ/100g) and skin was 332 kcal/100g (1412 kJ/100g).

The statistical analysis of the amino acid profiles from table 1 was depicted in table 2. Both linear correlation coefficient (r_{xy}) and the variance ($r_{xy}2$) were high at respective value of 0.9988 and 0.9975. The regression coefficient (Rxy) showed that for every one unit increase in AA in the girth, the increase was 0.0446 in the skin. The mean values for both girth and skin were close, this closeness could also be observed in standard deviation (SD) and CV%. The coefficient of alienation (C_A) or non-relationship was low at 0.0495 but with a corresponding high value of index of forecasting efficiency (IFE) with a value of 0.9505. The IFE is a value depicting the reduction in the error of prediction of relationship. This meant that the error of prediction between the values of the AA in girth and skin of duck was just 4.95% which is regarded as very low and favourable. This meant the relationship in the AA values of the girth can be used to predict the AA values of the skin and furthermore, it is an indication that the biochemical/physiological activities which the AA girth can be involved in can also be conveniently be involved in by the skin of the duck and vice-versa. The r_{xy} value calculated (r_c) > r_{xy} value in the critical table (r_T) thereby showing that significant differences existed in the two sets of AA of the female domestic duck breast (girth and skin).

Statistics	Girth		Skin
r_{xy}^{a}		0.9988	
r_{xy}^{2b}		0.9975	
Rxy^{c}		0.0446	
Mean	10.03		10.14
SD	19.4		19.6
CV%	194		193
C_A^{d}		0.0495	
IFE^{e}		0.9505	
Remark		*	

Table 2: *Statistical analysis of the amino acid profiles from table 1.*
*a: Correlation coefficient; b: Variance (coefficient of determination); c: Regression coefficient; d: Coefficient of alienation; e: Index of forecasting efficiency; *Results significantly different at n-2 [degree of freedom (df)] at r=0.05 (critical value = 0.456)*

Amino Acid Quality Parameters

The quality parameters of the amino acid profiles of the breast of domestic duck were depicted in table 3. The FAO/WHO/UNU [16] essential amino acid standards for pre-school children (2 - 5 years) are (g/100g protein): Leu (6.6), Phe + Tyr (6.3), Thr (3.4), Val (3.5), Ile (2.8), Lys (5.8), Met + Cys (2.5), His (1.9) and total (33.9 with His) and 32.0 (no His). Based on this information, the girth would provide more than enough of each of the AA except Lys (5.71) and Thr (1.85) whereas the skin would provide more than each value of the AA mentioned. The total sulphur amino acid (TSAA) recommended for infants is 5.8 g/100g [16], the present values were highly comparable to this value with concentrations of 5.47 (girth) - 5.65 g/100g (skin). The aromatic AA (ArAA) range recommended for ideal infant protein was 6.8 - 11.8g/100g protein [16]; the duck ArAA values were close to this particularly in the skin (11.27 g/100g). The percentage ratio of EAA to total AA (TAA) in samples were 38.8 - 41.75% which were good for 39% considered adequate for ideal protein food for infants, 26% for children and 11% for adults [16]. The total neutral AA (TNAA) ranged from 47.52 - 49.66 g/100g with corresponding percentage values of 53.56 - 55.38, showing that they formed the bulk of the AA; total acid AA (TAAA) ranged from 26.15 - 24.36 g/100g and corresponding percentage values of 29.47 - 27.17 which were lower than in TNAA; the total basic AA (TBAA) had values of 15.06 - 15.65 g/100g with corresponding percentage values of 16.97 - 17.45 which were lower than TAAA and much lower than TNAA.

Amino acid	Girth	Skin	Mean	SD	CV%
Total amino acid (TAA)	88.73	89.67	89.2	0.665	0.745
Total non-essential amino acid (TNEAA)	54.59	52.23	53.4	1.65	3.10
% TNEAA	61.5	58.24	59.87	2.31	3.85
Total essential amino acid (TEAA) - with His	34.16	37.44	35.8	2.32	6.48
- no His	31.96	34.94	33.45	2.11	6.30
% TEAA - with His	38.5	41.75	40.13	2.30	5.73
- no His	36.02	38.97	37.5	2.09	5.56
Total aliphatic amino acid (TAIAA; Class I[a])	25.38	24.12	24.75	0.891	3.69
% TAIAA	28.60	26.9	27.75	1.20	4.33
Total essential aliphatic amino acid (TEAIAA)	16.33	15.02	15.68	0.926	5.91
% TEAIAA	18.4	16.75	17.58	1.17	6.64
Total aromatic amino acid (TArAA; Class VI[a])	9.41	11.27	10.34	1.32	12.7
%TArAA	10.61	12.57	11.59	1.39	12.0
Total essential aromatic amino acid (TEArAA)	6.22	7.66	6.94	1.02	14.7
% TEArAA	7.01	8.54	7.78	1.08	13.9
Total acidic amino acid (TAAA; Class IV[a])	26.15	24.36	25.26	1.27	5.01
% TAAA	29.47	27.17	28.32	1.63	5.74
Total basic amino acid (TBAA; Class V[a])	15.06	15.65	15.36	0.417	2.72
% TBAA	16.97	17.45	17.21	0.339	1.97
Total neutral amino acid (TNAA)	47.52	49.66	48.59	1.51	3.11
% TNAA	53.56	55.38	54.47	1.29	2.36
Total hydroxy amino acid (THAA; Class II[a])	5.29	7.41	6.35	1.50	23.6
% THAA	5.96	8.26	7.11	1.63	22.9
Cyclic amino acid (CAA, Pro; Class VII[a])	4.15	3.71	3.93	0.311	7.92
% CAA	4.68	4.14	4.41	0.382	8.66
Total sulphur amino acid (TSAA; Class III[a])	5.47	5.65	5.56	0.127	2.29
% TSAA	6.16	6.30	6.23	0.099	1.59
% Cys in TSAA	25.96	23.01	24.49	2.09	8.52
Leu / Ile ratio	2.1	1.83	1.97	0.191	9.72
(Leu - Ile) difference	3.89	3.17	3.53	0.509	14.4
% (Leu - Ile) / Leu	53.07	45.48	49.28	7.37	10.9
$P\text{-}PER_1$[b]	2.52	2.32	2.42	0.147	6.06
$P\text{-}PER_2$[b]	2.46	2.32	2.39	0.101	4.24
pI[e]	5.11	5.23	5.17	0.081	1.56
EAAI[d]	88.24	88.36	88.3	0.085	0.096
Be	84.45	84.58	84.52	0.092	0.109
Phe : Tyr	1.26	1.43	1.35	0.120	8.94

Table 3: *Some quality parameters of the amino acid profiles of the breast of domestic duck.*
a: Amino Acid Group (as appropriate); b: Predicted Protein Efficiency Ratio; c: Isoelectric Point; d: Essential Amino Acid Index; e: Biological Value

Amino acids are sometimes grouped into classes. In table 3, seven classes were shown [23]. Class I are AA with aliphatic side chains (hydrogen and carbons) whose members are made up of Gly, Ala, Val, Leu and Ile constituting a range value of 25.38 - 24.12 g/100g (28.6 - 26.9%) with low CV%. Class II are AA with side chains that contain hydroxylic (OH) groups consisting of Ser and Thr with values of 5.29 - 7.41 g/100g and percentage values of 5.96 - 8.26 with slightly higher values of CV%: 23.6 (class II values) and 22.9 (% THAA values). Total sulphur amino acid (TSAA) form members of class III; they are AA with side chains containing sulphur atoms, they are Cys and Met with values of 5.47 - 5.65 g/100g and percentage of 6.16 - 6.30 with low CV%. Class IV contains the acidic AA of Glu and Asp; they have side chains that contain acidic groups or their amides. Class IV values ranged from 26.15 - 24.36 g/100g and percentage values of 29.47 - 27.17 with low CV%. Class V contains the amino acids with side chains containing basic groups (Arg, Lys, His) whose total values ranged from 15.06 - 15.65 g/100g and corresponding percentage of 16.97 - 17.45 with low CV%. In class VI, we have AA containing aromatic rings (His, Phe, Tyr, Trp); here, their total values ranged from 9.41 - 11.27 g/100g with corresponding percentage of 10.61 - 12.57 g/100g and low CV%. Class VII is the cyclic amino acid (CAA) containing the imino acid (Pro) consisting values of 4.15 - 3.71 g/100g with percentage levels of 4.68 - 4.14. The classes trend in the duck samples was different from the trend as observed in amino acid profiles of whole organism, flesh and shell of *Pandalus borealis* [24]; in *Callinectes latimanus* [25] and in amino acid profiles of the flesh of the heterosexual pairs of *Neopetrolisthes maculatus* [26]. It could be seen also that the percentage values were close to their individual principal values, e.g. value (percentage): class I, 25.38 - 24.12 (28.60 - 26.90); class II, 5.29 - 7.41 (5.96 - 8.26); etc. The AA classes showed the EAA were distributed into the various classes as follows: class I (3 EAA), class II (one EAA), class III (one EAA), class IV (no EAA), class V (3 EAA), class VI (3 EAA) and class VII (no EAA). In terms of essentiality therefore, class I ≡ class V ≡ class VI > class II ≡ class III; for non-essentiality, class IV ≡ class VII.

Most animal proteins contain low Cys. The (Cys/TSAA)% in guinea fowl was 26.2 (muscle) and 30.2 (skin) [19]; in pouch rat we have 28.1 (muscle) and 22.0 (skin) [20]; in turkey we have 26.0 (girth) and 26.5 (skin) [18] and in cane rat we have 19.8 (muscle) and 36.1 (skin) [21]. The present duck breast results had 25.96 (girth) and 23.01 (skin) corroborating the usual observed (Cys/TSAA)% in most animals. The percentage Cys in TSAA has been set at 50% in rat, chick and pig diets [9]. Cys is known to have positive effects on mineral absorption particularly zinc [27,28]. In plants, the % Cys/TSAA in most cases could be equal or greater than 50% as we have in the endosperm of cocnut having a value of 62.9% [29] and in *Anacardium occidentale* it was 50.5% [30]. The protein efficiency ratio had values of 2.52 (girth) and 2.32 (skin) in $P\text{-}PER_1$ but 2.46 (girth) and 2.32 (skin) in $P\text{-}PER_2$. The seeming similarity between the $P\text{-}PER_1$ and $P\text{-}PER_2$ in the skin and the slight disparity between the $P\text{-}PER_1$ and the $P\text{-}PER_2$ in the girth could be due to the relationship in the Leu/Tyr and Leu/Pro in the two samples; for Leu/Tyr, it was 2.3 (girth) but 2.1 (skin) and in Leu/Pro we have 1.77 (girth) but 1.93 (skin). Both $P\text{-}PER_1$ and $P\text{-}PER_2$ showed that the girth might be more physiologically utilized than the skin. In general, it has been found that the better the protein, the lower the level in the diet required to produce the highest protein efficiency ratio underlying the importance of the proper nutritive balance of all the AA to produce optimum metabolic efficiency. In the guinea fowl, the $P\text{-}PER_1$ was 2.25 (girth) and 1.81 (skin); in turkey it was 1.93 (girth) and 2.27 (skin); in pouch rat we had 2.41 (muscle) and 1.89 (skin) and in greater cane rat we had 2.49 (muscle) and 2.42 (skin).

The Leu/Ile ranged from 2.1 (girth) and 1.83 (skin). The values of 2.1 - 1.83 were within the value of 2.36 regarded as the most ideal Leu/Ile [9]; these result values would prevent concentration antagonism from the consumption of the samples. It has been suggested that an amino acid imbalance from excess Leu might be a factor in the development of pellagra [31]. It is known that a high Leu imbalance in the diet often impairs the metabolism of Trp and niacin deficiency in sorghum eaters [32]. Experiments using dogs showed that animals fed sorghum proteins with less than 11 g/100g protein Leu did not suffer from nicotinic acid deficiency [33]. The present Leu values ranged from 6.97 - 7.33 g/100g protein and regarded as being safe and could be beneficially exploited to prevent pellagra in endemic areas [34]. The samples isoelectric points (pI) showed values of 5.11 - 5.23 with low CV% of 1.56.

The essential amino acid index (EAAI) and their corresponding biological values (BV) were depicted also in table 3. The EAAI and BV values for girth were respectively 88.24 and 84.45 and the skin respectively also were 88.36 and 84.58 with skin being slightly higher in both parameters; however, they had very close values as shown by the CV% values: EAAI (0.096) and BV (0.109). These results were better than the values of poultry from literature [13]: chicken, muscle without skin, 82 (EAAI) and 78 (predicted BV); duck; muscle without skin, 82 (EAAI) and 78 (predicted BV). The present duck results were better than in beef cuts: 84 (EAAI) and 80 (BV); lamb cuts: 84 (EAAI) and 78 (BV); pork cuts: 83 (EAAI) and 79 (BV) [13]. Both the girth and the skin had EAAI and BV values all being better than all the literature values sighted showing the superiority of the duck meat over them. 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 processing methods or certain chemical reactions [35].

Amino Acid Scores

Scores based on whole chicken's egg

The amino acid scores of the duck breast girth and skin based on whole chicken's egg were shown in table 4. The amino acid scores (AAS) greater than 1.0 in girth were observed for Arg, Asp, Glu, Pro, Gly and Met. This is 6/18 or 33.3% of the amino acid related parameters. Also out of eight EAA determined only Met (1/8 or 12.5%) has AAS greater than 1.0. In the case of the skin, the following AA had scores greater than 1.0: Lys, His, Arg, Glu, Gly, Met and Phe; this is seven parameters (7/18 or 38.9%) having AAS greater than 1.0. Also out of the skin AAS greater 1.0, four of them were EAA meaning that 4/8 or 50% of the skin AAS were greater than 1.0. The differences in the AAS were also depicted in the table 4. The differences showed that the skin had 10 ASS greater than the values in the girth; this gave a value of 10/18 (55.6%) out of which six (6/8 or 75.0%) of them were EAA. The limiting AA (LAA) in the girth was Thr (0.36) whereas the LAA in the skin was Ser (0.42). The highest AAS for girth was 1.93 as observed in Gly and also the highest AAS was 1.53 as observed in the Gly skin. The aroma that comes from the meat when cooked appears to be a function of the combination of the glycine and fatty acids. To correct the LAA, the lowest value AAS is used, in girth it was 100/36 or 2.78 times as much of girth protein would have to be eaten when it serves as the sole protein source in the diet; whereas in the skin the multiplication value would be 100/42 or 2.38. The observations made in the girth and skin of duck for its LAA under the chicken's egg comparison was also observed in the muscle and skin of greater cane rat. The cane rat had Thr (0.39) as LAA in the muscle and Ser (0.39) in the skin [21]. However, Ser was the LAA in the muscle and skin of African giant pouch rat with respective values of 0.49 and 0.16 [20]; in the guinea fowl, Ser was limiting in muscle (0.51) and also in the skin (0.23). Gly had the highest AAS in the guinea fowl with value of 1.70 (muscle) and 0.87 (skin) [19]. Still on guinea fowl, the scores had values greater than 1.0 in Lys, His, Arg, Glu, Gly, Ala and Met (also six but some different AA as in duck breast girth) but no AA could measure up to this level in the skin [19].

Amino acid	Girth	Skin	Mean	SD	CV%	Difference	% Difference
Lys	0.92	1.02	0.97	0.071	7.29	-0.10	-10.9
His	0.92	1.04	0.98	0.085	8.66	-0.12	-13.0
Arg	1.17	1.12	1.15	0.035	3.09	+0.05	+4.27
Asp	1.05	0.86	0.955	0.134	14.1	+0.19	+18.1
Thr	0.36	0.81	0.585	0.318	54.4	-0.45	-125
Ser	0.44	0.42	0.43	0.014	3.29	+0.02	+4.55
Glu	1.24	1.26	1.25	0.014	1.13	-0.02	-1.61
Pro	1.09	0.98	1.04	0.078	7.52	+0.11	+10.1
Gly	1.93	1.53	1.73	0.283	16.3	+0.40	+20.7
Ala	0.60	0.84	0.72	0.170	23.6	-0.24	-40.0
Cys	0.79	0.72	0.755	0.049	6.56	+0.07	+8.86
Val	0.74	0.57	0.655	0.12	18.4	+0.17	+23.0
Met	1.27	1.36	1.32	0.064	4.84	-0.09	-7.09
Ile	0.61	0.68	0.645	0.049	7.67	-0.07	-11.5
Leu	0.88	0.84	0.86	0.028	3.29	+0.04	+4.55
Tyr	0.80	0.90	0.85	0.071	8.32	-0.10	-12.5
Phe	0.79	1.01	0.90	0.156	17.3	-0.22	-27.8
Total	0.888	0.898	0.893	0.007	0.792	-0.01	-1.13

Table 4: *Amino acid scores of domestic duck breast based on the whole chicken's egg profile.*

The statistical evaluation of the data from table 4 could be seen in table 5. The r_{xy} and $r_{xy}2$ were high with respective values of 0.8584 and 0.7368; the Rxy (0.3405) was much higher than Rxy value shown in table 2. The mean, SD and CV% were each close and low in value. The C_A was higher than the IFE thereby making the prediction of relationship slightly difficult. the rc was greater than the r_T at $r_{=0.05}$, hence significant differences existed in the AAS of girth and skin of duck on whole chicken's egg comparison.

Statistics	Girth		Skin
r_{xy}		0.8584	
r_{xy}^2		0.7368	
Rxy		0.3405	
Mean	0.916		0.937
SD	0.358		0.271
CV%	39.08		29.0
C_A		0.5130	
IFE		0.4870	
Remark		*	

Table 5: *Statistical analysis of the amino acid scores from table 4.*
Critical value of r=0.05 = 0.456

Amino acid scores based on provisional amino acid scoring pattern

The following AA in table 6 had AAS greater than 1.0 in girth: Lys, Met + Cys, Val, Leu, Phe + Tyr and total EAA making a total of six out of eight parameters (6/8 or 75.0%); equal number of AAS but different AA were also observed in the skin: Lys, Thr, Met + Cys, Leu, Phe + Tyr and total AA. As it was observed in the whole chicken's egg comparison in the AA of girth, Thr (0.463) was also limiting under the provisional AA scoring pattern. The correction for the girth protein under this pattern would be 100/46.3 or 2.16 multiplied by girth protein. In this result, skin has LAA of 0.85 in Val. Technically we could say that skin has no LAA [36] because the first three limiting AA are Lys, Met + Cys and Thr and number four is Trp (not determined here). However, for the purpose of this discussion, the correction value in the skin would be 100/85 or 1.18. In the differences column, it could be observed that out of the eight parameters shown, six (6/8 or 75.0%) of them showed where the AAS in the skin was higher than in the girth. As shown in the egg comparison scores where the highest between girth and skin was shown in Thr (125%), similar observation could also be seen in the provisional AA scoring pattern where Thr (122%) also showed the highest difference. Whilst total AA showed the least score difference (1.13%) in egg score comparison, Met + Cys (3.21%) showed the least score difference in the provisional scoring pattern. In the African giant pouch rat, Thr (0.69) was limiting in the muscle and Val (0.54) was limiting in the skin [20]; in the greater cane rat, Thr (0.50) was limiting in the muscle and Lys (0.73) was limiting in the skin [21]; in guinea fowl, Ile (0.848) was limiting in the muscle and Thr (0.51) was limiting in the skin [19]; in turkey, Ile (0.85) was limiting in muscle and Thr (0.60) in the skin [18].

Amino acid	Girth	Skin	Mean	SD	CV%	Difference	%Difference
Lys	1.04	1.15	1.095	0.078	7.10	-0.11	-10.6
Thr	0.463	1.03	0.747	0.401	53.7	-0.57	-122
Met + Cys	1.56	1.61	1.59	0.035	2.23	-0.05	-3.21
Val	1.11	0.85	0.980	0.184	18.8	+0.26	+23.4
Ile	0.86	0.95	0.905	0.064	7.03	-0.09	-10.5
Leu	1.05	1.00	1.03	0.035	3.45	+0.05	+4.76
Phe + Tyr	1.20	1.46	1.33	0.184	13.8	-0.26	-21.7
Total	1.04	1.14	1.09	0.071	6.49	-0.10	-9.62

Table 6: *Amino acid scores of domestic duck breast based on the provisional amino acid scoring pattern.*

The statistical analysis of results of the amino acid scores from table 6 can be found in table 7. Both r_{xy} and $r_{xy}2$ were low at respective values of 0.6606 and 0.4364 but with relatively high Rxy with a value of 0.5686. The C_A was high (0.7507) and about three times the value of IFE (0.2493); this will make the prediction of relationship difficult because the reduction in error of prediction (IFE) was low. In this result, $r_c < r_T$ at $r_{=0.05}$, hence, no significant difference occurred among the samples in this scoring pattern.

Statistics	Girth		Skin
r_{xy}		0.6606	
r_{xy}^2		0.4364	
Rxy		0.5686	
Mean	1.04		1.15
SD	0.309		0.260
CV%	29.7		22.7
C_A		0.7507	
IFE		0.2493	
Remark		NS[a]	

Table 7: *Statistical analysis of the amino acid scores from table 6.*
a: Results not significantly different at n-2 (df) at r=0.05 (critical value = 0.707)

Amino acid scores based on suggested essential amino acid requirement of pre-school child

Amino acid scores of the domestic duck breast based on the suggested requirement of the essential amino acid of a pre-school child was depicted in table 8. Out of the nine parameters determined girth had seven (7/9 or 77.8%) parameters with AAS having values greater than 1.0, exceptions were Lys (0.980) and Thr (0.54). It means in the girth, the LAA was Thr and would have a correction value of 100/54 or 1.85. In the case of the skin, all the EAA had scores greater than 1.00, hence no limiting AA. Again the highest difference in score was observed in Thr with a value of 124%. Both girth and skin had values of Met + Cys score more than double the standard score; girth had 2.19 and skin had 2.26. In the greater cane rat, Thr (0.59) was limiting in muscle and Lys (0.69) was limiting in the skin [21]; in guinea fowl, muscle had no LAA since all ranged as ≥ 1.0 and in the skin Thr (0.60) was limiting [19]; also in guinea fowl, Met + Cys was highest in muscle (1.90) and skin (1.16) [19]; in the African giant pouch rat, Thr was limiting in both the muscle (0.81) and skin (0.66).

Amino acid	Girth	Skin	Mean	SD	CV%	Difference	%Difference
Lys	0.98	1.09	1.035	0.078	7.52	-0.11	-11.2
His	1.16	1.32	1.24	0.113	9.12	-0.16	-13.8
Thr	0.54	1.21	0.875	0.474	54.1	-0.67	-124
Val	1.59	1.21	1.40	0.269	19.2	+0.38	+23.9
Met + Cys	2.19	2.26	2.32	0.049	2.22	-0.07	-3.20
Ile	1.23	1.36	1.295	0.092	7.10	-0.13	-10.6
Leu	1.11	1.06	1.085	0.035	3.26	+0.05	+4.50
Phe + Tyr	1.14	1.39	1.265	0.177	14.0	-0.25	-21.9
Total	1.18	1.29	1.235	0.078	6.30	-0.11	-9.32

Table 8: *Amino acid scores of domestic duck breast based on the suggested requirement of the essential amino acid of a pre-school child.*

Table 9 depicted the statistical analysis of the amino acid scores from table 8. The values of r_{xy}, $r_{xy}2$ and Rxy were all high. The CA was higher than the IFE with respective values of 0.6100 and 0.3900. However, the $r_c > r_T$ at $r_{= 0.05}$, showing the results to be significantly different.

Statistics	Girth		Skin
r_{xy}		0.7924	
r_{xy}^2		0.6278	
Rxy		0.5756	
Mean	1.24		1.35
SD	0.450		0.358
CV%	36.41		26.43
C_A		0.6100	
IFE		0.3900	
Remark		*	

Table 9: *Statistical analysis of the amino acid scores from table 8.*
Critical value at r=0.05 is 0.666

In table 10, we have the summary of all the results of AA compositions of the girth and skin in the categories of essential and non-essential amino acid into factors A and B. Table 10 shows the means of both factor A and factor B to be 44.6 g/100g as the overall summary.

	Samples (Factor A)		**Factor B means**
	Girth	Skin	
Amino acid composition			
Total essential amino acid	34.2	37.4	35.8
Total non - essential amino acid	54.6	52.2	53.4
Factor A means	44.4	44.8	44.6

Table 10: *Summary of the amino acid profiles of the breast of domestic duck into factors A and B.*

Conclusions

The fat free protein in skin (83.1 g/100g) > in girth (81.6 g/100g). Skin has better quality essential amino acids as shown in Lys, His, Thr, Met, Ile, Phe and total amino acids. Skin is better in the following amino acid quality parameters than the girth: total essential amino acids (TEAA), total essential aromatic amino acid (TEArAA), total basic amino acid (TBAA), total sulphur amino acid (TSAA), essential amino acid index (EAAI), biological value (BV) and Phe : Tyr. In the scoring patterns, skin was better than egg in Lys, His, Arg, Glu, Gly, Met and Phe; for provisional amino acid scoring pattern, skin was better than the standards in Lys, Thr, Met + Cys, Leu, Phe + Tyr and total amino acid; in the pre-school essential amino acid requirements, skin has values greater than the standard for all the essential amino acids. In all these observations, the girth does not have most of these important pride of place. Results also showed that the duck skin surpasses the amino acid quality of turkey, guinea fowl, African giant pouch rat, greater cane rat, beef cuts, lamb cuts and pork cuts. From all these, the skin of the breast of domestic duck (*Anas platyrhynchos*) should be consumed with the girth to enhance good and quality protein.

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