Amino Acids Content Comparison with Different Processing Methods (Cook, Raw and Fermented) and Inclusion Levels of *Delonix regia* in Formulated Fish Diets

Bosede Oyegbile*1, Okeke Rufina Obioma2, Yunusa Abubakar3, Idris Abdullahi4 and Stanley David Oziegbe5

1Department of Biological Sciences, Bayero University Kano, Nigeria.  
2Department of Animal Science, Ahmadu Bello University, Nigeria.  
3National Agricultural Extension and Research Liaison Services, Zaria, Kaduna State, Nigeria.  
4National Animal Production Research Institute, Kaduna State, Nigeria.  
5Department of Theriogenology and Production, University of Jos, Nigeria.

Authors’ contributions

This work was carried out in collaboration among all authors. Author BO designed the study. Author ORO performed the statistical analysis. Author YA managed the literature searches. Author IA proofread the manuscript. Author SDO managed the data cleaning. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJFAR/2019/v4i430059

Editor(s):
(1) Dr. Jorge Castro Mejia, Department of El Hombre Y. Su Ambiente, Universidad Autonoma Metropolitana Xochimilco, Mexico.  
(2) Dr. Luis Enrique Ibarra Morales, Research Professor, Faculty of International Trade, State University of Sonora, Sonora, Mexico.  
(3) Dr. Matheus Ramalho de Lima, Professor, Federal University of South of Bahia, Brazil.

Reviewers:
(1) Adeyeye, Samuel Ayofemi Olalekan, Ton Duc Thang University, Vietnam.  
(2) Tiogué Tekouenegning, The University of Dschang, Cameroon.  
(3) Mehady Islam, University of Dhaka, Bangladesh.

Complete Peer review History: [http://www.sdiarticle4.com/review-history/50872](http://www.sdiarticle4.com/review-history/50872)

Original Research Article

Received 12 July 2019  
Accepted 16 September 2019  
Published 25 September 2019

ABSTRACT

This study investigated the effects of different processing methods of *Delonix regia* seeds on amino acids composition of experimental diets. Ten isonitrogenous diets (40% crude protein) were formulated with cooked, raw and fermented *Delonix regia* seeds at 0% (Control), 10%, 20% and

*Corresponding author: Email: bigm4real@gmail.com*
30% inclusion levels respectively. Data were analysed using Analysis of Variance, significant differences in means were separated using Duncan Multiple Range Test. All the essential amino acids (lysine, arginine, threonine, valine, methionine, isoleucine, leucine and phenylalanine) differs significantly among the treatments except histidine which was statistically similar (P > 0.05) across the dietary treatments. The activity of essential and non-essential amino acid concentration was higher in cooked than the fermented and raw Delonix regia seeds. It was concluded that cooked Delonix regia seeds at 10% inclusion levels had the highest activities of essential and non-essential amino acids and could be used to supplement conventional feedstuff for livestock especially in fish nutrition and bioenergetics.

Keywords: Amino acids; Delonix regia; fermentation; cooking; bioenergetics.

1. INTRODUCTION

Fish feeds constitute 60-75% of the total cost of aquaculture production which is expensive and has led to studies on how to reduce the high cost of fish feed production using alternative feed ingredients [1]. The competition between humans and livestock for the conventional crop feed ingredient which has made it scarce and expensive. The use of unconventional plant sources of protein such as seeds, leaves and other agricultural by-products in the formulation of fish feed to attain a more economically sustainable, environmentally friendly and cheap fish feed have become desirable among the fish farmers. Generally, the ingredients that are essential for fish feed formulation are proteins and amino acids, lipids, carbohydrates, vitamins and minerals. Protein is the major concern during the formulation of fish feed. It is the most expensive components in fish feed and the important factors contributing to the growth performance of cultured species [2]. Protein requirement in fish diet can be related to the general energy requirement of the fish at certain water temperature and the ability to gain weight at present capacity [3]. Diet formulation based on digestible amino acids will allow the use of alternative protein sources with low digestibility coefficients because such formulation will improve the precision of least-cost diets and reduce nitrogen excretion from livestock operations [3]. Although the advantages of the digestible amino acid are recognized, diet formulation based on the total amino acid content is still widely used in many parts of the world. In the future, however, economic reasons will compel the fish industry to increase the use of an array of cheaper, alternative protein supplements with low digestibility coefficients such as Delonix regia in feed formulation. Amino acids are the substance derived from the ultimate product of digestion. There are about twenty naturally available amino acids which includes arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, protein, threonine, alanine, aspartic acid, asparagine, cystine, glutamic acids, glutamine, proline, tryptophan, valine, serine, tyrosine but only the first ten are essential for fish growth because they are not synthesized in fish and must be provided in the feed, because of this they are called “essential or indispensable” amino acids [4]. A particularly important amino acid for growth is lysine. Protein-rich in lysine can be obtained from a legume, fish meal, blood meal, or meat and bone meal. Tryptophan is very important for the growth of all cells and normal development, it is used in cell profile ration. Arginine and histidine play an important role in maintaining a normal and healthy bloodstream and has other complex functions [5]. Fish and other animals can synthesize their non-essential amino acids from carbohydrates and lipids and other nitrogen compounds but mainly from other non-essential amino acids. Any diet deficient in any of the essential amino acid will cause depressed appetite and growth rate of fish. Therefore, this study is designed to evaluate the effect of different processing methods of Delonix regia seeds on the amino acid composition of diets.

2. MATERIALS AND METHODS

The experiment was conducted at the aquaculture production technology unit of the Skill Acquisition and Development Centre, NAERLS, Ahmadu Bello University, Zaria, located at latitude 11º09'45.2" N and longitude 7º38'17.9" E. The experiment was conducted from September 2015 to March 2016.

2.1 Collection of Delonix regia (Flamboyant) Seeds

Matured and dry pods of Delonix regia (flamboyant) containing the seeds were collected from the annex campus of Nuhu Bamalli
Polytechnic Zaria. The seeds were collected by opening the pods manually. The average seeds per pod were between 30-37, the weight of 100 seeds was 42.5 g. The collected seeds were handpicked for the selection of healthy seeds.

2.2 Processing of Seeds

Seeds with identification number 1971 were weighed separately for processing, one part for cooking, the second for fermentation and the third left as raw.

2.2.1 Fermentation of Delonix regia (Flamboyant) seeds

The seeds were soaked in water for 12 hours. The drained soaked seeds were allowed to ferment naturally by tying in a polythene bag and kept in a dark cupboard for 72 hours without the addition of yeast [6]. The fermented seeds were allowed to dry for two days before grinding into homogenous powder using a hammer mill.

2.2.2 Cooking of Delonix regia (Flamboyant) seeds

The seeds were boiled to 100ºC for 80 minutes and were allowed to cool and dried for two days and later ground to homogenous powder using a hammer mill [7].

2.2.3 Raw Delonix regia (Flamboyant) seeds

The raw seeds were dried for two days and milled into a homogenous powder using a hammer mill.

2.3 Analysis of Differently Processed Delonix regia (Flamboyant) Seeds

The differently processed seeds, cooked flamboyant seeds (CFS), fermented flamboyant seeds (FFS) and raw flamboyant seed (RFS) were taken for analysis of amino acid profile. All analysis was carried out in triplicates.

2.4 Determination of Amino Acid Profile of Raw and Processed Delonix regia (Flamboyant) Seeds

The amino acid profile in the known sample was determined using the methods described by NRC [8]. 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 Analyser (TSM).

2.5 Defatting Sample

The sample was defatted using a chloroform/methanol mixture of ratio 2:1. 4 g of the sample was put in extraction thimble and extracted for 15 hours in the soxhlet extraction apparatus [8].

2.6 Nitrogen Determination

Two hundred milligramme (200 mg) of ground sample was weighed, wrapped in Whatman filter paper (No. 1) and put in the Kjeldahl digestion flask. 10ml of concentrated sulphuric acid was added. Catalyst mixture (0.5 g) containing sodium sulphate (Na₂SO₄), copper sulphate (CuSO₄) and selenium oxide (SeO₂) in the ratio of 10:5:1 was added into the flask to facilitate digestion and four pieces of anti-bumping granules were added.

The flask was then put in Kjeldahl digestion apparatus for 3hours until the liquid turned light green. The digested sample was cooled and diluted with distilled water to 100 ml in a standard volumetric flask. An aliquot (10 ml) of the diluted solution with 10 ml of 45 % sodium hydroxide was put into the Markham distillation apparatus and distilled into 10 ml of 2% boric acid containing 4 drops of bromocresol green/methyl red indicator until about 70 ml of distillate was collected.

The distillate was then titrated with standardized 0.01N hydrochloric acid to a grey colour.

Percentage of Nitrogen = \( \frac{(a-b) \times 0.01 \times 14 \times V \times 100}{W \times C} \)

Where;

a = Titre value of the digested sample
b = Titre value of the blank sample
V = Volume after dilution (100 ml)
W = Weight of the dried sample (mg)
C = Aliquot of the sample used (10 ml)
14= Nitrogen constant in mg

2.7 Hydrolysis of the Sample

A known weight of the defatted sample was weighed into glass ampoule. Seven (7) ml of 6N HCl was added and oxygen was expelled by passing nitrogen into the ampoule. This is to avoid possible oxidation of some amino acids
during hydrolysis (e.g. methionine and cysteine). The glass ampoule was then sealed with Bunsen burner flame and put in an oven preset at 105°C ± 5°C for 22 hours. The ampoule was allowed to cool before broken open at the tip and the content was filtered to remove the humins. It should be noted that the tryptophan is destroyed by 6NHCl during hydrolysis. The filtrate was then evaporated to dryness in a hot air oven. The residue was dissolved with 5ml to acetate buffer (pH 2.0) and stored in plastic specimen bottles which were kept in the freezer.

2.8 Loading of the Hydrolysate into TSM Analyzer

The amount loaded was between 5 to 10 microliter. This was dispended 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 an analysis lasted for 76 minutes.

2.9 Method of Calculating Amino Acid Concentration

An integrator attached to the analyzer calculates the peak area proportional to the concentration of each of the amino acids which include lysine, histidine, arginine, proline, glycine, alanine, cystine, valine, methionine, isoleucine, leucine, tyrosine and phenylalanine.

2.10 Statistical Analysis

Data obtained were subjected to one-way analysis of variance (ANOVA) using a general linear model (GLM of SAS 9.2). Duncan Multiple Range Test (DMRT) was used to test the difference between levels of means and mean separation was considered significant at P < 0.05.

3. RESULTS AND DISCUSSION

Table 1 shows the amino acid profile of diets fed H. bidorsalis fish at different inclusion levels of raw Delonix regia seeds. All the essential amino acids (lysine, arginine, threonine, valine, methionine, isoleucine, leucine and phenylalanine) differs significantly at different inclusion levels among the treatments except for histidine which was statistically similar (P > 0.05) across the dietary treatments. Lysine had the highest concentration (4.53g/100g protein) in RFSM1, while the least concentration (4.19g/100g protein) was observed in RFSM3. RFSM1 and RFSM2 recorded the highest arginine content (6.53g/100g Protein and 6.45g/100g Protein) and were statistically similar (P > 0.05) but differs significantly (P < 0.05) from the control (6.10g/100g Protein) and RFSM3 (5.16g/100g Protein). Threonine and valine recorded similar statistical trend with arginine. Methionine and leucine had the highest concentration in the control group (2.29g/100g Protein and 9.60g/100g Protein) which was statistically different from other treatments. RFSM1 had the highest concentration of isoleucine (3.14g/100g Protein) and phenylalanine (4.17g/100g Protein) which differs statistically (P < 0.05) from other treatments.

Non-essential amino acid (Glutamic acid, serine, aspartic acid, proline, glycine, alanine, cystine and tyrosine) were statistically different (P < 0.05) among the treatments. RFSM1 had the highest concentration of glutamic acid (12.87g/100g Protein) while the least concentration was observed in RFSM3 (11.50g/100g Protein). RFSM1 had the highest value for serine (3.59g/100g Protein), RFSM2 was intermediate (3.43g/100g Protein) while the control (3.08g/100g Protein) and RFSM3 recorded the lowest concentration (3.00g/100g Protein) and were statistically similar (P > 0.05). Aspartic acid was statistically different (P < 0.05) among the treatments except for RFSM3 (7.69g/100g Protein). RFSM1 had the highest levels of proline (3.25g/100g Protein) and glycine content (3.32g/100g Protein) which differs significantly (P < 0.05) from RFSM2 (3.14g/100g Protein and 3.25g/100g Protein), control (3.04g/100g Protein and 3.16g/100g Protein) respectively. RFSM1 had the highest concentration for alanine (3.98g/100g Protein) which differs significantly (P < 0.05) from RFSM2 (3.90g/100g Protein), control and RFSM3 respectively, though the control and RFSM3 were similar (P > 0.05). RFSM1 had the highest level of cysteine (1.15g/100g Protein) which differs significantly from the control, RFSM2 and RFSM3 respectively. Tyrosine concentration was highest in RFSM1 (2.75g/100g Protein) and RFSM2 (2.75g/100g Protein) which differs statistically from control (2.41g/100g Protein) and RFSM3 (2.41g/100g Protein) which were both statistically similar (P > 0.05).

Table 2 shows the amino acid profile of diets fed H. bidorsalis fish at different inclusion levels of fermented Delonix regia seeds. All the essential amino acids were statistically different (P < 0.05) among the treatment for lysine, arginine,
threonine, valine, isoleucine, leucine and phenylalanine except for histidine and methionine. FFSM₁ had the highest lysine content (4.85g/100g Protein), followed by FFSM₂ (4.77g/100g Protein), FFSM₃ (4.67g/100g Protein) and the control group (4.37g/100g Protein). FFSM₁ and FFSM₂ had the highest levels of arginine (6.88 and 6.7g/100g Protein) while the control group recorded the least level (6.10g/100g Protein).

Table 1. Mean amino acid profile of raw Delonix regia seeds fed H. bidorsalis at different inclusion levels of diet

| Amino acid (g/100 g Protein) | 0% (Control) | RFSM₁ | RFSM₂ | RFSM₃ | SEM |
|-----------------------------|--------------|-------|-------|-------|-----|
| EAA                         |              |       |       |       |     |
| Lysine                      | 4.34ᵃ        | 4.53ᵇ | 4.45ᵃ | 4.19ᵇ | 0.014 |
| Histidine                   | 2.23ᵇ        | 2.27ᵇ | 2.23ᵃ | 2.23ᵇ | 0.017 |
| Arginine                    | 6.10ᵇ        | 6.53ᵃ | 6.45ᵃ | 5.16ᶜ | 0.031 |
| Threonine                   | 2.99ᵇ        | 3.11ᵃ | 3.08ᵃ | 2.61ᶜ | 0.008 |
| Valine                      | 3.80ᵇ        | 3.97ᵇ | 3.94ᵇ | 3.74ᶜ | 0.016 |
| Methionine                  | 2.29ᵃ        | 2.19ᵇ | 2.19ᵇ | 2.19ᵇ | 0.018 |
| Isoleucine                  | 2.94ᶜ        | 3.14ᵃ | 3.07ᵇ | 2.68ᵈ | 0.021 |
| Leucine                     | 9.60ᵃ        | 6.94ᵇ | 6.59ᶜ | 5.25ᵈ | 0.034 |
| Phenylalanine               | 3.72ᵈ        | 4.17ᵃ | 4.08ᵇ | 3.81ᶜ | 0.018 |
| NEAA                        |              |       |       |       |     |
| Glutamic acid               | 11.96ᵇ       | 12.87ᵃ | 12.72ᵇ | 11.50ᶜ | 0.032 |
| Serine                      | 3.08ᵇ        | 3.59ᵇ | 3.43ᵇ | 3.00ᵇ | 0.034 |
| Aspartic acid               | 7.78ᵇ        | 7.90ᵃ | 7.87ᵃ | 7.69ᵇ | 0.046 |
| Proline                     | 3.04ᵇ        | 3.25ᵇ | 3.14ᵇ | 2.84ᵇ | 0.020 |
| Glycine                     | 3.16ᵇ        | 3.32ᵇ | 3.25ᵇ | 3.08ᵇ | 0.021 |
| Alanine                     | 3.79ᵇ        | 3.98ᵇ | 3.90ᵇ | 3.79ᵇ | 0.011 |
| Cysteine                    | 1.09ᵇ        | 1.15ᵇ | 1.09ᵇ | 1.09ᵇ | 0.007 |
| Tyrosine                    | 2.41ᵇ        | 2.75ᵇ | 2.75ᵇ | 2.41ᵇ | 0.020 |

Means with different superscripts cross the groups differed significantly (P<0.05)
EAA - Essential amino acid; NEAA - Non-essential amino acid

Table 2. Mean amino acid profile of fermented Delonix regia seeds fed H. bidorsalis at different inclusion levels of diet

| Amino acid (g/100 g Protein) | 0% (Control) | FFSM₁ | FFSM₂ | FFSM₃ | SEM |
|-----------------------------|--------------|-------|-------|-------|-----|
| EAA                         |              |       |       |       |     |
| Lysine                      | 4.34ᵃ        | 4.85ᵃ | 4.77ᵃ | 4.67ᵃ | 0.014 |
| Histidine                   | 2.23ᵇ        | 2.30ᵃ | 2.30ᵃ | 2.30ᵇ | 0.032 |
| Arginine                    | 6.10ᵇ        | 6.88ᵇ | 6.79ᵇ | 6.62ᵇ | 0.038 |
| Threonine                   | 2.99ᵇ        | 3.19ᵇ | 3.16ᵇ | 3.19ᵇ | 0.016 |
| Valine                      | 3.80ᵇ        | 4.24ᵃ | 4.18ᵃ | 4.09ᵇ | 0.019 |
| Methionine                  | 2.29ᵇ        | 2.21ᵇ | 2.21ᵇ | 2.21ᵇ | 0.017 |
| Isoleucine                  | 2.94ᶜ        | 3.30ᵇ | 3.21ᵇ | 3.21ᵇ | 0.023 |
| Leucine                     | 9.60ᵇ        | 7.79ᶜ | 7.50ᶜ | 7.18ᵈ | 0.043 |
| Phenylalanine               | 3.72ᵈ        | 4.25ᵃ | 4.25ᵃ | 3.99ᵈ | 0.017 |
| NEAA                        |              |       |       |       |     |
| Glutamic acid               | 11.96ᵃ       | 13.47ᵃ | 13.32ᵃ | 13.17ᶜ | 0.015 |
| Serine                      | 3.08ᵇ        | 3.81ᵃ | 3.81ᵃ | 3.78ᵃ | 0.023 |
| Aspartic acid               | 7.78ᶜ        | 8.18ᵇ | 8.09ᵇ | 8.06ᵇ | 0.016 |
| Proline                     | 3.04ᵇ        | 3.25ᵇ | 3.25ᵇ | 3.25ᵇ | 0.018 |
| Glycine                     | 3.16ᵇ        | 3.37ᵇ | 3.35ᵇ | 3.42ᵇ | 0.020 |
| Alanine                     | 3.79ᵇ        | 4.21ᵃ | 4.09ᵇ | 4.17ᵃ | 0.019 |
| Cysteine                    | 1.09ᵇ        | 1.27ᵃ | 0.97ᵈ | 0.97ᵈ | 0.016 |
| Tyrosine                    | 2.41ᵇ        | 3.09ᵇ | 2.92ᵇ | 2.93ᵇ | 0.017 |

Means with different superscripts across the groups differed significantly (P<0.05)
EAA - Essential amino acid; NEAA - Non-essential amino acid
FFSM1, FFSM2 and FFSM3 recorded higher concentration of threonine which differs significantly from the control group (2.99g/100g Protein). FFSM1 and FFSM2 were statistically higher (4.24 and 4.1g/100g Protein) than FFSM3 (4.09g/100g Protein) and the control (3.80g/100g protein) for valine concentration. FFSM1 had the highest concentration (3.30g/100g Protein) of isoleucine which was statistically different (P < 0.05) from FFSM2 (3.21g/100g Protein), FFSM3 (3.21g/100g Protein) and the control treatment (2.94g/100g Protein). Leucine was highest (9.60g/100g Protein) in the control which differs statistically (P < 0.05) from FFSM1 and FFSM2 recorded the highest concentration (4.25g/100g Protein) of phenylalanine which was statistically different (P < 0.05) from FFSM3 (3.99g/100g Protein) and the control diets (3.72g/100g Protein). All the non-essential amino acids (glutamic acid; serine, aspartic acid, proline, glycine, alanine cysteine and tyrosine) were statistically different (P < 0.05) across the dietary treatments. FFSM1 had the highest levels (13.47g/100g Protein) of glutamic acid which was statistically different (P < 0.05) from FFSM2 (13.32g/100g Protein), FFSM3 (13.17g/100g Protein) and the control (11.96g/100g Protein). FFSM1, FFSM2 and FFSM3 were statistically higher (P < 0.05) than the control group (3.08g/100g Protein) in serine. FFSM1 had the highest level of aspartic acid (8.18g/100g Protein) which was statistically different (P < 0.05) from FFSM2 (8.09g/100g Protein) and FFSM3 (8.06g/100g Protein) which were similar though higher than the control group (7.78g/100g Protein). Proline and glycine recorded a similar trend for FFSM1, FFSM2 and FFSM3 respectively and were statistically different (P < 0.05) from the control group. FFSM1 and FFSM3 had the highest levels of alanine (4.2g and 4.17g/100g Protein) and were statistically different (P < 0.05) from FFSM2 (4.0g/100g Protein) and the control group (3.79g/100g Protein). FFSM2 had the highest cysteine concentration (1.27g/100g Protein) which differs statistically from control (1.09g/100g Protein), FFSM1 (1.21g/100g Protein) and FFSM3 (0.97g/100g Protein). Tyrosine level was higher in FFSM1 (3.09g/100g Protein) which differs significantly (P < 0.05) across the dietary treatments. Amino acid profile of diets fed *H. bidorsalis* at different inclusion levels of cooked *Delonix regia* seeds are shown in Table 3. Essential amino acids concentration were statistically different (P < 0.05) across the dietary treatments. CFSM1 had the highest lysine content while the least was recorded in the control diet (4.34g/100g Protein). CFSM1 and CFSM2 were statistically similar (P > 0.05) in the concentration of histidine but were significantly different (P < 0.05) from CFSM3 and the control. CFSM1 had the highest arginine content.

Table 3. Mean amino acid profile of cooked *Delonix regia* seeds fed *H. bidorsalis* at different inclusion levels of diet

| Amino acid (g/100g Protein) | 0% (Control) | CFSM1 | CFSM2 | CFSM3 | SEM |
|-----------------------------|-------------|-------|-------|-------|-----|
| **EAA**                     |             |       |       |       |     |
| Lysine                      | 4.34<sup>a</sup> | 5.17<sup>a</sup> | 5.04<sup>b</sup> | 5.09<sup>b</sup> | 0.016 |
| Histidine                   | 2.23<sup>b</sup> | 2.36<sup>a</sup> | 2.23<sup>a</sup> | 2.27<sup>b</sup> | 0.017 |
| Arginine                    | 6.10<sup>d</sup> | 7.31<sup>a</sup> | 7.14<sup>b</sup> | 6.64<sup>c</sup> | 0.036 |
| Threonine                   | 2.99<sup>c</sup> | 3.24<sup>b</sup> | 3.22<sup>c</sup> | 3.36<sup>a</sup> | 0.017 |
| Valine                      | 3.80<sup>c</sup> | 4.44<sup>a</sup> | 4.30<sup>d</sup> | 4.30<sup>d</sup> | 0.035 |
| Methionine                  | 2.29<sup>a</sup> | 2.21<sup>b</sup> | 2.19<sup>b</sup> | 2.24<sup>ab</sup> | 0.020 |
| Isoleucine                  | 2.94<sup>b</sup> | 3.40<sup>a</sup> | 3.34<sup>a</sup> | 3.30<sup>a</sup> | 0.032 |
| Leucine                     | 9.60<sup>a</sup> | 8.29<sup>b</sup> | 8.08<sup>c</sup> | 7.21<sup>d</sup> | 0.033 |
| Phenylalanine               | 3.72<sup>d</sup> | 4.43<sup>a</sup> | 4.25<sup>b</sup> | 4.08<sup>c</sup> | 0.017 |
| **NEAA**                    |             |       |       |       |     |
| Glutamic acid               | 11.96<sup>d</sup> | 14.31<sup>b</sup> | 14.23<sup>b</sup> | 13.32<sup>c</sup> | 0.020 |
| Serine                      | 3.08<sup>c</sup> | 4.10<sup>a</sup> | 3.89<sup>b</sup> | 3.08<sup>c</sup> | 0.023 |
| Aspartic acid               | 7.78<sup>c</sup> | 8.50<sup>a</sup> | 8.40<sup>a</sup> | 8.00<sup>b</sup> | 0.032 |
| Proline                     | 3.04<sup>c</sup> | 3.35<sup>a</sup> | 3.35<sup>a</sup> | 3.25<sup>b</sup> | 0.022 |
| Glycine                     | 3.16<sup>c</sup> | 3.56<sup>a</sup> | 3.39<sup>b</sup> | 3.34<sup>b</sup> | 0.021 |
| Alanine                     | 3.79<sup>c</sup> | 4.47<sup>a</sup> | 4.28<sup>b</sup> | 4.28<sup>c</sup> | 0.038 |
| Cysteine                    | 1.09<sup>b</sup> | 1.21<sup>ab</sup> | 1.27<sup>a</sup> | 0.90<sup>c</sup> | 0.040 |
| Tyrosine                    | 2.41<sup>c</sup> | 3.09<sup>a</sup> | 3.09<sup>a</sup> | 2.75<sup>b</sup> | 0.023 |

<sup>abcd</sup> Means with different superscripts across the groups differed significantly (P<0.05)

EAA- Essential amino acid, NEAA- Non-essential amino acid
4. DISCUSSION

Both essential and nonessential amino acids (glutamic acid, serine, aspartic acid, proline, glycine, alanine, cysteine and tyrosine) differed significantly (P < 0.05) among the treatments CFSM₁ recorded the highest concentration (14.31g/100 g Protein) of glutamic acid, which differs significantly (P < 0.05) from CFSM₂ (14.23g/100 g Protein), CFSM₃ (13.32g/100 g Protein). Serine had the highest concentration (4.10g/100 g Protein) in CFSM₂ which was statistically different (P < 0.05) from other dietary treatments. CFSM₁ and CFSM₂ recorded the highest concentration of aspartic acid, proline and tyrosine which were statistically different (P < 0.05) from CFSM₃ and the control group. Glycine (3.5g/100 g Protein) and alanine (4.47g/100 g Protein) levels were highest in CFSM₁ which was statistically different from CFSM₂, CFSM₃ and the control. CFSM₂ and CFSM₃ were statistically similar (P > 0.05) for glycine and alanine, though significantly different from the control. CFSM₁ and CFSM₂ recorded significantly (P < 0.05) the highest concentration of cysteine (1.21g/100 g Protein and 1.27g/100 g Protein) which were statistically different (P < 0.05) from control (1.09g/100 g Protein) and CFSM₃ (0.90g/100 g Protein).

5. CONCLUSION

Essential and non-essential amino acid concentrations were higher in the cooked Delonix regia seeds than the fermented Delonix regia seeds. Cooking of Delonix regia seeds at 10% inclusion levels had the highest activities of essential and non-essential amino acids.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Balogun TF, Kaankuka FG, Bawa GS. Effect of period of boiling full fat soybeans on its amino acid profile and on performance on pigs. Nigerian Journal of Animal Production. 2001;28:45–51.
2. Benitez LV. Amino acid and fatty acid profile in aquaculture nutrition studies. 23 – 35, In: SS De Silva (ed). Fish Nutrition Research in Asia. Proceedings of the third Asian Fish Nutrition Network Meeting. Asian Fisheries Society Special Publication. Asian Fishery Society, Manila Philippines. 1889;4(1):166-169.
3. Deng J, Zhang X, Bi B, Kong L, Kang B. Dietary protein requirement of juvenile Asian red-tailed catfish Hemibagrus wyckioides, Animal feed Sci.and Tech. 2011;170:231-238.
4. Fagbenro O. Short communication apparent digestibility of various oil seed cakes/meals in African catfish diets, Aquaculture Int. 1988;6:317-322.
5. Findley JW, Ludin RE. Lipid hydroperoxide induced oxidation of cysteine in protein. Journal of Science. 1980;33:165–172.
6. Iyayi EA, Taiwo VO. The effects of diets incorporating Mucuna (M. pruriens) seed meal on the performance of laying hens and broilers. Tropical Subtropical Agro Ecosystem. 2003;1:239–246.

7. Liener EI. Toxic factors in edible legumes. American Journal of Clinical Nutrition. 1980;2:281-284.

8. NRC. Nutrients requirements of fish. National Academy Press, Washington DC. 1993;3-6.

9. Pandey G. Feed formulation and feeding technology for fishes, Int. Res. J. Pharm. 2013;4(3):23-29.

10. Tiamiyu LO, Ataguba GA, Jimoh JO. Growth performance of Clarias gariepinus fed different levels of agama agama meal diets, Pakistan Journal of Nutrition. 2013; 12(5):510-515.

11. Udensi EA, Okoronkwo KA. Effects of fermentation and germination on the Physico-chemical properties of Mucuna cochinchnensis protein isolates. African Journal of Biotechnology. 2006;5(10):896–900.

12. Oyegbile B, Abdullahi BA. The effects of processed delonix regia seed inclusion in the diet of heterobranchus bidorsalis (Geoffroy st hillaire 1809) fish on growth and nutrient utilization. International Journal of Fisheries and Aquaculture. 2017;9(7):81-85.

© 2019 Oyegbile et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/50872