Comparative studies on the binding potential and water stability of duckweed meal, corn starch and cassava starch

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Abstract

Duckweed meal was experimented for its binding potential and water stability property in pelleted fish feed. Two sets of feeds formulated at 45% crude protein were used for the experiments. The first set had three experimental feed namely D_1, D_2 and D_3 containing duckweed meal, corn starch and cassava starch at 2% respectively used for Experiment 1 while the second set had four formulated feeds namely Diets A, B, C and D containing 0%, 10%, 20% and 30% duckweed meal respectively used for Experiment 2. The experimental feeds were observed for sinking time index, absorption efficiency rate, relative absorption rate and water stability. The result of the experiments showed that highest water stability indices were recorded from diets with duckweed meal used as feed binder compared to cornstarch and cassava starch. Water stability potential also increased with increasing levels of duckweed meal in the experimental feeds. Based on the results of this study, there are indications that the inclusion of duckweed meal in fish feeds could improve its binding potential and water stability. [New York Science Journal. 2009;2(4):50-57]. (ISSN: 1554-0200).

Keywords: Binding potential, water stability, duckweed meal, sinking time, absorption efficiency

Introduction

The success of any fish farming depends largely on the provision of suitable and economical fish feed through which optimum growth can be obtained.

When the composition of a feed is considered, more attention is given to those components, which provide nutrient to the cultured species at the required level (Akimuya, 1988; Eyo, 1994). Fish feed are lost in water system due to early disintegration and leaching, thus making nutrient unavailable to fish. The implications are poor weight gain, unhealthy environment and economic losses to farmers. Therefore fish feed must be bonded well to ensure stability in water and nutrients retention for a considerable period of time (Hilton and Slinger, 1981). There is still some wastage of nutrient due to the generous safety margin applied by feed manufacturers, which are brought about by instability of nutrients in pond water (N.R.C, 1983).

Binders are used in fish feed to improve the feed consistency, minimize wastage, reduce disintegration and loss of nutrients thereby increasing feed efficiency (Hastings, 1971; Storebakan, 1985). According to Stiver (1970) there are at least three actions by which binders increase the hardness, help the feed to float and increase water stability of pellets.

As a result of scarcity and high cost of fish feed components several studies have been carried out to evaluate different types of natural, modified or synthetic substances used as binding agents for aquatic feed which have been reviewed by Hung (1989) and Heinen (1981). In this study duckweed meal used as fish feed component due to its high nutritive value was assessed for its binding potential and water stability in pelleted fish feed.

Materials and methods.

Duckweed (*Lemna pauciscostata*) was collected in the out door concrete tank in the Hatchery Complex of the National Institute for Freshwater Fisheries Research, New Bussa, Nigeria.

They were harvested with the aid of scoop net and brought to the Federal College of Freshwater Fisheries Technology, New Bussa, Nigeria in a sack after which they were spread on a flat wooden surface and sun dried for 3 days. The dried duckweed was gathered and grounded to fine powder using a milling machine. The ground duckweed meal was sieved through a mesh size of 2mm and stored in a polythene bag.

The fixed ingredients used were fishmeal, soybean meal, groundnut cake, and yellow maize. Binders used along with duckweed meal were cassava starch and guinea cornstarch. All ingredients were obtained locally within New Bussa. Yellow maize grain and locally extracted groundnut cake (kulikuli) were milled separately into fine powder by the hammer-milling machine sieved to obtain small particle size. Raw soybean (*Glycine max*) grown locally around New Bussa was toasted before being grounded to powder.

The feed ingredients were weighed into a bowl using a sensitive weighing balance model OHAS-LS-400. The ingredients were made into diet of 5mm dough and pelleted manually with a pelleting machine. This helped the pellets to form very fine,, smooth and well-compacted pellets. The pellets were spread evenly and sun dried. Three feeds namely D_1, D_2, D_3, were prepared for Experiment 1 containing two percent duckweed, cassava starch and guinea cornstarch respectively as a binder (Table 1). Diet A, B, C, D were prepared for Experiment 2 containing 0%, 10%, 20% and 30% duckweed meal l respectively (Table 2). 0% served as control.

Table 1: Percentage composition of experimental feed (Experiment 1)

Ingredients	**D1**	**D2**	**D3**
Fish meal	30	30	30
Yellow maize	5	5	5
Soybean meal	30	30	30
Groundnut cake	29	29	29
Vitamin premix	2	2	2
Bone meal	1.5	1.5	1.5
Salt	0.5	0.5	0.5
Duck weed meal	2	----------	----------
Guinea corn starch	---------	2	---------
Cassava starch	----------	--- -------	2
Total	**100 %**	**100 %**	**100 %**

Table 2: Percentage composition of experimental feed (Experiment 2)

Ingredients (g)	**A (0%)**	**B (10%)**	**C (20%)**	**D (30%)**
Duckweed meal	0	2.6	5.2	7.8
Fish meal	26	23.4	20.8	18.2
Yellow maize	48	48	48	48
Soybean meal	15	15	15	15
Groundnut cake	6	6	6	6
Vitamin premix	2	2	2	2
Bone meal	2.5	2.5	2.5	2.5
Salt	0.5	0.5	0.5	0.5
Total	100	100	100	100

Six and eight aquaria glass tanks of 60 cm x 30 cm x 30 cm were used for the experiments 1 and 2 respectively. The glass tanks were properly washed and filled with clean water to half of its volume. Two glass aquaria tanks were allocated to each treatment. 1g each of the two experimental feeds were taken and dropped into each of the glass tanks respectively for 1 hour to determine their sinking index and absorption rate. 5 g each of the two experimental feeds were also taken and put inside a nylon sieve cloth and immersed in the glass tank for 1 hour to determine the water stability potential (Dry matter percentage).

Proximate composition of the following nutrients from the experimental feeds was determined using standard procedures of AOAC (2000): moisture, crude protein, lipid, crude fibre and ash.

Water stability indices.

The following water stability indices were calculated.

Weight gain. (g): This was computed from the difference between the initial and final weight measured using sensitive balance.

Weight gain (g) = $(W_f - W_i)$

Sinking time rate (S.T.R): calibrated Stopwatch was used for the timing and recorded in seconds

Volume of water absorbed: The volume of water absorbed was determined in relation to the density of water (1g/cm). Volume of water absorbed = Mass (g) x density of water (g/cm).

Relative absorption rate = $\frac{W_f - W_i}{W_i} \times \frac{100}{1}$

Absorption efficiency rate (cm^3/sec).

$$= \frac{\text{Volume of water absorbed}}{\text{Time taken}}$$

Sinking time index (Sec^{-1})= $\frac{1}{\text{Time taken}}$

Water stability (%)

$$= \frac{\text{Final sample wgt.(\%) X LDM}}{\text{Initial sample wgt (\%) X IDM}} \times \frac{100}{1}$$

Where W_f = Final sample weight, W_i= Initial sample weight, IDM = Initial sample dry matter, LDM = final sample matter (Fagbenro and Jauncey 1995).

Results

The proximate analysis of duckweed meal (Table 3) showed high percentage of crude fibre and ash, 14.5% and 14.13% respectively; low moisture and lipid contents-2.8% and 4.90% respectively. The crude protein was 34.8%. Table 4 shows the proximate analysis of the experimental feeds. Highest crude protein of 45.06% was recorded in 0% duckweed meal (control) while the lowest, 41.87% was analyzed from 30% duckweed meal inclusion. The 0% duckweed feed had the lowest crude lipid of 11.76% while 20% duckweed meal inclusion had the highest crude lipid of 14.29%. Ash content was within the range of 12.00 -13.23% in all the experimental feeds. There was no significant difference ($P \geq 0.05$) between the proximate compositions of the feeds at different duckweed inclusion levels.

Table 5 shows sinking index and absorption rate of cassava and corn starches compared with duckweed meal. From the results the experimental feed containing duckweed meal had the highest sinking time of 4 sec while the lowest , 2 sec was recorded in feed with cassava starch. The maximum absorption efficiency rate and relative absorption rate of 2.92x10-4 cm^{3}sec^{-1} and 105% respectively were recorded from feed with duckweed meal while the lowest values of 1.72x10-4 cm^{3}sec^{-1} and 62.0% respectively were recorded from feed with cassava starch. Fig. 1 shows the relativeness of the feed stability indices. There was no significant difference ($P \geq 0.05$) between the absorption efficiency from all the experimental feeds. The feed containing duckweed meal however had the highest sinking time and volume of water absorbed.

Table 6 shows water stability potential (Dry matter) of the experimental feeds containing duckweed meal, cassava starch and cornstarch. The highest water stability of 82.81% was recorded in Diet 3 (cassava starch) while the lowest of 78.85% was recorded in Diet 1 (duckweed meal) (Fig.2). There was no significant difference ($p \geq 0.05$) between the water stability of the experimental feeds.Fig.3 shows the water stability of duckweed meal at different inclusion levels. Water stability increased with increase in duckweed meal in the experimental feeds.

Table 7 shows the sinking index and absorption rate of the experimental feeds with different percentage inclusion of duckweed meal. The highest sinking time of 488sec was recorded from 30% duckweed meal inclusion while the lowest; 193 sec was recorded in 0% feed. The volume of water absorbed by the experimental feeds was lowest in 0% duckweed meal ($0.50cm^3$) and highest ($0.61cm^3$) in 30% duckweed meal. There was no significant difference ($P \geq 0.05$) between the water stability indices at different duckweed meal inclusion levels.

Sinking time index/sec was highest in 0% duckweed meal with $5.18x10^{-3}$ and lowest in 30% with $2.05x10^{-3}$. Table 8 shows water stability potential (dry matter) of feeds with different percentage inclusion of duckweed meal. Percentage water stability of 0% duckweed meal was 86.49%, 10% was 98.2%, 20% was 98.41% and 30% having 99.20%.

Table 3: Proximate composition of nutrients in duckweed meal

Component	Percentage (%)
Moisture content	2.80
Crude protein	34.80
Lipid	4.90
Crude fibre	14.50
Crude ash	14.13
Nitrogen free extract	43.37

Table 4: Proximate composition of nutrients in experimental feeds (Experiment 2).

Percentage inclusion of duckweed meal	Moisture content%	Crude protein%	Lipid%	Crude fibre%	Ash%
A (0%)	2.30	45.06	11.76	4.90	13.23
B (10%)	1.05	43.35	14.02	6.50	12.30
C (20%)	1.36	42.56	14.29	4.46	12.00
D (30%)	2.46	41.87	12.83	5.13	12.83

Table 5: Sinking index and absorption rate of binders used.

Indices	Diet 1 (Duckweed meal)	Diet 2 (Guinea corn starch)	Diet 3 (Cassava starch)
Initial weight (g)	1.0	1.0	1.0
Final weight (g)	2.05	1.90	1.62
Weight gained (g)	1.05	0.90	0.62
Duration in water	1 HOUR	1 HOUR	1 HOUR
Sinking time (seconds)	4.00	3.00	2.00
Sinking time index. (sec^{-1})	$2.5 X 10^{-1}$	$3.33 X10^{-1}$	$5.0 X 10^{-1}$
Volume of water absorbed	$1.05Cm^3$	$0.90Cm^3$	$0.62Cm^3$
Absorption efficiency rate (cm^3/sec)	$2.92 X 10^{-4}$	$2.50X 10^{-4}$	$1.72 X 10^{-4}$
Relative absorption rate %	105.0	90.0	62.0

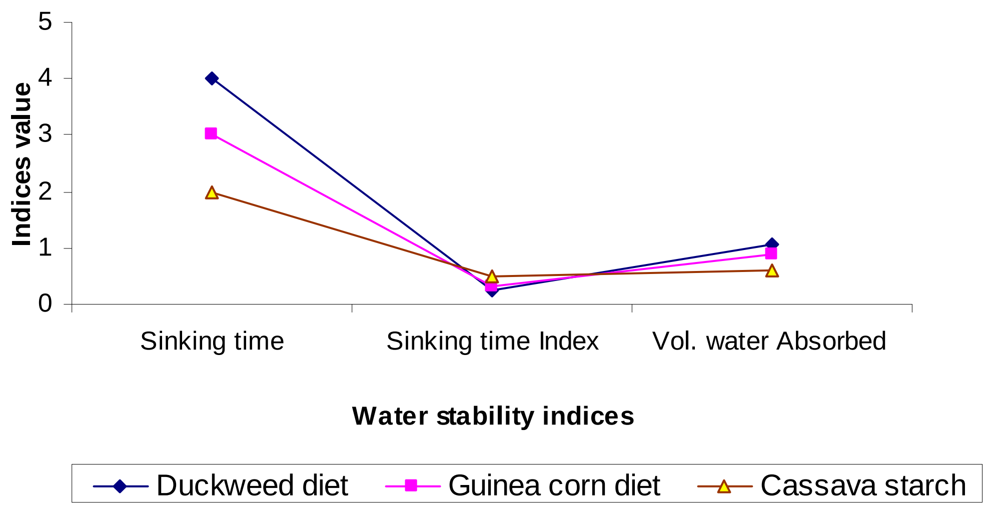

Figure 1.Relativeness of the feed stability indices

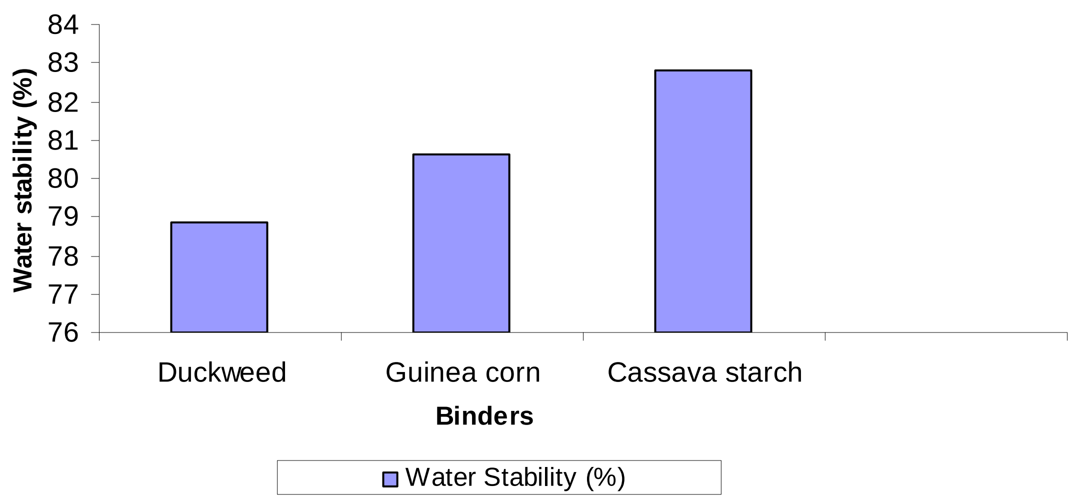

Figure 2. Variation in water stability (%) of different binders.

Table 6: Water stability potential (dry matter) of binders used

Parameter	**DIET 1 (duckweed meal)**	**DIET 2 (guinea corn starch)**	**DIET 3 (cassava starch)**
Initial weight (g)	5.0	5.0	5.0
Final weight (g)	4.40	4.46	4.54
Initial dry matter (g)	89.90	90.40	91.20
Final dry matter (g)	88.00	89.20	90.80
%Water stability	78.85	80.64	82.81

Table 7: Sinking index and absorption rate of diets with different percentage inclusion of duckweed meal.

Parameters	(a) 0% duckweed	(b)10% duckweed	(c) 20% duckweed	(d) 30% Duckweed
Initial weight (g)	1.0	1.0	1.0	1.0
Final weight (g)	1.50	1.51	1.60	1.61
Weight gained (g)	0.50	0.51	0.60	0.61
Sinking time (second $^{-1}$)	193	327	395	488
Duration in water	I HOUR	1 HOUR	1 HOUR	1 HOUR
Volume of water absorbed	0.50Cm^3	0.51Cm^3	0.60Cm^3	0.61Cm^3
Absorption efficiency rate (cm^3/sec)	1.39 X 10^{-4}	1.42 X 10^{-4}	1.67 X 10^{-4}	1.69 X 10^{-4}
Relative absorption rate %	50	51	60	61
Sinking time index. (Sec^{-1})	5.18 X 10^{-3}	3.06 X 10^{-3}	2.53 X 10^{-3}	2.05 X 10^{-3}

Table 8: Water stability potential (dry matter) of diets with different percentage of duckweed meal

Parameters	(a) 0% Duckweed meal	(b) 10% Duckweed meal	(c) 20% Duckweed meal	(d) 30% Duckweed meal
Initial weight(g)	5.0	5.0)	5.0	5.0
Final weight (g)	4.65	4.95	4.96	4.9
Initial dry matter {%)	90.86	97.52	97.85	97.15
Final dry matter (%)	84.50	96.55	97.07	95.21
% Water stability	86.49	98.02	98.41	96.04

Discussion

The use of synthetic binders in feed formulation has been a globally accepted technology but the norms of their side effect being non-biodegradable calls for more reliable binders of natural origin that will have no negative effect on the fish fed and harm to the consumer. Falayi *et al.* (2000) reported a comparative work on the binding capacity of some synthetic and natural binders. They reported that cassava starch was the best binder. The result from this study also shows the same inference.

The proximate analysis results were similar to the one reported by Skillicorn, *et. al* (1993) who stated that duckweed meal had 30% crude protein; ether extract, 6% along with nitrogen free extract, 45%. Ahahamad et al., (2003) also reported similar value of crude protein. Mbagwu and Adeniji (1988) and Mbagwu et al., (1987) both reported 4.40% as the maximum crude lipid content in duckweed meal while Culley and Epps (1973) and Culley *et al.* (1981) reported 6.3% as the maximum lipid content when they concluded analysis on various species of duckweed. The results from this experiment were similar to those reported by these authors. NRC (1993) reported that binders are incorporated into fish feeds to improve stability in water, increase pellet firmness, and reduce the amount of fines produced during processing and handling. The water stability indices calculated from this study showed no significant difference between duckweed meal, cassava starch and cornstarch incorporated feeds.

Conclusion and recommendation.

Duckweed meal has been in used as a feed ingredient in fish feed. Its utilization as a binder is therefore encouraged, as this will be of economic importance to the fish farmer serving as a nutrient source as well as a 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.

The result of this study shows the potential of duckweed meal being used as a binder to improve water stability in pelleted fish feed.

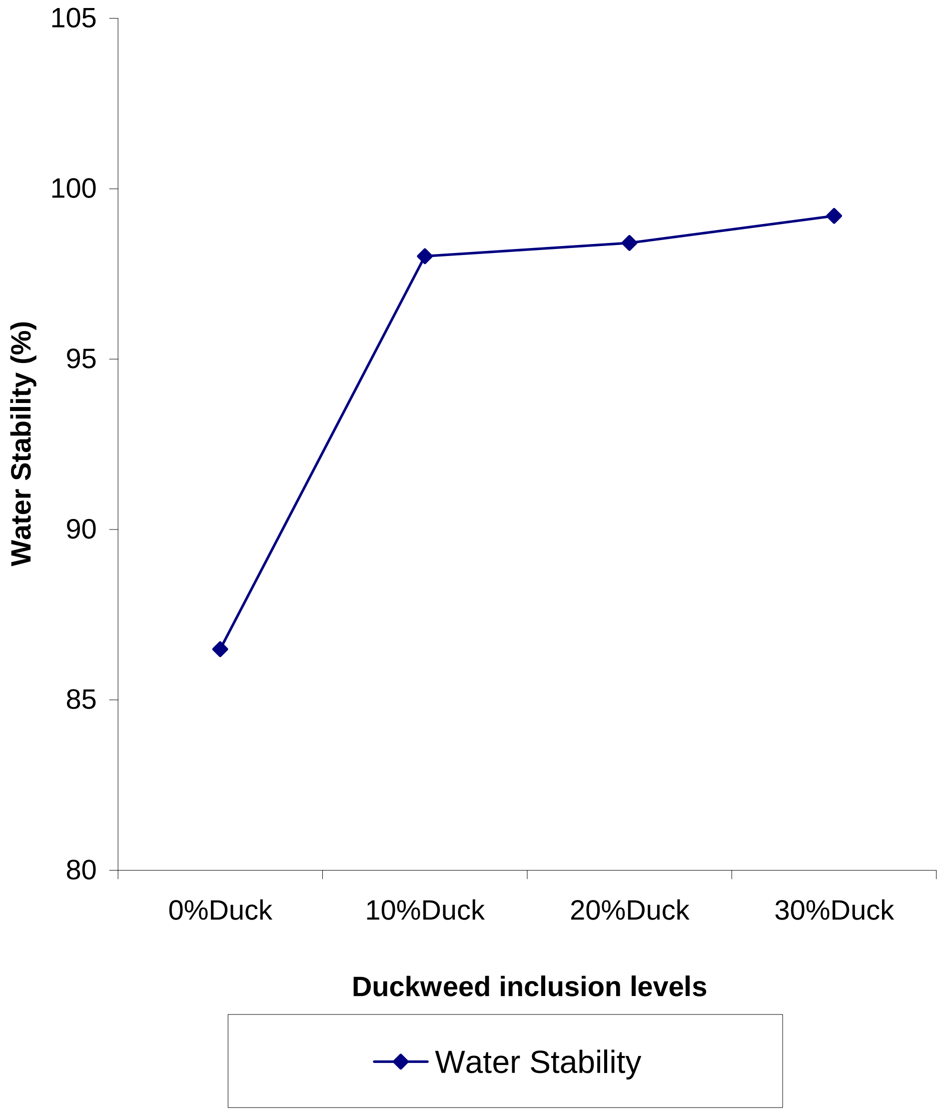

Figure 3. Water Stability of Duckweed meal at different inclusion levels.

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