The Nutritive Value of Aquatic Plants and their Utilization in Fish and Animal Feed

Soheir A..Bahnasy* .Gamal A. Kamel[1] and Samia E. Saaffan[2]
[1] Department Ground water Research Institute, National Water Research Center, Egypt
[2] Botany Department, Faculty of Science, Zagazig University Al Sharkia, Egypt.
*Corresponding E-mail: soheirbahnasy@gmail.com

Abstract

Using of dried aquatic plants as daily protein to animal and fish was the topic of investigation in this study. Analyses of different plants (water hyacinth, duckweed and lotus) in Laboratory. This is to evaluate their potentials in animal and feed composition. The proximate analysis shows that the moisture content ranged from 6.25% in the plant to 32.5% for the crude lipids, the least value of 2.5 to 5.4 in the whole plant while the percentage crude fiber ranged from 4.5 to 11.1% in the whole plant. The percentage crude protein ranged from 8.55% to 14.2 %. In the whole plant duckweed plant is conceder the prefer plant can used as nutritive source of animal and fish feed then water hyacinth and lotus. Total amino acid are large amount in water hyacinth than lotus and duckweed (397.638, 175.98 and 95.915 mg/g).

Keywords: *water hyacinth, duckweed, lotus, mutative value, protein, amino acid*

1. Introduction

Aquatic plants grow copiously in different aquatic bodies such as lakes and waterways all around the world (Muhammed et al., 2012). Marine protein sources are often utilized in aquatic feeds because they are an excellent
source of essential amino acids, fatty acids, vitamins and minerals, and because they generally enhance palatability (Davis and Arnold, 2000)). However, nearly all researchers agree that an alternative ingredient should be used in the aqua feed industry and animal feed in place of fish meal, whose supplies are limited although demand for it is expected to rise. For this reason, many studies have been conducted on the replacement of expensive marine proteins with lower cost ingredients.

Considerable attention has been devoted to the replacement of fish meal with plant protein sources such as soy-bean meal (Oliva-Teles et al., 1994); Refstie et al., 1998), mucuna seed meal (Siddhuraju and Becker, 2001) Globally, the food research emphasis on the production of high quality food and feeds of plant origin as the green plants are recognized as excellent source of protein, fats and pharmacological active and secondary metabolism. Recent studies reveals that the aquatic plants are good source of primary and secondary metabolism. Duckweed, as a natural protein source, has a better array of essential amino acids than most other vegetable proteins and more closely resembles animal protein (Hillman and Culley, 1978).
Newly harvested duckweed plants contain up to 43% protein by dry weight and can be used without further processing as a complete feed for fish. Compared with most other plants, duckweed leaves contain little fiber percentage of (5% in dry matter for cultivated plants) and little to almost zero indigestible material even for mono gastric animals (Chaturvedi et al., 2003). This contrasts with the compositions of many crops such as soy beans, rice, and maize, approximately 50% of whose biomass comprises residues high in fiber and low in digestibility. Duckweed grown on nutrient-rich water has a high concentration of trace minerals, potassium (K), phosphorus (P), and pigments, particularly carotene and xanthophyll, which make duckweed meal an especially valuable dietary supplement for fish

(Leng et al., 1995).In most studies, duckweed is used as a protein source in place of fish meal made of other feedstuffs (Wee, 1991)). Water hyacinth (WH) can be used fresh, ensiled or wilted to animals. Whole plants, chopped or ground can be used as feedstuffs for both ruminants and monogastrics. Water hyacinth contains high levels of cellulose and hemicellulose, which could serve as energy sources for ruminants (Mukherjee & Nandi, 2004)). Fresh WH has been utilized as partial replacement of para grass (Brachia ria mutica) in diets to cattle (Thu, 2011),) and has given better growth than after wilting when fed to goats (Aregheore and Cawa, 2000). Supplementation of wilted WH in a rice straw-based diet had positive effect on intake and growth of beef cattle (Islam et al., 2009). Lotus is a floating attached plant, which is an important and popular cash crop in many Asian countries. Lotus has multiple uses, for example, stems and rhizomes as fresh vegetables; seeds as dessert and medicine; flowers as religious ornaments, and several parts as raw materials to produce cosmetics (Yi et al., 2002).To enhance the full utilization of those weed, the evaluation of its nutritive value in this study has the objectives to evaluate based on its nutritive value, its potentials in fish feed and animal feed of the various plants (water hyacinth ,duckweed and lotus) .

2. Materials and Methods

2.1. Sampling and pretreatment

The samples of each plant were representative for the different part of the plants occurred in the studied drain.

Since the chemical composition may vary strongly, dependent for different plant parts (leaf, stem, root), physiological age and growth conditions.

The plants (chosen for study) were obtained from el khyree drain. All plants were in good condition (healthy) and in similar state of growth,(young) roots and leaf color to ensure uniform absorption areas and each type of plant put in bucket contained 2 liter in tab water and leave for one month.

Pre-treatment of the sample involves drying and grinding, preceded by washing if the fresh plant material is polluted by dust and salts from water are the usual contaminants; these may be washed out by tap water. The plant sample is dried at 70 C in a well-ventilated drying oven till dry (often within 24 hours). The material is then finely ground, to obtain a homogeneous sample and pass a 1-mm sieve when less than 1 gram is to be weighed out.

2.2. Determination of total ash content

About 2 gm powdered plant grained with accurately weight in silica was crucible which weight previously the powdered extracted speeded as fine even layer on the bottom of the silica crucible and was incinerated at 550 ̊c until it become free from carbon the silica crucible cooled and was weighted again several time until constant weight . The percentage of total ash was calculated with reference to air dried extract (A.O.A.C., 2000).

2.3. Determination of Moisture

Content Moisture content was determined by drying in an oven 100-105o °C to constant weight (A.O.A.C., 2000).

2.4. Determination of Protein

The protein content was evaluated by the digesting of the sample was determined and then nitrogen determination by a spectrophotometer method as described by (Devani, et al.,1989) and the protein content was obtained by multiplying the quantity of nitrogen by the coefficient 6.25.

2.4.1. Amino Acid Analysis

Analysis of amino acids is required in several areas of research, and it is a fundamental tool in product analysis. The application imposes different requirements on the analytical method because the amino acids play different roles. Amino acids are the basic constituents of proteins. Qualitative and quantitative analysis of the amino acid composition of hydrolyzed samples of pure proteins or peptides is used to identify the material and to directly measure its concentration by o-phthalaldehyde (OPA) method (Liu., 2000).

Procedure of amino acid analysis in plants:

Samples. Water hyathine, Duckweed and Lotus were analyzed for their amino acid content. Then, a mixture of samples was made in the mass ratio 70:15:15.The mixture was divided into four parts, and one part, marked as “zero”, was used as such, while the other three parts were supplemented with methionine, threonine and lysine in different concentrations. The mixtures “one”, “two” and “five” contained 0.1, 0.2 and 0.5 % of each added amino acids, respectively. Preparation of protein hydrolysates. The fodder samples and the mixtures were finely ground to pass through a 0.5 mm sieve. The samples were then hydrolyzed First, 0.1–1.0 g was weighed (equivalent to 10 mg nitrogen content) into a screw capped test tube and 2 cm3 of 6 mol dm^3 HCl was added.

The tubes were capped and the samples were hydrolyzed for 24 h at 110 °C. After the hydrolysis, the mixtures were evaporated to dryness under vacuum. The hydrolysates were reconstituted in 2 cm^3 of 0.1 mol dm^3 HCl.27 In the second procedure, samples of the same mass were weighed into vacuum hydrolysis sis tubes and 7 cm^3 of 6 mol dm^3 HCl with 0.1 % of phenol were added and mixed gently. Hydrolysis was realized in a ReactiTherm TM heating/stirring module for 6 h at 150 °C. After the hydrolysis, the samples were cooled to room temperature and evaporated to dryness using a ReactiTherm TM heating/stirring module and Reacti-VapTM Evapora-tor, at 70 °C under a stream of nitrogen. The residues were quantitatively transferred into 50 cm^3 volumetric flasks using 0.1 mol dm^3 HCl. The solutions were filtered through quantitative filter paper into glass tubes and the filtrates were purified using 0.22 μm pore size, cellulose membrane syringe filters.27
HPLC Determination The chromatographic conditions employed were in accordance with the Agilent method, Henderson,(2000) ex-cept for mobile phase A, which consisted of 5.678 g of Na_2HPO_4 per 1 dm^3 water, adjusted the pH to 7.8 with a 6 mol dm^3 HCl solution (buffer strength 40 mmol dm^3). The mobile phase B was acetonitrile–methanol–water (45:45:10, vol. %). Briefly, the hydrolyzed samples or the solutions the standard amino acid mixture were automatically derivatised with OPA by programming the auto sampler.

2.5. Determination of Total Lipids

Total lipids were determined by continuous extraction in a Sox let apparatus for 8 hours using hexane as solvent. (A.O.A.C., 2000).
Crude fiber was determined by sequential hot digestion of the defatted sample with dilute acid and alkaline. Total carbohydrate was determined by subscribing as follow: Crude fiber = (100-moisture, crude protein, ash, crude fiber and crude lipid) (A.O.A.C., 2000).

2.6. Determination of Crude Fibers

Crude fiber was determined by sequential hot digestion of the defatted sample with dilute acid and alkaline. Total carbohydrate was determined by subscribing as follow: Crude fiber = (100-moisture, crude protein, ash, crude fiber and crude lipid) (A.O.A.C., 2000).

3. Results And Discussion

3.1. The nutrient values of aquatic plants and their utilization in animal and fish feed

The ash content, which is an index of mineral contents, for lotus, was higher in comparison with the values re-ported for other aquatic plants. The crude protein content of both water hyacinth and duckweed was higher than lotus while comparing our study to the previous ones on crude fiber, the results of our study was somewhat similar to that of Anjana and Matai (1990) and Muhammed et al,. (2012). The crude protein of water hyacinth leaves is higher than that of corn grit 'maize' (10.77) (Boyd, 1969); guinea corn (11.22) and very close to palm kernel cake (19.06) (Eyo, 1994) and duck weed (26.30) (Mbagwu & Adeniji (1988). These are ingredients either taken directly by fishes or used as major ingredient in fish feed formulation. Amounts of protein, lipid, carbohydrates and fibers in duckweed is higher than other aquatic plants. One of the most commonly encountered difficulties, when alternative protein sources are used, is acceptability due to the palatability of the diets fed to fish (Rodriguez et al., 2011).

Table 1. Percentage Moisture Content, Ash Content, Crude Protein Content, Crude Fat/Lipid Content, Fiber Content, of studied aquatic plants.

PLANT	Moisture	Ash	Crude Protein	Crude Fiber	Crude Lipid	Total Carbohydrat
Water	6.91	15.37	12.52	4.5	2.5	58.2
Duck weed	32.5	16.8	14.12	11.1	5.4	64.8
Lotus	6.25	21.35	8.55	4.97	3.95	54.93

Anti-nutrients are defined as substances which by themselves, or through their metabolic products arising in living systems, interfere with food utilization and affect the health and production of animals (Makkar, 1993). In an earlier study, common carp that were fed diets containing higher than 13% mucuna meal showed significantly poorer growth and nutrient utilization indices, compared to carp that were fed a control diet. In contrast, in the current experiment, common carp fry fed diets containing different amounts of duckweed did not show significant differences with respect to growth or feed utilization. These findings support the opinion that duckweed has a higher nutritional value than both mucuna and sesbania meals (Makkar and Becker, 1999), found that methionine n supple-mentation in feeds containing winged bean meal provided similar growth compared to control, but methionine deficiency could be compensated for by the cysteine content of the winged bean meal, which was >2.0 g cysteine/100 g protein. Furthermore, Viola et al,. (1982) determined that when 80% of fish meal was replaced by soy-bean meal, most aquatic plants have good potentials as animal feed. This includes Azolla species and Lemna species. Muhammad et al,. (2014) found water lotus high in crude protein while low in crude fiber.

3.2. Amino acid in Aquatic plants

The determination of the amino acid composition of the proteins in food is of great importance.1 Namely, the amino acid level is an indicator of the nutritional value of food and fodder proteins.2 As a laboratory technique, the analysis of amino acid plays an important role in biochemical, pharmaceutical and biomedical fields.3 Hither-to,(IGOR,et. al ., 2012).

Water hyacinth indicated that high content in fiber (Igbintosun,. andAmako,1988) and very high in amino acid profile (Wolyerton and Mcdonald, 1978) the high fiber contebt of the hole water hyacinth plant meal has put great limitation into its effect utilization by fish as feed ingredient (Igbintosun,. andAmako,1988, and Nwalinna and Ajani, 2005). Duckweed, as a natural protein source, has a better array of essential amino acids than most other vegetable proteins and more closely resembles animal protein (Hillman and Culley, 1978). Duckweed grown on nutrient-rich water no essential amino acid (EAA) deficiencies (Siddhuraju and Becker, 2001). Similar results were obtained in another study, in which feeding common carp diets containing more than 12% sesbania meal produced significantly poorer growth and feed utilization compared to fish fed a= control diet, despite good feed acceptability and no EAA deficiencies.

3.2. Amino acid in Aquatic plants

The determination of the amino acid composition of the proteins in food is of great importance.1 Namely, the amino acid level is an indicator of the nutritional value of food and fodder proteins.2 As a laboratory technique, the analysis of amino acid plays an important role in biochemical, pharmaceutical and biomedical fields.3 Hither-to,(IGOR,et. al ., 2012).
Water hyacinth indicated that high content in fiber (Igbintosun,. andAmako,1988) and very high in amino acid profile (Wolyerton and Mcdonald, 1978) the high fiber contebt of the hole water hyacinth plant meal has put great limitation into its effect utilization by fish as feed ingredient (Igbintosun,. andAmako,1988, and Nwalinna and Ajani, 2005). Duckweed, as a natural protein source, has a better array of essential amino acids than most other vegetable proteins and more closely resembles animal protein (Hillman and Culley, 1978). Duckweed grown on nutrient-rich water no essential amino acid (EAA) deficiencies (Siddhuraju and Becker, 2001). Similar results were obtained in another study, in which feeding common carp

diets containing more than 12% sesbania meal produced significantly poorer growth and feed utilization compared to fish fed a= control diet, despite good feed acceptability and no EAA deficiencies.

This was again attributed to the presence of anti-nutrients such tannins, phytic acid, saponins, trypsin inhibitor and lectins in sesbania meal (Hossain et al., 2001). According figure (1,2,3) and tables (2,3,4)Amino acid in water hyacinth in order aspartic acid, asparagine, glutamine, glycine, tyrosine, leucine, valine, phenyl alanine, threonine, praline, glutamic acid and Cystine (31.137, 22.345, 2.2388, 2.567, 2.567, 112.8, 110.36, 5.9367, 3.6845, 90.585, 2.267 and 1.6385) Amino acid in lotus in orders serine, aspartic acid, glutamic acid, glycine, tyrosine, leucine, lysine, phenylalanine, valine, histidine, praline and isoleucine(,8.66, 0.505, 1.795, 6.655, 6.655, 9.821, 33.42. 16.89, 0.446, 1.14and 24.69mg/g). Amino acid in duckweed in orders serine, methionine, leucine, lysine, tyrosine, valine, phenyl alanine, tryptophan and histidine (29.219, 7.13, 7.13, 103.52, 1.352, 101.93, 1.2739, 0.5211 and 0.002). Total amino acid are large amount in water hyacinth than lotus and duckweed (397.638, 175.98 and 95.915 mg/g) this result agree with the result of total nitrogen according to tables (2.3,4).

Table (2) : External Standard Report for Duckweed

Amino Acid	Retention Time	Concentration (mg/ g)
Serine	13.373	29.219
Methionine	18.005	7.13
Leucine	21.953	7.9198
Lysine	230504	103.52
Tyrosine	23.711	1.3521
Valine	25.593	101.93
Phenylalanine	26.962	1.2739
Tryptophan	26.769	0.5211
Histidine	29.560	0.002
Total		252.87

Table (3): Show external standard report for Water Hyacinth

Amino Acid	Retention Time	Concentration (mg/ g)
Aspartic acid	13.510	31.1
Asparagine	18.089	22.3
glutamine	19.805	2.23
glycine	20.151	2.5
tyrosine	21.590	3.72
leucine	21.953	11
valine	25.593	110.
Phenylalanine	26.962	5.93
Threonine	33.275	3.68
Proline	33.790	90.5
glutamic acid	34.711	2.2
Cystine	35.448	1.63
Total		389.

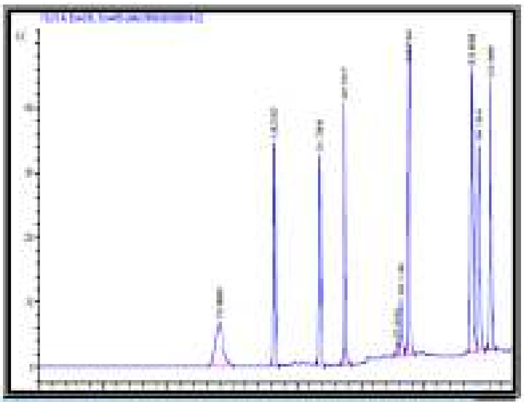

Figure (1): Show HPLC peak areas for duckweed

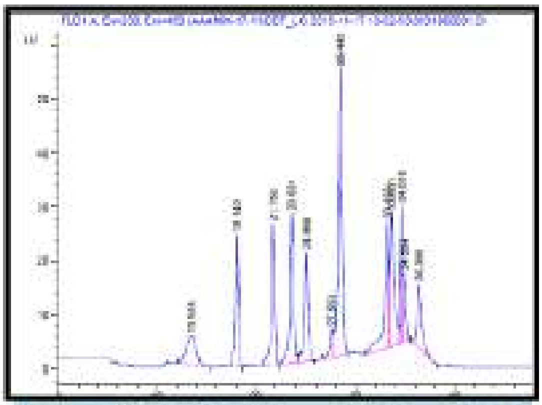

Figure (2) Show HPLC peak areas for Water Hyacinth

Table (4) : External Standard Report for Lotus

Amino Acid	Retention Time	Concentration (mg/g)
Serine	13.373	8.66
Aspartic acid	13.510	0.505
Glutamic acid	16.689	1.795
Glycine	20.151	8.414
Tyrosine	21.590	6.655
Leucine	21.953	6.655
Lysine	23.0564	9.821
Phenylalanine	26.962	33.42
Valine	25.593	16.89
Histidine	29.566	0.446
Proline	33.790	1.149
Isoleucine	36.904	24.69
Total		119.4

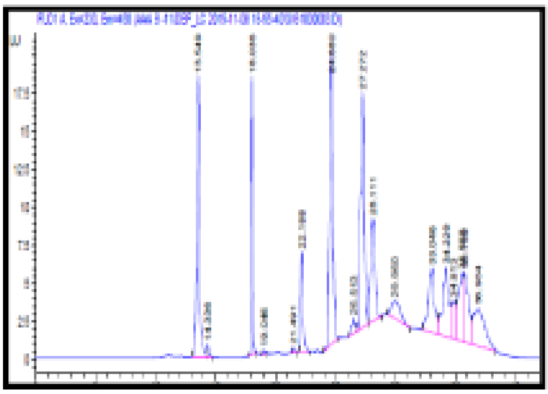

Figure (3) Show HPLC peak areas for Lotus

4. Conclusion & Recommendations

The nutritive values of the water plants are mainly include (total carbohydrate, crude protein crude lipids, total amino acids) this measurements show the high rate in water hyacinth and duckweed than lotus. This observation could contribute to the value of water plants as a feed material in .Further work is clearly necessary to test the effectiveness of water plants as a feed material in crustacean diets.

References

Akmal, M., Hafeez-ur-Rehman, M., Ullah, S., Younus, N., Khan, K. J., & Qayyum, M. (2014). Nutritive value of aquatic plants of Head Baloki on Ravi River, Pakistan. Int. J. Biosci, 4(10), 115-122.

Association of Official Analytical Chemists, & Association of Official Agricultural Chemists (US). (2000). Official Methods of Analysis of the Association of Official Analytical Chemists (Vol. 15). Association of Official Analytical Chemists.

Banerjee, A., & Matai, S. (1990). Composition of Indian aquatic plants in relation to utilization as animal forage. J Aquat Plants Manage, 28, 69-73.

Boyd, C. E. (1968). Fresh-water plants: a potential source of protein. Economic Botany, 22(4), 359-368.
Chaturvedi, K. M. M., Langote, D. S., & Asolekar, R. S. (2003). Duckweed-fed fisheries for treatment of low strength com-munity waste water. WWWTM Newsletter-Asian Institute of Technology, India.

Davis, D. A., & Arnold, C. R. (2000). Replacement of fish meal in practical diets for the Pacific white shrimp, Litopenaeus vannamei. Aquaculture, 185(3), 291-298.

Eyo, A. A. (1994, February). The requirement for formulating standard artificial fish feed. In 11th Annual Conference of the fisheries society of Nigeria (FISON) held at the Lagos State Auditorium Secretariat Alausa, Ikeja, Lagos State, 22nd–24th February (p. 15).

Henderson, J. W., Ricker, R. D., Bidlingmeyer, B. A., & Woodward, C. (2000). Amino acid analysis using Zorbax Eclipse-AAA Columns and the Agilent 1200 HPLC.

Hillman, W. S., & Culley, D. D. (1978). The Uses of Duckweed: The rapid growth, nutritional value, and high biomass productivity of these floating plants suggest their use in water treatment, as feed crops, and in energy-efficient farming. American Scientist, 66(4), 442-451.

Hossain, M. A., Focken, U., & Becker, K. (2001). Evaluation of an unconventional legume seed, Sesbania aculeata, as a dietary protein source for common carp, Cyprinus carpio L. Aquaculture, 198(1), 129-140.

Igbinosun, J. E., Roberts, O. O., & Amako, D. (1988). Investigation into the probable use of water hyacinth (Eichornia Cras-sipes) in tilapia feed formulation.

Islam, S., Khan, M. J., & Islam, M. N. (2009). Effect of feeding wilted water hyacinth (Eichhornia crassipes) on the perfor-mance of growing bull cattle. Indian Journal of Animal Sciences, 79(5), 494-497.

Jajić, I., Krstović, S., Glamočić, D., Jakšić, S., & Abramović, B. (2012). Validation of an HPLC method for the determina-tion of amino acids in feed. Journal of the Serbian Chemical Society, 78(6), 839-850.

Leng, R. A., Stambolie, J. H., & Bell, R. (1995). Duckweed-a potential high-protein feed resource for domestic animals and fish. Livestock Research for Rural Development, 7(1), 36.

Liu, H. (2000). Methods of amino acids Mol. Biol. 159123.

Makkar, H. P. S. (1993). Antinutritional factors in foods for livestock. BSAP occasional publication: An occasional publica-tion of the British Society of Animal Production.

Makkar, H. P. S., & Becker, K. (1999). Nutritional studies on rats and fish (carp Cyprinus carpio) fed diets containing un-heated and heated Jatropha curcas meal of a non-toxic provenance. Plant Foods for human nutrition, 53(3), 183-192.

Mbagwu, I. G., & Adeniji, H. A. (1988). The nutritional content of duckweed (Lemna paucicostata Hegelm.) in the Kainji Lake area, Nigeria. Aquatic Botany, 29(4), 357-366.

Mohammed, H. A., Uka, U. N., & Yauri, Y. A. B. (2013). Evaluation of nutritional composition of water lily (Nymphaea lo-tus Linn.) from Tatabu Flood Plain, north-central, Nigeria. Journal of Fisheries and Aquatic Science, 8(1), 261.

Mukherjee, R., & Nandi, B. (2004). Improvement of in vitro digestibility through biological treatment of water hyacinth bi-omass by two Pleurotus species. International biodeterioration & biodegradation, 53(1), 7-12.

Nwalinna,L.and E.,Ajani. (2005). Effect of diets containing water Hyacinth on growth and blood parameters of African catfish Clortus garepinus/ Journal of sustainable Tropical Agriculture Reaches,13.7-10.

Oliva-Teles, A., Gouveia, A. J., Gomes, E., & Rema, P. (1994). The effect of different processing treatments on soybean meal utilization by rainbow trout, Oncorhynchus mykiss. Aquaculture, 124(1), 343-349.

Peña-Rodríguez, A., Mawhinney, T. P., Ricque-Marie, D., & Cruz-Suárez, L. E. (2011). Chemical composition of cultivated seaweed Ulva clathrata (Roth) C. Agardh. Food chemistry, 129(2), 491-498.

Refstie, S., Strorebakken, T. and Roem, A.J. (1998). Feedconsumption and conversion in Atlantic salmon (Salmo salar) fed diets with fish meal, extracted soybean meal or soybean meal with reduced content of oligosaccharides, trypsin inhibitors, lectins and soya antigens. Aquaculture, 162: 301-312.

Siddhuraju, Perumal, and Klaus Becker. "Preliminary nutritional evaluation of Mucuna seed meal (Mucuna pruriens var. uti-lis) in common carp (Cyprinus carpio L.): an assessment by growth performance and feed utilisation." Aquaculture 196, no. 1 (2001): 105-123.

Thu, N. V. (2011). Effects of water hyacinth (Eichhornia crassipes) in local cattle diets on nutrient utilization, rumen param-eters and microbial protein synthesis. In SAADC 2011 strategies and challenges for sustainable animal agriculture-crop sys-tems, Volume III: full papers. Proceedings of the 3rd International Conference on sustainable animal agriculture for devel-oping countries, Nakhon Ratchasima, Thailand, 26-29 July, 2011 (pp. 422-426). Suranaree University of Technology.

Viola, S., Mokady, S., Rappaport, U., & Arieli, Y. (1982). Partial and complete replacement of fishmeal by soybean meal in feeds for intensive culture of carp. Aquaculture, 26(3), 223-236.

Wee, K. L. (1991). Use of non-conventional feedstuff of plant origin as fish feeds–is it practical and economically feasible. In Fish Nutrition Research in Asia, Proceedings of the fourth Asian Fish Nutrition Workshop, Manila, Asian Fisheries Soci-ety (pp. 13-32).

Wolyerton,B.C. and Mcdonald, R.C. (1978). National comparison of water hyacinth growth on demostic sewage. NASA_ERL Report No.173, Washngton, USA.

Yi, Y., Lin, C. K., & Diana, J. S. (2002). Recycling pond mud nutrients in integrated lotus–fish culture. Aquaculture, 212(1), 213-226.