INCREASE FISH FEED STABILITY USING GUAR GUM (INDIGESTIBLE BINDER):A CASE STUDY OF *CHANNA STRIATA*

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ABSTRACT

This research aimed to study the effects of Guar Gum, an indigestible binder, addition to the rainbow trout feed on the growth rate of *Channa striata* and its feces characteristics. Guar Gum was added to increase faces stability or, in another words, to lower the breakdown of feces that causes dispersion of nitrogen, carbon, and phosphorus sources into the wastewater. *Channa striata* was selected as experimental fish with an approximate body length of approximately 4 inches. Guar gum was varied at 0.01, 0.02, and 0.03% of guar gum to trout feed. Specific growth rates and feed conversion were calculated based on fish weights. Characteristic of feces and organic nitrogen in feed and water were analyzed. Feces stability increased as percentage of guar gum addition increased. The binder-stabilized feces remained larger, denser, and easier to collect. The diets containing guar gum had more effect to feed conversion and growth rate. The growth rates of *Channa striata* were 50.0%, 48.4%, 48.4% and 48.3% at 0.0 (control), 0.01, 0.02, and 0.03% of guar gum, respectively.

Keywords: *Channa striata*, Guar gum, Feed formula, Rainbow trout, feces stability

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INTRODUCTION

The Royal Project Foundation at Doi Inthanond initated the experimental fishery station to harvest rainbow trout. The trout used a flow-through system that required high amount of water from Siriphum Waterfalls. During the summer time, the trout farm decreased the number of ponds since the water quantity was limited. Thus, the trout stocking density in each pond increased generating a higher demand for dissolved oxygen (DO) in water and an increase in ammonia concentration (Warinthorn , 2003). To solve the problem, the station sometimes stops feeding the rainbow trout resulting in a lower growth rate of the fish.

Major wastes produced by aquaculture operations are uneaten and/or spilled feed and feces which directly affect water quality, such as ammonia, nitrogen, pH, temperature and dissolved oxygen (Pond, et al, 1995). In addition, feces are major sources of organic nitrogen and phosphorus that are transformed by microorganisms to toxic compounds such as ammonia, nitrite, and nitrate (Wan, 2001).

The addition of guar gum, a high-viscosity, indigestible binder, to the fish feed can slow the breakdown of feces and reduce the dispersion of the aforementioned toxic compounds. Guar gum is neither digestible nor absorbed to fish. Thus, it could help pro-long usage life of water in the rainbow trout ponds (Alexander and Wolfgang, 2004)

The objective of this research was to study the effects of adding guar gum in fish feed composition on the fish growth rate and feces characteristics. *Channa striata* were used as a preliminary case study before applying to the trout aquaculture, since it have resemblance in morphology and physiology of digestive tract and feeding behavior (Leitritz, et al, 1980).

MATERIALS AND METHODS

2.1 Diet and husbandry

Channa striata was selected as experimental fish. Each had an approximate body length of 10 cm. The fish were fed at the 5th days during the period of 20 days. The daily intake was 0.5% of its body weight. The feed was dispensed manually at 9:30 am and 4 pm. The remaining feed was removed after half an hour after feeding. This feeding regime resulted in the production of fecal pellets on the verge of excretion at 11:30 p.m. The fecal pellets were collected to study the physical and density characteristics. Ammonia, nitrite and nitrate were determined.

Four diets were formulated from the basic feed formula containing balanced level of amino acids, fatty acids, vitamins and minerals. All components exceeded the levels recommended by standard of trout feed. One negative control was without the Guar gum binder, while the other three contained the binder in different concentrations (table 1). The diets were produced by grinding basic diets and mixing with guar gum.

Table 1. Composition of the experimental diets *(BD= basic diet, VG= viscosity guar gum*

	Unit	Diet 1	Diet 2	Diet 3	Diet 4
		BD	VG 0.01%	VG 0.02%	VG 0.03%
BD	g kg^{-1}	1000	1000	1000	1000
Guar gum	g kg^{-1}	-	0.1	0.2	0.3

Channa striata size were 4±1 inches. Experiments were conducted in 10 aquarium tanks (height: 35 cm., weight: 40 cm., length: 50 cm) with the water volume of 30 liters. The water flow for each tank was adjusted to 12 L/min.

2.2 Specific growth rate and feed conversion ratio

For each diets test, three experimental trials were conducted with duplicate groups of *Channa striata.* The effects of the dietary binder treatments on specific growth rate (SGR) and feed conversion ratio (FCR) were investigated. The SGR and FCR were calculated by weighing fish at every 5 days and calculated from the intake feed (Castell and Tiews, 1980; Halver, 1972). Differences of SGR and FCR in each treatment were analyzed using multiply comparison in statistics. The fish SGR was calculated as shown in the following equation using the initial and final mean weights.

$$SGR[\%d] = \frac{In(MFW) - In(MIW)}{t(final\ date) - t(initial\ date)} x100$$

(1)

MFW = mean final weight

MIW = mean initial weight

The FCR was calculated as:

$$FCR = \frac{Feed\ [kg]}{Weight\ [kg]}$$

2.3 Feces dispersion

Fish feces were collected for image analysis and size measurement. Microscopic method was used to observe physical characteristics of the feces. During the experiment, feces were preserved in aluminium dishes, hermetically sealed with a plastic film to prevent dehydration, and cooled at 4°C (Wicks, 2001)

2.4 Water quality

Samples for water quality analysis were collected every day. Ammonia, nitrite and nitrate were determined. The differences were determined using the statistical multiply comparison method Clesceri, et al., 1998)

RESULTS AND DISCUSSION

3.1 Specific growth rate and feed conversion ratio

Channa striata were fed for 20 days with the basic diets, diets with guar gum of 0.01%, 0.02% and 0.03%. Table 2 presents the SGR calculated from the experimental results. The specific growth rate (SGR) were affected by guar gum at 0.05 significant level and SGR in treatment with guar gum were not different at 0.05 significant level.

Table 2. Specific growth rate of *Channa striata* were fed by basic diet, diet with 0.01%%, 0.02% and 0.03% of guar gum within 20 days (Mean ± S.D.)

Days	Diet	Specific growth rate (Mean ± S.D.)
5	Rainbow trout's feed	$46.89^{a} \pm 0.23$
	Rainbow trout's feed + 0.01% guar gum	$45.18^{b} \pm 0.14$
	Rainbow trout's feed + 0.02% guar gum	$45.04^{b} \pm 0.47$
	Rainbow trout's feed + 0.03% guar gum	$45.30^{b} \pm 0.76$
10	Rainbow trout's feed	$48.31^{a} \pm 0.28$
	Rainbow trout's feed + 0.01% guar gum	$46.58^{b} \pm 0.23$
	Rainbow trout's feed + 0.02% guar gum	$46.67^{b} \pm 0.41$
	Rainbow trout's feed + 0.03% guar gum	$46.78^{b} \pm 0.25$
15	Rainbow trout's feed	$49.20^{a} \pm 0.30$
	Rainbow trout's feed + 0.01% guar gum	$47.61^{b} \pm 0.22$
	Rainbow trout's feed + 0.02% guar gum	$47.58^{b} \pm 0.30$
	Rainbow trout's feed + 0.03% guar gum	$47.48^{b} \pm 0.21$
20	Rainbow trout's feed	$49.99^{a} \pm 0.30$
	Rainbow trout's feed + 0.01% guar gum	$48.40^{b} \pm 0.19$
	Rainbow trout's feed + 0.02% guar gum	$48.37^{b} \pm 0.29$
	Rainbow trout's feed + 0.03% guar gum	$48.28^{b} \pm 0.17$

Normally, the specific growth rate of juvenile *Channa striata* were 90-95% with the feed weight of 1-1.5% of fish weight (Fange and Grove , 1997). However, the SGR were 50.0%, 48.4%, 48.4% and 48.3% in basic diet, diet with guar gum 0.01%, 0.02% and 0.03%, respectively. Suitable rate of guar gum in feed should not exceed 0.05% because it maybe toxic to fish (Raven and Walker, 1980). The cause of a lower SGR than the normal rate was the lower feed weight of 0.5% of fish weight. The SGR with diets with guar gum addition was lower than that without guar gum addition, since guar gum is indigestible and may obstruct the absorption of nutrients of the fish especially fat, that is one of the most important nutrients for growth (Brett, 1997; Manop, 2004).

The feed conversion ratio (FCR) was analyzed at 95% confident interval by feeding at 0.5%of fish weight per day. With an addition of guar gum, FCRs were insignificantly different at approximately 0.6 per feeding at 0.5% of fish weight (table 3). Normally, the FCR of *Channa striata* were 1.6 per feeding at 1.2-1.5% of fish weight (Jarean , 1977). During the feeding time between 5-10 days, FCR decreased to 0.2-0.3 due to fish were sick during that period (Halver, 1972).

Table 3. Feed conversion ratio (FCR) of *Channa striata* fed by basic diet, diet with 0.01%, 0.02% and 0.03% of guar gum within 20 days (Mean ± S.D.)

Days	Diet	Feed conversion ratio (Mean ± S.D.)
5	Rainbow trout's feed	$0.51^{a} \pm 0.10$
	Rainbow trout's feed + 0.01% guar gum	$0.54^{a} \pm 0.06$
	Rainbow trout's feed + 0.02% guar gum	$0.54^{a} \pm 0.06$
	Rainbow trout's feed + 0.03% guar gum	$0.54^{a} \pm 0.13$
10	Rainbow trout's feed	$0.24^{a} \pm 0.02$
	Rainbow trout's feed + 0.01% guar gum	$0.27^{a} \pm 0.03$
	Rainbow trout's feed + 0.02% guar gum	$0.27^{a} \pm 0.08$
	Rainbow trout's feed + 0.03% guar gum	$0.27^{a} \pm 0.06$
15	Rainbow trout's feed	$0.51^{a} \pm 0.10$
	Rainbow trout's feed + 0.01% guar gum	$0.54^{a} \pm 0.06$
	Rainbow trout's feed + 0.02% guar gum	$0.54^{a} \pm 0.04$
	Rainbow trout's feed + 0.03% guar gum	$0.54^{a} \pm 0.13$
20	Rainbow trout's feed	$0.59^{a} \pm 0.08$
	Rainbow trout's feed + 0.01% guar gum	$0.64^{a} \pm 0.06$
	Rainbow trout's feed + 0.02% guar gum	$0.64^{a} \pm 0.07$
	Rainbow trout's feed + 0.03% guar gum	$0.64^{a} \pm 0.07$

3.2 Feces dispersion

In rainbow trout farm systems, suspended particles comprise mainly of fish feces significantly impact the total pollutant load in the system (Summerfelt, 1999). A proportion of those solids could be removed mechanically by sieves and sedimentation devices for prevent disperse of ammonia from these waste (Cripps and Bergheim, 2000). The addition of dietary binders to fish feeds may result in the production of large feces particles with an enhanced potential to retain leachable components such as ammonia that resulting to prolong shelf-life of water in fish culture (USDA/CSREES, 1997).

Channa striata fed with rainbow trout diet 0, 0.01, 0.02 and 0.03% guar gum affected the physical characteristics of the fish's feces.

The characteristics were observed through the dimension of feces. The fish feces had dimensions of 4x3, 1x7, 2x9, and 1.5x13cm for 0, 0.01, 0.02, and 0.03% guar gum addition, respectively. Further, the increase in guar gum addition increased feces density visualized by the microscope (100x). Guar gum as a binder possesses an exceptional structural integrity due to continuous re-entanglement of the polysaccharide network (Fox J.E., 1992). This structural robustness created effective adhesion of feces material to form large particles and hard compaction (Morris, et al.,1981).

1.3 Water quality

Water temperature, dissolved oxygen, and pH were measured every day. The temperature, dissolved oxygen, and pH were in the range of 26-27.5°C, 7.5-8.2 and 7-8, respectively. Ammonia, nitrite and nitrate concentrations were measured and statistically analyzed by multiply comparison at 95% confident interval. Fish excrete ammonia directly through gill respiration and, in addition, bacteria break down fish feces and uneaten feed to generate ammonia, nitrite (NO_2^-) and nitrate (NO_3^-) from the nitrification process by Nitrifying bacteria (Maccrimmon, 1971). An addition of guar gum at 0.01, 0.02, and 0.03% affected the ammonia, nitrite and nitrate concentrations (table 4). Ammonia concentration decreased slightly over time. They were different at 0.05 significant levels. The experiment with 0.03% of guar gum showed the lowest ammonia concentration. The same trend was seen with nitrite concentrations. In addition, nitrite concentration decreased slightly over time. It may be resulted from the nitrification process that *Nitrobacter* subsequently transformed nitrite to nitrate Bergheim and Asgard, 1996; Bergheim, et al., 1998). An addition of 0.03% guar gum yielded the lowest nitrate concentration (Azevedo, et al., 1998).

Table 4. Ammonia, nitrite, and nitrate concentrations (Mean ± S.D.)

Days	Diet	Ammonia concentration (Mean ± S.D.)	Nitrite concentration (Mean ± S.D.)	Nitrate concentration (Mean ± S.D.)
5	Rainbow trout's feed	0.38^{a} ± 0.0000	12.51^{a} ± 0.36	24.46^{a} ± 0.23
	Rainbow trout's feed + 0.01% guar gum	0.37^{b} ± 0.0058	11.44^{b} ± 0.42	21.13^{ab} ± 0.68
	Rainbow trout's feed + 0.02% guar gum	0.35^{c} ± 0.0067	10.90^{b} ± 0.11	19.78^{b} ± 0.49
	Rainbow trout's feed + 0.03% guar gum	0.33^{c} ± 0.0061	11.65^{b} ± 0.31	13.65^{c} ± 1.17
10	Rainbow trout's feed	0.14^{a} ± 0.0035	12.18^{a} ± 0.49	21.78^{a} ± 0.22
	Rainbow trout's feed + 0.01% guar gum	0.13^{a} ± 0.0116	11.19^{ab} ± 0.82	20.44^{ab} ± 0.68
	Rainbow trout's feed + 0.02% guar gum	0.13^{a} ± 0.0064	10.39^{b} ± 0.15	19.12^{b} ± 0.50
	Rainbow trout's feed + 0.03% guar gum	0.12^{a} ± 0.0157	10.73^{b} ± 0.03	12.96^{c} ± 1.17
15	Rainbow trout's feed	0.11^{a} ± 0.0020	10.50^{a} ± 0.10	19.41^{a} ± 0.22
	Rainbow trout's feed + 0.01% guar gum	0.07^{b} ± 0.0007	9.37^{b} ± 0.41	18.12^{ab} ± 0.69
	Rainbow trout's feed + 0.02% guar gum	0.06^{c} ± 0.0035	8.05^{c} ± 0.29	16.75^{b} ± 0.48
	Rainbow trout's feed + 0.03% guar gum	0.05^{d} ± 0.0000	7.40^{c} ± 0.40	10.64^{c} ± 1.16
20	Rainbow trout's feed	0.09^{a} ± 0.0020	9.89^{a} ± 0.27	14.72^{a} ± 0.45
	Rainbow trout's feed + 0.01% guar gum	0.05^{b} ± 0.0012	8.87^{ab} ± 0.60	13.52^{ab} ± 0.17
	Rainbow trout's feed + 0.02% guar gum	0.04^{c} ± 0.0031	7.49^{b} ± 0.46	12.26^{b} ± 0.72
	Rainbow trout's feed + 0.03% guar gum	0.02^{d} ± 0.0042	5.67^{c} ± 0.76	5.93^{c} ± 1.16

CONCLUSION

Experiments were conducted to test the effects of guar gum addition to the rainbow trout diets using Channa striata as a case study. The results showed that guar gum addition lowered the FCRs with a benefit of heightening the feed stability, resulting in lower concentrations of ammonia, nitrite and nitrate in water.

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