Effects of Nutrient Inclusion levels on Aquafeed Buoyancy

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Abstract
The production of on-farm floating fish feed using non-extrusion technology remains a challenge to fish farmers. This has made most fish farmers to depend on commercial extruded feeds. Thus, the investigation into the effect of nutrient inclusion levels (crude protein and different dietary lipids) on diets buoyancy. Nineteen (19) diets were formulated at two crude protein levels; 30% and 42% and three dietary lipids; Shea butter oil, palm oil and vegetable oil incorporated at three inclusion levels; 5%, 10% and 15% respectively. Data obtained were subjected to descriptive statistics. The results obtained indicated varying levels of buoyancy among diets. Thirty percentage (30% CP) crude protein with 5% vegetable and 10% sheabutter oil-based diets exhibited 100% floatation for over 60 minutes of immersion in water while 10% palm oil and shea butter oil-based diets showed 90% and 70% floatation respectively. However, the 42% crude protein with 10% sheabutter oil indicated 90% floatation for 60 minutes while 15% vegetable and sheabutter oil lipid inclusion levels diets did not float at all. It is therefore concluded that, 30% crude protein with 5% vegetable oil or 10% sheabutter oil or 10% palm oil inclusion levels would produce 100% floating pellets for 60 minutes and above and thus, recommended for fish farmers for adoption.

Keywords: floating, pellet, lipids, crude protein

Introduction

Fish feed production has direct effect on growth potential of the sector and is an important factor to consider in subsistence and commercial fish farming (Tsevis and Azzaydi, 2000). This feed has to be rich in nutrient and stable in water to reduce nutrients leaching as well as able to withstand handling during transportation (Suleiman *et al.,* 2008 and Suleiman *et al.,* 2009). With steady rise in global demand for fish food, it is imperative to sustain good quality and affordable feed for small scale farmers (Auta, *et al.,* 2012). The cost of extruded fish feed has a disadvantage over both the dried and moist pellet feeds that are locally produced (Lovell, 1988). Pelleted fish feed easily lose intactness which results in nutrient loss and water pollution (Holm and Walther, 1998; Lopez-Alverado *et al.,* 1994; Falayi *et al.,* 2005; Yisa, 2008). However, extruded floating feed enables farmers to observe how active the fish are and their consumption rate, the farmer also has knowledge of the number of fish during harvesting and restocking without draining (Mgbenka and Lovell, 1984; Falayi *et al.,* 2004). The extruded feeds are more digestible as a result of cooking process. It also allows for incorporation of high dietary lipid in fish feed. Lipids has been reported to regulate buoyancy due to their non-polar molecules that do not bond with water but rather form a layer on top of the water. Lipid is used to coat the extruded pellet in other to improve the palatability and appearance of feeds and aids absorption of fat soluble vitamins (Russo, 2009). In aquaculture, the use of alternative lipids to marine products has increased drastically; fish oil is now commonly replaced by vegetable oils due to environmental and economic considerations (Olsen, 2011). However, inspite of the numerous merits of fish oil, most farmers cannot afford it due to its high cost (Eyo, 1995). The substitution of fish oil in feeds does not only modify the fatty acid composition in the feed but also reduces the level of cholesterol (Norambuena *et al.,* 2013). Palm oil which is very rich in monenes, an additional benefit to fillet quality and health of the consumer. It also improves on the growth performance of African catfish in it diets (Lim *et al.,* 2001; Orire and Sadiku 2014). Sheabutter oil is not just readily available but cheap (Yusuf *et al.,* 2009). Sheabutter oil is an important oil due to the presence of alpha-tocopherol, an anti-oxidant which aid reduction of degenerative disease and mopping up of free radicals that could damage cell membrane (Olukemi *et al.,* 2005). Inclusion of groundnut oil in fish diet has been reported by Aderolu and Akinremi (2009), the authors asserted that, groundnut oil resulted in high mean weight and protein efficiency ratio of Catfish. Recent research has also shown that palm oil, coconut oil and peanut oil can be used as energy substitute in fish diet without any negative effect on growth (Ng *et al.,* 2003; Ng, 2004). Thus, this research evaluated the effects of nutrients (crude protein and lipid) inclusion levels on aquafeed buoyancy.

Materials and methods

Experimental location

This experiment was conducted in the laboratory of Water resources, Aquaculture and Fisheries Technology Department of the Federal University of Technology Minna, Niger state located at Gidan Kwano Campus.

Feedstuffs and materials

Feed ingredients used for the research work included fish meal, wheat flour, Saccharomyces cerevisiae, vitamin-mineral premix, palm oil, vegetable oil, and shea butter oil. Other equipment used were sensitive weighing balance (M300 citizen), warm water (28°C), hand pelleting machine and bowls. The fish meal, wheat flour, *Saccharomyces cerevisiae,* palm oil, vegetable oil, Shea butter oil and bowls were purchased from Kure Ultra-Modern market in Minna, Niger State, Nigeria while vitamin-mineral premix was obtained from fish feed store in Minna, Niger State.

Feed formulation and preparation was done using the Pearson square method. Nineteen (19) diets containing 30% and 42% crude proteins respectively to contain wheat flour, fish meal, vitamin mineral-premix, palm oil, vegetable oil and shea butter at three inclusion levels of 5%, 10% and 15% (Orire, 2010) and 5% Saccharomyces cerevisiae (Orire *et al.,* 2015) as floating catalyst while the control experiment had 0% lipid inclusion. The diets were designated as diet 1 (control), diet 2 (5% palm oil), diet 3 (10% palm oil), diet 4 (15% palm oil), diet 5 (5% vegetable oil), diet 6 (10% vegetable oil), diet 7 (15% vegetable oil), diet 8 (5% shea butter), diet 9 (10% shea butter), diet 10 (15% shea butter) for 30% crude protein and diet 11 (5% palm oil), diet 12 (10% palm oil), diet 13 (15% palm oil), diet 14 (5% groundnut oil), diet 15 (10% groundnut oil), diet 16 (15% groundnut oil), diet 17 (5% shea butter), diet 18 (10% shea butter), diet 19 (15% shea butter) for 42% crude protein diets respectively (Tables 1 and 2).

Feed preparation

Each feedstuff was measured in the right proportion as formulated into a dry plastic bowl. The entire ingredients were then thoroughly mixed to form a perfect dough which was then pelleted and oven dried at 60°C for 24 hours according to the method of Orire *et al.,* 2015.

Table 1: Formulated diets at 30% crude protein at varying inclusion levels of dietary lipids

Feedstuffs	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7	Diet 8	Diet 9	Diet 10
Fish meal	29.10	47.06	44.29	41.52	47.06	44.29	41.52	47.06	44.29	41.52
Wheat flour	60.90	37.94	37.71	33.48	37.94	37.71	33.48	37.94	37.71	33.48
Saccharomyces cerevisiae	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Vitamin-mineral premix	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Palm oil	0.00	5.00	10.00	15.00	0.00	0.00	0.00	0.00	0.00	0.00
Vegetable oil	0.00	0.00	0.00	0.00	5.00	10.00	15.00	0.00	0.00	0.00
Shea butter oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	10.00	15.00

Key: Diet 1(D1)=5% palm oil (PO)/30% crude protein (cp); D2=10% PO/30% cp, D3=15% PO/30%cp, D4=15% PO/30%cp, D5=5% vegetable oil (VO)/30%cp, D6=10% VO/30%cp, D8=15%VO/30%cp, D9=5% sheabutter oil (SO)/30%cp, D10=10% SO/30%cp, 15% SO/30%cp

Table 2: Formulated diets at 42% crude protein

Feedstuffs	Diet 11	Diet 12	Diet 13	Diet 14	Diet 15	Diet 16	Diet 17	Diet 18	Diet 19
Fish meal	27.50	25.90	24.30	27.50	25.90	24.30	27.50	25.90	24.30
Wheat flour	57.50	54.10	50.70	57.50	54.10	50.70	57.50	54.10	50.70
Saccharomyces cerevisiae	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Vitamin-mineral premix	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Palm oil	5.00	10.00	15.00	0.00	0.00	0.00	0.00	0.00	0.00
Vegetable oil	0.00	0.00	0.00	5.00	10.00	15.00	0.00	0.00	0.00
Shea butter oil	0.00	0.00	0.00	0.00	0.00	0.00	5.00	10.00	15.00

Diet 11(D11)=5% palm oil (PO)/42% crude protein (cp); D12=10% PO/42% cp, D13=15% PO/42%cp, D14=15% PO/42%cp, D15=5%vegetable oil(VO)/42%cp, D16=10% VO/42%cp, D17=15%VO/42%cp, D18=5% sheabutter oil (SO)/42%cp, D19=10% SO/42%cp, 15% SO/42%cp

Feed buoyancy test

pellets for produced the nineteen experimental diets were subjected to buoyancy test by dropping 10 pieces of pellets into a 500 ml beaker half filled with water. A digital stop watch was used to record the numbers of pellets that sink every five minutes for 60 minutes.

Statistical analysis

Descriptive statistics was used to analyse the experimental data generated using line graphs with the aid of Microsoft Excel office 2016.

Results

Figure 1 shows the floatation rate for 30% crude protein with 5% varying lipids diets immersed in water for 60 minutes. Diet with 5% vegetable oil had 100% floatation for 60 minutes while the palm oil and shea butter oil diets exhibited 90% floatation for 60 minutes respectively. Figure 2 shows the floatation rate

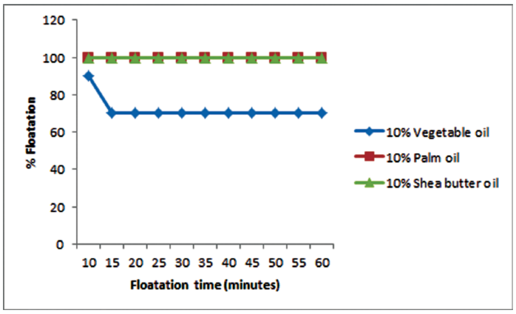

Figure 2: Effects of 10% inclusion level of varying lipids on feed buoyancy at 30% crude protein level

for 30% crude protein diets with 10% different lipids. Palm oil and shea butter oil-based diets had 100% floatation for 60 minutes while vegetable oil-based diet had 70% floatation for the rest of the period. The floatation percentage for 15% varying lipids is shown in figure 3 which exhibited 90% floatation for palm oil-based diet whose floatation lasted for about 15 minutes then, dropped steadily to 80, 70, 50%

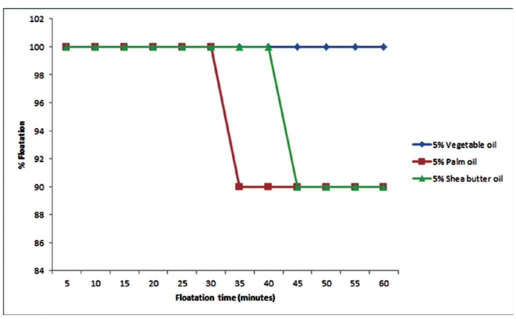

Figure 1: Effects of 5% inclusion level of varying lipids on feed buoyancy at 30% crude protein level

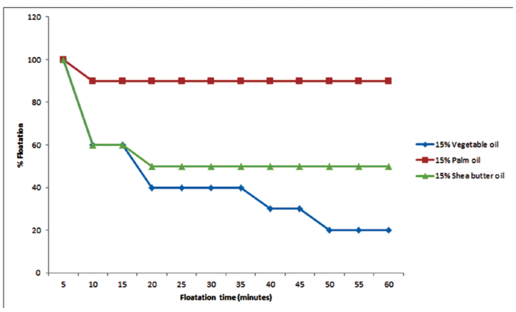

Figure 3: Effects of 15% inclusion level of varying lipids on feed buoyancy at 30% crude protein level

and finally 40% for the rest of the rest of the period. The shea butter oil and vegetable oil-based diets gave 50 and 30% floatation for 60 minutes respectively.

Figure 4 displays the floatation percentage for 42% crude protein with 5% varying lipids. It was observed that diets with vegetable oil and palm oil had 70% floatation for 60 minutes while the shea butter oil-based diet gave 30% floatation for the first 50 minutes which then dropped to 20% for 60 minutes. At 10% lipids inclusion level, sheabutter and palm oil-based diets had 90 and 80% floatation for 60 minutes respectively while vegetable oil-based diet showed the floatability of 10% for 60 minutes (Figure 5). At the highest inclusion level of 15%, only palm oil based diet had between 40% and 10% floatation while sheabutter and vegetable oil-based diets did not float at all (Figure 6).

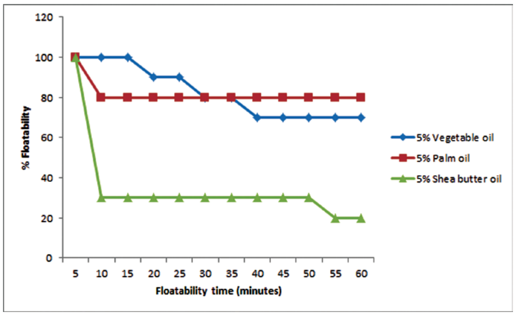

Figure 4: Effects of 5% inclusion level of varying lipids on feed buoyancy at 42% crude protein level

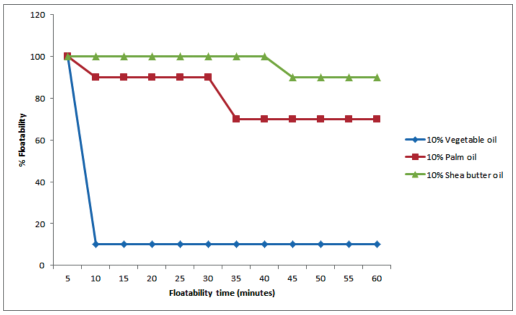

Figure 5: Effects of 10% inclusion level of varying lipids on feed buoyancy at 42% crude protein level

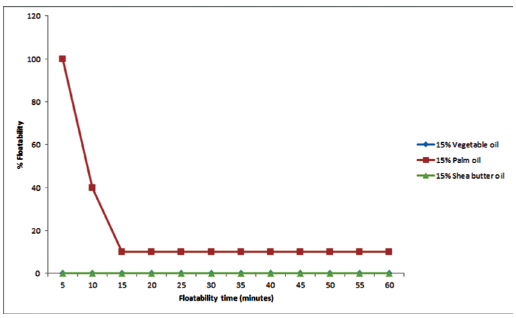

Figure 6: Effects of 15% inclusion level of varying lipids on feed buoyancy at 42% crude protein level

Discussion

The lipids had positive impact on the buoyancy of the experimental diets as observed in the results (Russo, 2009). However, the floatability rate was directly affected by the lipid type as well as inclusion level which can be attributed to the molecular weight of the lipids. The molecular weight of the lipid played significant role in the diet buoyancy as observed with vegetable oil and shea butter oil which gave 0% floatability at highest inclusion level of 15% compared with palm oil that had 100% floatability of about 10 minutes of immersion in water. This is agreement with the finding of Adekunle *et al.,* (2012) who reported that molecular weight of feedstuffs determine diet buoyancy. Similarly, at higher crude protein level (42%), low floatation rate was observed irrespective of lipid types and levels compared with 30% crude protein diets, this could be attributed to high protein density of 42% crude protein-based diets compared to a high energy-based feedstuff of 30% crude protein diets. This is in agreement with the report of ABC Machinery (2020) that, decrease in the molecular weight of starch during extrusion causes feed buoyancy. However, in contrast, a high crude protein level (42%) diet with 10% sheabutter showed 90% floatation due to the low molecular weight of the lipid compared with palm oil and vegetable oil incorporated at the same rate. The palm oil at 10% inclusion level, vegetable oil (5%) and Shea butter oil (10%) respectively gave 100% floatation for 60 minutes for 30% crude protein diets while 42% crude protein diets of same inclusion level of various lipids gave 80%, 70% and 90% floatation for 60 minutes respectively. The differences in buoyancy can be attributed to their density (Smith, 2017). At low inclusion level of 5%, vegetable oil with a medium density of 0.9110 g/cm^3 exhibited 100% floatability while palm oil (0.9210 g/cm^3) and sheabutter oil (0.917 g/cm^3) of denser nature exhibited lower floatability especially at high inclusion levels. Thus, at 15% inclusion level, there was decline in floatability for all diets irrespective of lipid type however, palm oil based diet showed some level of floatation compared to sheabutter and vegetable oil. This trend can be attributed to the positive upthrust tendency of the lipids according to Archimede's principle (Hidetaka, 2016). Hence, for the vegetable oil at 5% and sheabutter and palm oil at 10% respectively to produce 100% pellets buoyancy is an indication of positive upthrust of the lipids and its non-polar nature (Russo, 2009) in agreement with the finding from this study.

Conclusion

Appropriate inclusion crude protein and dietary lipid (palm oil, vegetable oil and shea butter oil) in fish diet can cause feed buoyancy. Inclusion of 5% vegetable or 10% sheabutter oil in 30% crude protein diet can produce 100% feed floatation for more than 60 minutes while 10% inclusion of sheabutter oil at 42% crude protein gives 90% floatation while 15% level of vegetable and sheabutter oil at 42% crude protein did not float at all.

Recommendation

Production of 100% on-farm floating feed that will float for more than 60 minutes can be achieved by adding 5% vegetable oil or 10% sheabutter oil for 30% crude protein. Ninety percent (90%) floatation for 60 minutes could also be attained by inclusion of 10% sheabutter oil at 42% crude.

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