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Comparability of the proximate and amino acids composition of maggot meal, earthworm meal and soybean meal for use as feedstuffs and feed formulations

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ABSTRACT

Levels of proximate and amino acid compositions were determined in Maggot meal (MM), Earthworm meal (EM) and Soybean meal (SM). Maggot meal was best in Ile, Leu, Lys, Try, Asp, Cys and Pro whereas Earth worm meal was best in Arg, His, Met, Phe, Val, Glu, Ser and Tyr while Soybean meal was only best in Gly, when compared on pair-wise basis. The total amino acid contents were: Maggot meal (58.4g/100g crude protein), Earthworm meal (56.3g/100g crude protein) and Soybean meal (34.9g/100g crude protein) and an average of 49.9g/100g crude protein with respective essential amino acids of 34.5g/100g crude protein, 31.4g/100g crude protein and 18.3g/100gcrude protein. The Predicted Protein Efficiency Ratio (P-PER) levels were: 2.16 (Maggot meal), 1.45 (Earthworm meal) and 1.14 (Soybean meal). On average basis, the limiting amino acid based on whole hen's egg amino acid scoring pattern and Provisional amino acids scoring pattern was threonine. However, significant differences occurred between Maggot meal/Earthworm meal (MM/EM), Maggot meal/Soybean meal (MM/SM), Quality of amino acid (QAA) of Maggot meal/ Earthworm meal (MM/EM) and Maggot meal/ Soybean meal (MM/SM) at r = 0.05 and n-2 degree of freedom. When comparing the quality of amino acids of feedstuffs on pair wise basis, the coefficients of alienation (C_A) were fairly low (24.0 - 40.7%), meaning that there is a better relationship between them while on the other hand the Index of Forecasting Efficiency (IFE) values were very high (59.4 – 76.0%) indicating that the error of prediction was very low. The three feedstuffs could then be compounded in other to employ them in feed formulation for fish, poultry and other animals.

Introduction

Several studies have shown that fish meal improves growth and immune system function in nursery pigs (Kim and Easter, 2001; Young *et al.*, 2002; Gaines *et al.*, 2005). However, responses to fish meal tend to beinconsistent because of its variability (Wiseman *et al.*, 1991). Plant proteins, such as soybean meal, are less expensive than animal protein sources but contain antinutritional factors that are not suitable to be fed as the sole protein source post-weaning (Friesen *et al.*, 1993; Qin *et al.*, 1996). Research has indicated that pigs fed fermented, rather than solventextracted, soybean meal have improved feed efficiency and AA digestibility (Min *et al.*, 2004; Kim *et al.*, 2007; Cho *et al.*, 2008). The fermentation process is thought to eliminate residual trypsin inhibitors and some oligosaccharides in soybean meal that can decrease pig performance.

The problems of environmental pollution such as water,domestic waste, air pollutants are serious pending to solve in industrialization. The insects such as earthworm, maggots play a significant role in recycling many forms of waste and other accumulated nutrients in the environment (Dwivedi and Tripathi, 2007; Laishram *et al.*, 2007; Parthasarathi *et al.*, 2007). It is well known that maggots, which appear during the biological treatment of chicken droppings, improve the growth rate of broiler chickens. The pollution problems caused by livestock effluent, and the mass accumulation of poultry waste, could be solved by using chicken droppings as a growth medium for certain living organisms,, including house flies (Musca domestica L.)(Boushy, 1991); the resulting maggots offer a high protein feed for livestock such as poultry and fish (Zuidhof *et al.*, 2003; Ogunii *et al.*, 2007). Insects in adult, larval, and pupal forms are naturally ingested by wild birds and free range poultry. Some research has demonstrated that insects can be used as selective feed for poultry (Despines and Axtell, 1995), in which turkey poultry were successfully fed darkling beetle (Alphitobius diaperinus) larvae and crickets,respectively. Calvert *et al*. (1969) suggested that dried house fly pupae left by house flies growing in poultry waste, and having high protein (63.1%) and fat (15.5%) contents, were a better source of quality feed than soybean meal and could be substituted for soybean meal in chick feed during the first two week after birth. In addition, Inaoka *et al*. (1999) successfully fed poultry maggots and pupae growing on chicken feces. Dried maggots and pupae contain 56.9 and 60.7% crude protein, and 20.9 and 19.2% crude fat, respectively; they have protein and amino acid compositions similar to fish meal; and can replace 7% of the fish meal in broiler chicken feed. Many earlier studies are available on the utilization of maggots as poultry feed supplement (Onifade *et al.*, 2001). For any aquaculture venture to be viable and profitable, it must have a regular and adequate supply of balanced artificial diets for the cultured fishes. This is so because the dissolved nutrients that promote primary and secondary production in the natural environment are seasonal and might be insufficient or may not occurred in required proportion to meet the nutritional demand for cultured fishes.

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Supplementary feeding satisfies this need and ensures that the fish gets the appropriate spectrum of its basic food requirement for optimum growth (Adesina, 2011). This work reports on the comparability of amino acid compositions of Maggot meal (MM), Earthworm meal (EM) and Soybean meal (SM). This will give information on the best way to employ them based on the quality of protein in their various feed uses and formulation.

Materials and methods

Preparation of samples

Culture of maggots

Maggots were raised on pig hairs, chicken droppings and chicken feathers. Each was made into a slurry to cause putrefaction in a particular container measuring 40 x 25 x 10cm, left open under a shade to allow housefly to lay eggs. Maggots were harvested from the fifth day from culture media separately without the organic substrates.

Culture of Earthworms

Earthworm hatchings of 0.05g each were cultured on mixtures of sterilized, oven-dried sand and cattle dung, maize cobs/ saw dust. Each of the organic substrates was mixed with sand at varying proportions 1:1, 1:2, 1:4, 2:1 and 4:1 respectively in order to establish the medium that support growth maximally. Each medium was sprinkled with water abundantly to damp at field capacity. Then each was placed under a shade in a wooden box measuring 40x 25 x 20cm, screened to prevent predation and escape of the cultured earthworms.

Harvested samples of each of these invertebrates were steamed to death, sundried and milled into fine representative samples and kept in air-tight containers before analysis.

Crude protein determination and fat extraction

The micro-Kjeldahl method (Pearson,1976) was followed to determine the fat-free crude protein. The fat was extracted with a chloroform/methanol (2:1 v/v) mixture using Soxhlet extraction apparatus(AOAC, 2005) .

Amino acid analysis

Amino acid analysis was done by ion-exchange chromatography5 using a Technicon Sequential Multisample Amino Acid Analyzer (Technicon Instruments Corporation, New York, USA).

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).

Estimation of predicted protein efficiency ratio (P-PER)

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

Estimation of dietary protein quality

The amino acid scores were calculated using two different **procedures:**

- Scores based on whole hen's egg amino acid scoring pattern (Paul *et al.*,1976);
- Scores based on provisional amino acid scoring pattern (FAO/WHO, 1973).

Leucine/isoleucine ratio

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

Statistical analysis

The statistical analysis carried out included the determination of the grand mean, standard deviation (SD) andthe coefficients of variation percent (CV %). Other calculations made were the simple linear correlation coefficient (r_{xy}), coefficient of determination ($r_{xy}{}^{2}$), coefficient of alienation (or index of lack of relationship) (CA) and index of forecasting efficiency (IFE) and subjected to Table standards to test for significance difference, the level of probability was set at $r_{=0.05}$ at n-2 degrees of freedom (Oloyo, 2001).

Results and Discussion

Table I summarizes the nutrient content of the dried maggots, earthworms and soybean meals. The data indicate that maggot and soybean meals were rich in high quality crude protein (42.5 and 47.8 % respectively) and only maggot meal contained a high level of crude fat (31.5%), whereas low levels of crude fats were obtained for earthworm and soybean meals. Analysis results for protein, amino acid, and fat contents were different from those reported by Calvert *et al.* (1969), probably due to differences in either the analysis procedures employed or the medium used to produce the maggots and earthworms.

Table I also presents the amino acid composition of the samples. In most of the results on pair wise basis, the values for the maggot meal (MM) were all better than the values or earthworm and soybean meal samples. On the other hand, levels of Ile, Leu, Lys, Met, Thr, Ala, Asp, Cys, Pro and Leu in maggot meal were correspondingly higher than those in earthworm meals (EM) and soybean meals (SM), meaning that maggot meal (MM) was 40.9% best in 10 parameters (8/18) of the amino acids than in earthworm meal, but 44.3% best in 17 parameters (17/18) of the amino acids in the soybean meal. Similar trend between raw and germinated wheat flours amino acid profile have also been observed (Adeyeye, 2011).

Leucine was the highest concentrated EAA in (6.35g/100g) maggot meal; Arginine was the most concentrated EAA in earthworm meal and soybean meal (6.54 and 3.64g/100g) respectively. Similar observations were also reported by Adeyeye (2011) in which Leu was the most concentrated EAA in raw wheat and millet samples (Adeyeye, 2009).

The most concentrated amino acids in MM was Leucine (6.35g/100g) a value that compared favourably with the value reported for leucine in germinated wheat. Glutamic acid was the most concentrated amino acid in earthworm meal (10.9g/100), this value compared favourably with the values reported for raw, steeped and germinated wheat (Adeyeye, 2011).

Generally, the values for amino acids were fairly widespread for the three samples with CV% ranging between 15.9 – 15.4% within which exceptionally high variation observed in the results of tryptophan and Glutamic acid (i.e 154-8701%) respectively. Results in MM and EM EAA were better than in SM. Even though the lysine content in the samples (2.38-4.23g/100g c.p) were lower than the lysine content of the reference egg protein (6.2g/100g c.p),they can be enhanced by mixing with legumes which are high in lys. The increase in amino acid content of the EM might be due to increase in the protease activity of enzymes which break down the protein to release amino acids needed for the activity.

Table II shows several quality parameters of protein in the samples. The EAA ranged between 18.3g/100g cp to 34.5g/100g cp. These values were far from the values of 56.6g/100g cp of the egg reference protein (Paul *et al*, 1976) but slightly close to 43.5g/100g cp for peanut meal (….., 1979) and better than 19.0g/100g cp for *Colocynthis citrulus* flours (Akobundu *et al*., 1982); 21.5g/100g cp in sorghum grains (Adeyeye, 2008) and 21.0-23.4g/100g cp in millet grains (Adeyeye, 2009), but the values of EAA in MM and SM were comparably close to the values reported for raw, steeped and germinated wheat flours (30-32.9g/100g cp).

The total sulphur AA (TSAA) of the samples were 3.02, 2.78 and 1.06g/100g cp for maggot meal, earthworm meal and soybean meal respectively. The percentages of EAA/TAA for the three samples (59.1(MM), 55.7(EM) and 52.5(SM)) could be favourably compared with that of egg (50%) (FAO/WHO, 1990), pigeon pea flour (43.6%) (Oshodi *et al.*, 1993), 53.1-56.7% in sorghum flours (Adeyeye, 2008), beach pea protein isolates (43.8-44.4%) (Chavan et al, 2001). The P-PER as shown in table II ranged from 1.14 to 2.16. The experimentally determined PER usually range from 0.0 for a very poor protein to a maximum possible of just over 4 (Muller and Tobin, 1980). In the samples (as shown in table II), it could be seen that the values for Leu and Try (from which P-PER were calculated) were almost half of each other (MM (6.35 and 2.47g/100g cp respectively), EM (4.81 and 2.55g/100g cp respectively) and SM (1.20 and 3.26g/100g c.p. respectively).

The P-PER in the sample were: MM (2.16), EM(1.45) and SM(1.14) meaning that the physiological utility in the body of maggots would be much better than earthworm and soybean grains. On the average, the three would be much better than the sorghum (with P-PER of 0.0-0.29) (Adeyeye, 2008) and in millet (with P-PER of 1.32 – 1.66) (Adeyeye, 2009).

The Leu/Ile values ranged as follows: 2.08 (MM), 2.35 (EM), and 1.85 (SM). In all the samples (Table I) the level of Leu was more than twice the level of Ile in each sample. Endemic pellagra in cereal- eating populations was first described by Gopalan and Srikantia (1960) particularly in poor agricultural labourers around Hydrabad in Andhra , Pradesh (India). It has been suggested that an amino acid imbalance from excess leucine might be a factor in the development of pellagra (FAO, 1995). High leu in the diet may impair tryptophan and niacin metabolism and is responsible for niacin deficiency in sorghum eaters (Balavady et. Al. 1963) and hence, the hypothesis that excess leucin in sorghum is aetiologically related to tellagra in sorghum eating populations (FAO, 1995).

The study of Krishnaswamy and Gopalan (1971) had suggested that the Len/Ile balance is more important than dietary excess of leu alone in regulating the metabolism of Try and niacin and hence the disease process. It has also been suggested that factors other than excess leu and poor leu/Ile balance in cereal protein are responsible for the development of the disease. Krishnaswamy et. al. (1976) have shown that vitamin B_6 is involved in the metabolism of leu as well as that of Try and niacin suggesting that of pellagra might be related to the nutritional status of population in terms of vitamin B_6. Experiments in dogs have shown that animals fed sorghum proteins with less than 11.0/100g c.p. Leu did not suffer from nicotinic acid deficiency (Belavady and Udayasekhara Rao, 1976). The current report shows Leu to range from 3.26 – 6.35g/100g c.p. which was far less than 11.0g/100g c.p, therefore, samples are considered safe and could be beneficially exploited to prevent pellagra in erdemic areas (Deosthale, 1980). Table II shows that the % cys in TSAA ranged from 28.8 – 39.7%. Cys can spare with met in improving protein quality and has positive effects on mineral absorption, particularly Zinc (Mendoza, 2002). % Cys/TSAA obtained in this study for MM (39.7%), EM (28.8%) and SM (34%) were comparably lower than the value of 62.9% reported for coconut endosperm (Adeyeye, 2004) and 44.4% in *Parkia biglobosa* seeds (Adeyeye, 2006). Most animal protein are low in Cys and hence %Cys/TSAA; 25.6 in *Zonecerous variegates* (Adeyeye, 2005a). this for animal proteins, Cys is unlikely to contribute up to 50% of the TSAA (FAO/WHO,1991). The % Cys in TSAA had been set at 50% in rat, Chick and pig diets (FAO/WHO, 1991).

The calculated pI in the samples ranged form 2.22 – 3.53. the imfromation on pI is a good starting point in predicting the pI for protein in order to enhance quick precipitation of protein isolate form biological samples.

Table III contains a summary of the differences between MM/EM and between MM/SM. the highest CV% was observed in protein with a value of 95.5, among the amino acids, the highest CV% was observed in serine with a value of 135 whereas Try had a CV% of 0.93. on a general note, the three samples showed some complementary factors in the differences meaning that for optimum efficiency as feed ingredients, combined usage might be better.

Table IV shows the amino acid scores based on whole hen's egg (Paul *et al.*(1976). Valine was limiting in MM with a value 0.25 (25%), threonine was limiting in EM with a value of 0.15 (15%) while Tryptophan was limiting in SM with a value of 0.06 (6%). In order to correct for the whole amino acids profile in the samples, 100/25, 100/15 and 100/6 or 40, 6.66 and 16.99 times as much MM,EM and SM protein would have to be consumed when they serve as sole protein source in the diet respective (Bingham, 1977).

Table V contains the essential amino acids scores of the samples based on EAA scoring pattern (FAO/WHO; 1973) which shows that met + Cys (0.03 or 3%) was limiting EAA in SM, Try (0.14 or 14%) was limiting in EM while Valine (0.38 or 38%) was limiting in MM, therefore, in order to fulfil the day's need for all the EAA in the sample, 100/3, 100/14 and 100/38 or 33.3, 7.14 and 2.63 times as much SM, EM and MM protein would have to be consumed when it is the only protein source in the diet.

Table VI depict the summary of the statistical analysis of results depicted in tables I, II and III. Using the results form Table II to illustrate the information from other tables. The correlation coefficient (r_{xy}) between MM/SM was 0.9677 which was significantly different since r_c = 0.9346 was greater than tabular r-value or r_t = 0.468 at n – 2 (=16) and r = 0.05 the degree of association for MM/SM i.e (r_{xy}^2) was 0.93 which was very high. The coefficient of alienation (C_A) was low in the MM/SM with a value of 25.6% but with a corresponding high value of index of forecasting efficiency (IFE) 74.4%. Actually IFE normally gives a value in the reduction of the error of prediction of relationship. This a value of 72% means the error of prediction was first 25.6% showing that both variables were associated or related with one another is a linear way . This type of reasoning goes down for the other variables of Table VI.

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Table I. Proximate (%) and amino acid (g/100g crude protein) compositions of Maggot meal (MM), Earthworm meal (EM) and Soybean meal (SM)

Parameters	MM	EM	SM	Mean	SD	CV%
Dry matter	91.4	76	88	85.1	8.09	9.51
Moisture	8.62	14	12	11.54	2.72	23.6
Crue protein	42.5	15.3	47.8	35.2	17.4	49.5
Crude fat	31.5	3.64	7.5	14.2	15.1	106
Crude fibre	9.95	1.74	6.00	5.9	4.11	69.6
Ash	8.15	6.4	3	5.85	2.62	44.8
Gross Energy (kcal/g)	30.1	26.2	31.4	29.2	2.71	9.3
Amino Acids (g/100g)						
Arginine	6.06	6.54	3.67	5.42	1.54	28.4
Histidine	3.01	4.63	1.15	2.93	1.74	59.4
Isoleucine	3.05	2.05	1.76	2.29	0.68	29.6
Leucine	6.35	4.81	3.26	4.81	1.55	32.1
Lysine	4.23	2.38	2.54	3.05	1.03	33.6
Methionine	1.82	1.98	0.7	1.5	0.7	46.5
Phenylalanine	3.53	5.33	2.31	2.72	1.52	55.9
Threonine	2.09	0.74	1.76	1.53	0.7	46
Tryptophan	3.17	0.14	0.1	1.14	1.76	154
Valine	1.91	2.77	1.09	1.92	0.84	43.8
Alanine	3.84	2.33	3.01	3.06	0.76	24.7
Aspatic acid	4.31	3.41	3.23	3.65	0.58	15.9
Cystine	1.2	0.8	0.36	0.79	0.42	53.2
Glutamic acid	3.87	10.9	1.75	5.52	4.81	87.1
Glycine	2.76	1.13	3.68	2.52	1.29	51.2
Proline	1.58	0.64	1.55	1.26	0.534	42.4
Serine	3.14	3.17	1.81	2.71	0.777	28.7
Tyrosine	2.47	2.55	1.2	2.07	0.757	36.6

Table II. Total, Essential, Non-Essential, Neutral, Acidic, Basic, Sulphur, Aromatic Amino acid (g/100g crude protein). Protein Efficiency Ratio (P-PER), Isoelectric Point (pI), Lue/Ile ratio, Leu-Ile Difference of Maggot meal (MM), Earthworm meal (EM) and Soybean meal (SM) (on dry weigth basis)

Parameters	MM	EM	SM	Mean	SD	CV%
TAA[a]	58.4	56.3	34.9	49.9	13	26
TEAA[b]						
with His	34.5	31.4	18.3	28.1	8.6	30.6
without His	31.5	26.7	17.2	25.1	7.28	28.9
%TEAA						
with His	59.1	55.7	52.5	55.8	3.3	5.91
without His	53.9	47.5	49.2	50.2	3.32	6.6
TNEAA[c]	23.9	24.9	16.6	21.8	4.53	20.8
%TNEAA	40.9	44.3	47.5	44.2	3.3	5.91
TNAA[d]	36.9	28.4	22.6	29.2	7.22	24.7
%TNAA	63.2	50.5	64.7	59.5	7.8	13.1
TAAA[e]	8.18	14.3	4.98	9.15	4.74	51.8
%TAAA	14	25.4	14.3	17.9	6.5	36.3
TBAA[f]	13.3	13.6	7.36	11.4	3.52	30.9
%TBAA	22.8	24.1	21.1	22.7	1.5	6.63
TSAA[g]	3.02	2.78	1.06	2.29	1.07	46.7
%TSAA	5.17	4.94	3.03	4.38	1.17	26.8
Cys in TSAA	1.2	0.8	0.36	0.79	0.42	53.2
%Cys in TSAA	39.7	28.8	34	34.2	5.45	18.3
TArAA	9.17	8.02	3.61	6.93	2.93	42.4
%TArAA	15.7	14.2	10.3	13.4	2.79	20.8
P-PER	2.16	1.45	1.14	1.58	0.52	33.1
Leu/Ile	2.08	2.35	1.85	2.09	0.25	12
Leu-Ile	3.3	2.76	1.5	2.52	0.92	36.7
%(Leu-Ile)	52	57.4	46	51.8	5.7	11
PI	3.53	3.4	2.22	3.05	0.72	23.7

[a] = total amino acid; [b] = total essential amino acid; [c] = total non-essential amino acid; [d] = total neutral amino acid; [e] = total acidic amino acid; [f] = total basic amino acid; [g] = total sulphur amino acid.

Table III. Summary of the differences in the nutrient compositions of Maggot meal/ Earthworm meal (MM/EM) and Maggot meal/Soybean meal (MM/SM)

Parameters	MM-EM	MM-SM	Mean	SD	CV%
Dry matter	15.4(16.8%)	3.4(3.72%)	9.4	8.49	90
Moisture	-5.38(62.4%)	3.38(39.2%)	4.38	1.41	32.3
Crue protein	27.19(63.9%)	-5.3(12.5%)	16.2	15.5	95.5
Crude fat	27.86(88.4%)	24(76.2%)	25.9	2.73	10.5
Crude fibre	8.21(82.5%)	3.95(39.7%)	6.08	3.01	49.5
Ash	1.75(21.4%)	5.15(63.2%)	3.45	2.4	69.7
Gross Energy	3.9(12.9%)	-1.3(4.32%)	2.6	1.84	70.7
Amino Acids (g/100g)					
Arg	-0.48(7.92%)	2.39(39.4%)	1.44	1.35	93.1
His	-1.62(53.8%)	1.86(61.8%)	1.74	0.17	9.8
Ile	1(32.7%)	1.29(42.3%)	1.15	0.205	17.8
Leu	1.54(24.2%)	3.09(48.7%)	2.32	1.1	47.2
Lys	1.85(43.7%)	1.69(40.0%)	1.77	0.113	6.39
Met	16.22(89.1%)	1.12(61.5%)	8.67	10.7	123
Phe	-1.8(50.9%)	1.22(34.6%)	1.51	0.41	27.2
Thr	1.35(47.8%)	0.33(15.8%)	0.84	0.72	85.9
Try	3.03(95.5%)	3.07(96.8%)	3.05	0.028	0.93
Val	-0.86(45.0%)	0.82(42.9%)	0.84	0.028	3.34
Ala	1.51(39.3%)	0.83(21.6%)	1.17	0.481	41.1
Asp	0.9(20.8%)	1.08(25.1%)	0.99	0.127	12.9
Cys	0.4(33.3%)	0.84(70.0%)	0.62	0.311	50.2
Glu	-7.03(181.6%)	2.12(54.8%)	4.58	3.47	75.8
Gly	1.63(59.0%)	-0.92(33.3%)	1.28	0.502	39.2
Pro	0.94(59.4%)	0.03(1.90%)	0.485	0.643	132
Ser	-0.03(0.95%)	1.33(42.4%)	0.68	0.092	135
Tyr	-0.08(3.23%)	1.27(51.4%)	0.675	0.841	125

Table IV. Scores based on the whole hen's egg amino acids scoring pattern

Amino Acid	MM	EM	SM	Mean	SD	CV%
Arg	0.99	1.07	0.60	0.89	0.25	28.3
His	1.25	1.93	0.48	1.22	0.73	59.5
Ile	0.55	0.37	0.31	0.99	0.82	82.6
Leu	0.77	0.58	0.39	0.58	0.19	32.8
Lys	0.68	0.38	0.41	0.53	0.21	40
Met	0.57	0.66	0.22	0.48	0.23	48.4
Phe	0.69	1.05	0.45	0.87	0.25	29.3
Thr	0.41	0.15	0.35	0.28	0.18	65.7
Try	1.76	0.08	0.06	0.63	0.98	54.9
Val	0.25	0.37	0.15	0.31	0.08	27.4
Ala	0.71	0.43	0.56	0.57	0.20	34.7
Asp	0.4	0.32	0.30	0.36	0.06	15.7
Cys	0.67	0.44	0.20	0.56	0.16	29
Glu	0.32	0.91	0.15	0.46	0.4	86.7
Gly	0.92	0.38	1.23	0.84	0.43	51.2
Pro	0.42	0.17	0.41	0.33	0.14	42.9
Ser	0.4	0.4	0.23	0.34	0.10	28.9
Tyr	0.62	0.64	0.30	0.52	0.19	36.7
Total	0.69	0.61	0.38	0.56	0.16	28.7

Table V. Scores based on the Provisional amino acids scoring pattern.

Amino Acid	MM	EM	SM	Mean	SD	CV%
Ile	0.76	0.51	0.44	0.57	0.17	29.5
Leu	0.91	0.69	0.47	0.69	0.22	31.9
Lys	0.77	0.43	0.46	0.55	0.19	34.2
Met+Cys	0.69	0.79	0.03	0.74	0.07	9.60
Phe+Tyr	1.00	1.31	0.59	0.97	0.36	37.2
Thr	0.52	0.19	0.44	0.38	0.17	43.4
Try	3.17	0.14	0.10	1.14	1.76	54.5
Val	0.38	0.55	0.22	0.38	0.17	43.4
Total	0.81	0.65	0.42	0.63	0.20	31.1

Table VI. Summary of Statistical analysis of the nutritional qualities of Maggot meal/ Earthworm meal (MM/EM) and Maggot meal / Soybean meal (MM/SM)

Correlated Parameter	r_{xy}	$r_{xy}2$	C_A	IFE	n-2	r-Value	Remark
MM/EM	0.9164	0.8397	40.7	59.4	16	0.468	*
MM/SM	0.9677	0.9346	25.6	74.4	16	0.468	*
MM/EM (QAA)	0.9708	0.9424	24	76	16	0.468	*
MM/SM (QAA)	0.9524	0.9071	30.5	69.5	16	0.468	*

QAA = Quality of amino acid, C_A = Coefficient of Alienation, IFE = Index of Forecasting Efficiency, * = Significant difference.