

Research Application Summary

Effect of different types and levels of binding agents on stability and nutritional availability of formulated diets of *Oreochromis shiranus* (Pisces: Cichlidae)

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Abstract

Binding agents are -important ingredients in fish diets which provide stability to the pellet and reduces leaching of nutrients into the water. However, major weakness of most binding agents are instability, they are affected by heat, oxidation, light and moisture, among others. Therefore, a study was conducted to assess the effect of different types and levels of binding agents on stability and nutritional availability of formulated diets on performance of *Oreochromis shiranus* fingerlings. The experiment was conducted in a CRD design and used eight different diets with different binder combinations and each treatment (diet) was replicated three times. Main ingredients in the diets included soybean, fish (usipa), maize meal and wheat bran. Main binders in the diets included wheat (*Triticum aestivum*), cassava (*Manihot esculenta*), arabic gum (*Acacia senegal*) and okra (*Abelmoschus ficulneus*). The experiment was carried out for 12 weeks (From 11 March to 3 June 2019). Both male and female fingerlings of *O. shiranus* with an initial average body weight of 6 ± 1 g were collected from Bunda fish farm. Fifteen (15) fingerlings were stocked in each aquarium, each treatment had 45 fingerlings. Each type of diet was used twice per day (9am and 2pm) into three aquariums (triplicate) at 5% body weight of the fingerlings used. Every two weeks, eight fingerlings from each aquarium were sampled. The weight of each sampled fish was measured using electronic balance and total length was measured using a measuring board. Preliminary plot of growth performance shows that fingerlings given diet 1 which had 5% wheat flour binder, diet 3 with 5% cassava flour binder, diet 5 with 5% Arabic gum binder and diet 7 with 5% okra binder produced better growth performance in terms of weight and length compared to the four other diets. Reasons for the differences are being explored.

Key words: Binder, feed, fish diet, fingerlings, growth performance, ingredients, *Oreochromis shiranus*

Résumé

Binding agents are -important ingredients in fish diets which provide stability to the pellet and reduces leaching of nutrients into the water. However, major weakness of most binding agents are instability, they are affected by heat, oxidation, light and moisture, among others. Therefore, a study was conducted to assess the effect of different types and levels of binding agents on stability and nutritional availability of formulated diets on performance of *Oreochromis shiranus* fingerlings. The experiment was conducted in a CRD design and used eight different diets with different binder combinations and each treatment (diet) was replicated three times. Main ingredients in the diets included soybean, fish (usipa), maize meal and wheat bran. Main binders in the diets included wheat (*Triticum aestivum*), cassava (*Manihot esculenta*), arabic gum (*Acacia senegal*) and okra (*Abelmoschus ficulneus*). The experiment was carried out for 12 weeks (From 11 March to 3 June 2019). Both male and female fingerlings of *O. shiranus* with an initial average body weight of 6 ± 1 g were collected from Bunda fish farm. Fifteen (15) fingerlings were stocked in each aquarium, each treatment had 45 fingerlings.

Each type of diet was used twice per day (9am and 2pm) into three aquariums (triplicate) at 5% body weight of the fingerlings used. Every two weeks, eight fingerlings from each aquarium were sampled. The weight of each sampled fish was measured using electronic balance and total length was measured using a measuring board. Preliminary plot of growth performance shows that fingerlings given diet 1 which had 5% wheat flour binder, diet 3 with 5% cassava flour binder, diet 5 with 5% Arabic gum binder and diet 7 with 5% okra binder produced better growth performance in terms of weight and length compared to the four other diets. Reasons for the differences are being explored.

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Background

In fish culture the cost of feed accounts for 50 to 60 percent of the total cost of production (Moond *et al.*, 2004). Good water stable pellets are a major concern for the aquaculture industry (Dominy *et al.*, 2003). Binding agents have been widely employed to improve the stability of aquatic animal feed. Binders are believed to prevent or at least reduce major nutrient loss and feed softness which is inevitable when pellets stay in water for long periods of time. Preventing or reducing such an inconvenience has beneficial consequences on the aquaculture industry (Paolucci *et al.*, 2012). Stability and availability of binding agents in the diet can optimize performance of fish species such as *Oreochromis shiranus* by ensuring proper management and controlling environmental factors.

Binding agents are important ingredients in fish diets which provide stability to the pellet and reduces leaching of nutrients into the water. Carbohydrates (starch, cellulose, pectin) and various other polysaccharides, such as extracts or derivatives from animals (gelatin), plants (gum Arabic, locust bean), and seaweeds (agar, carrageenan, and other alginates) are also popular binding agents (Jasmine, 2000; Moond *et al.*, 2004). However, major weakness of most binding agents are instability, as they are affected by heat, oxidation, light and moisture, among others (Falayi *et al.*, 2005). Some binders are not suitable for feeding aquatic animals due to poor ingestion, feed conversion, and reduced water quality. For instances, pellets need to be stable in water until consumed by the target animal (Shailendra *et al.*, 2012). Good pellet stability is required for slow-feeding species and particle size is important to insure appropriate consumption. Therefore, most organic binders are good for about 30 – 45 minutes of submergence. On the other hand, chemical binders (e.g., Basfin) have good binding potential, form cross-linkages with carbohydrate and protein, but are toxic. These binders can affect growth, health or the processed product. Furthermore, other researches document that some binders such as organic matrix (lingosulfonates or polysaccharides) and chemical compounds (sodium hexameta phosphate) are used for improving water stability (reduced leaching and nutrient loss) (Bhilave *et al.*, 2010).

Therefore, this study was designed to assess the effect of different types and levels of binding agents on stability and nutritional availability of formulated diets on performance of *O. shiranus* fingerlings. The information generated from the study will help the farmers in enhancing feed utilization and in turn increase production of *O. shiranus* through using locally available binding agents in fish feeds. This would increase food security to fish farming families and increase daily incomes. Furthermore, this information will also help feed processors and manufacturers to develop fish diets with low cost that will help fish farmers to have more profit. The specific objective of this study was to determine the effect of different types (wheat flour, cassava flour, Arabic gum flour and ladies finger flour) and levels of (5% and 15%) of binding agents used in diets formulation on growth rate and survival rate of *O. shiranus*.

Materials and Methods

Experimental design. The experiment was setup in Completely Randomised Design (CRD) using 24 plastic aquariums of 56 liters capacity at LUANAR Aquaculture and Fisheries Laboratory (Figure 1). The experiment used eight different diets with different binder combinations and each treatment (diet) was replicated three times.



Figure 1. PhD student (Mohammed Ahmed) from Sudan setting up the experiment in the laboratory at LUANAR

Main ingredients preparation. Soybean was purchased from Mitundu market and autoclaved in sterilization machine for 15 minutes at a temperature of 123°C to remove anti-nutrients subsequently it was placed under the shade for two days to dry before milling to powder form. Fish (usipa) was purchased from Mitundu market and placed under the shade for three days to dry and milled to powder form. Maize meal was purchased from Mitundu market and then milled to powder form. Wheat bran premixes (minerals, vitamins and amino acids) were purchased from Sudan.



Figure 2. From top left to the right: Soybean, usipa, maize meal and wheat bran

Proximate analyses of main ingredients: Proximate analysis of each type of ingredient and diets formulated was conducted at Aquaculture and Fisheries Science laboratory to determine moisture, ash, crude protein, crude lipid, fiber and gross energy according to AOAC (2002) procedures. The variables (moisture, ash, crude protein, lipid, fiber and gross energy) were analyzed in three replicates for each ingredient and diets.

Table 1. Proximate analysis of ingredients used in diet formulation

Ingredients	Dry mater %	Ash %	Crude protein %	Crude fat %
Fish meal	91.96±1.587	4.81±0.3656	60.72±1.237	11.28±1.371
Soybean	92.37±1.764	4.01±1.1223	40.42±0.9126	15.21±0.546
Maize meal	88±1.826	5.11±0.2331	9.0±0.3714	3.41±0.3625
Wheat bran	90.13±1.235	5.82±0.8532	18±0.8152	3.45±0.491

Binders preparation: Wheat (*Triticum aestivum*) was purchased from Lilongwe market and milled to powder form. Cassava (*Manihot esculenta*) was purchased from Mitundu market and placed under the shade for one week to dry and milled to powder form. Arabic gum (*Acacia senegal*) was purchased from Sudan and milled to powder form. Okra (*Abelmoschus ficulneus*) was purchased from Sudan and placed under the shade for one week to dry and milled to powder form.



Figure 3. From top left to the right: Wheat, cassava, Arabic gum and Okra

Feed formulation: Eight diets (Table 2) with different binder combinations were formulated at 30% crude protein by Trial and Error method using Excel program. Four (4) types of binder were added at two different levels of 5% and 15% in the diets, to formulate eight (8) diets. Wheat flour starch was used in Diet 1 at 5% (control diet) and Diet 2 at 15% while Diets 3 and 4 contained cassava flour starch at 5% and 15%. Diets 5 and 6 contained Arabic gum flour at 5% and 15%, while Diets 7 and 8 contained okra gum at 5% and 15%.

All ingredients (soybean, fish meal, wheat bran, maize meal and binder), vitamins, minerals and salt were well mixed and water was added to form moist dough. Traditional sinking pellets were made from the eight diets that were formulated. Small size (2mm) pellets (Figure 3) were made by using pelleting machine (meat mincer) and were dried under shade. The pellets were further crumbled to small pieces for feeding fingerlings.

Table 2. Diets with different binders and levels (5 - 15 %) and their inclusion levels

Ingredients	Diets							
	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7	Diet 8
Soybean (%)	54	54	54	54	54	54	54	54
Fish (%)	7	10	7	10	7	10	7	10
Maize (%)	12	7	12	7	12	7	12	7
Wheat (%)	18	10	18	10	18	10	18	10
Binder (%)	5 WF	15 WF	5 CF	15 CF	5 OKF	15 OKF	5 GAF	15 GAF
Premixes (%)	3	3	3	3	3	3	3	3
Salt (%)	1	1	1	1	1	1	1	1
Total (%)	100	100	100	100	100	100	100	100
Crude protein %	30.38	30.31	30.38	30.31	30.38	30.31	30.38	30.31



Figure 4. Pellets (2 mm) made using pelleting machine (meat mincer)

Proximate analysis of diets. Proximate analysis of each diet formulated was conducted at Aquaculture and Fisheries Science laboratory to determine moisture, ash, crude protein, crude lipid, fiber and gross energy according to AOAC (2002) procedures. The summary of analysis is presented in Table 3.

Table 3. Proximate analysis of eight diets (pellets) formulated

Diets	DM %	Ash %	C. Protein %	C. Fat %	C. Fiber %	Gross energy cal/g
Diet 1	88.43±0.12	4.44±0.14	30.48±0.21	10.13±0.66	8.64±0.09	4749±17.95
Diet 2	87.71±0.17	4.35±0.05	31.03±0.5	10.15±0.78	7.38±0.21	4791±23.54
Diet 3	89.40±1.86	4.40±0.06	30.42±0.27	10.07±0.44	8.23±0.38	4730±21.08
Diet 4	88.49±1.24	4.28±0.17	30.92±0.15	10.09±0.31	7.50±0.14	4738±22.65
Diet 5	88.98±0.57	4.71±0.05	30.44±0.27	10.25±0.21	8.46±0.04	4766±25.24
Diet 6	89.01±1.81	4.84±0.03	31.11±0.5	10.30±0.24	7.48±0.36	4780±19.04
Diet 7	88.96±0.17	4.55±0.40	30.41±0.05	10.02±0.68	8.61±0.28	4736±24.06
Diet 8	89.93±0.32	4.37±0.03	30.89±0.15	10.10±0.49	7.66±0.17	4751±21.52

Feeding trail. The experiment was carried out for 12 weeks (From 11 March to 3 June 2019). Both male and female fingerlings (*O. shiranus*) with an initial average body weight of 6±1 g were collected from Bunda fish farm. Subsequently, 15 fingerlings were stoked in each aquarium, each treatment had 45 fingerlings. Each type of diet was fed to the fingerlings twice per day (9 am and 2 pm) in three aquariums (triplicate) at 5% body weight.

Preliminary Results

Every two weeks, eight fingerlings from each aquarium were sampled. The weight of each sampled fish was measured using electronic balance and total length was measured using a measuring board. Preliminary plot of growth performance (Figures 5 and 6) shows that fingerlings given diet 1 which had 5% wheat flour binder, diet 3 with 5% cassava flour binder, diet 5 with 5% Arabic gum binder and diet 7 with 5% okra binder produced better growth performance in terms of weight and length compared to the other four diets.

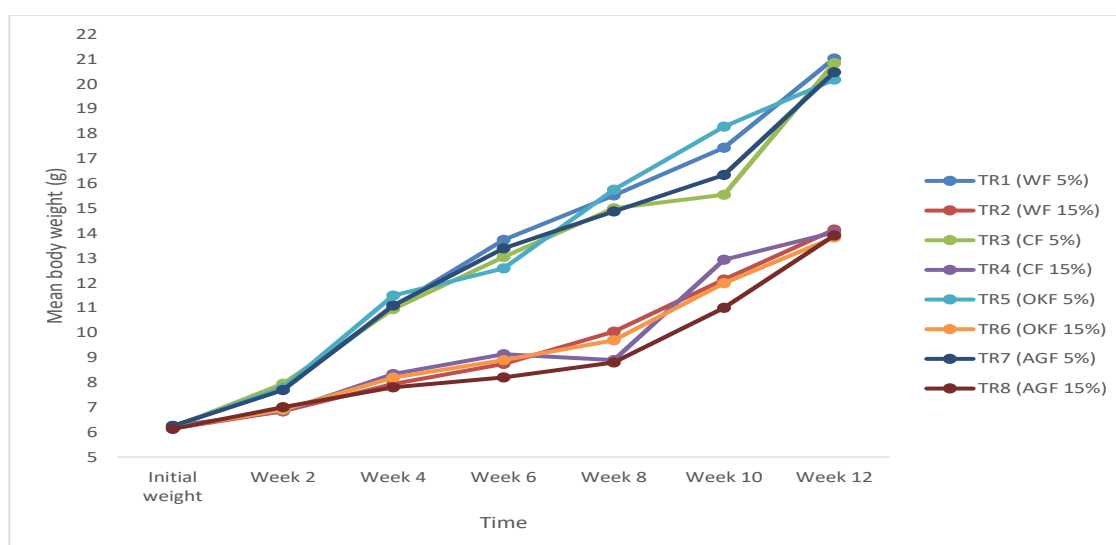


Figure 5. Mean body weight for fingerlings with different diets

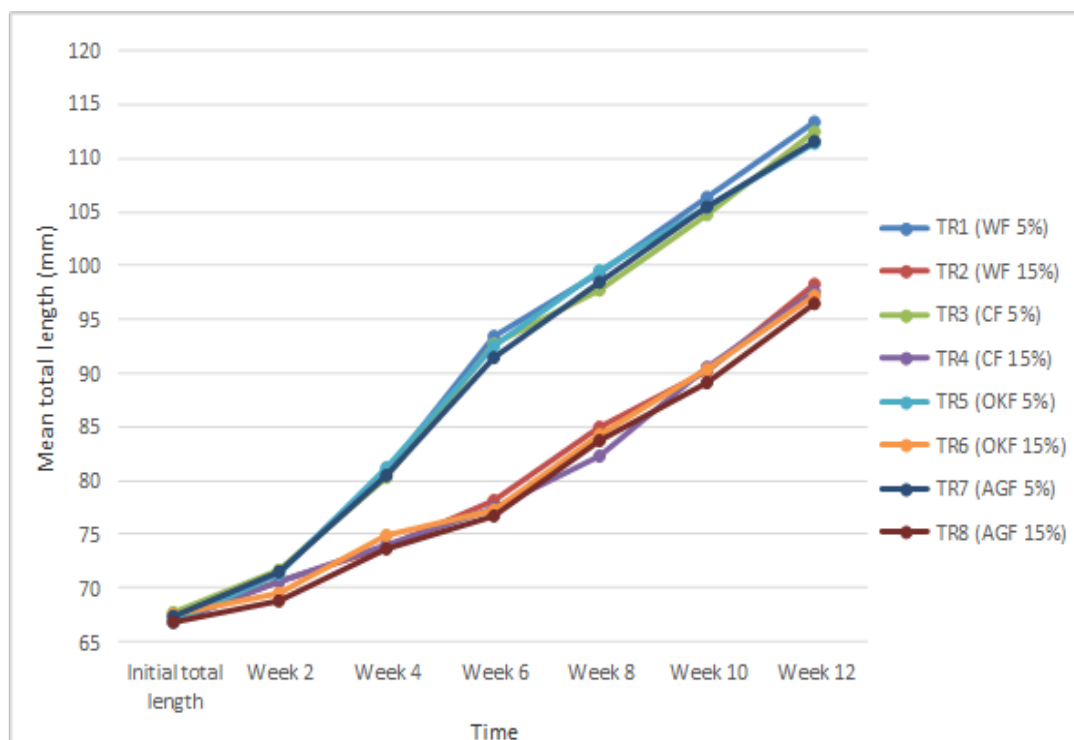


Figure 6. Mean total length of fingerlings fed with different diets

The reasons for differences in growth patterns will be explored in subsequent studies.

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