CHEMICAL COMPOSITION AND BINDING POWER OF DRIED PULP WASTES PRODUCED FROM THE AFRICAN LOCUST BEAN (*PARKIA BIGLOBOSA*) IN LOW-COST FISH DIETS

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(*Submitted*: 20 February 2004; *Accepted*: 15 June 2004)

Abstract

The chemical compositions of pulp wastes produced from fermented African locust bean before and after fermentation were assessed in order to determine their possible utilization. The fermented bean pulp waste contained protein 11.75 %; ash, 15.86 %; crude fibre, 21.55 %; starch, 32.14 %; dry matter, 93.5% and moisture, 6.5 % while the unfermented pulp contained protein 10.13 %; ash content, 14.14%; crude fibre 22.63%; starch, 28.20%; dry matter, 92.5% and moisture, 7.5%. The unfermented locust bean pulp waste contained some essential amino acids including methionine, lysine, leucine and isoleucine and some non-essential amino acids include histidine, proline, glycine and tyrosine. Concentrations of tannin and oligosaccharides were generally very low. The pulp waste was used wholly and partially to replace corn starch (yellow maize) as a binder in the preparation of the diet of cultured fish (*Clarias gariepinus*). Six diets were formulated using the pulp waste in various proportions. The binding power and the crumbling rate were assessed. The crumbling rate declined with increased inclusion of the pulp. The unfermented locust pulp waste exhibited a stronger binding effect than corn starch after 12 weeks storage. Diets stored in jute bags showed minor quality deterioration due to insect infestation, while diets stored in polythene bags maintained good quality throughout the study period. The use of locust bean waste can thus serve the dual purpose of (a) turning the waste into a useful and value-added farm product and (b) effective substitution for corn starch as a binder in fish feeds.

Keywords: Chemical composition, binding power, locust bean, fish diets.

1. Introduction

The need for on-farm produced feed mixtures for aquaculture, using locally available technology and feed ingredients in many developing countries has been advocated (Coche, 1995). The use of cheaper feedstuffs has shown great potentials in terms of their nutrient supply as well as reduction in feeding costs (Falaye, 1992, 1995). The African locust bean (*Parkia biglobosa* Jacq) is a perennial tropical legume (Campbell-Platt, 1980). In West Africa, the seed of this leguminous tree crop is fermented to yield a traditional food condiment called "dawadawa" or "iru" (Odunfa, 1981). The freshly harvested African locust beans are contained in pods. The pods contain a yellow dry powdery pulp in which the dark brown seeds are embedded.

The first major operation in the production of dawadawa is the removal of the locust bean seeds from the pods. One of the by-products of this operation is the yellow pulp, which forms a thick pulp when water is added. This locust bean pulp is usually an eyesore and a menace, causing pollution in the water and even in the environment where harvesting and large scale processing of this savanna crop is a viable trade.

The possibility of using this waste (pulp) as fish feed concentrates and binder deserves some trial. Over the years, it has been discovered that the by-products and waste materials from mills, mill packing, fish processing industries, oil seed processing and other processing industries have considerable feed value (Lu and Kevern, 1975; Edwards, 1980; Wee and Ng, 1986; Falaye, 1992, 1998). This study is one of the major evaluation works in the investigation of the nutritional qualities and binding potential of the waste.

As of date, little information is available on the nutritional composition of the yellowish pulp of *P. biglobosa.* Our preliminary analyses of the pulp shows that it has among others, a higher protein value compared to corn starch, which is commonly used locally as fish diet binder. In fish nutrition, binders are food and non-food materials, which are incorporated in food constituents to help bind the nutrients together thereby reducing the leaching of soluble essential nutrients.

The commonest binder used in fish feed formulation is starch which is in form of dextrin, carboxyl-methyl-cellulose (CMC), sodium bentonite, Guam gum, agar and gelatin, vegetable oils such as soybean oil which contain crude lecithin as binder (Wallace, 1985).

In Nigeria, there is now an awareness of the need for supplementary binders for fish feed formulation among the small-scale fish farmers (Akegbejo-Samsons, 1986). It is

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envisaged that finding local sources of binders will help to reduce the dependence on imported binders in the feed industries of Nigeria.

This paper reports the assessment of the nutrient quality of the pulp of the locust bean and its potential use as a binder in the fish feed industry.

2. Methods

Preparation of the experimental pulp

The pods of *P. biglobosa* were collected from the trees within the University of Agriculture, Abeokuta premises, and stored in jute bags for several weeks. The seeds were removed from the pods and soaked in water for about 12 h so as to separate the mass from the seeds. Natural fermentation occurs during this period, thus making the removal of the seeds to be easy. The pulp which were obtained before the 12 h fermentation period was regarded as the 'unfermented pulp', while those obtained after the 12 h fermentation were regarded as the 'fermented pulp'. In the normal fermentation production of 'dawadawa' from locust beans, these pulps are discarded as wastes as no local use has been found for them.

The pulp wastes that were obtained were dried for four days using sunlight energy. The resultant dried yellow pulp was then ground into powder using a blending machine.

Preparation of low cost fish diets

Six dry diets were prepared using common fish feed ingredients (Table 1). The ingredients were purchased locally. The diets were isonitrogenous with 40% crude protein value. The prepared diets had the pulp replaced wholly or partially with corn starch (from yellow maize), i.e. from 0-100% pulp inclusion levels at 20% incremental rates with corn starch as follow: Diet 1: 100% cornstarch (control diet); diet 2: 20% pulp & 80% cornstarch; diet 3: 40% pulp & 60% cornstarch; diet 4: 60% pulp & 40% cornstarch; diet 5: 80% pulp & 20% cornstarch; diet 6: 100% pulp (no corn starch).

Proximate analysis of the diets

The proximate analysis of the diets was determined on dry weight basis using the AOAC (1990) methods. The analyses were carried out in triplicates.

Tannin contents of the pulp powder were assessed using the method described by Makkar and Goodchild (1996). The amino acid contents were assessed using colorimetric analysis (Rosen, 1957). The chromatographic estimation of the amino acids were carried out using the thin-layer chromatography plate guide strip in locating the position of amino-acid on plates.

Evaluation of binding characteristics of the pulp/Binding power assessment

The cohesive/binding power of the pulp was assessed by subjecting the diets containing the pulp powder to series of local shearing and shaking processes such as running the diets through hard plastic containers and polythene containers. The rate of crumbling were observed and assessed as follows: (a) A crumblier (a roller mill with rolls specially designed for breaking up pellets into smaller particles) was used. The diets were passed through the crumblier and the rate of crumbling assessed by comparing the initial sizes and conformation (before passing through) of the pellets with the final sizes after passing through the crumblier.

(b) A sifter (an oscillating separator with a number of screens) was further used to examine the particle sizes of the different diets.

Storage quality assessment

The prepared diets were stored in jute bags and polythene bags for a period of 12 weeks at ambient condition and temperature temperature (29°C $\pm$ 3°C). Appearance and odour were critically assessed in all the diets. The assessment of the diets during storage was carried out by a panel of five assessors made up of the students and staff of the Department of Home Sciences Studies of the University of Agriculture, Abeokuta. Samples of the prepared diets were compared with a control sample of freshly prepared fish feed from one of the industries. The physical appearance and odour were assessed using a three-point score method. The scoring system for the appearance and odour was as follows:

→3 = appearance and odour similar to control sample.

→2 = appearance and odour slightly different from control sample.

→1 = appearance and odour different from control sample and unappealing.

Statistical Analysis

Data obtained from all analyses were subjected to statistical analysis using analysis of variance (ANOVA) and correlation analysis system programme (SAS, 1988).

3. Results

Proximate composition of fermented and unfermented pulp

The proximate composition and dry matter (DM) contents of the fermented and unfermented pulp waste are presented in Table 1. The crude protein content of the unfermented pulp is slightly higher than that of the fermented pulp. The dry matter value of the fermented is however higher than that of the unfermented. Results from this work show that there is an increase in the fat, ash and crude protein contents in the fermented samples compared to the unfermented samples respectively (1.38, 15.86 and 11.75 %). The sugar content in the unfermented samples was higher than the fermented waste.

Decrease in crude fibre, carbohydrates and moisture content in the fermented samples was noticed, this is due to the softening of the pulp during the fermentation period.

The samples were strongly acidic with pH of 3.22 and 2.98 for fermented and unfermented pulp respectively. Both fermented and unfermented pulp were found to be very rich in

Table 1: Dry matter and proximate composition of the African locust bean pulp (waste) pulp.

COMPONENTS (%)	FERMENTED WASTE	UNFERMENTED WASTE
Moisture	6.50± 0.87	7.50± 0.87
Dry matter (DM)	93.50± 0.88	92.50± 0.67
Ash content	15.86±0.15	14.14± 0.03
Crude Fibre content	21.55± 0.04	22.63± 0.28
Crude protein content	11.75± 0.12	10.13± 0.06
Fat content	1.38± 0.03	1.30± 0.07
Sugars	8.94± 0.19	13.32± 0.58
Starch	32.14± 0.57	28.20± 0.09
NFE	28.70± 0.30	26.30± 0.02
Carbohydrates	44.06± 0.01	46.26± 0.70
pH	3.22±0.05	2.97± 0.05

Table 2: Amino acid profile of the African locust bean pulp (waste) pulp.

Name of amino acid	Fermented waste (mg/100g)	Unfermented waste (mg/100g)
Histidine	1.39± 0.02	1.94± 0.03
Methionine	0.55± 0.04	0.74± 0.03
Lysine	3.15± 0.04	3.89± 0.02
Leucine	4.26± 0.01	3.79± 0.01
Isoleucine	2.59±0.01	2.22± 0.02
Proline	6.67± 0.04	6.57± 0.01
Phenylalanine	3.70± 0.02	3.52± 0.02
Cysteine	1.11± 0.02	1.29± 0.01
Threonine	1.01± 0.02	1.20± 0.02
Glycine	2.32± 0.01	2.04±0.02
Tyrosine	2.41±0.02	1.85± 0.01

Table 3: Tannin and Oligosaccharides contents of the African locust bean pulp (waste) pulp.

Contents/ Form	Fermented waste	Unfermented waste
Tannin (mg/100g)	0.020± 0.001	0.520± 0.002
Oligosaccharides (%)	0.002± 0.001	20.22± 0.03

carbohydrates, this could be a viable substrate for agar or other microorganisms culture. There was no significant difference ($P<0.05$) in all values between the fermented and unfermented pulp, therefore either could be used as a binder in fish feed. When compared to that of yellow maize/corn starch, which had a lower crude fibre value (3.0) and a lower protein content value (9.5) respectively, it can therefore be concluded the fairly high crude fibre and protein contents of this pulp will make it a suitable source of feed for fish (Akegbejo-Samsons, 1999).

There was a very close similarity in proximate composition of the fermented and unfermented, except for the sugar. This may likely be due to sampling methods and probably not necessarily due to the effects of fermentation.

Amino acid profile of fermented and unfermented pulp

Table 2 shows the amino acid profile of both fermented and unfermented pulp waste. There were 11 amino acids identified in the samples at various levels of concentration. Proline had the value of 6.67 for the unfermented and 6.57 for the fermented. This is followed by leucine and phenylalanine in a descending order.

The lowest amino acid value in the samples was methionine. It can be inferred that inclusion of the pulp to fish feed will improve the amino acid supplementation of such feeds, when compared with the results obtained from the work of Akegbejo-Samsons (1999).

Tannin and oligosaccharides content

Table 3 shows the tannin and oligosaccharides contents in the samples of both fermented and unfermented pulp waste. The tannin content is very insignificant ($P<0.05$) with a value of 0.02 mg/100g for the fermented and 0.52mg/100g for the unfermented pulp. In spite of this low value, fermentation was observed to lower the value the tannin in the samples. The low tannin content suggest the ease of digestibility of the formulated feeds containing the pulp powder. Aletor (1993) observed that high molecular weight condensed tannins have limited solubility and extractability. Low tannin level in the pulp of the African locust bean causes good growth response and nutrient utilization in some fish species as shown in the work carried out by Akegbejo-Samsons and Olagunju (2002) similar feed of this component was fed to *Clarias gariepinus.*

The results of this study show that fermented pulp of the African locust bean pulp is nutritionally rich, and can be added as thickening agent, binder or energy source to fish feed. Its usefulness in supplementation and fortification of maize flour based diets can be well considered. It is envisaged that the environmental 'mess' that is left after the processing and extraction of the seeds can be considerably reduced by over 80% by the utilization of the pulp.

Gross and proximate composition of the diets

The different ingredients used for the preparation of the fish diets, gross and proximate composition of the diets used to assess the binding ability of the pulp is presented in Table 4, while the proximate composition of the diets is presented in Table 5.

The crude protein of the diets ranged from 39.6 % in diet 3 to 40.1 % in diet 5. Moisture content was least in diet 5 with a value of 5.88 and highest in diet 6 (8.72). Crude fibre ranged from 5.23% in diet 1 to 4.73 in diet 6.

Sensory, crumbling and binding evaluation

These diets were tested for sensory, crumbling and binding qualities.

The appearance and odour of all the 6 diets after storage inside the freezer (-4°C) for over 3 weeks remained unchanged. However the appearance and odour of all these diets changed considerably when stored in jute bags at room temperature. This was due largely to insect infestation and bacteria attack. Diets stored inside jute bags at room temperature did not show any infestation. The initial sweet smell was retained while the pelleted sizes were maintained. Based on the judgment of the assessors, the diets had a graded point of 3 for storage in freezer, and 2 for storage in jute bags and polythene bags at room temperature. However, all the diets had similar appearances and odour to the control feed sample when stored in the freezer. When they were stored in jute bags and polythene bags at room temperature, there were slight differences in appearance and odour when compared with the control sample. This shows that if well stored under hygienic conditions, diets prepared from *P. biglobosa* pulp will not loose its odour and appearance over a long time.

Crumbling evaluation and Binding power

After preparation and storage of diets for over 12 weeks, it was observed that diets with high concentration of pulp crumbled less than those with less concentration of the pulp, when passed through the crumblier. In other words, diet 6 with 100% pulp maintained the binding quality, having minimal crumbles. The control diet (diet 1) with 100% corn crumbled gradually into powder over time. Diet 5 (80% pulp) was next to the control diet. This was followed by diets 4, 3 and 2.

This study shows that the crumbling rate of diets containing higher quantity of corn starch as a binder (diets 1,2 and 3) were faster in crumbling than those with lesser inclusion of *P. biglobosa* pulp. They (those with higher cornstarch inclusion) were found with greater quantities of fine particles after passing through the sifter. However diets with higher quantities of *P. biglobosa* pulp had a higher sticking and binding properties for the fish diets when compared to corn starch.

4. Conclusion

A critical look at the demand for livestock feedstuffs, such as cereals by man for his own consumption, shows a precarious situation for both the human populace and his animals in Nigeria. Yellow maize, from which cornstarch is obtained is seasonally available at exhorbitant prices in the northern part of country, while *P. biglobasa* pulp waste is

Table 4: Gross composition of experimental diets (g)

Ingredients	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
Corn starch	25.79	14.10	10.57	7.05	3.52	-
Pulp	-	3.52	7.05	10.57	14.10	24.68
Fish meal	16.34	18.38	18.38	18.38	18.38	16.61
Soybean meal	49.00	55.15	55.15	55.15	55.15	49.83
Bone meal	2.50	2.50	2.50	2.50	2.50	2.50
Oyster meal	0.50	0.50	0.50	0.50	0.50	0.50
Vitamin/Premix	0.60	0.60	0.60	0.60	0.60	0.60
Salt	0.25	0.25	0.25	0.25	0.25	0.25
Vegetable oil	5.00	5.00	5.00	5.00	5.00	5.00
Total	100.00	100.00	100.00	100.00	100.00	100.00
[1]CPV (%)	40	40	40	40	40	40

[1]CPV= Calculated Protein Value

Table 5: Proximate compositions of the experimental diets, pulp and yellow maize

Nutrients→ Diets↓	Moisture content	Ash content	Crude protein	Fat content	Crude fibre	NFE
Diet 1	5.68	14.96	39.8	6.32	5.23	28.01
Diet 2	6.74	13.42	39.9	6.04	5.14	28.16
Diet 3	8.68	11.96	39.6	5.52	4.98	29.26
Diet 4	7.45	10.74	39.7	5.36	4.88	31.87
Diet 5	5.88	10.74	40.1	4.98	4.76	34.26
Diet 6	8.72	9.94	39.7	4.88	4.73	32.03
Pulp	9.34	12.30	7.9	2.25	18.94	49.23
Yellow maize	6.90	2.80	9.5	4.10	3.00	73.70

readily available from the African locust bean. The animal production sector in Nigeria spends over N4 billion every year sourcing for yellow maize. A reduction in the quantity of yellow maize when the locust pulp is incorporated is envisaged. As a result an estimated amount of about N1 billion would be saved by the feed industries.

Apparently, the use of this pulp waste is a viable step towards the recycling of the pulp, which constitutes environmental menace and economic waste in areas where the locust bean trees are harvested and processed. From the result of this study, it is evident that the pulp can be effectively substituted for cornstarch to obtain a cheaper fish feed for the culture of some fish species. The use of this pulp will further reduce the competition for yellow maize in the country.

REFERENCES

Akegbejo-Samsons, Y., 1986. Biological and economic evaluation of the efficiency and utilization of the different feeds and feedstuffs used in Nigerian fish farms. M.Sc. Thesis (Unpubl.) University of Ibadan, Nigeria. 115pp.

Akegbejo-Samsons, Y., 1999. The use of cassava flour as a substitute for yellow maize in diets for *Clarias gariepinus* fingerlings. Jour. Aqua. Trop. 14(3): 247-253.

Akegbejo-Samsons, Y. and Olagunju, P.K., 2002. Growth response and nutrient digestibility of *Clarias gariepinus* fed varying levels of *Parkia biglobosa* as energy sources. Applied Fisheries & Aquaculture Vol. II (I): 1-6.

Aletor, V.A., 1993. Allelochemicals in plant food and feeding stuffs, 1. Nutritional, biochemical and physiopathological aspects in animal production. Vet. and Human Toxicology 35(1): 57-67.

AOAC (Association of Official Analytical Chemists), 1990. Official Methods of Analysis, 15th ed. AOAC, Arlington, VA.

Campbell-Platt, G., 1980. African locust beans and its West African fermented food product. Ecology of food & Nutrition 9: 123-132.

Coche, A.G., 1995. Aquaculture research in sub-saharan Africa: Limitations, Priorities and Plan of action. In: J.-J. Symoens and J.-C. Micha (Eds.), Proc. of seminar, The management of integrated freshwater agro-piscicultural ecosystems in tropical areas. Brussels, 16-19 May, 1994. pp. 63-84.

Edwards, P., 1980. A review of recycling organic wastes into fish with emphasis o n *Aquaculture* 2: 261-275. r

Falaye, A.E., 1995. Utilization of agro-industrial wastes as fish feedstuffs in Ni- g e r th Annual Conference of the Fisheries Society of Nigeria (FISON) Abeokuta, Nigeria, 16-20 November, 1992. pp. 47-57.

Falaye, A.E., 1998. Effects of maize bran diets on the growth and nutrient utilization of Tilapia (*Oreochromis niloticus*). In: S.O. Otubusin *et al.* (Eds.), Sustainable Utilization of Aquatic/Wetland Resources. Publication of the Nigerian Association for Aquatic Sciences. pp. 105-113.

Lu, J.D. and Kevern, N.R., 1975. The feasibility of using waste materials as supplementary fish feed. *The Progressive Fish Culturist 37 (4):* 241-244.

Makker, H.P.S. and Goodchild, A.V., 1994. Quantification of tannins: A laboratory manual. International Center for Agricultural Research in the Dry Areas, Aleppo, Syria.

Odunfa, S.A., 1981. Microorganisms associated with fermentation of African locust bean during 'iru' preparation. Journal of plant foods 3: 245-250.

Rosen, H., 1957. A modified Ninhydrin colometric: Analysis for Amino acids. *BiochemBiophy* 67: 10-15.

Robert, W.S., 1985. History of the feed industry formula. *Feed manufacturing Technology III.* American Feed Industry Association Inc. pp. 2-5.

SAS (Statistical Analysis System), 1988. A software package for solving statistical Problem. VI Model 200 SAS Institute, Inc. Cavey, NC.

Wallace, L.L., 1986. Binders. Fish feed manufacturing technology. American Feed Industry Association Inc. pp. 242-248.

Wee, K.C. and Ng, L.T., 1986. Use of cassava as energy source in pelleted feed for the tilapia, *Oreochromis niloticus* L. *Aquaculture & Fish Management* 17:129-138.