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Effect of ingredients substitution on binding, water stability and floatation of farm-made fish feed

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Abstract
Eight 40% crude protein diets with approximately 3000KCal/Kg metabolizable energy were formulated for juvenile catfish. Four test ingredients (Rice milling, Millet Offal, Wheat offal and Brewer's Dry Grain) were used as binders, such that Diets 1, 3, 5 and 7 contained each of the binders respectively, while Diets 2, 4, 6 and 8 contained each of the binders with baker's yeast as a water stability enhancer. The influence of these binders and the inclusion of yeast was tested on the physical characteristics, floatation and water stability of each compounded diet. Diet 6 (Wheat offal + Yeast) had the best expansion (50.00±0.00) as well as floatation (16.67±5.77 after 20minutes in water), this was followed by Diet 2 (Rice Bran + Yeast) with expansion (33.33±14.43) and floatation (13.33±5.77 within 10 minutes). Diet 1 however recorded the least water absorption (39.77±1.74) and thus the best water stability (90.92±1.89) among the test ingredients. Diets with yeast generally had significantly higher expansion but less water stability. Diet with wheat offal supports floatation best among the test ingredients while Rice Bran facilitates water stability. Also, the inclusion of yeast enhanced floatation. It was therefore recommended that wheat offal and rice bran can be added in fish feed to enhance floatation and water stability of pellets.

Keywords: Floatation; Water stability; Compounded fish feed; expansion rate.

1. Introduction

The cost of feeding represents about 60 – 80% of total cost of raising fish from start to finish (Orire and Sadiku, 2014 [1]; Adekunle *et al.*, 2012 [2]). Commercial fish diets in Nigeria are often imported floating feeds and as a result of the high cost of producing such diets they are usually expensive, creating a huge cost margin compared to when locally produced sinking feeds are used. Although most farmers often use a combination of both types, about 15% floating feeds and 85% sinking feeds (Lovell, 2013) [3].

Fish diet production begins with ingredient selection and feed formulation (Adeparusi and Famurewa, 2011) [4]. To formulate a diet that meets a target fish requirement, information on its nutrient requirement, the nutrient composition of individual ingredients as well as their anti-nutrient compositions are required (Craig and Helfrich, 2009) [5]. Selection of ingredients can be done from a wide range of choices, therefore it is often necessary to consider the locally availability and cost of the ingredients.

The manufacturing process includes grinding the feedstuff to reduce particle size, mixing the feedstuff, subjecting them to moisture (water or steam), and applying heat and pressure to produce a particular product physical form (Tidwell and Allan, 2001) [6]. The choice of physical form may depend on the species of fish, nature of culture system and stage of maturity of fish (Falayi and Sadiku, 2013) [7]. Also different ingredients combinations produce different levels of pellet buoyancy or spatial characteristic within the water column (Strahm and Plattner, 2001) [8]. Floating extruded pellets are in greater demand than sinking pellets, this is because they enable the farmer to observe the feeding activity of the fish thus prevent wastage of feed. They also exhibit superior characters such as greater water stability, digestibility, water protection, zero water pollution and zero wastage of raw materials (Almaraaj, 2010) [9], and in addition supply higher energy than sinking pelleted feed (Johnson and Wandsvick, 1991) [10]. Most locally produced fish feed are the sinking pelleted type (Orire and Sadiku, 2014) [1]. Continuous use of these feed type poses some major setback to the fish farmers by denying them the opportunity to observe the feeding activities of the fish under culture, as a result they tend to over supply the pond more feed than can be consumed at a time by fish (Jauncey *et al.*, 2007) [11].

Uneaten feeds that sink to the bottom of the pond usually end up as fertilizers causing high algal bloom and related water pollution problems (Bolorunduro, 2002) [12] such as eutrophication and depletion of oxygen from the culture medium. This is a very deleterious problem especially in locality where water availability is a challenge. The direct implication is that most of the feed end up uneaten resulting in waste of resources while additional cost and labor incurred in maintaining healthy water conditions are secondary consequences (Falayi *et al.*, 2006) [13]. The use of sinking feeds may also result in impaired growth of fish since it involves a high feed conversion ratio (Johnson and Wandsvick, 1991) [10]. However owing to the relatively low cost of producing them and the wide distribution of the technology required, they remain the popular choice amongst most fish farmers especially in developing countries such as Nigeria.

Although extrusion technology remains the best method for achieving floating, water-stable pellets (Jauncey *et al.*, 2007) [11], a careful combination of ingredients to achieve pellets with relatively low bulk density and high buoyancy is possible (Obi *et al.*, 2011) [14]. Achievement of this characteristics in feeds is often aided by the inclusion of good quality binders such as cassava tuber starch, maize flour starch, wheat flour starch, etc. (Solomon *et al.* 2011), with other ingredients capable of creating air traps within the pellets of the formulated feed, such as yeast, duckweed, honeycomb (Falayi and Sadiku, 2013) [7], and melon shell (Obi *et al.,* 2011) [14].

The presence of starches in carbohydrate-rich ingredients make them suitable candidates to be considered as binders (Bairagi *et al.,* 2002) [15], while the relatively low bulk densities of these ingredients when included in appropriate amounts in the diets present an opportunity for them to support floatation in farm-made pelletized fish feeds. However the presence of the above characteristics in rice milling, wheat offal, millet offal and brewer's dry grain inform their selection for this experiment.

2. Materials and Methods

2.1 Experimental Location

The study was carried out within the main campus of Usmanu Danfodiyo University, Sokoto. Sokoto State is located in the northwest geographical zone of Nigeria within longitude 13° 05' N and latitude 05° 15' E, covering an area of 25,973 km^2. Its annual average temperature is 28.3°C (82.9°F) with maximum daytime temperature for most of the year at 40°C (104.0°F). The warmest months are between March and June when daytime temperature can exceed 45°C (113°F), the rainy season is from June to October while the other times of the year are characterized by Harmattan (Mamman *et al.,* 2014) [16].

2.2 Selection of Ingredients

Feed ingredients were majorly sourced from Ojuanu Agro Enterprise Sokoto while, Brewers' dry grain was sourced from a feed mill in Ibadan; rice milling was obtained as the byproduct of the second milling of rice to produce edible rice, from local rice processors in Arkilla area of Sokoto and millet offal a bye product obtained from the production of millet gruel locally called "Kunu" was as well obtained from a local producer in Sokoto.

2.3 Proximate Analysis

Samples of all the ingredients used were subjected to proximate analysis to determine their nutrient composition, according to method described by AOAC (2000) [17]. Crude protein content was determined using Kjeldahl method, crude fiber content using acid-alkaline digestion method, ash content by burning the dried residue for 24hrs in a Galle Kamp Hot spot furnace at 450 ^{0}C, moisture content by oven drying of sample at 105 ^{0}C until a steady weight was achieved, and crude lipid content by extraction using N-Hexane.

2.4 Experimental Diets

Eight (8) isoproteic diets were formulated and designated as Diet 1, Diet 2, Diet 3, up to Diet 8 using the Pearson's' square method. Four test ingredients – rice milling, millet offal, wheat offal and brewers' dry grain (BDG) – were included among the diets at ratios determined by the formulation (Table 2). Yellow maize was fixed at 10% for all the diets while Baker's yeast (*Saccharomyces cerevisiae*) was included as a protein supplement in diets 2, 4, 6, and 8.

Table 1: Proximate Composition of Ingredients

Ingredient	Moisture (%)	Crude Protein (%)	Crude Lipid (%)	Crude Fiber (%)	Ash (%)	NFE (%)	M.E (Kcal/Kg)
Rice Bran	1.5	13.30	1.0	11.4	2.0	72.30	2921
Millet Offal	2.5	15.58	1.0	12.1	1.0	70.32	2651
Wheat Offal	2.5	18.60	2.0	10.5	2.0	66.90	2093
Brewes' Dry Grain	2.5	21.88	4.5	15.3	2.5	55.82	2507
Maize	9.5	10.34	4.0	6.5	3.0	76.16	3554
Fish meal	3.5	68.50	10.2	2.5	8.0	10.9	2860
Soybean Meal	1.0	44.90	8.5	7.8	6.0	32.8	2868
Yeast	7.0	45.20	1.0	2.7	4.2	46.9	2842

2.5 Production of Pellets

All ingredients except the premixes and Bakers' yeast were severally milled in order to produce fine particles. Milled ingredients were further sieved using 0.5mm mesh size to ensure a homogenous particle size for proper mixing and adequate compaction of the diets (Houlihan, 2008[18]; Jauncey *et al.*, 2007[11]; Hardy, 1989[19]).

The ingredients including premixes were then measured using Metla® digital weighing balance according to the percentage composition in the formulation, after which they were mixed using a mini mixer until a homogenous blend was obtained. Hot water was used to prepare the ingredients into a consistent dough, and the pellets were produced using 4mm die holes on a pelletizing machine.

2.6 Experimental Tests

2.6.1 Bulk Density (g cm^{-3})

Bulk density was calculated as follows

$$\text{Bulk density} = \frac{M}{AL}$$

Where M = Mass (g) of the pellet
L = Length (cm) of the pellet
A = Cross-sectional area of the pellet

2.6.2 Expansion Ratio
Expansion ratio was calculated as described by Misra *et al.* (2002) [20]. The average pellet diameter for each diet treatment was measured using a vernier caliper. The expansion ratio which is the increase in the pellet cross-sectional area compared to the die cross-sectional area was then calculated as follows:

$$\text{Expansion ratio (\%)} = \left[\left(\frac{D_p}{D_d}\right) - 1\right] * 100$$

Where D_p = Pellet diameter
D_d = Die dimeter

2.6.3 Floatation test
The buoyancy of each of the test diets was determined by placing samples containing 10 pellets replicated 3 times into 2litres bowls filled to about 75% with water. The number of pellets from each sample remaining afloat after every 60seconds interval was recorded for a period of 30 minutes. Percentage floatation at any time interval was determined as follows:

$$\text{\% Floatation} = \frac{\text{Number of pellets afloat}}{\text{Number of pellets in sample}} \ x\ 100\%$$

(Misra *et al.*, 2002) [20].

2.6.4 Relative absorption rate (RAR)
RAR which is the measure of the volume of water absorbed in relation to the initial weight of the pellets was calculated as follows:

$$\text{RAR} = \left(\frac{M_2 - M_1}{M_1}\right) * 100\%$$

(Fagbenro and Jauncey, 1995) [21]

Where M_2 = Mass of wet pellets
M_1 = Initial mass of dry pellets
$M_2 - M_1$ = Weight gain after immersion in water .

2.6.5 Water Stability
Water stability of each diet was measured for a period of 30 minutes and 60 minutes. This was done by placing 10 pellets of each replicate into a nylon sieve, tied with a string, and inserted into a bowl containing pond water. After the duration elapsed, the remaining portion of the feed were sun-dried for 3 days and the weight were recorded as M_{30} and M_{60} representing final dry weights after 30 minutes and 60 minutes immersion respectively. Water stability was then calculated as follows

$$\text{Water Stability} = \left(\frac{M_{30}}{M_1}\right) * 100\% \text{ (for 30 minutes)}$$

$$\left(\frac{M_{60}}{M_1}\right) * 100\% \text{ (for 60 minutes)}$$

Where M_{30} = Weight of pellet after 30 minutes immersion and drying
M_{60} = Weight of pellet after 60 minutes immersion and drying
M_1 = Initial dry weight of pellets (Fagbenro and Jauncey, 1995) [21].

Table 2: Gross Composition of Diets

Ingredients	Diet 1 (RB)	Diet 2 (RB+Y)	Diet 3 (MO)	Diet 4 (MO+Y)	Diet 5 (WO)	Diet 6 (WO+Y)	Diet 7 (BDG)	Diet 8 (BDG+Y)
Rice Bran	15.05	15.17	-	-	-	-	-	-
Millet Offal	-	-	15.89	16.01	-	-	-	-
Wheat Offal	-	-	-	-	17.15	17.28	-	-
BDG	-	-	-	-	-	-	18.76	18.9
Yeast	-	16.27	-	16.06	-	15.74	-	15.34
Fish Meal	32.6	32.54	32.18	32.12	31.55	31.49	30.75	30.68
Soybean Meal	32.6	16.27	32.18	16.06	31.55	15.74	30.75	15.34
Maize	10	10	10	10	10	10	10	10
Lysine	1	1	1	1	1	1	1	1
Methionine	1	1	1	1	1	1	1	1
Vit. Premix	1	1	1	1	1	1	1	1
Bone meal	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Vegetable Oil	4	4	4	4	4	4	4	4
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total (%)	100	100	100	100	100	100	100	100
Calc. CP (%)	40	40	40	39.99	40	39.99	40	40.01
Metabolizable Energy (KCal/Kg)	3032.03	2986.05	2989.6	2985.18	2891.2	2886.13	2956.77	2952.28

2.7 Data Analysis
All recorded data on the physical properties of the various diets were analyzed by one way ANOVA to test for significance difference in the mean recorded for each parameter. Regression analysis was done to describe the relationships between different parameters where necessary. All Analysis were done using SPSS statistical data analysis package.

3. Results
3.1 Proximate Analysis
There was a slight difference between calculated crude protein and analyzed crude protein for all the diets (Table 3). Diets 3, 4, 5, 6 and 7 had slightly higher crude protein while Diets 1, 2 and 8 had lower levels than the calculated crude protein. Moisture content was generally below 4.0% and crude lipid were high (between 6.00 – 9.54%). The crude fiber was also low while ash and NFE were relatively high.

3.2 Physical Characteristics of Pellets
Diet 6 (WO + Yeast) had the highest expansion ratio (50%) and was significantly higher than other diets with between 25 and 33% expansion. The diets with yeast (Diets 2, 4 and 6) had greater expansion than their corresponding diets without yeast (Diets 1, 3 and 5) respectively. Diets 7 and 8, both had expansion of 25%, thus showing no difference in expansion with inclusion of yeast. Diet 1 (RB) had the highest bulk density (1.05 ± 0.02), and was significantly different from Diet 6 (WO + Yeast) with the least bulk density (0.57 ± 0.03). However there was no significant difference in bulk density between Diets 3 (MO), 5 (WO) and 8 (BDG + Yeast) (Table 4.2).

Table 3: Proximate Composition of Pellets

Nutrient	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7	Diet 8
Moisture (%)	2.50	3.10	3.20	3.50	2.95	3.05	3.60	3.80
Crude Protein (%)	38.20	38.50	40.95	41.00	42.00	42.87	41.35	39.69
Crude Lipid (%)	9.50	6.80	6.20	6.00	8.40	7.50	6.30	6.50
Crude Fibre (%)	2.00	1.50	2.00	1.50	1.50	1.50	1.50	2.00
Ash (%)	7.30	7.45	7.57	8.15	6.13	6.76	6.75	5.71
NFE (%)	40.5	42.65	40.08	39.85	39.02	38.32	40.5	42.30

Table 4: Physical Characteristics of Pellets

Parameter	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7	Diet 8
Expansion Ratio (%)	$25.00^{b} \pm 0.00$	$33.33^{b} \pm 14.43$	$25.00^{b} \pm 0.00$	$33.33^{b} \pm 14.43$	$33.33^{b} \pm 14.43$	$50.00^{a} \pm 0.00$	$25.00^{b} \pm 0.00$	$25.00^{b} \pm 0.00$
Bulk Density (g/cm^3)	$1.05^{f} \pm 0.02$	$0.69^{b} \pm 0.02$	$0.92^{d} \pm 0.02$	$0.85^{c} \pm 0.02$	$0.89^{d} \pm 0.02$	$0.57^{a} \pm 0.03$	$0.98^{e} \pm 0.02$	$0.92^{d} \pm 0.02$
Relative Absorption Rate (%)	$39.77^{a} \pm 1.74$	$54.95^{de} \pm 1.67$	$47.34^{c} \pm 0.99$	$66.68^{f} \pm 1.06$	$44.43^{b} \pm 1.76$	$52.67^{d} \pm 1.02$	$55.69^{e} \pm 1.93$	$70.57^{g} \pm 2.39$

Treatments with different alphabets as superscript indicates significance ($P<0.05$) difference between their means.

Mean RAR was widely dissimilar among the diets except Diet 2 (RB + Yeast) which was significantly similar ($P>0.05$) to Diet 6 (WO + Yeast) and Diet 7 (BDG). Diet 1 (RB) had the best water absorption (39.77 ± 1.74) while Diet 8 (BDG + Yeast) was poorest in terms of water absorption (70.56 ± 2.40). Also, the inclusion of yeast seem to have had influence on relative absorption ratio of all the diets, the diets with yeast had higher water absorption than their corresponding diets without yeast.

3.4 Floatation and Water Stability of Pellets
Percentage floatation period varies among diet combinations. At the first five minutes, all the pellets floated at different proportions. 100% of the pellets from diets 4 (MO + Yeast) and 6 (WO + Yeast) floated and were significantly higher ($P<0.05$) than the others, while the least percentage floatation was observed on diet 8 where only 76.67% of the pellets floated.

Within the second time interval (6 – 10 minutes), only Diets 2 (RB + Yeast) and 6 (WO + Yeast) floated at 13.33% and 76.67% respectively, and significantly higher than other diets. Subsequently only Diet 6 (WO + Yeast) continued to float, although with decreasing percentage floatation with increase in time. All the diets fortified with yeast had higher percentage floatation than their corresponding counterparts without yeast within throughout the duration of test. None of the diets without yeast floated for longer than 5 minutes, while Diet 2 (RB + Yeast) had 13.33% floatation between 6 and 10 minutes, and 16.67% of Diet 6 (WO + Yeast) floated beyond the 20 minutes duration. Water stability was highest in Diet 1 after 30 minutes and 60 minutes; 90.92 ± 1.89 and 70.46 ± 1.77 respectively, and was lowest in Diet 8 (BDG + Yeast) for both experimental durations. There was significant difference between all the pellets ($P<0.05$), except those of Diets 1 (RB) and 5 (WO), which were similar for both experimental durations.

Also Table 4.3 shows that all diets with yeast had lower water stability after 30 minutes and 60 minutes immersion in water than their corresponding counterparts without yeast on both machines.

Table 5: Percentage Floatation and Water Stability of Pellet

Parameter		Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7	Diet 8
Floatation	1 – 5	$86.67^{bcd} \pm 5.77$	$96.67^{ab} \pm 5.77$	$90.00^{abc} \pm 10.00$	$100.00^{a} \pm 0.00$	$93.33^{ab} \pm 5.77$	$100.00^{a} \pm 0.00$	$76.67^{d} \pm 5.77$	$80.00^{cd} \pm 10.00$
	6 – 10	0.00^{c}	$13.33^{b} \pm 5.77$	0.00^{c}	0.00^{c}	0.00^{c}	$76.67^{a} \pm 5.77$	0.00^{c}	0.00^{c}
	11 – 15	0.00^{b}	0.00^{b}	0.00^{b}	0.00^{b}	0.00^{b}	$73.33^{a} \pm 5.77$	0.00^{b}	0.00^{b}
	15 – 20	0.00^{b}	0.00^{b}	0.00^{b}	0.00^{b}	0.00^{b}	$33.33^{a} \pm 11.55$	0.00^{b}	0.00^{b}
	> 20	0.00^{b}	0.00^{b}	0.00^{b}	0.00^{b}	0.00^{b}	$16.67^{a} \pm 5.77$	0.00^{b}	0.00^{b}
Water Stability	30	$90.92^{a} \pm 1.89$	$75.84^{c} \pm 3.63$	$80.08^{b} \pm 2.84$	$51.58^{f} \pm 1.56$	$89.88^{a} \pm 1.82$	$70.27^{d} \pm 1.51$	$59.49^{e} \pm 1.93$	$41.17^{g} \pm 1.79$
	60	$70.46^{a} \pm 1.77$	$58.24^{c} \pm 1.67$	$63.16^{b} \pm 0.58$	$42.94^{f} \pm 3.55$	$67.66^{a} \pm 0.96$	$52.67^{d} \pm 1.02$	$48.10^{e} \pm 1.92$	$28.24^{g} \pm 0.57$

Treatments with different alphabets as superscript indicates significant difference ($P<0.05$) between their means.

4. Discussion

4.1 Expansion Ratio

According to Hardy (1989) [19], expansion in pellets is as a result of extrusion or cooking of the pellets as they are forcefully ejected out of the machine die, while extrusion itself is influenced by the quantity of moisture and heat applied during pellet production usually about 20 – 24% and 120 – 125 ^{0}C respectively. The difference in expansion among the pellets can be attributed to the chemical characteristics of their test ingredients. Diets 5 and 6 containing wheat offal had better expansion than other diets with the other test ingredients. This could be attributable to the presence of relatively higher amounts of gluten and other proteins in wheat, and their interaction with lipids in the diets. (Falayi and Sadiku, 2013) [7] have reported that in dough making and diet preparation, between 30 -70% of non-polar lipids and practically all polar lipids interact with gluten fibers and to a lesser degree, with other cereal proteins by both hydrophobic and hydrophilic bonds, which leads to the formation of Starch-glycollipid-gluten complexes that causes appreciable expansion in the volume of the dough.

Furthermore the diets with yeast generally had greater expansion than those without yeast – Diet 2 (Rice bran + Yeast) had greater expansion than Diet 1(Rice bran), Diet 4 (Millet offal + Yeast) had greater expansion than Diet 3 (Millet offal), and Diet 6 (Wheat offal + Yeast) had greater expansion than Diet 5 (Wheat offal). Yeast which is a leavening agent causes the creation of air bubbles within the pellets. This was possible because part of the starch in the ingredients that formed the diets' dough were converted to sugar, capable of being fermented by the yeast to alcohol with the simultaneous release of carbon-dioxide gas (Watanabe, 1990) [22]. However it was only in the diets containing BDG that there was no difference in expansion between its treatment with yeast (Diet 8) and that without yeast (Diet 7), this could be as a result of the low amount of starch in BDG which reduced its ability to form protective coat that seals the CO_2 produced by yeast within its pellets.

4.2 Bulk Density

The lower the bulk density of a body, the greater its potential to float. Specifically objects that float on water have to be less than 1g/cm^3 (density of water) in bulk density (Riaz, 2009) [23]. The relatively less bulk density of Diet 6 (WO + Yeast) could be attributed to the expansion of the pellets, this agrees with Jauncey *et al*. (2007) [11] have revealed that the greater the expansion of the pellets the less its bulk density. This is because as pellets expand, their volumes increase disproportionately with their masses, leading to reduction in bulk density. Also the inclusion of yeast might have caused the distention of the dough molecules by CO_2 produced during fermentation, hereby resulting in expansion of surface area of the pellets and a greater volume to mass ratio. Rice bran performed next to wheat-based diets in terms of bulk density ahead of those containing millet and BDG. This agrees with the findings of Adeparusi and Famurewa (2011) [4] who observed that bulk density was lower for diets containing rice bran than those containing BDG and maize bran at 10% each.

4.3 Water Absorption

Diet 1 (RB) had the best water absorption and it was significantly different from all the other diets. Diet 8 (BDG + Yeast) however absorbed the highest volume of water in relation to its initial weight within the test duration. This finding is supported by that of Adeparusi and Famurewa (2011) [4] that reported that Diets with Rice bran absorbed less amount of water than those with BDG. Furthermore it was observed that diets with yeast absorbed water faster than diets without yeast. This was probably because the baker's yeast used had larger particle size than all the other ingredients and were not milled during ingredient preparation. The larger particles in this case might have caused weaker adhesion between the ingredients in the diets.

4.4 Water Stability

There was significant difference in water stability between all the diets after 30 and 60 minutes for both machine. The results on tables 4 and 5 suggest that there might be a negative correlation between water absorption and water stability of the pellets – diets with the least water absorption were seen to have the greatest water stability and vice versa. Although water stability reduced for all the diets after 60 minutes, the general trend was still maintained, and Diet 1 (RB) still had significantly higher stability than the other diets except Diet 5 (Wheat). The better performance of rice and wheat as binders may be due to some degree of pre-gelatinization that might have taken place in the dough (Adeparusi and Famurewa, 2011) [4]. Starch possesses a unique ability to lose its crystalline structure and become a viscous gel during processing, this allows it to disperse through and around structures of other origins (Svihus *et al*., 2005) [24], hence resulting in the stringer adhesion that might have been observed in the Diets 1 and 5.

4.5 Floatability

In the first 5 minutes of the test, all the diets floated with over 76.67% floatation. This could also be as a result of the uniform particle size (< 0.5mm) of ingredients that were used in their production (Hardy, 1989) [19]. Diet 6 (WO + Yeast) had the best floatation among the diets tested, the high content of gluten in wheat aided by the leavening property of yeast could have been responsible for this. However Diets 1 and 7 had the least floatation. The floatation of the diets was also observed to be greatly influenced by the bulk density of their pellets – Diet 6 with the least bulk density had the best floatation while Diets 1 and 7 had the least floatation. This supports the claim by Riaz (2009) [23] that objects must have bulk densities less than that of water (1g/cm^3) to float. It also agrees with the findings of Rokey and Plattner (2006) [25] which suggests that pellets will sink very fast when immersed in water if their bulk density is greater than 640g/cm^3.

The result obtained within the first 15 minutes is similar to that of Falayi and Sadiku (2013) [7] when yeast was included as a floating additive to wheat in the production of 30% CP diets, but was less subsequently. The subsequent difference in floatation could be attributed to the higher inclusion of heavy plant protein ingredients in this diet required to meet up the 40% CP target of the diet. The diet however had better floatation than recorded by Adeparusi and Famurewa (2011) [4] when 40% CP diets were produced, possibly as a result of the inclusion of yeast in this diet. The influence of yeast was also observed on Diet 2 (RB + Yeast) which also recorded 13.33% floatation within 6 – 10 minutes.

5. Conclusion and Recommendation

5.1 Conclusion

Among the ingredients tested, wheat offal holds the highest potential to enhance floatation of pellets, especially when it is fortified with yeast. Rice bran however comes second to wheat offal in terms of floatation and more stable in water after both pellets have sank to the bottom. Diets made of BDG were observed to have been the least water stable despite the fact that they were subjected to similar conditions of processing with diets made of the other test ingredients. Also, it was observed that the inclusion of yeast will not support significant floatation in all cases, since most of the diets had similar percentage floatation with or without yeast within the same time interval.

Therefore the results of the experiment indicates that a careful selection and formulation of ingredients can be done to produce pellets that can float relatively well in water, using wheat offal as a binding agent.

5.2 Recommendation

Wheat offal holds great potential for the aquaculture industry, the ingredient could be used efficiently to produce partially floating feeds. However, subsequent researches need to be directed towards determining the digestibility and nutrient utilization of these diets on different species of fish.

6. References

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