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EFFECTS OF DIFFERENT GRAIN STARCHES AS FEED BINDERS FOR ON-FARM AQUA-FEEDS

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ABSTRACT

This study was carried out to screen and evaluate the effects of different grain starches namely millet starch (DT_1); rice starch (DT_2); guinea corn starch (DT_3); wheat starch (DT_4) and maize starch (DT_5) as feed binders for on-farm aqua-feed respectively. Starches obtained from these grains in addition with other feed ingredients were used to formulate five (5) isonitrogenous diets at 35% crude protein. The starches were incorporated into the diets at 5% inclusion levels. The evaluation of the physical parameters revealed that there were significant difference ($P<0.05$) in pelletability, hardness, dustiness, water stability and friability among the treatments (diets). The diet with wheat starch (DT_4) had the highest values of pelletability, water stability and lowest dustiness value. Similarly, the diet with millet starch (DT_1) had the lowest value for pelletability and highest value for dustiness. From this study, it revealed that the promotion of starch sourcing from natural carbohydrates (grains) could produce alternatives to conventional binders especially synthetic binders. It also revealed that among the grain starches screened and evaluated, wheat grain starch (DT_4) is superior to others and could be recommended as binder for on-farm aqua-feed.

KEY WORDS: Grain Starches; Feed Binder, AQUA-Feed, Pelletability Water Stability.

INTRODUCTION

The largest cost component in aquaculture production is feed, which constitute between 40-60% of the total operation costs of the farm. The major characteristics which affect the quality of fish feed include, colour, pellet size, shape, bulk density, water absorption and solubility, hardness or softness, resiliency, buoyance and water stability (Kazamzadeh, 1989). Pelleted feeds for terrestrial animals can be produced without applying a pelleting binding aid (binder). But producing pellets for aquatic animals (fish inclusive), the use of binder is a most. In aquaculture, mash feed will not only lead to leaching of nutrients in the feed but also pollute the water. Binders are products that are used to bind, glue or hold the various feed ingredients together in order to maintain pellet integrity (Baudon and Hancock, 2003). They are firming agents that are added to fish feed to improved the quality of pellets, water stability, hardiness and bulk density.

Starch is a biopolymer which comprises of two types of macro-molecules; namely amylase and amylopectin (Brouillet-Fourmann *et al*., 2003). It is well known that a key modification during processing is micro molecular degradation of starch which affects both amylase and amylopectin components (Colonna and Mercier, 1983; Davidson *et al*., 1984). Starch an important carbohydrate constituents is best characterize d in terms of loss of crystallinity and gelatinization during processing (Colonna *et al*., 1984; Gomez and Aguilera. 1984; Chinnaswamy *et al*; 1989). Starch plays a vital role in the production of floating and sinking pellet feeds because it acts as a binder and impacts product expansion. Riaz (1997), reported that the minimum starch content needed for floating and sinking pelleted feeds are generally between 18-22 and 5-11% respectively.

In most fish feed industries (floating and sinking pelleted feeds), there is great demand for the use of binders. However, the type of binders used in most cases are synthetic in nature which are imported, adding to the prohibitive cost of feed as well as unavailability of the synthetic binders.

There is the need for local sourcing of natural binders (starches) to assist small scale fish farmers who should rely principally on on-farm aqua feed. Great potential abound in the tropics for the establishment of starch manufacturing industries in view of abundance of agricultural crops (grains) that could be harnessed for starch production which could also be used as binders for on-farm aqua-feed production. Among most common agricultural cereal grains are millet (*pennisetum typhoides*); rice (*Oryva stiva*); guinea-corn (*Sorghum vulgare*); maize (*Zea mays*) and wheat (*Tritichum aestiuum*).

Therefore, this study was carried out to screen the various grain cereals locally available for starch and test for their physical properties such as pelletability, hardness, water stability etc which will invariably assist in their incorporation in on farm aqua feed and thus

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reduce dependence on synthetic binders and also cost.

MATERIALS AND METHODS

Starch Processing

1 Kg of each of the five (5) cereal grains namely millet; guinea-corn; maize; wheat and rice were soaked in water over night with the exception of the polished rice. Thereafter, the top water was decanted while the grains were washed, destoned and other foreign materials removed. Each of the grains were ground separately using domestic hammer mill grinding machine. The pastes of each grain was diluted with 1 litre water to make a solution. The solutions were then sieved using cheese muslin cloth to obtain the starch soluble filtrate. The starch soluble filtrate of each cereal grain was left to stand over night after which the supernatant was decanted to obtain the wet starch. Thereafter sun dried to obtain dried starch of each cereal grain.

DIET PREPARATION AND PELLETING

Five (5) isonitrogenous diets were formulated with the starches from the 5 (five) cereal grains incorporated for the different diets at 5% as shown in Table 1. The different grain starches were incorporated in its raw form with other ingredients and hot water was then added, stirred thoroughly to obtain a good dough. The formed dough was then fed into a motorized millet (pelleter) with a 3mm die. The pellet strands were cut at 5mm length, sun dried and packaged.

EVALUATION OF PHYSICAL PROPERTIES OF THE PELLETS.

The following physical tests were conducted on the five (5) prepared pellets, namely; pelletability, hardness; dustiness, friability and water stability as reported by Orire *et al*., 2001 and Orire *et al*; 2005.

Pelletability: This is the pellet integrity of the diet. The percentage (%) pelletability was obtained by expressing the total number of well-formed pellets as percentage of the total number of pellets produced. The pellets were separated; the well-formed from the unformed pellet.

Hardness: This the degree of firmness of the pellets. The procedure used was to determine the force required to cause a pellet to fragment under pressure. A pellet sample of 5mm in length was placed longitudinally between two (2) rods in an improvised pentagon nut, and gently tighten the grip. The pentagon nut was then turned or screwed and the calibration read at the point when the pellets get broken. This procedure was repeated for 30 pellets and then the mean value taken.

Dustiness: This is the degree of powder or dust found in each of the pelleted diets. This parameter was evaluated by weighing 50g of each pellet sample and placed under normal stress-condition, such as handling, packaging and repackaging, transportation for a period of 2-4 weeks. Then the dust particles produced by these activities was collected through a 2mm sieve and its weight expressed as a percentage of the original sample weight.

Friability: Fifty grams (50g) of pellets sample of each diet was put in a container and fixed on to a rotary machine at different preset speed levels of rotation per minute) (rpm) (e.g. 20, 30 and 40 rpm) for 20 minutes. The dust generated from the agitated pellets was then collected through 2mm sieve and was weighed and expressed as a percentage of the sample weight.

Water Stability: Fifty grams (50g) of the pellet samples was placed in a beaker which contains about 200ml of tap water. Then allowed to standstill but with an occasional gentle shaking for 20 seconds every 2 minutes for 20 minutes. The content of the beaker was then pass over a 2mm sieve, the particles retained was then sun dried and then weighed. The weight obtained was then expressed as a percentage (%) of the original sample.

Experimental Design:- A completely randomized designed was adopted and all treatments were triplicated for pelletability, hardness, friability, dustiness, water-stability. While 5 x 4 factorial design i.e 5 starches with 4 levels of rpm was adopted for pellet friability.

Statistical Analysis:- The data collected were subjected to arc-sine transformation (Zar. 1984) before being analysed by a One-way Analysis of Variance (ANOVA). Means comparison was done using multiple range test (Steel and Torrie, 1960).

RESULTS

Table 1 shows the percentage composition of the experimental diets from various grains starches as feed binders. Similarly, Table 2 shows the proximate composition of the experimental diets. There was no significant difference (P>0.05) in percentage moisture, crude protein and crude fibre contents of the experiment diets. However, the ash, ether extract and nitrogen free extract contents differed significantly (P<005). Tables 3 and 4 depict the evaluation of physical parameters of the different grain starches as feed binders.

Pelletability: The evaluation of pelletability of the grain starches showed that there was signficiant difference (P<0.05) among the diets. The diet with wheat starch (DT_4) had the highest percentage pelletability (96.36%) while that with millet starch (DT_1) had the least percentage pelletability.

Hardness: Pellet hardness evaluation showed that there was significant difference (P<0.05) among the diets. The diet with rice starch (DT_2) had the highest percentage hardness (6.20%) while that of millet starch (DT_1) had the least (4.50%).

Dustiness: The dustiness evaluation differed significantly (P<0.05) among the treatment diets. Diet with millet starch (DT_1) had the highest (0.08%) while lowest dustiness was recorded for diet DT_1 and DT_5 both having 0.04%.

Water Stability: The evaluation of water stability showed that there was significant difference (P<0.05) among the diets. DT_4 had the highest water stability of 48.12% while DT_3 had the least of 46.22%.

Friability Evaluation

The evaluation of friability of starches in different treatments (diets) is represented in Table 4. There was significant difference (P<0.05) of the evaluation of friability among the starches in 20; 30 and 40 rotation per minute respectively. Percentage friability was highest for millet starches (DT_1) at 0.06; 0.06 and 0.07 for 20; 30; 40 rotation per minutes respectively. While the friability was lowest for wheat starches at 0.04; 0.05 and 0.06 and 0.07 for 20; 30; 40 rotation per minutes respectively. While the friability was lowest for wheat starches at 0.04; 0.05 and 0.06 for 20; 30 and 40 rotation per minutes respectively.

DISCUSSION

Apart from being able to withstand the rigour of handling and transportation, aqua feeds should also be relatively stable in water, minimizing disintegration and loss of nutrients due to leaching. Water stability of aqua feeds are influenced by a number of factors among which are, diet composition, the manufacturing process and the nature of the binders used (De Silva and Anderson, 1995). Wheat starch (DT_4), had the lowest crude fibre content and perhaps this account for while it has the best pelletability. Pellet durability is a direct measurement of a pellet's ability to withstand breakage and disintegration (Chang and Wang, 1988; Chang *et al*., 1999). It is also an indirect measure of mechanical strength, which is a very important quality of feed material (Rosentrater *et al*., 2005). Diet 4, similarly had the lowest ether extract values. Fat and oil had been known to affect pelletability. This finding is similar to that reported by Scheideler (1995) and Chevanan *et al*, (2007) that ingredients such as fat can decrease the pellet quality and durability.

The hardness of a pellet is also a measure of the strength, aquafeeds unlike livestock feed require adequate level of hardness. Such feed should be hard and firm and maintain reasonable degree of stability in aquatic medium long enough for fish to consume it. This quality of pellets is being exhibited by both DT_2 and DT_4. This findings is similar to that reported by Wood (1993) who reported that for optimum availability and utilization of diet by target fish, such aquafeed should be hard and firm to avoid disintegration in water. Similarly, DT_4 was observed to have least percentage degree of dustiness which in an indication that the diet was firm. While DT_1 had the highest dustiness which may be attributable to lack of enough starch as a binding property.

The water stability index was highest for treatment DT_4 and lowest for DT_1 an indication of superior binding properties. Therefore the starch produced from wheat can be said to be superior to other starches. This findings is supported by Rokey and Plattner (2003), they reported that the amount starch gelatinized during processing depends on the quality and starch type, particle size and processing condition. Similarly, Kannadhason *et al*., (2009), they also reported that, starch getalinization during aquafeed processing affect feed digestibility, expansion and water stability.

The evaluation of friability indicated that DT_4 had the least friability percentages an indication that the pellet yielded minimum dust and exhibited good water stability as also reported by Glencross and Hawkinson (2007). They reported that wheat starches have a superior binding properties than other grains starches.

From this study, it had revealed that natural grain starches can support aquafeed pelletability instead of synthetic binders which are not readily available and affordable by fish farmer. The use of these grain starches as aqua feed binders may also have beneficial advantages which include availability of raw materials; nutritional contribution, affordability, minimize feed cost and conserves foreign exchange instead of importing synthetic binders for aqua feed. The starch from wheat source showed superiority over other grain starches in terms of pelletability, water stability and lowest dustiness even though rice starches diet had the highest hardness.

Table 1: Percentage Composition of the Experimental Diets with various grain starches as feed binders.

	DIETS				
Ingredients	**1**	**2**	**3**	**4**	**5**
Fishmeal	20.00	20.00	20.00	20.00	20.00
Soybean Meal	49.06	49.06	49.06	49.06	49.06
Yellow Maize Meal	9.97	9.97	9.97	9.97	9.97
Rice Bran Meal	9.97	9.97	9.97	9.97	9.97
Millet Starch	5.00				
Rice Starch		5.00			
Guinea-Corn Starch			5.00		
Wheat Starch				5.00	
Maize Starch					5.00
Vitamin-Mineral Premix	5.00	50.00	5.00	5.00	5.00
Salt	0.50	0.50	0.50	0.50	0.50
Oil	0.50	0.50	0.50	0.50	0.50
TOTAL	100.00	100.00	100.00	100.00	100.00

Diet 1 - Millet Starch
Diet 2 - Rich Starch
Diet 3 - Guinea-Corn Starch
Diet 4 - Wheat Starch
Diet 5 - Maize Starch

Table 2: Proximate composition of the experimental diets

% Composition	DIETS 1	2	3	4	5
Moisture	7.50^{a}	8.25^{a}	8.00^{a}	7.75^{a}	8.15^{a}
Ash	12.00^{a}	15.25^{b}	13.75^{a}	14.65^{ab}	16.00^{b}
Crude Protein	34.85^{a}	35.15^{a}	35.05^{a}	34.90^{a}	35.00^{a}
Crude Fibre	9.50^{a}	9.50^{a}	9.25^{a}	9.05^{a}	9.15^{a}
Ether Extract	12.25^{b}	9.75^{a}	10.75^{a}	9.20^{a}	12.00^{b}
*Nitrogen Free Extract	23.90^{b}	22.10^{ab}	23.20^{b}	23.05^{ab}	19.70^{a}
TOTAL	100.00	100.00	100.00	100.00	100.00

*Determined by Subtraction from 100 percentage of other parameters.

Diet 1 – Millet Starch
Diet 2 – Rice Starch
Diet 3 – Guinea-Corn Starch
Diet 4 – Wheat Starch
Diet 5 – Maize Starch.

Table 3: Evaluation of Physical Parameters of the Grain Starches as Feed Binders

Parameters (%)	DIETS 1	2	3	4	5
Pelletability	50.42^{a}	69.92^{b}	71.92^{b}	96.36^{b}	70.46^{ab}
Hardness	4.50^{a}	6.20^{b}	5.30^{ab}	6.10^{b}	5.40^{b}
Dustness	0.08^{c}	0.06^{ab}	0.05^{ab}	0.04^{a}	0.04^{a}
Water Stability	46.72^{a}	46.92^{ab}	46.22^{a}	48.12^{b}	46.72^{ab}

Data on the same row carrying different superscripts differed significantly from each other ($P<0.05$).

Diet 1 – Millet Starch - (DT_1)
Diet 2 – Rice Starch - (DT_2)
Diet 3 – Guinea-Corn Starch - (DT_3)
Diet 4 – Wheat Starch - (DT_4)
Diet 5 – Maize Starch - (DT_5)

Table 4: Evaluation of Friability of Grain Starches (%)

Starches	Rpm 20	Rpm 30	Rpm 40
Millet (DT_1)	0.60^{b}	0.06^{ab}	0.07^{ab}
Rice (DT_2)	0.05^{ab}	0.07^{b}	0.07^{ab}
Guinea-Corn (DT_3)	0.05^{ab}	0.05^{a}	0.06^{a}
Wheat (DT_4)	0.04^{a}	0.05^{a}	0.06^{a}
Maize (DT_5)	0.05^{a}	0.05^{a}	0.07^{ab}

Data on the same column carrying different superscripts differed significantly ($P<0.05$) from each other.
rpm - rotation per minute

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