PJN
ISSN 1680-5194
ansinet.com/pjn

PAKISTAN JOURNAL OF NUTRITION

Science Alert
scialert.net

ANSInet
an open access publisher
http://ansinet.com

OPEN ACCESS Pakistan Journal of Nutrition

ISSN 1680-5194
DOI: 10.3923/pjn.2020.191.196

Research Article
Amino Acid Composition of Bamboo Materials (*Bambusa vulgaris*) as Potential Organic Fish Feed Supplements

[1]Babatunde Taiwo Adesina, [1,5]Ekemini Moses Okon, [1]Babatunde Michael Falana, [1]Enoch Olayiwola Oyawoye, [2]Omobowale Adedayo Adesina, [1]Solomon Ekpeshe Inape, [2]Ayoola Olusegun Akinwole, [3]Festus Idowu Adeosun and [4]Akinniyi Oyetunji Ajibade

[1]Department of Animal Science, College of Agricultural Sciences, Landmark University, P.M.B. 1001 Omu-Aran, Kwara State, Nigeria
[2]Department of Aquaculture and Fisheries Management, Faculty of Renewable and Natural Resources, University of Ibadan, Nigeria
[3]Department of Aquaculture and Fisheries Management, College of Environmental Resources Management, Federal University of Agriculture, Abeokuta, Nigeria
[4]Department of Fisheries Technology, Oyo State College of Agriculture,P.M.B.10, Igboora, Oyo State, Nigeria
[5]Institute of Aquaculture, Faculty of Natural Sciences, University of Stirling, Stirling, Stirlingshine FK9 4LA, U.K

Abstract

Objective: The objective of this study was to evaluate the essential amino acid composition of three tropical bamboo materials (*Bambusa vulgaris*) to determine their nutritional suitability as integrated organic feed supplements. **Materials and Methods:** *Bambusa vulgaris* materials, including mature bamboo leaves, young bamboo shoots and bamboo charcoal, were analyzed in triplicate to determine their essential amino acid composition using an automatic amino acid analyzer (PARTEN DA 7250) in a randomized complete block design experiment. **Results:** Leucine was the most abundant amino acid obtained in the study, ranging from 0.42% in young bamboo shoots to 5.19% in bamboo charcoal. Leucine was significantly higher in bamboo charcoal compared to the other bamboo material samples. Arginine ranged from 2.55% in mature bamboo leaves to 3.94% in bamboo charcoal and was significantly higher in bamboo charcoal than the other materials. The values observed for lysine in the study indicated a range from 2.50% in mature bamboo leaves to 4.19% in bamboo charcoal. The highest significant value for lysine was observed in bamboo charcoal, followed by young bamboo shoots and mature bamboo leaves, which had similar significant values. Methionine was only observed in bamboo charcoal (1.50%), which also had the highest significant value. **Conclusion:** Among the bamboo materials used in this study, bamboo charcoal was the best source of lysine and methionine, suggesting its possible use as fish feed supplement to improve fish growth performance in aquaculture.

Key words: Aquaculture, bamboo charcoal, *Bambusa vulgaris*, fish feed, fish growth

Received: July 18, 2018 Accepted: March 18, 2019 Published: March 15, 2020

Citation: Babatunde Taiwo Adesina, Ekemini Moses Okon, Babatunde Michael Falana, Enoch Olayiwola Oyawoye, Omobowale Adedayo Adesina, Solomon Ekpeshe Inape, Ayoola Olusegun Akinwole, Festus Idowu Adeosun and Akinniyi Oyetunji Ajibade, 2020. Amino acid composition of bamboo materials (*Bambusa vulgaris*) as potential organic fish feed supplements. Pak. J. Nutr., 19: 191-196.

Corresponding Author: B. T. Adesina, Department of Animal Science, College of Agricultural Sciences, Landmark University, P.M.B.1001 Omu-Aran, Kwara State, Nigeria

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The development of commercial aquaculture feed has traditionally been dependent on fishmeal due to its high protein content, excellent amino acid profile, high digestibility and general lack of antinutrients[1,2]. Fishmeal contains a complete essential amino acid profile required for the protein requirement of most freshwater fish species[3]. However, the limited availability of fishmeal has created a need for a replacement, taking into account all possible physiological or metabolic consequences, since amino acids play a vital role in fish nutrition for growth and metabolism and functional roles in protein synthesis, energy deposition and health maintenance and as substrates for key metabolic pathways[4-8].

Due to high and unstable market price of fishmeal and its limited availability as a feed ingredient, feed formulations have shifted to alternative protein sources using limited fish meal or animal proteins by blending plant-based protein concentrates and supplemental amino acids from plant sources[3]. This supplementation ensures that the amino acid content meets or exceeds the requirements of freshwater fish in the right proportion to increase growth and provide a better cost benefit to fish farmers in developing countries[9,10]. A study on plant-based protein diets found that the growth rates of channel catfish fry fed soybean meal did not differ from those fed fishmeal protein[11]. The growth performance and intestinal function of Aigamo ducks and weaned piglets also improved with supplementation of dietary bamboo charcoal powder and bamboo vinegar solution[12,13].

Many efforts have been made to produce high quality animal products without using drugs to reduce environmental contamination through efficient utilization of natural substances from plants. Some plant-based substances, which include wood charcoal, bamboo charcoal and coconut shell charcoal, are not described in the scientific literature but are used locally in conventional fish production[14].

Bamboo charcoal can be used as a universal adsorbent due to its numerous benefits as an environmentally-friendly natural substance that is rich in amino acids, flavonoids and several other polysaccharide compounds with synergistic inhibition potentials[15,16]. Additionally, fresh bamboo shoots are rich in protein and contain 17 amino acids, 8 of which are essential for fish and human nutrition[17-19]. Bamboo leaf extract is virtually non-poisonous, indicating its suitability as potential organic feed material for freshwater fish in integrated aquaculture of fish with livestock[20,21].

It is important to identify an alternative low cost and readily available fish feed material and create strategic methods to increase fish production using organic feed materials without damaging the aquatic environment[22]. This study evaluated the essential amino acid composition of tropical bamboo (*Bambusa vulgaris*) materials to be used as potential organic fish feed supplement in integrated aquaculture.

MATERIALS AND METHODS

Experimental site: This research was conducted at the Department of Animal Science Laboratory, Landmark University Omu-Aran in Kwara State, which is located on latitudes 8° and 9'N and on longitudes 50° and 61'E. It is located on a section of Elliu Hill and is the highest point above sea level in Kwara State (Source: Google Earth, 2014: Landmark University) with an average annual rainfall of 1273 mm.

Collection of plant materials: The materials used in this study (*Bambusa vulgaris)* were collected at the citrus plantation at Landmark University, Omu-Aran in Kwara State. Fresh and green bamboo leaves were collected from 1.5 m above ground level from stands that were more than three years old and placed in a black polythene bag[23]. Pieces of bamboo stems were also taken from matured Bambusa vulgaris for further processing[24].

Preparation of materials: Bamboo charcoal was prepared from pieces of bamboo stem. The mature stem was cut into small pieces and preserved in a tightly sealed container. Pieces of the bamboo stem were then burned inside an oven at temperatures over 65°C[23]. When the fire was completely out, the container was left to cool down completely before it was opened[25,26]. The bamboo charcoal was then pounded into a fine powder prior to amino acid analysis. The other bamboo materials for the research which include bamboo leaves and shoots were air dried for three weeks and were ground into a uniform size using a blender. The materials were later sieved to obtain fine powder for the amino acid analysis.

Amino acid profile: Amino acid content was determined using an automatic amino acid analyzer (PARTEN DA 7250) at the Central Laboratory, Landmark University, Omu-Aran in Kwara State, Nigeria.

Statistical analysis: Data were statistically analyzed using a one-way analysis of variance (ANOVA) with SPSS (Statistical Package for Social Science) version 17.0. Differences between treatments means were compared by Duncan's multiple range

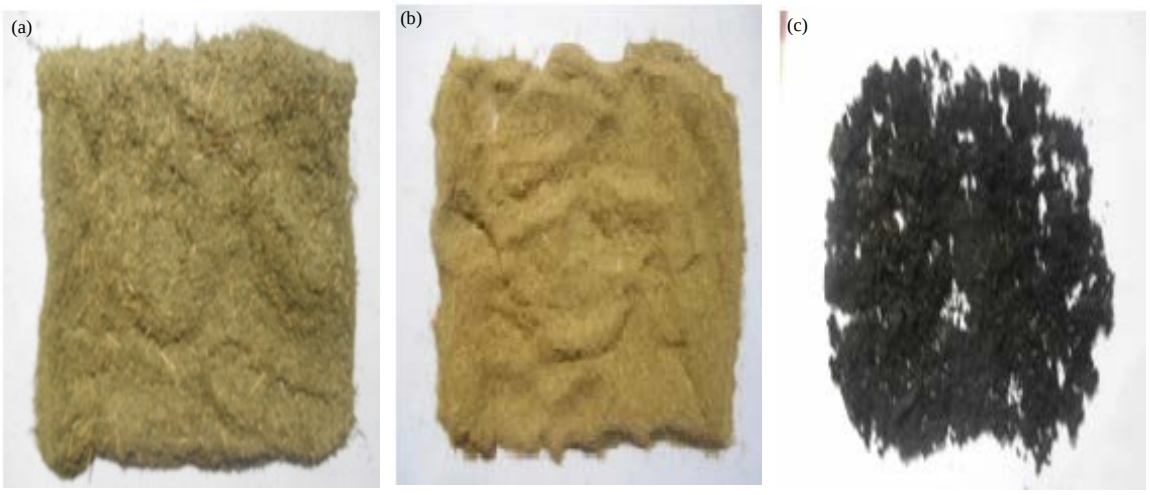

Fig. 1(a-c): (a) Mature bamboo leaf powder (b) Young bamboo shoot powder and © bamboo charcoal powder

Table 1: Amino acid composition of dry powdered samples from different bamboo materials

Amino acids (%)	Mature bamboo leaves	Young bamboo shoots	Bamboo charcoal
Arginine	2.550±0.02^{b}	2.59±0.02^{b}	3.940±0.05^{a}
Phenylalanine	1.570±0.00^{b}	1.48±0.03^{b}	2.060±0.16^{a}
Isoleucine	1.760±0.00^{b}	1.55±0.02^{b}	2.590±0.21^{a}
Leucine	0.880±0.01^{b}	0.42±0.02^{b}	5.193±0.41^{a}
Lysine	2.500±0.02^{b}	2.69±0.03^{b}	4.190±0.09^{a}
Methionine	0.003±0.00^{b}	0.00±0.00^{b}	1.500±0.32^{a}
Threonine	1.300±0.01^{b}	1.06±0.01^{b}	2.440±0.12^{a}
Tryptophan	0.090±9.81^{b}	0.05±0.00^{b}	0.360±0.01^{a}
Valine	1.160±0.02^{a}	1.16±0.02^{a}	0.780±0.02^{b}
Histidine	0.480±0.02^{b}	0.36±0.02^{b}	1.920±0.01^{a}

Each value is a mean of triplicate determinations±standard error, Means (in same row) with different superscripted letters differ significantly (p<0.05)

test[27], while the standard error of mean was determined using PAST version 2.17c. The significant level was set at p<0.05.

RESULTS

Arginine values ranged from 2.55% in mature bamboo leaves to 3.94% in bamboo charcoal. Arginine was significantly higher (p<0.05) in bamboo charcoal than the other materials; similar significant values were found for mature bamboo leaves and young bamboo shoots (p<0.05). Leucine was the most abundant amino acid obtained in the study and ranged from 0.42% in young bamboo shoots to 5.19% in bamboo charcoal. Leucine was significantly (p<0.05) higher in bamboo charcoal compared to the other bamboo material samples; similar significant (p<0.05) values were obtained in mature bamboo leaves and young bamboo leaves. The highest value of isoleucine was found in bamboo charcoal (2.59%) followed by mature bamboo leaves (1.76%) and the lowest value was found in young bamboo foliage (1.55%) (Table 1). Bamboo charcoal had the significantly highest value (p<0.05), while similar significant (p<0.05) values were found in mature bamboo leaves and young bamboo shoots. Mature bamboo leaves and young bamboo shoots had the highest valine content (1.16%), while bamboo charcoal had the lowest value (0.78%). Similarly, mature bamboo leaves and young bamboo leaves had significantly highest (p<0.05) value, while the lowest (p<0.005) value was found for bamboo charcoal.

Lysine values ranged from 2.50% in mature bamboo leaves to 4.19% in bamboo charcoal; the highest (p<0.05) value was found in bamboo charcoal, followed by young bamboo shoots and mature bamboo leaves, which also had similarly significant (p<0.05) values. Methionine was not detected in mature bamboo leaves and young bamboo shoots; however, methionine was present in bamboo charcoal (1.50%), which also had the highest significant (p<0.05) value. Bamboo charcoal had the highest threonine content (2.44%) and Young Bamboo Leaves had the lowest value (1.06%).

Bamboo charcoal had the highest significant ($p<0.05$) value compared to the other bamboo materials, which were similar to each other ($p<0.05$).

Tryptophan content ranged from 0.05% in young bamboo shoots to 0.36% in bamboo charcoal. Bamboo charcoal had the significantly highest ($p<0.05$) value, while similarly significant ($p<0.05$) values were recorded in mature bamboo leaves and young bamboo shoots. Phenylalanine content ranged from 1.48% in young bamboo shoots to 2.06% in bamboo charcoal. Bamboo charcoal was significantly ($p<0.05$) higher than the other materials in phenylalanine; similarly significant ($p<0.05$) values were found in mature bamboo leaves and young bamboo shoots in the current study.

DISCUSSION

While bamboo may serve as potential fish feed formulation, there is a paucity of data on its usage in fish production and there are no detailed analyses of the amino acid content in the *Bambusa vulgaris* species of bamboo in Nigeria; as similarly reported[19]. This study identified 10 amino acids inmature bamboo leaves, young bamboo shoots and bamboo charcoal.

The protein content in fish feed material depends on the ability of such materials to be utilized by fish in their diet. The relative amount of amino acid content is a precursor for alkaloids synthesis that is responsible for defense against parasites and environmental stressors[23].

This study reported that bamboo charcoal material contained high quantities of arginine, which is the essential amino acid responsible for growth performance and health status in fish; however, fish cannot synthesize arginine alone due to lack of the enzyme P5C synthase[6]. A similar finding was reported for *Moringa peregrina* seeds which have the highest composition of arginine[26]. Mature bamboo leaves, young bamboo shoots and bamboo charcoal contain ten essential amino acids that are not synthesized by humans. These findings are in agreement with previous studies that reported the availability of large amounts of amino acids in various bamboo materials[28,29].

The amino acid profile of bamboo materials in this study were much higher than those in other edible vegetables, including cabbage, carrot, onion, pumpkin and tomatoes[29]. Bamboo charcoal has an abundance of leucine, lysine, arginine and isoleucine in ranking order of abundance, with the least values obtained for tryptophan, valine and methionine, respectively[30-34]. These observations are in agreement with a study that found leucine to be the highest in *Moringa oleifera* compared to *Detarium microcarpum* and *Bauhinia monandra*[35]. Leucine is responsible for regulating blood sugar concentration, growth of muscles/tissues and repair, hormone synthesis, wound healing and energy production[35,36]. However, leucine content in bamboo charcoal had the highest value of amino acids in the current study. These values differ from studies on corn grain, groundnut oil cake and cottonseed meal[30-32].

Young bamboo shoots in the current study had an abundance of lysine, followed by arginine, but did not have methionine, which is in agreement with previous studies on amino acids profile of different bamboo species[37-40].

The composition of amino acids invariably decreases during the aging process in *Bambusa tulda*, as reported by researchers who observed cysteine as dominant amino acid followed by tyrosine and lysine[37,38]. The current study on bamboo materials from *Bambusa vulgaris* did not, however, follow the trend of *Bambusa tulda*. In mature bamboo leaves, arginine content was the highest, followed by lysine and isoleucine, respectively. These findings indicate that different bamboo species may have different types of amino acids at different stages of growth and development[38].

The six free amino acids, which include alanine, aspartate, glutamine, glycine and tyrosine, have been detected in bamboo shoots; however, in the current study, no free amino acids were detected[39]. Different parts of bamboo materials possess unique patterns of amino acids, with tyrosine forming the minor component in common available edible fruits and vegetables; bamboo shoots contain a majority of total free amino acids[40-42]. The findings of this study differ from the current study, where tyrosine as free amino acid and methionine as an essential amino acid were completely absent in the young shoots of *Bambusa vulgaris*.

CONCLUSION

The results from this study indicated the potential of bamboo charcoal to be a feed supplement in aquaculture nutrition and production research. Bamboo charcoal has high composition of leucine, lysine and arginine as part of the amino acids required by fish for rapid growth and good health status in aquatic environment. This study will pave the way for innovative ideas on the amino acids content of *Bambusa vulgaris* species for bamboo research development as formulated feed materials available in Nigeria.

ACKNOWLEDGMENTS

The authors would like to thank Landmark University Management for the financial responsibility on publication charges of this research work. Also for the provision of Automated Amino Acid Analyzer (PARTEN DA7250) at the Central Laboratory, Landmark University, Omu-Aran, Kwara State, Nigeria. The contributions of O.A., A.O. and F.I. for supplying materials on the final corrections are highly appreciated. Suggestion of Ajibade on amino acids profile of other plants beautifies the work. We also appreciate the editorial work done by E.O. on discussion aspects of the work. The technical support of S.I. in the laboratory was greatly acknowledged.

REFERENCES

1. Gatlin, III D.M., F.T. Barrows, P. Brown, K. Dabrowski and T.G. Gaylord *et al*., 2007. Expanding the utilization of sustainable plant products in aquafeeds: A review. Aquacult. Res., 38: 551-579.
2. Chiu, S.T., S.L. Wong, Y.L. Shiu, C.H. Chiu, W.C. Guei and C.H. Liu, 2016. Using a fermented mixture of soybean meal and earthworm meal to replace fish meal in the diet of white shrimp, *Penaeus vannamei* (Boone). Aquacult. Res., 47: 3489-3500.
3. Rhodes, M.A., Y. Zhou and D.A. Davis, 2015. Use of dried fermented biomass as a fish meal replacement in practical diets of florida pompano, *Trachinotus carolinus*. J. Applied Aquacult., 27: 29-39.
4. Kaushik, S.J. and I. Seiliez, 2010. Protein and amino acid nutrition and metabolism in fish: current knowledge and future needs. Aquacult. Res. 41: 322-332.
5. Bequette, B.J., 2003. Amino Acid Metabolism in Animals: An Overview. In: Amino Acids in Animal Nutrition, D'Mello, J.P.F. (Eds.)., Chapter 5. CABI., USA., pp: 87-102.
6. Andersen, S.M., R. Waagbø and M. Espe, 2016. Functional amino acids in fish health and welfare. Front. Biosci., 8: 143-169.
7. D'Mello, J.P.F., 2003. Amino Acids in Animal Nutrition. 2nd Edn., CABI Publication, UK., Pages: 544.
8. Jorjani, S., A. Ghelichi and H. Jorjani, 2015. Comparison of Chemical Compositions and Fatty Acid Profile of Cultured Common Carp (*Cyprinus carpio*) and Silver Carp (*Hypophthalmichthys molitrix*). In: Biology Education and Research in a Changing Planet, Daniel, E.G.S. (Ed.)., Springer, Singapore, pp: 167-172.
9. Sogbesan, A.O. and A.A.A. Ugwumba, 2008. Nutritional values of some non-conventional animal protein feedstuffs used as fishmeal supplement in aquaculture practices in Nigeria. Turk. J. Fish. Aquat. Sci., 8: 159-164.
10. Hardy, R.W., 2010. Utilization of plant proteins in fish diets: Effects of global demand and supplies of fishmeal. Aquacult. Res., 41: 770-776.
11. Sink, T.D., R.T. Lochmann and N.R. Kinsey, 2010. Growth and survival of channel catfish, *ictalurus punctatus*, fry fed diets with 36 or 45% total protein and all plant or animal protein sources. J. World Aquacult. Soc., 41: 124-129.
12. Ruttanavut, J., K. Yamauchi, H. Goto and T. Erikawa, 2009. Effects of dietary bamboo charcoal powder including vinegar liquid on growth performance and histological intestinal change in aigamo ducks. Int. J. Poult. Sci., 8: 229-236.
13. Huo, Y., Z. Liu, H. Xuan, C. Lu, L. Yu, W. Bao and G. Zhao, 2016. Effects of bamboo vinegar powder on growth performance and mRNA expression levels of interleukin-10, interleukin-22 and interleukin-25 in immune organs of weaned piglets. Anim. Nutr., 2: 111-118.
14. Quaiyum, M.A., 2014. Effects of bamboo charcoal added feed on reduction of ammonia and growth of *Pangasius hypophthalmus*. J. Aquac. Res. Dev., Vol. 5, No. 6. 10.4172/2155-9546.1000269
15. Yue, Y.D., H.Q. Cao and F. Tang, 2007. Advance in bamboo chemical ingredients and its utilizations. J. Anhui Agric. Univ., 34: 328-333.
16. Li, X., S. Deng, H. Fu and X. Xie, 2014. Synergistic inhibition effects of bamboo leaf extract/major components and iodide ion on the corrosion of steel in H_3PO_4 solution. Corros. Sci., 78: 29-42.
17. Qiu, F.G., 1992. The recent development of bamboo foods. Proceedings of the International Symposium on Industrial Use of Bamboo, December 7-11, 1992, International Timber Organization and Chinese Academy of Forestry, Beijing, China, pp: 333-337.
18. Ferreira, V.L.P., A. Azzini, I.B. de Figueriredo, A.L. Salgado and M.K. Barbieri, 1995. Evaluation of bamboo shoots for human consumption. Coletanea Inst. Tecnol. Alimento, 16: 23-36.
19. Chongtham, N., M.S. Bisht and S. Haorongbam, 2011. Nutritional properties of bamboo shoots: Potential and prospects for utilization as a health food. Comp. Rev. Food Sci. Food Saf., 10: 153-168.
20. Lu, B.Y., X.Q. Wu, X.W. Tie, Y. Zhang and Y. Zhang, 2005. Toxicology and safety of anti-oxidant of bamboo leaves. Part 1: Acute and subchronic toxicity studies on anti-oxidant of bamboo leaves. Food Chem. Toxicol., 43: 783-792.
21. Lu, B., X. Wu, J. Shi, Y. Dong and Y. Zhang, 2006. Toxicology and safety of antioxidant of bamboo leaves. Part 2: Developmental toxicity test in rats with antioxidant of bamboo leaves. Food Chem. Toxicol., 44: 1739-1743.
22. Pretty, J.N., J.I.L. Morison and R.E. Hine, 2003. Reducing food poverty by increasing agricultural sustainability in developing countries. Agric. Ecosyst. Environ., 95: 217-234.

23. Rawnak, J., M.A. Quaiyum, N. Jahan, T. Akhter and M.S. Islam, 2014. Dietary added bamboo charcoal can evoke Pangasianodon growth and can reduce ammonia from culture medium. Int. J. Fish. Aquacult., 6: 87-93.
24. Antwi-Boasiako, C., G.Y. Coffie and N.A. Darkwa, 2011. Proximate composition of the leaves of *Bambusa ventricosa*, *Oxytenanthera abyssinica* and two varieties of *Bambusa vulgaris*. Sci. Res. Essays, 6: 6835-6839.
25. AlRawashdeh, N.Q., I.M. AlRawashdeh and T.M. AlZghoul, 2016. Amino acids and mineral composition analysis of *Moringa peregrina* forssk (fiori) in Jordan. J. Agric. Biol. Sci., 11: 175-179.
26. El-Lamey, T.M., 2015. Ecophysiological responses of moringaperegrina (forssk.) Fiori growing naturally under different habitat conditions of Eastern Desert and Fieran Oasis, Egypt. IOSR J. Agric. Vet. Sci., 8: 8-21.
27. Duncan, D.B., 1955. Multiple range and multiple F tests. Biometrics, 11: 1-42.
28. ICFRE., 2009. Bamboo as food and medicine. Indian Council of Forestry Research and Education, Dehradun, India. https://www.scribd.com/document/168614019/Bamboo-Food-Medicine-221206.
29. Singhal, P., L.M. Bal, S. Satya, P. Sudhakar and S.N. Naik, 2013. Bamboo Shoots: A Novel Source of Nutrition and Medicine. Crit. Rev. Food Sci. Nutr., 53: 517-534.
30. Li, X., R. Rezaei, P. Li and G. Wu, 2011. Composition of amino acids in feed ingredients for animal diets. Amino Acids, 40: 1159-1168.
31. Koushik, G. and S. Mandal, 2015. Nutritional evaluation of groundnut oil cake in formulated diets for rohu, *Labeo rohita* (Hamilton) fingerlings after solid state fermentation with a tannase producing yeast, *Pichia kudriavzevii* (GU939629) isolated from fish gut. Aquacult. Rep., 2: 82-90.
32. Hulshof, T.G., A.F.B. van der Poel, W.H. Hendriks and P. Bikker, 2016. Amino acid utilization and body composition of growing pigs fed processed soybean meal or rapeseed meal with or without amino acid supplementation. Animal, 1: 1125-1135.
33. Rumsey, G.L., J.W. Page and M.L. Scott, 1983. Methionine and cystine requirements of rainbow trout. Progressive Fish-Culturist, 45: 139-143.
34. Cowey, C.B., C.Y. Cho, J.G. Sivak, J.A. Weerheim and D.D. Stuart, 1992. Methionine intake in rainbow trout (*Oncorhynchus mykiss*), relationship to cataract formation and the metabolism of methionine. J. Nutr., 122: 1154-1163.
35. Anhwange, B.A., V.O. Ajibola and S.J. Oniye, 2004. Amino acids compositions of the seeds of *Moringa oleifera* (LAM) *Detarium mirocarpum* (Guill & Perr) *Bauhinia monandra* (Linn). ChemClass J., 1: 9-13.
36. Anonymous, 2002. Reference guide for amino acids, visitor (1995-2002) 671:323. http://anrvitamins.com/aminoacd.html.
37. Nirmala, C., E. David and M.L. Sharma, 2007. Changes in nutrient components during ageing of emerging juvenile bamboo shoots. Int. J. Food Sci. Nut., 58: 612-618.
38. Giri, S.S. and L.S. Janmejay, 2000. Effect of bamboo shoot fermentation and aging on nutritional and sensory qualities of *Soibum*. J. Food Sci. Technol., 37: 423-426.
39. Nongdam, P. and L. Tikendra, 2014. The nutritional facts of bamboo shoots and their usage as important traditional foods of Northeast India. Int. Scholarly Res. Not., Vol. 2014. 10.1155/2014/679073
40. Kozukue, E., N. Kozukue and T. Kurosaki, 1983. Organic acid, sugar and amino acid composition of bamboo shoots. J. Food Sci., 48: 935-938.
41. Nirmala, C., M.S. Bisht, H.K. Bajwa and O. Santosh, 2018. Bamboo: A rich source of natural antioxidants and its applications in the food and pharmaceutical industry. Trends Food Sci. Technol., 77: 91-99.
42. Maroli, A., V. Nandula, S. Duke and N. Tharayil, 2016. Stable isotope resolved metabolomics reveals the role of anabolic and catabolic processes in glyphosate-induced amino acid accumulation in *Amaranthus palmeri* biotypes. J. Agric. Food Chem., 64: 7040-7048.