

## WATER STABILITY OF AQUAFEED PELLETS USING BINDERS FROM SELECTED ROOT AND TUBER CROPS

By

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### ABSTRACT

This study was carried out to evaluate the water stability of aquafeed pellet using starch from yam (*Dioscorea rotundata*), sweet potatoes (*Ipomea batatas*), cassava (*Manihot esculenta*) and cocoyam (*Colocasia esculenta*) as binders. The starches obtained from these roots and tubers in addition with other feed ingredients were used to formulate four (4) isonitrogenous diet at 25% crude protein. The root and tuber starches were incorporated into the diet at 10% and 20% inclusion level. Results obtained showed that at 10 % inclusion level of binders, the leached weight of feed was significantly higher ( $p < 0.05$ ) in DT<sub>3</sub> ( $8.41 \pm 0.59$  g) containing sweet potato starch with percentage stability of  $42.83 \pm 0.12$  % and least ( $2.34 \pm 1.34$  g) in DT<sub>2</sub> (cocoyam starch) with percentage stability of  $68.25 \pm 0.51$  %. At 20 % inclusion level, leached weight of feed was significantly higher ( $p < 0.05$ ) higher in DT<sub>4</sub> ( $3.71 \pm 0.46$  g) containing yam starch with percentage stability of  $63.16 \pm 0.01$  % and least ( $1.22 \pm 0.15$  g) in DT<sub>2</sub> (sweet potato starch) with percentage stability of  $88.88 \pm 0.10$  %. Findings of this study revealed that starch obtained from natural root and tuber crops have good binding ability in aquafeed which enhances water stability. Also, water stability of aquafeed pellets can be significantly improved by proper selection of feed ingredients, techniques and equipment used in processing and binder incorporation at the correct inclusion level. Therefore, optimal water stability could be achieved by incorporating sweet potato and cassava starch as binders in aquafeed at 10 % inclusion level.

Keywords: Water stability, Fish feed, Pellets, Binder, Root crops, Tuber crops

### 1.0 INTRODUCTION

Aquaculture feeds which is either extruded or pelleted should be of high durability to withstand processing, transportation and handling stress (Lim and Cuzon, 1994). High quality aquafeed should possess a high water stability index to reduce leaching of nutrients and disintegration and upon exposure to fish culture water (Eyo, 2013). Production and usage of a water stable pellet will ensure optimal utilization of available nutrients by the fish. Also, there will be minimum wastage which is of utmost economic benefit to aquaculture operations with regards to nutrient utilization especially in the application of the broadcasting method. (Sadiku and Jauncey 1995; Wood, 1993). In aquafeed industries, water stability in fish feeds is greatly improved through the use of binders. According to Lim and Cuzon (1994), a wide variety of binders obtained from natural, modified or synthetic products have been successfully used in aquafeeds. Aquafeeds should be firm to handling and should exhibit a reasonable degree of stability in fish culture water, long enough for fish to consume it (Fagbenro and Jauncey, 1995, Misra *et al*; 2003). A stable pelleted feed formulated with a good binder will prevent leaching of nutrients in a feed (Sadiku and Jauncey, 1995; Tihamiyu *et al*; 2003a; Tihamiyu *et al*; 2003b). Starch plays a major role in binding feed as well as promoting pellet expansion during feed

production process. Riaz (1997) reported 18 to 22% as the minimum starch contents required for floating pellets and 9 to 11 % for sinking pellets respectively. Interestingly, Rokey and Plattner (2003) maintained that the amount of starch gelatinized during feed processing is dependent on the type of starch, processing conditions and particle size. Studies have been documented on the use of alternative binders in fish feed such as baobab leaf meal (*Adansonia digitata*) reported by Eze and Eyo (2018); local starch source and yeast (Solomon *et al.*, 2011). The role of binders in aqua-feed cannot be overemphasized but the high cost and unavailability of conventional synthetic binders become a serious challenge for farmers who depend on farm-made feed or locally formulated feed. This has resulted in farmers searching for alternative binders for feed formulation. Therefore, this study was carried out to evaluate the water stability of aquafeed pellet using starch from yam (*Dioscorea rotundata*), sweet potatoes (*Ipomea batatas*), cassava (*Manihot esculenta*) and cocoyam (*Colocasia esculenta*) as binders.

## **2.0 Materials And Method**

### **2.1 Collection of Root and Tubers**

Tubers of yam (*Dioscorea rotundata*) and cassava (*Manihot esculenta*) and root of sweet potatoes (*Ipomea batatas*) and cocoyam (*Colocasia esculenta*) were bought from Watt Market, Calabar, Cross River State.

### **2.2 Processing of tubers and roots to binders**

The raw fresh roots and tubers such as cocoyam, cassava, yam and sweet potatoes were peeled, washed and grounded separately using domestic hammer mill grinding machine. The pastes from each of the roots and tuber source were diluted with sufficient water to make a solute before sieving the solution with muslin cloth to obtain the starch soluble filtrates. The solution was then allowed to stay over-night for thorough separation. The supernatants were decanted to obtain the starches, which were sun dried for about 6 hours and package for use.

### **2.3 Feed preparation and formulation**

The experimental feed was formulated using the Pearson square method to contain 25 % crude protein. Groundnut cake, fish meal and soybean meal were used as protein supplement while as maize was used as the basal feed ingredient. Vitamins and mineral premix were also included in their required percentage. Table 1 and 2 shows the percentage composition of the experimental diets at 10% and 20 % inclusion level of binders obtained from roots and tubers of crops.

Table 1: Percentage composition of the experimental diet at 10% inclusion level of binders obtained from roots and tubers of crops

| FEEDSTUFF           | DT <sub>1</sub> (CAS) | DT <sub>2</sub> (COS) | DT <sub>3</sub> (SPS) | DT <sub>4</sub> (YAS) |
|---------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Soybean meal        | 11.24                 | 11.24                 | 11.24                 | 11.24                 |
| White maize         | 56.25                 | 56.25                 | 56.25                 | 56.25                 |
| Groundnut cake      | 11.24                 | 11.24                 | 11.24                 | 11.24                 |
| Fishmeal            | 11.24                 | 11.24                 | 11.24                 | 11.24                 |
| Vit/mineral premix  | 5.00                  | 5.00                  | 5.00                  | 5.00                  |
| Cassava starch      | 10.00                 | -                     | -                     | -                     |
| Cocoyam starch      | -                     | 10.00                 | -                     | -                     |
| Sweet potato starch | -                     | -                     | 10.00                 | -                     |
| Yam starch          | -                     | -                     | -                     | 10.00                 |
| Salt                | 0.50                  | 0.50                  | 0.50                  | 0.50                  |

\*CAS = Cassava Starch, COS = Cocoyam Starch, SPS = Sweet potato starch, YAS = Yam starch

Table 2: Percentage composition of the experimental diet at 20% inclusion level of binders obtained from roots and tubers of crops

| FEEDSTUFF           | DT <sub>1</sub> (CAS) | DT <sub>2</sub> (COS) | DT <sub>3</sub> (SPS) | DT <sub>4</sub> (YAS) |
|---------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Soybean meal        | 11.24                 | 11.24                 | 11.24                 | 11.24                 |
| White maize         | 56.25                 | 56.25                 | 56.25                 | 56.25                 |
| Groundnut cake      | 11.24                 | 11.24                 | 11.24                 | 11.24                 |
| Fishmeal            | 11.24                 | 11.24                 | 11.24                 | 11.24                 |
| Vit/mineral premix  | 5.00                  | 5.00                  | 5.00                  | 5.00                  |
| Cassava starch      | 20.00                 | -                     | -                     | -                     |
| Cocoyam starch      | -                     | 20.00                 | -                     | -                     |
| Sweet potato starch | -                     | -                     | 20.00                 | -                     |
| Yam starch          | -                     | -                     | -                     | 20.00                 |
| Salt                | 0.50                  | 0.50                  | 0.50                  | 0.50                  |

\*CAS = Cassava Starch, COS = Cocoyam Starch, SPS = Sweet potato starch, YAS = Yam starch

### 2.3.1 Pelleting of Experimental Feed

After mixing of the feed ingredients as shown in Table 1 and Table 2, hot water was added and stirred continuously until a homogenous dough was obtained. The formed dough was pelleted using 4mm dice. The pellets were collected and sundried carefully for 3 days and packed afterwards.

### 2.3.2 Experimental Set-Up

Twelve (12) glass aquaria of 20 liters capacity measuring  $50 \times 29 \times 25 \text{ cm}^3$  was filled to  $\frac{3}{4}$  of its holding capacity with tap water. The aquaria were labeled A<sub>1</sub>, A<sub>2</sub>, A<sub>3</sub>, B<sub>1</sub>, B<sub>2</sub>, B<sub>3</sub>, C<sub>1</sub>, C<sub>2</sub>, C<sub>3</sub>, D<sub>1</sub>, D<sub>2</sub> and D<sub>3</sub>. The experiment was conducted in triplicate. A<sub>1</sub>, A<sub>2</sub>, and A<sub>3</sub> were used for DT<sub>1</sub>, B<sub>1</sub>, B<sub>2</sub>, and B<sub>3</sub> was used for DT<sub>2</sub>, C<sub>1</sub>, C<sub>2</sub> and C<sub>3</sub> was used for DT<sub>3</sub>, D<sub>1</sub>, D<sub>2</sub> and D<sub>3</sub> was used for DT<sub>4</sub>.

### 2.3.3 Water Stability Test

Triplicate samples (10g) containing 15 single pellets for each diet was put in nylon in a sieve material of 0.1mm, tied with a twine carefully to avoid breaking of the feeds and was slowly immersed in the aquarium set-up above. All samples were allowed to remain in the aquarium for a test period of 60 minutes. The set-up was observed every 10 minutes interval. After the 60 minutes test period, the samples were lifted slowly with the aid of the twine and allowed to drain for 3 minutes, and the content put on a flat board and sun-dried, weighed to obtain the weight which represents the left over from the original 10g after immersion for each test period. The water stability of the test feed was expressed as a percentage of sample dry weight as follows:

$$\text{Water stability} = \frac{\text{Initial Feed Weight}}{\text{Final Feed Weight}} \times 100$$

### 2.3.4 Proximate Analysis of the Experimental Diets

Proximate analysis of the experimental diets was done according to standard methods and protocols given by AOAC (2000). Lipid and protein were determined by the soxhlet extraction and micro kjeldahl of samples.

### 2.3.5 Statistical Analysis

Data were subjected to One-way Analysis of Variance (ANOVA) using Predictive Analytical Software (PASW) version 18 at a probability level of  $P = 0.05$ . effect with a probability of  $p < 0.05$  were considered significant.

## 3.0 RESULTS

### Proximate Composition of the Experimental Diet

Proximate composition of the experimental diets at 10% and 20% inclusion levels of binders from root and tuber sources (Table 3) showed that ash content was highest in DT<sub>1</sub> (cassava starch) with  $9.43 \pm 0.01$  % at 10% inclusion level, followed by  $9.01 \pm 0.01$  % for DT<sub>3</sub> (sweet potato starch) at 10 % inclusion level and DT<sub>4</sub> (yam starch) and least ( $8.22 \pm 0.01$  %) in DT<sub>1</sub> (cassava starch) at 20 % inclusion level. Lipid content was highest in DT<sub>2</sub> (cocoyam starch) with  $9.10 \pm 0.01$  % at 10% inclusion level, followed by  $8.90 \pm 0.01$  % for DT<sub>4</sub> (yam starch) at 10 % inclusion level and least ( $7.19 \pm 0.01$  %) in DT<sub>1</sub> (cassava starch) at 20 % inclusion level. Fibre content was highest in DT<sub>4</sub> (yam starch) with  $8.02 \pm 0.01$  % at 10% inclusion level, followed by  $7.71 \pm 0.01$  % for DT<sub>2</sub> (cocoyam starch) at 10 % inclusion level and least ( $6.10 \pm 0.01$  %) in DT<sub>3</sub> (sweet potato starch) at 20 % inclusion level. For crude protein, DT<sub>4</sub> (yam starch) had the highest value of  $25.92 \pm 0.01$  % at 10% inclusion level, followed by  $25.19 \pm 0.01$  % for DT<sub>2</sub> (cocoyam starch) at 10 % inclusion level and least ( $23.75 \pm 0.01$  %) in DT<sub>3</sub> (sweet potato starch) at 20 % inclusion level. For nitrogen free extract (NFE), DT<sub>1</sub> (cassava starch) had the highest value of  $47.29 \pm 0.02$  % at 20% inclusion level, followed by  $45.94 \pm 0.01$  % for DT<sub>3</sub> (sweet potato starch) at 20 % inclusion level and least ( $40.78 \pm 0.03$  %) in DT<sub>4</sub> (yam starch) at 10 % inclusion level.

### 3.1 Water Stability of Experimental Feed After 60-Minute of Exposure

Results obtained showed that at 10 % inclusion level of binder, leached weight of feed was highest ( $8.41 \pm 0.59$  g) in DT<sub>3</sub> (sweet potato starch) with percentage stability of  $42.83 \pm 0.12$  %, followed by  $8.07 \pm 0.19$  g recorded for DT<sub>1</sub> (cassava starch) with percentage stability of  $49.73 \pm 0.10$  %, followed by  $5.76 \pm 0.99$  g obtained for DT<sub>4</sub> (yam starch) with percentage stability of

58.92  $\pm$  0.01 % and least (2.34  $\pm$  1.34 g) in DT<sub>2</sub> (cocoyam starch) with percentage stability of 68.25  $\pm$  0.51 %. At 20 % inclusion level of binder, leached weight of feed was highest (3.71  $\pm$  0.46 g) in DT<sub>4</sub> (yam starch) with percentage stability of 63.16  $\pm$  0.01 %, followed by 2.89  $\pm$  0.29 g recorded for DT<sub>1</sub> (cassava starch) with percentage stability of 71.33  $\pm$  0.20 %, followed by 2.27  $\pm$  0.84 g obtained for DT<sub>4</sub> (cocoyam starch) with percentage stability of 87.67  $\pm$  0.10 % and least (1.22  $\pm$  0.15 g) in DT<sub>2</sub> (sweet potato starch) with percentage stability of 88.88  $\pm$  0.10 %.

**Table 3: Proximate composition of the experimental diet at 10 % and 20 % inclusion level**

| Indices             | DT <sub>1</sub> (CAS) |            |         | DT <sub>2</sub> (COS) |            |         | DT <sub>3</sub> (SPS) |            |         | DT <sub>4</sub> (YAS) |            |         |
|---------------------|-----------------------|------------|---------|-----------------------|------------|---------|-----------------------|------------|---------|-----------------------|------------|---------|
|                     | 20 %                  | 10%        | P-value | 20%                   | 10%        | P-value | 20%                   | 10%        | P-value | 20%                   | 10%        | P-Value |
| <b>Moisture (%)</b> | 7.37±0.00             | 7.91±0.01  | 0.0001  | 7.49±0.01             | 7.83±0.01  | 0.0022  | 8.21±0.01             | 7.59±0.01  | 0.0007  | 7.21±0.01             | 7.60±0.01  | 0.0003  |
| <b>Ash (%)</b>      | 8.22±0.01             | 9.43±0.01  | 0.0001  | 8.49±0.01             | 9.32±0.01  | 0.0003  | 8.82±0.01             | 9.01±0.01  | 0.0055  | 9.01±0.01             | 8.80±0.01  | 0.0030  |
| <b>Lipid (%)</b>    | 7.19±0.01             | 8.24±0.01  | 0.0002  | 7.89±0.01             | 9.10±0.01  | 0.0001  | 7.21±0.01             | 8.22±0.01  | 0.0001  | 8.04±0.01             | 8.90±0.01  | 0.0002  |
| <b>Fiber (%)</b>    | 6.11±0.00             | 6.90±0.01  | 0.0001  | 6.49±0.01             | 7.71±0.01  | 0.0001  | 6.10±0.01             | 7.21±0.00  | 0.0001  | 6.82±0.01             | 8.02±0.01  | 0.0001  |
| <b>Protein (%)</b>  | 23.83±0.01            | 24.52±0.01 | 0.0004  | 24.11±0.01            | 25.19±0.01 | 0.0001  | 23.75±0.01            | 24.15±0.01 | 0.0003  | 24.22±0.01            | 25.92±0.01 | 0.0001  |
| <b>NFE (%)</b>      | 47.29±0.02            | 43.02±0.01 | 0.0001  | 45.55±0.04            | 40.87±0.03 | 0.0001  | 45.94±0.01            | 43.83±0.02 | 0.0001  | 44.72±0.01            | 40.78±0.03 | 0.0001  |

\*Means with P-value less than 0.05 are significantly different

**Table 4: Water stability of experimental feed after 60-minute of exposure**

\* Means with P-value less than 0.05 are significantly different

#### 4.0 DISCUSSIONS

According to Eze and Eyo (2018), one of the major challenges faced by fish farmers is poor stability and sinking of locally produced feed. This may lead to leaching of required nutrients into the water, feed disintegration, growth of harmful bacteria and water pollution which may predispose aquatic organisms including fish to diseases or result in poor growth and reduced profitability (Eyo *et al.*, 2014). Results obtained from this study showed that starch obtained from varying sources including cassava, yam, cocoyam and sweet potato showed binding efficacy in fish feed although some binders had better binding ability than some at different inclusion levels. At 10% inclusion level of binders from varying sources, water stability was significantly better ( $p < 0.05$ ) in DT<sub>3</sub> (sweet potato starch) with a leached weight of  $8.41 \pm 0.59$  g followed by  $8.07 \pm 0.19$  g obtained for DT<sub>1</sub> containing cassava starch and least ( $2.34 \pm 1.34$  g) in DT<sub>2</sub> (cocoyam starch). At 20 % binder inclusion level, water stability was significantly better ( $p < 0.05$ ) ( $3.71 \pm 0.46$  g) in DT<sub>4</sub> (yam starch) and least ( $1.22 \pm 0.15$  g) in DT<sub>2</sub> containing sweet potato starch. Effiong *et al.*, (2009) reported a water stability test as high as 82.81% for fish feed formulated using cassava starch as binder after one hour of exposure to water. This is, however, higher than the value obtained in this study for 10 % and 20% cassava starch inclusion rate. This could be attributed to the difference in treatment as duckweed was added to the binders hence accounting for the difference in water stability. Also, the moisture content in the diets and the time of exposure may be responsible for the variation in water stability obtained in this study. Dominy *et al.*, (2003) compared different commercial binders for water stability, leaching and performance in shrimp feed. Diets with binders based on urea-formaldehyde showed a lower leaching rate compared to others. The water stability of natural binders (natural milo grain, wheat gluten, guar gum, vegetable wax, bone meal and blended ingredients) differed a lot but all had good growth responses from the shrimp. The diets with binders containing urea-formaldehyde performed generally very well for water stability and leaching, but their growth response was inferior compared to other binders.

#### 5.0 CONCLUSION

Findings of this study revealed that water stability of aquafeed pellets can be significantly improved by proper selection of feed ingredients, techniques and equipment used in processing and binder incorporation at the correct inclusion level. However, starch obtained from natural root and tuber crops has good binding ability in aquafeed which enhances water stability. These natural binders are cheap, economical, easy to process and available all year round for farmers who depend on formulated feed. Therefore, optimal water stability could be achieved by incorporating sweet potato and cassava starch as binders in aquafeed at 10 % inclusion level.

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