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Amino Acid Composition of two Fancy Meats (Liver and Heart) of African Giant Pouch Rat (*Cricetomys gambianus*)

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ABSTRACT

An investigation into the concentrations of amino acids in the liver and heart of *Cricetomys gambianus* was carried out. The most abundant amino acid was Glu (12.9-13.0 g/100 g) and Leu was the most abundant essential amino acid (6.94-7.65 g/100 g). Whilst total amino acid content was 83.4-91.4 g/100 g crude protein, the total essential amino acid content was 38.6-42.2 g/100 g or 46.2-46.3% with His but 35.6-39.9 g/100 g crude protein or 42.5-43.7% without His. When compared with whole hen's egg, Ser was the limiting amino acid in the two samples (0.38-0.47) whereas it was 1.12 (Lys) in liver and 1.26 (His) in heart. In comparison with pre-school child requirement, Leu (1.16) was limiting in liver and Thr (0.78) was limiting in heart. In comparison with provisional amino acid scoring pattern: Met+ Cys (0.95) was limiting in liver but Thr (0.66) was limiting in heart. The predicted protein efficiency ratio (P-PER) was 2.32-2.62 whereas the essential amino acid index was 1.20-1.31. Significant differences existed between the liver and the heart in their amino acid compositions and their comparisons with the whole hen's egg at r = 0.05.

Key words: Amino acid, Liver and heart, *Cricetomys gambianus*.

INTRODUCTION

The Gambian pouch rat (*Cricetomys gambianus*), also known as the African giant pouch rat is a nocturnal rat of the giant pouched rat genus *Cricetomys*. It is the largest muroid in the world. Native to Africa, it is an invasive species in Grassy Key in the Florida Keys, with great potential to damage native wildlife on the mainland; because of this it is illegal to import it into the United States[1].

The Gambian pouch rat can grow to be as big as a raccoon and weigh up to 4 kg. It has very poor eyesight and so depends on its senses of smell and hearing. Its name comes from the large, hamstarlike pouches on its cheeks. It is not a true rat, but is part of a uniquely African branch of muroid rodents. Scientific classification: Kingdom: Animalia; Phylum: Chordata; Class: Mammalia; Order: Rodentia; Super family: Muroidea; Family:

Nesomyidae; Subfamily: Cricetomyinae; Genus: *Cricetomys*; Species: *C. gambianus;* Binomial name: *Cricetomys gambianus* Waterhouse, 1840. In its native African, this rat lives in colonies of up to twenty, usually in forests and thickets, but also commonly in termite mounds. It is omnivorous, feeding on vegetables, insects, crabs, snails, and other items, but apparently preferring palm fruits and palm kernels.

Unlike domestic rats, it has cheek pouches like a hamster. These cheek pouches allow it to gather up several kilograms of nuts per night for storage under ground. It has been known to stuff its pouches so full of date palm nuts so as to be hardly able to squeeze through the entrance of its burrow. The burrow consists of a long passage with alleys and several chambers, one for sleeping and the others for storage.

Commercial – scale giant rat farming is now being established in southern Nigeria. This is a promising development because giant rats are a common "bush meat" throughout much of Africa. Since they are well known there, and are acceptable as foods, they may have as much or more potential as meat animals than the introduced rabbits that are getting considerable attention (2).

The main aim of this paper was to investigate the amino acid compositions of *Cricetomys gabianus* Waterhouse, 1840 skin and muscle and to compare their values with the amino acid levels of the whole hen's egg. Eating the skin and muscle together or eating the muscle alone depends on preference.

MATERIAL AND METHODS

Sampling

The life size female African giant pouch rat was obtained from a traditional farmer who was commissioned to trap the animal for this exercise.

Sample Treatment

The animal was brought into the laboratory; the fur burnt off, washed the body and dissected. The liver, kidney, heart and other edible internal organs were removed, washed with distilled water, oven-dried at 95 ^{0}C for 8 h. The cooled dried samples were ground using mortar and pestle into a fine powder, kept in plastic rubbers in freezer (-4 ^{0}C) pending analysis.

Determination of Amino Acid Profile

The amino acid profile in the samples was determined using the methods described by Spackman *et al*., (3). Each sample was dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Technicon Sequential Multi-sample Amino Acid Analyzer (TSM) (Technicon Instruments Corporation, New York).

Defatting of Sample

About 2.0 g of each sample were weighed into extraction thimble and the fat was extraction with chloroform/methanol (2:1 v/v mixture) using Soxhlet extraction apparatus as described by AOAC (4). The extraction lasted for 15 h.

Hydrolysis of the Samples

About 30 mg of the defatted sample was weighed into glass ampoules. Seven milliliters of 6 M HCl were 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 ampoule was then sealed with Bunsen burner flame and put in an oven preset at 105±5 ^{0}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 ^{0}C under vacuum in a rotary evaporator. The residue was dissolved with 5 ml acetate buffer (pH 2.0) and stored in plastic specimen bottles which were kept in the freezer.

Loading of the hydrolysate into the TSM analyzer/amino acid analysis

The amount loaded was between 5 to 10 microlitres. This was dispensed into the cartridge of the analyzer. The TSM analyzer is designed to separate and analyze free acidic, neutral and basic amino acids of the hydrolysate. The period of analysis lasted for 76 min. The gas flow rate was 0.50 ml/min at 60 ^{0}C with reproducibility consistent within ±3 %.

Method of calculating amino acid values from the 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 of 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

A constant S was calculated for each amino acid in the standard mixture:

$S_{std} = NE_{std} \times$ mol. Weight $\times \mu MAA_{std}$

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

Concentration (g/100 g protein) = NH x W @ NH/2 x S_{std} x C

Where

C = Dilution x 16/Sample wt (g) x N% x 10 vol. loaded ÷ NH x W (nleu)

Where: NH = net height

W = width @ half height

Nleu = norleucine

The amino acid values reported were the averages of two determinations.

Tryptophan was not determined. Norleucine was the internal standard.

Estimation of the quality of dietary protein

Amino Acid Scores

The total amino acids scores were calculated based on the whole hen's egg amino acid profiles (5) while the essential amino acids scores were calculated using the formula (6):

Amino acid score = Amount of amino acid per test protein [mg/g] / Amount of amino acid per protein in reference [mg/g], based on provisional amino acid scoring pattern.

The essential amino acids scores (including His) based on pre-school child suggested requirement (7).

Predicted Protein Efficiency Ratio

The predicted protein efficiency ratio (P-PER) was determined using one of the equations developed by Alsmeyer *et al.* (8); i.e.:

P-PER = -0.468 + 0. 454 (Leu) –0.105 (Tyr).

Essential Amino Acid Index

The essential amino acid index was calculated by using the ratio of test protein to the reference protein for each eight essential amino acids plus histidine in the equation (9):

$$\text{Essential amino acid index} = \sqrt[9]{\frac{\text{mg Lysine in 1 g test protein}}{\text{mg Lysine in 1 g reference protein}} \times \text{etc. for all 8 essential amino acids + His}}$$

Other 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) and total acidic amino acids (TAAA) and total basic amino acids (TBAA) were estimated from the results obtained for amino acids profiles. The leucine/isoleucine ratios were calculated.

Calculation of isoelectric point

The theoretical estimation of isoelectric point (pI) was carried out using the equation (10, 11):

$$IPm = \sum_{i=1}^{n} \mathrm{IPiXi}$$

Where: IPm 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.

Statistical analysis

All data generated were analyzed statistically (12). Calculated for were the grand mean, standard deviation in percent (CV %). Subjected to simple linear correlation coefficient of r_{xy}, simple regression coefficient, R_{xy}, coefficient of alienation, C_A, coefficient of determination, r_{xy}^2, and index of forecasting efficiency, IFE, were the amino acids compositions of the samples and their various scores. The r_{xy} values were compared to correlation coefficient critical levels at $r = _{0.05}$ and n-2 degrees of freedom to determine if significant differences existed between liver/ heart in those parameters determined whilst the CV % gave values of the level of closeness or dispersion between values of liver and heart on pair wise comparison.

RESULTS

Table 1 shows the amino acid (AA) composition for each sample. Glutamic acid and aspartic acid had the highest concentrations among their groups and are both acidic AA. Leucine constituted the highest single essential AA (EAA) in both samples. Table 2 shows the concentrations of total AA (TAA), total essential AA (TEAA), total acidic AA (TAAA), total neutral AA (TNAA), total sulphur AA (TSAA), total aromatic AA (TArAA) and their percentage levels. Table 4 shows that serine had the lowest AA score (AAS) in both samples; in Table

Table 1: Amino acid profiles of the fancy meats on dry weight (g/100 g crude protein)

Amino acid	Liver	Heart	Mean	SD	CV %
Lysine (Lys) [a]	6.96	6.03	6.50	0.66	10.1
Histidine (His)[a]	2.30	3.03	2.67	0.52	19.4
Arginine (Arg)[a]	6.38	6.50	6.44	0.08	1.32
Aspartic acid (Asp)	9.70	10.6	10.2	0.64	6.27
Threonine (Thr)[a]	4.20	2.65	3.43	1.10	32.0
Serine (Ser)	3.72	3.00	3.36	0.51	15.2
Glutamic acid (Glu)	13.0	12.9	13.0	0.07	0.55
Proline (Pro)	4.22	3.50	3.86	0.51	13.2
Glycine (Gly)	8.00	4.20	6.10	2.69	44.0
Alanine (Ala)	4.18	4.07	4.13	0.08	1.88
Methionine (Met)[a]	2.16	2.40	2.28	0.17	7.44
Cystine (Cys)	1.20	1.20	1.20	0.00	-
Valine (Val)[a]	5.60	5.02	5.31	0.41	7.72
Isoleucine (Ile)[a]	4.20	3.65	3.93	0.39	9.90
Leucine (Leu)[a]	7.65	6.94	7.30	0.50	6.88
Phenylalanine (Phe)[a]	4.30	4.19	4.25	0.08	1.83
Tyrosine (Tyr)	3.65	3.49	3.57	0.11	3.17
Tryptophan (Try)	-	-	-	-	-
Protein[b]	86.9	86.3	86.6	0.42	0.49

(-), Not determined.

[a] Essential amino acid.

[b] Dry and fat free.

5 the essential AAS (EAAS) was leucine in liver but threonine in heart; in Table 6 the EAAS was Met +Cys in liver but threonine in the heart.

DISCUSSION

The protein values for the two samples given in Table 1 (86.9 g/100 g, 86.3 g/100 g) were close to the value of the different muscles of ostrich: 91.0 % (iliofibularis), 92.4% (femorotibialis medius), 92.5 % (gastrocnemius pars interna) on dry matter and fat free basis (13) and 92 %, 92.1 % and 89 % in three different fresh water fishes consumed in Nigeria (14).

Glu, Asp and Phe+ Tyr trends in the present study followed the trends in *Gymnarchus niloticus* (Trunk fish) (15), and in *Clarias anguillaris,*

Table 2: Concentrations of essential, non- essential, acidic, neutral, sulphur, aromatic (g/100 g crude protein) of giant rat samples (dry weight of sample)

Amino acid	Liver	Heart	Mean	SD	CV %
Total amino acid (TAA)	91.42	83.37	87.4	5.69	6.51
Total non- essential amino acid (TNEAA)	49.2	44.77	47.0	3.13	6.66
Total essential amino acid (TEAA)					
With His	42.22	38.6	40.4	2.56	6.34
No His	39.92	35.6	37.8	3.05	8.08
% TNEAA	53.8	53.7	53.8	0.07	0.13
% TEAA With His	46.2	46.3	46.3	0.07	0.15
No His	43.7	42.5	43.1	0.85	1.97
Total neutral amino acid (TNAA)	53.1	44.3	48.7	6.22	12.8
% TNAA	58.0	53.1	55.6	3.46	6.24
Total acidic amino acid (TAAA)	22.7	23.5	23.1	0.57	2.45
% TAAA	24.8	28.2	26.5	2.40	9.07
Total basic amino acid (TBAA)	15.6	15.6	15.6	0.00	-
% TBAA	17.1	18.7	17.9	1.13	6.32
Total sulphur amino acid (TSAA)	3.36	3.60	3.48	0.17	4.88
% TSAA	3.67	4.32	4.00	0.46	11.5
% Cys in TSAA	35.7	33.3	34.5	1.70	4.92
Total aromatic amino acid (TArAA)	7.95	7.68	7.82	0.19	2.44
% TArAA	8.69	9.21	8.95	0.37	4.11

Table 3: Other calculated parameters from the amino acid profiles of the giant rat liver and heart

Parameter	Liver	Heart	Mean	SD	CV %
P-PER[a]	2.62	2.32	2.47	0.21	8.59
Leu/Ile ratio	1.82	1.90	1.86	0.06	3.04
Leu/Ile (difference)	3.45	3.29	3.37	0.11	3.36
% Leu-Ile (difference)	45.1	47.4	46.3	1.63	3.52
pI[b]	5.22	4.82	5.02	0.28	5.63
EAAI[c]	1.31	1.20	1.26	0.08	6.20

[a] Predicted protein efficiency ratio. [b] Isoelectirc point.

[c] Essential amino acid index

Oreochromis niloticus and *Cynoglossus senegalensis* (14). Arginine (6.38-6.50 g/100 g crude protein, cp) is essential for children and reasonable levels were present here. The lysine contents of the samples (6.03-6.96 g/100 g cp) were very close to the content of the reference egg protein (63 mg/g), and they will therefore serve as good sources for fortification of cereal weaning foods. The coefficient of variation percent, CV % levels were low although Thr was 32 % varied and Gly was 44 % varied. The EAA compositions of the present study were close to the values in the heart and liver of cattle and pig (16) but better than: heart His (2.7 g/100 g) and liver Lys (6.9 g/100 g) of cattle; heart Tyr (3.4 g/100 g) and heart His (2.5 g/100 g) as well as liver Tyr (3.6 g/100 g) in pig; heart Met, Cys, Tyr, Val, His, (2.2, 0.8, 3.1, 5.5, 2.3 g/100 g respectively) and liver Lys, Met, Cys, Tyr, Val (5.4, 2.1, 1.0, 3.6, 5.0 g/

Table 4: Amino acid scores of the samples based on whole hen's egg

Amino acid	Liver	Heart	Mean	SD	CV %
Lys	1.12	0.97	1.05	0.11	10.1
His	0.96	1.26	1.11	0.21	19.1
Arg	1.05	1.07	1.06	0.01	1.33
Asp	0.91	0.99	0.95	0.06	5.95
Thr	0.82	0.52	0.67	0.21	31.7
Ser	0.47	0.38	0.43	0.06	15.0
Glu	1.09	1.08	1.09	0.01	0.65
Pro	1.11	0.92	1.02	0.13	13.2
Gly	2.67	1.40	2.04	0.90	44.1
Ala	0.77	0.75	0.76	0.01	1.86
Met	0.68	0.75	0.72	0.49	6.92
Cys	0.67	0.67	0.67	0.00	-
Val	0.75	0.67	0.71	0.06	7.97
Ile	0.75	0.65	0.70	0.07	10.1
Leu	0.92	0.84	0.88	0.06	6.43
Phe	0.84	0.82	0.83	0.14	1.70
Tyr	0.91	0.87	0.89	0.03	3.18
Try	-	-	-	-	-
Total	1.01	0.85	0.93	0.11	12.2

Table 5: Essential amino acid scores of the samples based on suggested requirements for pre- school children (2-5 years)

Amino acid	Liver	Heart	Mean	SD	CV %
Lys	1.20	1.04	1.12	0.11	10.1
His	1.21	1.59	1.40	0.27	19.2
Thr	1.24	0.78	1.01	0.33	32.2
Val	1.60	1.43	1.52	0.12	7.93
Met +Cys	1.34	1.44	1.39	0.07	5.09
Ile	1.50	1.30	1.40	0.14	10.1
Leu	1.16	1.05	1.11	0.08	7.04
Phe +Tyr	1.26	1.22	1.24	0.03	2.28
Total	1.29	1.18	1.24	0.08	6.30

100 g respectively) in the sheep. The present EAA in liver was 42.22 g/100 g and heart was 38.6 g/100 g whereas the EAA (with Try) in cattle were (g/100 g): cattle, liver 49.1, heart 47.1; pig, liver 48.9, heart 47.7; sheep, liver 42.7, heart 43.8 (16) showing that the sample results were favourably comparable with conventional fancy meat sources in their EAA.

The present contents of TEAA are comparable to some literature values of non-conventional meat sources (g/100 g): 35.1 (*Zonocerus variagatus*) (17); 35.0 (*Macrotermes bellicosus*) (18); 42.8 (L*imicolaria sp.*), 36.1 (*Archatina archatina*), 45.0 (*Archachatina marginata*) (19). The contents of TSAA were generally lower than the 5.8 g/100 g cp

Table 6: Essential amino acid scores of the samples besed on provisional amino acid scoring pattern

Amino acid	Liver	Heart	Mean	SD	CV %
Lys	1.27	1.10	1.19	0.12	10.1
Thr	1.05	0.66	0.86	0.28	32.3
Met +Cys	0.95	1.03	0.99	0.06	5.71
Val	1.12	1.00	1.06	0.08	8.00
Ile	1.05	0.91	0.98	0.10	10.1
Leu	1.09	0.99	1.04	0.07	6.80
Phe +Tyr	1.33	1.28	1.31	0.04	2.71
Total	1.14	1.02	1.08	0.08	7.86

Table 7: Summary of the statistical analysis of the data in Table 1, 4-6

Table	r_{xy}	r_{xy}^2	R_{xy}	C_A	IFE	X	Y	Remark
1.Liver/Heart	0.9986	0.997	-0.45	0.052	94.8	9.91	9.43	*
4.Liver/Heart	0.7542	0.569	0.46	0.657	34.3	0.97	0.86	*
5.Liver/Heart	0.4194	0.176	0.299	0.908	9.2	1.31	1.22	NS
6.Liver/Heart	0.6605	0.436	-0.05	0.751	24.9	1.13	0.999	NS

*Results significant at $r_{= 0.05}$ NS = result not significantly different at $r_{= 0.05}$
X = mean; Y = mean

Table 8: Summary of the amino acid profile of the samples

	Giant rat samples (Factor A)		
	Liver	Heart	Factor B means
Amino acid composition (Factor B)			
Total essential amino acid	42.22	38.6	40.41
Total non- essential amino acid	49.2	44.77	46.99
Factor A means	45.71	41.69	43.7

recommended for infants (7). The ArAA range suggested for ideal protein (6.8-11.8 g/100 g) (7) has present values greater than the minimum and close to the maximum, i.e.7.68-7.95 g/100 g cp.

The ArAA are precursors of epinephrine and thyroxin (20). The percentage ratios of TEAA to the TAA in the samples were 46.2 and 46.3 which are well above the 39 % considered to be adequate for ideal protein food for infants, 26 % for children and 11 % for adults (7). The TEAA/TAA percentage contents were strongly comparable to that of egg (50 %) (21), 43.6 % reported for pigeon pea flour (22) and 43.8-44.4 % reported for beach pea protein isolate (23).

Most animal proteins are low in cystine (Cys) and hence in Cys in TSAA. For examples, (Cys/TSAA) % were 36.3 in *M. bellicosus* (18); 25.6 in *Z. variegatus* (17); 35.5 in *A. marginata*, 38.8 in *A. archatina* and 21.0 in *Limicolaria* sp., respectively (19); 23.8 %-30.1 % in three fresh fish consumed in Nigeria (14) and 29.8 % in *G. niloticus* (15). In contrast, many vegetable proteins contain substantially more Cys than Met, for examples, 62 .9 % in coconut endosperm (24, 25); its range is 58.9-72.0 % in guinea corn (26); it is 50.5 % in cashew nut (27); it is 40.7 % in *Triticum durum* (28) and 44.4 % in *Parkia biglobosa* seeds (29). Thus, for animal protein, Cys is unlikely to contribute up to 50 % of the TSAA (30). The % Cys/TSAA had been set at 50 % in rat, chick and pig diets (30) but not in men. Cys can spare with Met in improving the protein quality and has positive effects on mineral absorption, particularly zinc (31). The % Cys in TSAA obtained in this study were very comparable to the literature values of the animal proteins.

The P-PER (Table 3) values were higher than in fish sources: 2.22, 1.92, 1.89 in three fresh water fishes (14) compared with liver (2.62) and heart (2.32). The P-PER of the whole hen's egg is 2.88 which is closer to the value of the liver P-PER. The experimentally determined PER usually ranged from 0.0 for a very poor protein to a maximum possible of just over 4 (32). The present result indicated that the physiological utility in the body of the liver would be much better than the heart. A common feature of sorghum and maize is that the proteins of these grains contain a relatively high proportion of leucine. It was therefore suggested that an amino acid imbalance from excess Leu might be a factor in the development of pellagra (33). It has been shown that high Leu in the diet impairs the metabolism for Try and niacin and is responsible for niacin deficiency in sorghum eaters (34). High Leu is also a factor contributing to the pellagragenic properties of maize (35). Further studies have shown that the biochemical and clinical manifestations of dietary excess of Leu could be counteracted not only by increasing the intake of niacin or tryptophan but also by supplementation with isoleucine (36, 37). These studies suggested that the leucine/isoleucine balance is more important than dietary excess of Leu alone in regulating the metabolism of Try and niacin hence the disease process. The present Leu/Ile ratios were low in value and lower than in three fresh water fishes of 2.0-2.6 (14). The present report shows Leu to range from 6.94-7.65 g/100 g cp which were lower than 11.0 g/100 g cp, therefore considered safe and could be beneficially exploited to prevent pellagra in endemic areas (38). The calculated isoelectric point (pI) ranged from 4.82-5.22. The information on pI is a good starting point in predicting the pI for proteins in order to enhance a quick precipitation of protein isolate from biological samples (10). The relatively low values of pI could be a function of the TAAA (22.7-23.5 g/100 g cp) or 24.8-28.2 % which were much higher than the TBAA (15.6-15.6 g/100g cp or 17.1-18.7 %) (Table 3). The essential amino acid index (EAAI) ranged from1.20-1.31 (Table 3) which was close to the value of 1.26 in defatted soy flour (39) but lower than 1.55 in whole hen's egg. It should be noted that the absence of Try in the present report bore no significance in the EAAI; for example EAAI without Try in soy flour remained 1.26 while it reduced to 1.54 in the whole hen's egg, i.e., a reduction of 0.01 or 0.645 %. The EAAI method can be useful as a rapid tool to evaluate food formulations for protein quality (40).

Table 4 shows serine to be the limiting amino acid of both samples on comparison with whole hen's egg. However, the correction factors are not similar; this is because the limiting serine value in liver was 0.47 and 0.38 in the heart. In order to fulfill the daily need for the entire AA in the samples, it would require 100/47 or 2.13 times as much liver protein, 100/38 or 2.63 times as much

heart protein to be eaten when they are the sole protein in the diet. In Table 5 no EAA could be strictly said to be limiting because all the EAAS were greater than 1.0, however, Val had the highest level of EAAS of 1.60 whilst least EAAS was Leu with 1.16. On the other hand Thr with a value of 0.78 was the limiting EAA in the heart. This would require a correction value of 100/78 or 1.28. In Table 6, Met+Cys (0.95) was limiting in the liver whilst it was Thr (0.66) in the heart with respective correction values of 100/95 (1.05) and 100/66 (1.52). It should be noted however that the EAA most often acting in a limiting capacity are Lys, Met+Cys, Thr and Try in that order (41). Therefore, Thr (third most essential AA) was limiting in the liver (Table 6).

Table 7 gives a statistical summary of the results from Table 1, 4, 5, 6. From Tables 1 and 4, the correlation coefficient (r_{xy}) were positively high with respective values of 0.9986 and 0.7542 and both were significant at $r = _{0.05}$ at n-2 degrees of freedom. The degrees of association (determination) r_{xy}^2 were also high for both results. The regression coefficient (R_{xy}) showed that for every one unit increase in the liver, there was reduction of -0.45 in the heart in the AA concentration whereas for everyone unit increase in the AA score of liver based on whole hen's egg, there was an increase of just 0.46 unit in the heart. The coefficient of alienation was low (0.052 or 5.2 %) from Table 1 results but high (0.657 or 65.7 %) from Table 2 results. The index of forecasting efficiency (IFE) was 94.8 % (from Table 1) but 34.3 % (from Table 4). The IFE measures the reduction in the error of prediction of relationship; e.g. from Table 1, the reduction in error of prediction would be 100-94.8 = 5.2 that is the error was only 5.2 %. The higher the IFE the easier to predict the relationship between the two compared results. When r_{xy} is 0.9 or greater, it can be taken that the estimation was accurate enough and that liver might replace the heart in its physiological functions as a food source. The coefficient of determination (r_{xy}^2), 99.7 % of the variation in the liver was being explained by the heart; the remaining 0.3 % was probable error. This explanation goes through the members of Table 7.

In conclusion, it is seen in Table 8 that TEAA trend was liver > heart and also in TNEAA it was liver > heart in *Cricetomys gambianus*. Factor B means relates to all the samples for their TEAA and TNEAA. Both Factor A means and Factor B means gave a total value of 43.7. On the whole both the liver and heart of *C. gambianus* were good in P-PER, low in Leu /Ile ratio, good in EAAI, high in EAAS and good comparison between liver and heart with positively high r_{xy} value; both liver and heart have good comparisons with whole hen's egg protein, liver and heart of cattle, pig and sheep.

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