



## **Determination of Some Engineering Properties of Floatable Fish Feed Obtained from Different Companies**

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### **Authors' contributions**

*This work was carried out in collaboration between both authors. Author OOK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author YMA managed the analyses of the study and the literature searches. Both authors read and approved the final manuscript.*

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### **ABSTRACT**

This research work presents useful information about different floatable fish feeds obtained from different companies, which serves as database for people work intensively in fish farming and help them in solving many problems associated with the feeding effectiveness and feed handling. The main objective of this project is to study some physical and mechanical properties of fish feed pellets of different sizes. These properties included; Density, Moisture content, Surface area, Floatability, Sizes, Sinking velocity, Expansion ratio, Repose angle. The actual sizes of the extruded fish feed used ranged from 3 mm to 9 mm, However, Company 1 did not have 9 mm for producing that size of the pellet. The floatability ranged from 79.51 to 98.00%, the density ranged from 0.03 to 0.08 g/cm<sup>3</sup>, the moisture content ranged from 8.94 to 29.26%, the expansion ratio ranged from 1.02 to 1.54%, the sinking velocity ranged from 0.008 to 0.1 m/s<sup>2</sup>, the repose angle ranged from 27 to 38° while the colour of the feed ranged from light to dark brown according to Tables 1, 2 and 3 respectively. The results obtained from the experiment were subjected to ANOVA test using SPSS (Special Packages for Social Science) package. The physical and Mechanical properties of the floatable fish feed obtained from these three companies were significantly different from one another.

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## 1. INTRODUCTION

The conversion efficiency of feed to aquaculture, Product was only around 20% at best, so 80% of the inputs were wasted. Fish Fish contributes a high proportion of animal protein in human diets in most Asian countries and most countries are trying to increase fish production through aquaculture. Therefore, many nutritional scientists have now struggled to formulate fish feeds with the highest nutritional value and maximum digestibility [1]. Feed however is a responsible for 60-80% of the total cost of production in aquaculture [2] and this has necessitated the growing interest in the use of cheap non- conventional feed staff in fish nutrition in Nigeria. Pelleted fish feed are prone to leaching of nutrient in pond water due to poor water stability, poor nutrient retention and immediate sinking and disintegration to the bottom of ponds at feeding. This is a big loss in aquaculture input management. In essence, the conversion efficiency of feed to aquaculture product was only around 20% at best, so 80% of the inputs were wasted [3].

Maximum nutrient utilization allows fish to utilize almost all of the food they have eaten and this provides another benefit such as less waste as a by-product in the tank and a healthier environment for fish. Currently starch is required to bind the ingredients in order to form a durable pellet. At the same time, starch is a requirement for expansion and floating of pellet. Unfortunately, expansion can result in pellets with a weaker overall structure, even at high degree of gelatinization [4].

Water soluble and hygroscopic ingredients weaken pellets structure in water, allowing components to separate and making the feed only partially accepted. Commercial feeds for fish culture normally float for a few minutes and started to sink and breakdown at the bottom of the tank. Previous study reported that the sinking pellets were very moist and unattractive for halibut [3].

The actual extruding machine for floating feed such as insta PRO 2000 is very expensive and all efforts to procure the machine by the National Agriculture Research Project (NARP) during the World Bank Project in 1900's proved abortive in that less effective (Insta PRO 600) extruder, made solely to process soybean for African

countries were brought to Nigeria [5]. This has made Nigeria permanent buyer of expanded floating feeds at high cost from United State of America and other western countries. The Nigeria economy policy should not support such outrageous wastage of our foreign exchange. Therefore, emphasis should be geared towards the technology of developing buoyant (floating) fish feeds without adverse effect on the quality of compounded nutrients. Such feed must be very stable and afloat in water for a period of time before it sinks [6].

### 1.1 Objectives of the Study

The main objective of this research work is to determine some engineering properties of floatable fish feed obtained from different companies.

The specific objectives are:

- (i) To determine the physical engineering properties of floatable fish feed obtained from different companies.
- (ii) To determine the mechanical engineering properties of floatable fish feed from different companies.
- (iii) To determine the effects of these engineering properties on the nutritive value of the fish feed.

## 2. EXPERIMENTAL PROCEDURE

The Floating fish feeds used for the experiment ranged from 3 mm – 9 mm and were obtained from three different Company 1 in Akure, Company 2 in Ado-Ekiti and Company 3 in Ibadan at their various wet stages. The feeds of different sizes were weighed on a weighing balance in a container at their various wet stages and recorded. The wet fish feeds were sundried in order to reduce the water/moisture content in the feed. After sun drying, the feeds were poured back into the container and weighed on a weighing machine in order to determine their various dry weights, each weight of different sizes were recorded after weighing.

20 samples were selected at random from each sizes of feed from different companies and Vernier caliper was used to measure the height and diameter of each feed size that was selected at random and recorded, in other to determine the surface area and the volume of the feed.

Other parameters were obtained as discussed below.

## 2.1 Physical Properties

### 2.1.1 Determination of the moisture content

The wet basis method was employed in this experiment using the formulae below. The weight of the empty container was determined and recorded while wet fish feed samples of different sizes from each companies were put into the container and weighed on the weighing balance and also recorded. The weight of the empty container was subtracted from the total weight to get the weight of the feed (the initial weight of the wet sample).

The weighed samples was spread on cardboards and put into the sun to be dried. After sun-drying, the dried materials was put into the container and weighed on the weighing balance.

$$\text{Moisture Content} = \frac{\text{weight of wet pellet} - \text{weight of dry pellet}}{\text{Weight of dry pellet}} \times 100$$

$$M_c = \frac{(W_w - W_d)}{W_w} \times 100 \quad (1)$$

### 2.1.2 Determination of floatability

20 Samples of dried feed from each company were randomly selected and poured into a beaker of water to allow it to float. After some time, few of the selected feeds sank. The floatability was obtained using the formulae below according to [7].

$$\% \text{ ball afloat} = \frac{\text{Final number of balls afloat}}{\text{Total number of ball placed in water}} \times 100$$

$$= \frac{F_{ba}}{T_b} \times 100 \quad (2)$$

### 2.1.3 Determination of surface area

20 Samples of dried feed from each company were also randomly selected. The height and diameter of each sample was measured with the aid of a digital Vernier Caliper and recorded using the formulae below:

$$\text{Surface Area} = 2\pi r(r + h) \quad (3)$$

Where,  $r$  = the radius of the extruded feed  
 $h$  = the height of the feed.

### 2.1.4 Determination of unit density

20 Samples of dried feed from each company were also randomly selected. The mass of each

sample was taken using a sensitive electronic balance of model JA-5000 and the volume determined by the formula below according to Sankaranandh, et al. [8].

$$V = \pi r^2 l$$

Where,  $V$  = Volume of extrudate ( $\text{cm}^3$ )  
 $r$  = Radius of the extrudate (cm)  
 $l$  = Length of the extrudate (cm)

The Unit Density was calculated using the formula:

$$UD = \frac{M}{V} \quad (4)$$

Where  $UD$  = Unit Density of extrudates ( $\text{g}/\text{cm}^3$ ),  
 $M$  = Mass (g),  
 $V$  is the volume ( $\text{cm}^3$ ).

### 2.1.5 Determination of sinking velocity

Some samples of dried feeds were thrown into clean water and were monitored for 10-15 minutes for all the feed to sink to the bottom of the container. Thus,

$$\text{Sinking Velocity (SV)} = \frac{h}{t} \quad (5)$$

Where  $SV$  = Sinking Velocity (m/s),  
 $h$  = the height of the water column (m), and  
 $t$  = the time taken by the extrudates to reach the bottom of the container(s).

## 3. RESULTS AND DISCUSSION

### 3.1 Results

The results for the Physical and Mechanical Properties of the Floating Fish Feed obtained through experiments are summarized in Tables and graphs drawn as shown below:

### 3.2 Physical Properties

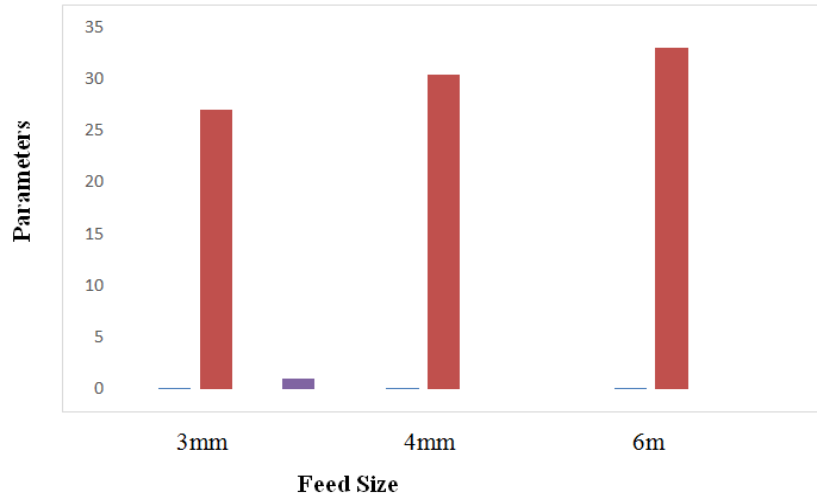
Tables 1, 2 and 3 show the physical properties of the floating fish feed obtained from different companies *visa-viz*: The moisture content, floatability, surface area, unit density, sinking velocity and colour.

### 3.3 Mechanical Properties

Tables 4, 5 and 6 show the mechanical properties of the floating fish feed obtained from different companies *visa-viz*: the expansion ratio and repose angle.

**Table 1. Feeds from Company 1**

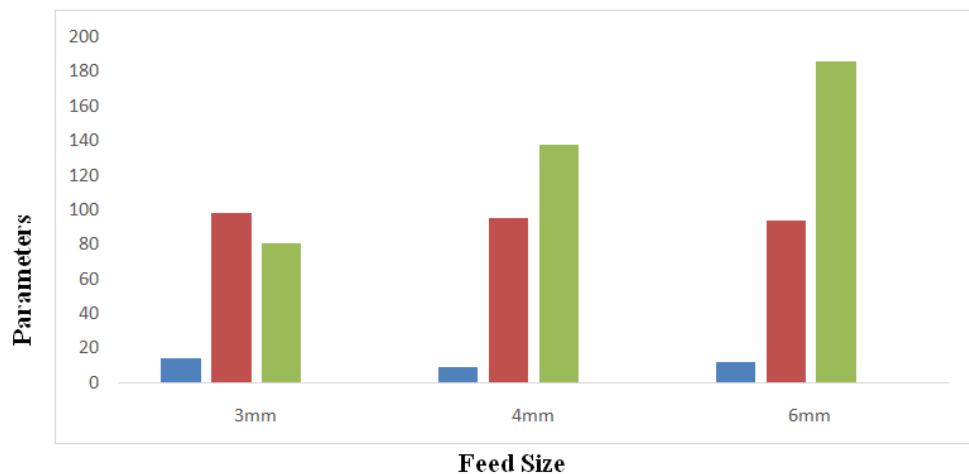
Parameters	3 mm	4 mm	6 mm
Moisture Content (%)	16.19	18.65	11.76
Floatability (%)	93.73	91.55	79.51
Surface Area(mm <sup>2</sup> )	138.28	221.61	412.05
Unit Density (g/cm <sup>3</sup> )	0.03	0.04	0.05
Sinking Velocity (m/s)	0.090	0.087	0.075
Colour	Brown	Brown	Brown



**Fig. 1. Graph of parameters against feed size from Company 1**

**Table 2. Feeds from Company 2**

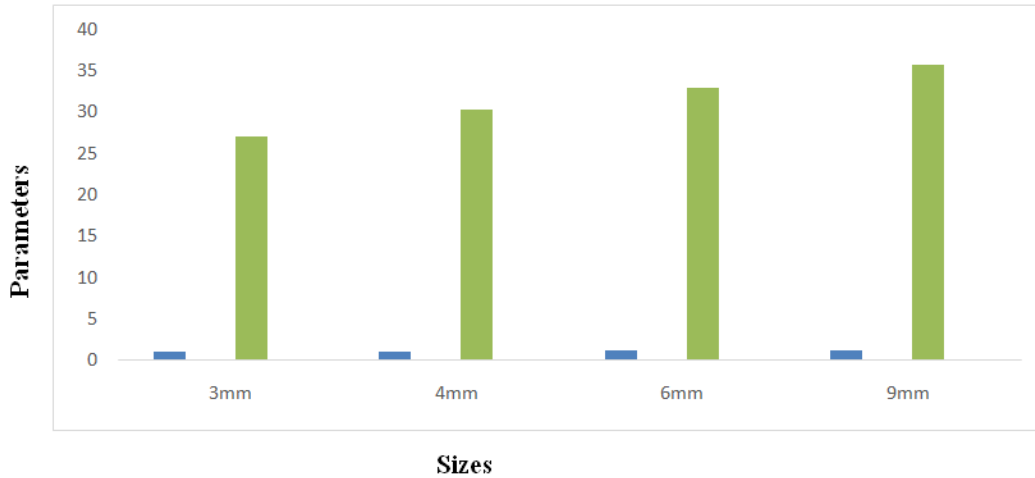
Parameters	3 mm	4 mm	6 mm	9 mm
Moisture Content (%)	11.79	29.26	25.82	21.94
Floatability (%)	94.05	93.24	89.89	85.01
Surface Area (mm <sup>2</sup> )	65.74	173.23	448.37	776.62
Unit Density (g/cm <sup>3</sup> )	0.04	0.05	0.05	0.06
Sinking Velocity (m/s)	0.025	0.016	0.019	0.0125
Colour	Light Brown	Light Brown	Light Brown	Light Brown



**Fig. 2. Graph of parameters against feed size from Company 2**

**Table 3. Feeds from Company 3**

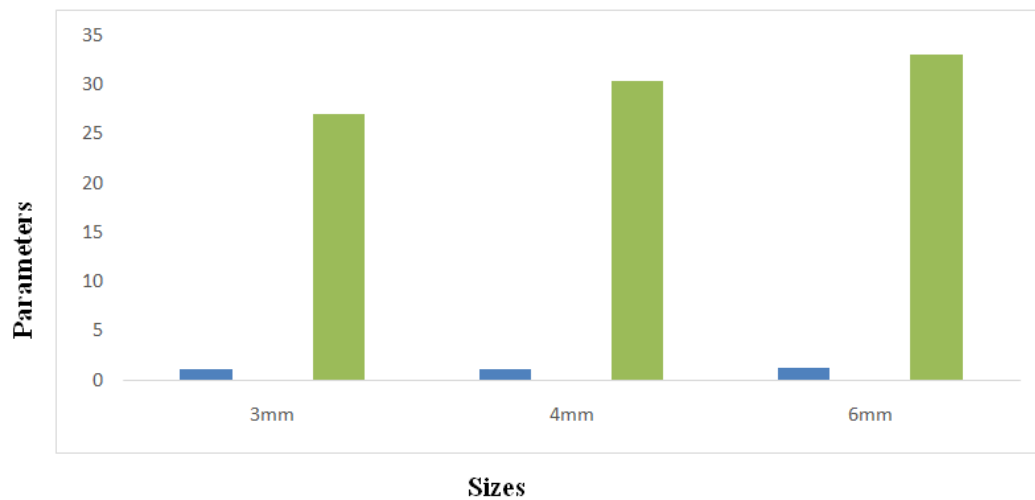
Parameters	3 mm	4 mm	6 mm	9 mm
Moisture Content (%)	14.18	8.94	11.65	13.59
Floatability (%)	98.00	95.51	94.02	87.82
Surface Area(mm <sup>2</sup> )	80.22	138.03	185.78	523.60
Unit Density (g/cm <sup>3</sup> )	0.03	0.05	0.06	0.08
Sinking Velocity (m/s)	0.017	0.019	0.01	0.0083
Colour	Brown	Brown	Brown	Brown



**Fig. 3. Graph of sizes against parameters Company 3**

**Table 4. Feeds from Company 1**

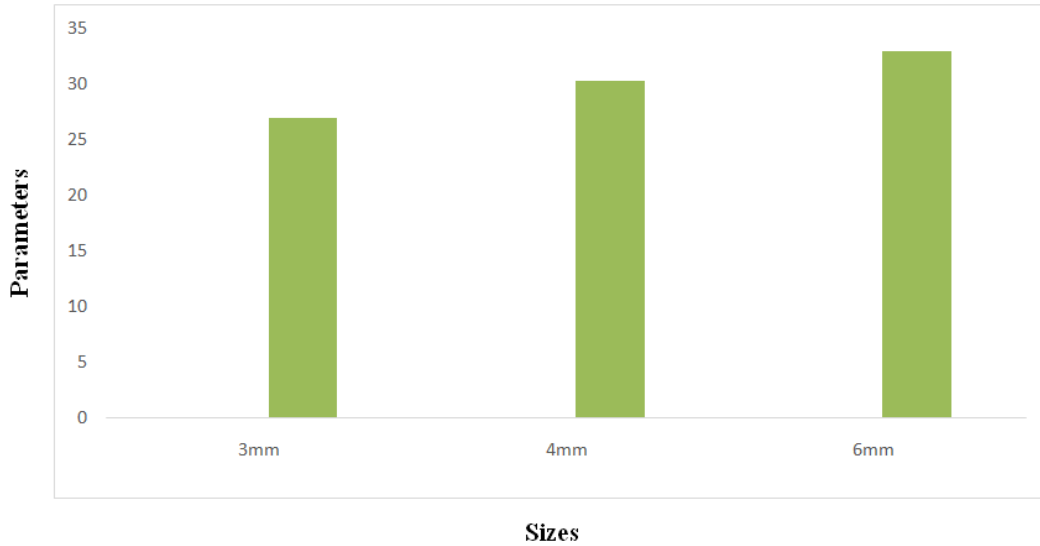
Parameters	3 mm	4 mm	6 mm
Expansion Ratio	1.15	1.18	1.23
Repose Angle (°)	31.00	34.67	38.00



**Fig. 4. Graph of sizes against parameter Company 1**

**Table 5. Feeds from Company 2**

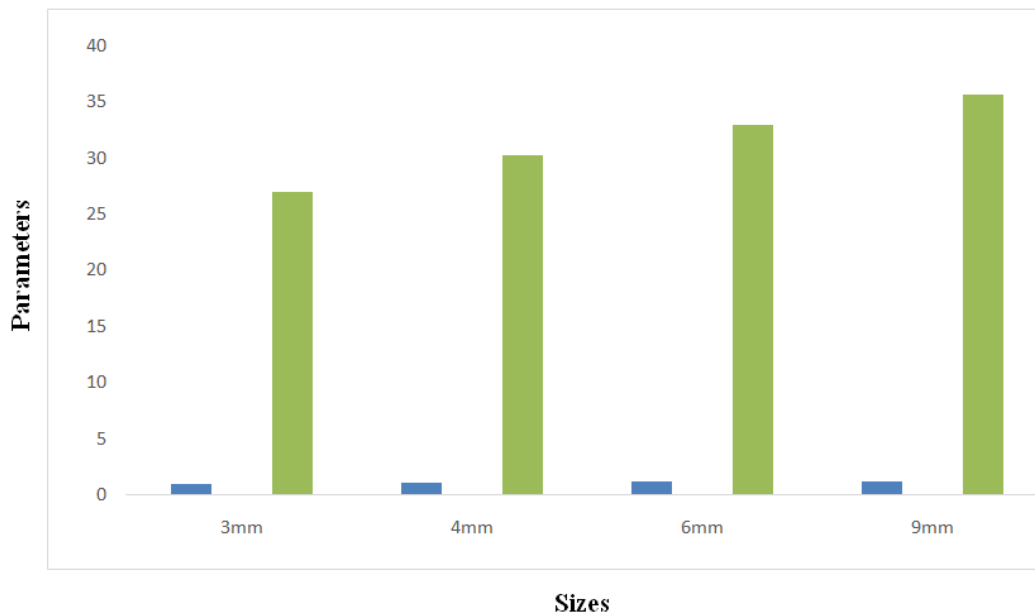
Parameters	3 mm	4 mm	6 mm	9 mm
Expansion Ratio	1.20	1.26	1.37	1.54
Repose Angle( <sup>0</sup> )	30.67	33.00	35.08	36.67



**Fig. 5. Graph of sizes against parameters Company 2**

**Table 6. Feeds from Company 3**

Parameters	3 mm	4 mm	6 mm	9 mm
Expansion Ratio	1.02	1.09	1.23	1.28
Repose Angle( <sup>0</sup> )	27.00	30.33	33.00	35.67



**Fig. 6. Graph of sizes against parameters Company 3**

### 3.4 Discussion

For the three companies were the feeds were obtained, they produced pellets of different sizes ranging from 3 mm to 9 mm. However, that of Company 1 did not have 9 mm for producing that size of the pellet.

#### 3.4.1 Physical properties

The results of some of the physical properties determined viz: The moisture content, floatability, surface area, unit density, colour and sinking velocity of the feed are discussed below:

##### (i) Moisture content

The moisture content ranged from 11.76 to 18.19% (Company 1 feed), 11.79 to 29.26% (Company 2 feed), and 8.94 to 11.18% (Company 3 feed) as shown in Table 1 depending on the quantity of samples from each company.

##### (ii) Floatability of the feed

The floatability of the extruded fish feed pellets decreased with increase in the pellet size. It indicated that when the pellet sizes increased from 3 to 9 mm, the floatability decreased from 93.73 to 79.51% (Company 1 feed) in as shown in Table 1, 94.05 to 85.01% (Company 2 feed) in Table 2, and 98.00 to 87.01% (Company 3 feed) in Table 3.

##### (iii) Surface area

The surface area of the fish feed sizes increased with increase in the sizes of the pellets. It indicated that when the pellet sizes in increased from 3 to 9 mm, the surface area increased from 138.28 to 412.05 mm<sup>2</sup> (Company 2 feed) as shown in Table 1, 65.74 to 776.62 mm<sup>2</sup> (Company 2 feed) in Table 2 and 80.22 to 523.60 mm<sup>2</sup> (Company 3 feed) in Table 3.

##### (iv) Unit density

The unit density of the fish feed sizes increased with increase in the sizes of the pellets. It indicated that when the pellet sizes increased from 3 to 9 mm, the unit density also increased from 0.03 to 0.05 g/cm<sup>3</sup> (Company 1), 0.04 to 0.06 g/cm<sup>3</sup> (Company 2), and 0.03 to 0.08 g/cm<sup>3</sup> (Company 3) as shown in Tables 1, 2 and 3 respectively.

##### (v) Colour

The colour are majorly brownish in colour, but some countries do makes there's light brown while some make dark brown.

##### (vi) Sinking velocity

The sinking velocity of the fish feed sizes decreased with increase in the sizes of the pellets. It indicated that when the pellet sizes in increased from 3 to 9 mm, the sinking velocity decreased from 0.090 to 0.075 m/s (Company 1), 0.025 to 0.013 m/s (Company 2), and 0.017 to 0.008 m/s (Company 3) as shown in Tables 1, 2 and 3 respectively.

#### 3.4.2 Mechanical properties

The results of some of the mechanical properties determined viz: The moisture content, floatability, surface area, unit density, colour and sinking velocity of the feed are discussed below:

##### (i) Expansion ratio

The expansion ratio of the extruded pellets increased in sizes after drying. That is, the sizes of each pellet increased slightly in the dry form when compared to its original size when it was in its wet form as shown in Tables 4, 5 and 6.

##### (ii) Repose angle

The repose angle of the fish feed sizes increased with increase in the sizes of the pellets. When the pellet sizes increased from 3 to 9 mm, the repose angle increased from 31 to 38° (Company 1 feed), 31 to 37° (Company 2 feed) and 27 to 36° (Company 3 feed) as shown Tables 4, 5 and 6.

The physical and mechanical properties of the floatable fish feed obtained from Company 1, Company 2 and Company 3 were subjected to ANOVA test at  $P \leq 0.05$ . They were significantly different from one another since their values were less than 0.5.

## 4. CONCLUSIONS AND RECOMMENDATIONS

### 4.1 Conclusions

The experiment was successfully carried out in determining the physical and mechanical

properties of extruded fish feed from different companies (Company 1, Company 2, Company 3) and of different sizes (3 mm- 9 mm). However, Company 1 did not have 9 mm for producing that size of the pellet. Therefore, the following were deduced:

- (i) The floatability ranged from 79.51 to 98.00%. The density ranged from 0.03 to 0.08 g/cm<sup>3</sup>. The moisture content ranged from 8.94 to 29.26%. The expansion ratio ranged from 1.02 to 1.54%. The sinking velocity ranged from 0.008 to 0.1 m/s<sup>2</sup>. The repose angle ranged from 27 to 38° and the colour of the feed ranged from light to dark brown according to Tables 1, 2 and 3 respectively.
- (ii) From the ANOVA test, it was observed that all the sizes from each company were significantly different from each other.

#### 4.2 Recommendations

Having carried out the experiment successfully, the followings were recommended:

- (1) Emphasis should be geared towards the technology of developing buoyant (floating) fish feeds without adverse effect on the quality of compounded nutrients.
- (2) A study should be carried out on formulation of floatable fish feed.
- (3) Companies should not look at the cost of producing floatable feeds since they are costlier than the ones for sinking feeds.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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