

BINDING POTENTIAL, WATER STABILITY AND PHYSICAL PROPERTIES OF FOUR LOCALLY AVAILABLE BINDERS ON FORMULATED FISH FEED.

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ABSTRACT

The effect of cassava, corn, millet and potato starches as binders on water stability and physical properties on formulated fish feed was conducted. Four diets were formulated using the four different binders at 10% inclusion level. Feed formulated using these binders were designated treatments 1, 2, 3 and 4, respectively. The physical properties of the various treatments were evaluated by its dustiness. Water stability was evaluated by water stability test, weight gain, sinking time rate, relative absorption rate, absorption efficiency rate and volume of water absorbed. The result showed that all the binders have a high binding potential. However, pelletability was highest in treatment 1 which was also significantly different ($p < 0.05$) from all the other treatments. There were no significant differences ($p > 0.05$) in dustiness amongst the treatments. The water stability test shows that treatment 1 had the highest sinking time which was significantly different ($p < 0.05$) from the other treatments. Treatment 1 had the lowest volume of water, weight gain, sinking time index and absorption efficiency, respectively, which was not significantly different ($p > 0.05$) with treatment 2, but significantly different ($p < 0.05$) from the other treatments, with treatment 3 having the highest values in all of them respectively. Cassava flour proved to be the most efficient binder.

KEYWORDS: Binders, Formulated diets, Aquaculture, Quality feed.

INTRODUCTION

Successful aquaculture requires among others, the intake of feed sufficient in both quality and quantity (NRC, 1993). Quality fish feed are judged by their physical characteristics and nutrient content (Falayi, 2000). Formulation of a well-balanced diet and adequate feeding are among the major requirements for successful aquaculture. Fish feed are prone to leaching of nutrients at feeding due to poor and inadequate binding agents. This leads to instability and disintegration of food nutrients (Foster *et al.*, 1995), thereby leading to inadequacy in nutrient consumption by the fish in captivity as well as water pollution. (Falayi *et al.*, 2004). It is noteworthy that one of the factors militating against aquaculture development in Nigeria, which is high cost of feed, is still unsolved, so care should be taken to ensure that fish feed nutrients do not leach away due to poor binding as this will have an effect on fish growth, economic loss, reproduction rate as well as death (Teshima *et al.*, 1993).

Aquaculture feed can either be extruded or pelleted and should be durable in order to withstand handling, transportation and most importantly be of good water stability (Lim and Cuzon, 1994). The presence of starches in carbohydrate-rich ingredients like cassava, maize, potato and millet flours make them suitable candidates to be considered as binders (Bairagi *et al.*, 2002). Starch is a biopolymer, comprising of two types of macro-molecules; namely amylose and amylopectin (Brouillet-Fourmann *et al.*, 2003). One way to ensure that feed given to fish remains intact for their utilization is to formulate fish feed with a more stable binder. A good binding agent in the formulation of fish feed

will ensure that fish utilizes most of the nutrients if not all that is given to them. Binders are incorporated during feed formulation. It improves the efficiency of the feed manufacturing processes by reducing feed wastage and makes diets more water stable. Binding feedstuffs with binders help to achieve good quality pellets with good chemical, physical and biological potential (Storebakan, 1985). However, most farmers have little or no knowledge as to the selection of a binder to use during fish feed formulation. They are also confused on the water stability of any binder so chosen. Most of their decisions are based primarily on assumption. To add to this is the fact that the binding power of every binding agent primarily depends on the level of starch it contains (Ajayi, 2004) which most local fish farmers cannot comprehend.

Suffice it to say that fish feeds and its cost which happens to be one of the major factors militating against aquaculture development in Nigeria (Ajayi, 2004) is still unsolved. It is therefore most essential to bridge the gap between high costs of fish feed and loss of fish feed nutrients through leaching by formulating fish feeds with good binders. This will make pelleted fish feed nutrients available to fish and pollution to the culture medium is prevented. This study will therefore investigate and compare the binding effect, water stability and suitability of the locally available carbohydrate sources namely; cassava starch, maize starch, millet starch and potato starch for use as binders by farmers as well as recommend the best binding agent amongst the four.

MATERIALS AND METHOD

Prior to the commencement of the research, a survey was made to determine farmers' most commonly used binders in Abia State. Ten fish farmers were randomly selected in various parts of Abia State. These farmers were presented with a list of commonly available binders and from this; the four top ranking binders were used for this research. These were cassava (*Manihot esculenta*), maize (*Zea mays*), sweet potato (*Ipomoea batatas*) and millet (*Panicum milaeceum*). This work was carried out in the Department of Fisheries and Aquatic Resources Management, Michael Okpara University of Agriculture Umudike. The cassava tubers were collected from National Root Crops Research Institute Umudike. They were peeled, washed, cut into tiny pieces and sundried for 3 days. They were later milled with a milling machine and then sieved through a mesh to obtain cassava flour. Maize and millet grains were purchased from Umuahia market and milled into maize flour and millet flour using hammer mill. They were later sieved through a mesh. Potato tubers were purchased from the market, washed thoroughly, peeled and sundried for 3 days. It was milled with hammer mill and then sieved to obtain potato flour. Feed formulation was carried out using feed ingredients namely; fishmeal, soyabean, wheat offal, oil, salt and bone meal. They were bound with the four local binders namely cassava, maize, millet and potato flour to form the various diets.

An experimental diet with crude protein level of 35% was formulated. Four experimental diets were prepared each with a different binder. The diets were grouped into treatments namely: treatment 1 which was formulated using cassava flour as binder, treatment 2 which was formulated using maize flour as binder, treatment 3 which was formulated using millet flour as binder and treatment 4 was formulated using potato flour as binder, respectively. All the binders were in 10% inclusion levels in the diets. All the four treatments were replicated three times.

All the diets were formed into dough by mixing thoroughly with hot water and pelleted using meat mincer which served as a local pelleting machine using a 2mm die. The pellets obtained were oven dried at 50°C for 3 days.

Samples of feed ingredients and formulated feed were analyzed for proximate composition analysis according to AOAC (1990).

The following physical tests were conducted on the treatments (Fagbenro and Jauncey, 1995).

Pelletability

The pellets feed was sifted to separate the well-formed pellets from the unformed. The percentage pelletability was obtained by expressing the pellet weight to the total weight.

Dustiness

Sample pellet of fifty grams (50g) by weight was placed under normal stress conditions

such as handling, packaging etc for 2 weeks. The dust produced was then taken after sieving through 2mm sieve and measured as a percentage of the original weight sample.

The following water stability tests were conducted on the treatments.

Weight Gain

Five grams (5g) of feed sample was placed in a beaker containing 200ml of tap water. It was then allowed to stand with occasional gentle shaking i.e. for 20 seconds every 2 minutes for 20 minutes. Weight gained was determined by calculating the difference between initial and final weight of sample using a sensitive balance.

Weight gain (g) = $w_f - w_i$

Where w_f = final weight

w_i = initial weight

Sinking Time Rate

This was determined by dropping the pellets in water and using a calibrated stop watch and recorded in seconds.

Volume of Water Absorbed

The volume of water absorbed was determined in relation to the density of water 0.9979/cm³ at 25°C = 1g/cm³.

Therefore volume of water absorbed in cm³ = Mass (g) x density of water (g/cm³)

Relative Absorption Rate

This is determined thus = $\frac{w_f - w_i}{w_i} \times 100$

Where w_f = final weight

w_i = initial weight

Sinking Time Index

Sinking Time Index (Sec⁻¹) is calculated as = $1 / \text{time taken}$

Water Stability

Fifty grams (%) of the feed sample was placed in a beaker containing 200ml of tap water. It was then allowed to stand with occasional gentle shaking i.e. for 20 seconds every 2 minutes for 20 minutes. It was then sieved and the material retained was sundried. The retained dry weight was expressed as a percentage of the sample dry weight.

All the water stability indexes and weight gain test were for a period of 20 minutes in water.

The data collected was analyzed using one way Analysis of Variance (ANOVA) and significant in means were separated using Duncan Multiple Range test (Duncan, 1955). Percentages were transformed using arc sine transformation before subjecting to ANOVA (Gomez and Gomez, 1984).

RESULTS

Table 1 is the proximate composition analysis of the four formulated diets which were bound with the different binders, namely, cassava flour, maize flour, millet flour and potato flour, respectively. Table 2 is the proximate composition

analysis of the various feed ingredients use in the formulation of the various diets. Table 3 shows the physical parameters of the treatments. There was no significant difference ($p>0.05$) between treatments 2 and treatment 4 for pelletability. Treatment 1 which had the highest value of 98.00%, was significantly different ($p<0.05$) from the other three treatments with respect to pelletability, while treatment 3 had the least value of 92.6%. There was no significant difference ($P>0.05$) amongst the treatments for dustiness, however, treatment 1 had the least value of 3% while treatment 2 had the highest value of 7%.

Table 4 Shows water stability indices, absorption rate and sinking time of the various treatments. Treatment 1 has the highest sinking time rate which was significantly different ($p<0.05$) from the other treatments, while treatment 3 had the least.

Treatment 1 absorbed the lowest volume of water per 5g of sample weight which was not significantly different ($p>0.05$) from treatment 2, but significantly different ($p<0.05$) from the other treatments. Treatment 3 absorbed the highest volume of water of $19.50 \pm 0.50 \text{ cm}^3$. Treatment 1 had the lowest weight gain, sinking time index and absorption efficiency rate which were all not significantly different ($p>0.05$) from treatment 2, but were all significantly different ($p<0.05$) from the other treatments, with treatment 3 having the highest values in all of them respectively. The water stability test shows a significant difference ($P<0.05$) amongst the treatments with treatment 1 having the highest value of 84% and treatments 3 the lowest value of 74%. There were no significant difference ($p>0.05$) between treatment 2 and treatment 4 in water stability and sinking rate time.

Table 1. Proximate composition of the formulated diets.

PROXIMATE COMPOSITION							
FEEDS	CP	EE	CF	ASH	MC	NFE	FE/kcal
DIET 1	34.78	7.27	3.43	13.39	6.75	34.38	342.10
DIET 2	34.70	5.77	4.47	13.30	6.95	34.81	329.97
DIET 3	34.90	5.65	3.47	12.41	6.61	36.96	346.25
DIET 4	34.86	7.60	5.34	14.90	6.38	30.92	331.54

Table 2. Proximate analysis of the various feed ingredients.

PROXIMATE COMPOSITION							
FEEDSTUFFS	MC	CP	EE	CF	ASH	NFE	FE/kcal
Wheat offal	12.23	19.05	5.4	6.68	5.05	51.59	331.18
Soyabean	7.51	43.71	7.25	5.8	8.35	27.39	345.76
Fishmeal	6.08	48.31	6.37	3.9	14.3	21.04	334.73

Keys

CP = Crude Protein, EE = Ether Extract, CF = Crude Fiber, NFE = Nitrogen Free Extract, MC = Moisture Content, FE = Feed Energy

Table 3. Mean physical parameters of the different treatments used.

Variables	Treatments			
	1	2	3	4
Pelletability (%)	98.00 ± 0.00^a	95.60 ± 0.40^b	92.60 ± 0.60^c	94.60 ± 0.60^b
Dustiness (%)	3.00 ± 1.00^a	7.00 ± 1.00^a	6.00 ± 2.00^a	5.00 ± 1.00^a

Mean values with the same superscript letters in the same row were not significantly different ($P>0.05$). Data are mean values of the duplicate of the treatments \pm standard error.

Table 4. Mean sinking index, absorption rate and water stability of the different treatments used.

Variables	Treatments			
	1	2	3	4
Initial weight (g)	5.00 ± 0.00 ^a	5.00 ± 0.00 ^a	5.00 ± 0.00 ^a	5.00 ± 0.00 ^a
Final weight (g)	11.00 ± 1.00 ^c	14.00 ± 1.00 ^c	24.00 ± 0.50 ^a	19.00 ± 1.00 ^b
Weight gain (g)	6.00 ± 1.00 ^c	9.00 ± 1.00 ^c	19.50 ± 0.50 ^a	14.00 ± 1.00 ^b
Sinking Time Rate (secs)	1.73 ± 0.28 ^a	1.53 ± 0.02 ^{ab}	1.15 ± 0.01 ^b	1.28 ± 0.02 ^{ab}
Vol. of water absorbed (cm ³)	6.00 ± 1.00 ^c	9.00 ± 1.00 ^c	19.50 ± 0.50 ^a	14.00 ± 1.00 ^b
Relative absorption rate (%)	1.20 ± 20.00 ^c	1.80 ± 20.00 ^c	3.90 ± 10.00 ^a	2.80 ± 20.00 ^b
Sinking Time Index (sec ⁻¹)	0.60 ± 0.10 ^b	0.66 ± 0.01 ^b	0.88 ± 0.01 ^a	0.78 ± 0.01 ^{ab}
Absorption Efficiency				
Rate (cm ³ /Sec)	0.005 ± 0.00 ^c	0.008 ± 0.00 ^c	0.016 ± 0.00 ^a	0.012 ± 0.00 ^b
Water Stability (%)	84.00 ± 2.00 ^a	78.00 ± 2.00 ^{ab}	74.00 ± 2.00 ^b	76.00 ± 2.00 ^{ab}
Duration in water (mins)	20.00 ± 0.00 ^a	20.00 ± 0.00 ^a	20.00 ± 0.00 ^a	20.00 ± 0.00 ^a

Mean values with the same superscript letters in the same row were not significantly different (P>0.05). Data are mean values of the duplicate of the treatments ± standard error.

DISCUSSION

The use of synthetic binders in feed formulation has being very rampant and generally accepted, but their side effect is that most of them are non-biodegradable. This therefore, calls for binders of natural origin that will have no negative effect on the fish and resultant harm to the consumer. (Efiiong *et al.*, 2009). The result of the work shows that all the four binders can well be used as binding agents in feed formulation. This is evident in the palatability test and dustiness. Hardness of pellets is a measure of its strength, as such, fish feed need to be firm to withstand pressure. Dustiness is a measure of such. Treatment 1 prove to have the least value of dustiness which is an indication of firm diet, while treatment 2 had the highest value which may suggest lack of enough starch strength as a binding property. Pelletability is the ability of the feed to form pellets and to withstand breakage. Treatment 1 had the best pelletability value which maybe as a result of its lowest crude fiber value. This is in agreement with findings of Tihamiyu and Solomon (2012) who observed that in a pelletability test, the diet with the lowest crude fiber had the best pelletability value. Feed formulated using cassava flour as binder proved to have a better water stability index. The water stability index is an indication that the starch obtained from cassava flour is superior to the other starches used in the research. Rokey and Plattner (2003), reported that the amount of starch gelatinized during processing depends on the quality, starch type, particle size and processing condition. On the other hand, Kannadhasan *et al.*, (2009), reported that, starch getalinization during aquafeed processing affect feed digestibility, expansion and water stability. Falayi *et al.* (2006) reported that cassava starch was the best binder when a binding capacity of some natural and synthetic binders were understudied. The result from

this study also shows the same inferences with these findings as cassava flour prove to be a better binder than the others. Amylose content of starch dictates most of its uses and in most cases determine the properties of starch (Nuwamanya *et al.*, 2011). Nuwamanya *et al.* (2011) reported that firmness of feed increases as amylose content becomes higher, hence increasing resistance of starch to take up water. Ferouz *et al.* (2016) reported that starch with higher amylose content has better sinking velocity and water absorption index than starch with a lower or no amylose content. While starch with a higher amylopectin content exhibit a high expansion ratio. The better performance of cassava flour as a binder in comparison with the other binders may be as a result of its high amylose content. Cassava flour has proved to have a high amylose content together with wheat when compare with maize, millet and potato (Nuwamanya *et al.*, 2011).

The result is not in agreement with the observation of Efiiong *et al.* (2009) who observed a non significant difference in the water stability of experimental feeds bind with cassava starch and maize binders. These may be as a result of the variety of corn used, since he used guinea corn. The binders served the advantageous purpose of binding the dry ingredients as methods of improving the feed consistency, reduction of wastages through loss of feed nutrients to water. The other binders also exhibit a good binding effect though not better than cassava. Maybe at a particular percentage they may do better. Potato binder had the second best in the physical properties and a competing effect with maize in the water stability results.

CONCLUSION AND RECOMMENDATION

The result of this study shows that cassava starch has the advantage of producing a water stable diet. Cassava starch has been used as a feed

ingredient in fish feed. Its utilization as a binder is therefore encouraged, as this will be of economic important to the fish farmer serving as a nutrient source as well as binder enhancing feed stability in water. This will no doubt reduce feed wastage and improve water quality thereby stimulating healthy growth and performance in cultured fish. However, more research has to be conducted using other binders such as duckweeds, wheat flour, sorghum, molasses etc. in the formulation of fish feed in order to find more suitable binders for farm-made aqua feed production. Also percentage usage or incorporation of the binder can also be tested to see if there is a percentage that will enhance a better binding potential that this work couldn't bring out.

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