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308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

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Evaluation of Practical Diets Containing High Levels of Corn Distillers Dried Grains with Soluble on Red Tilapia Floating Net Cage Production Performance

Muhamad Agus Suprayudi[1], Dedy Yaniharto[2], Nurbambang Priyoutomo[1], Ari Kurnianto[1], Julie Ekasari[1], DediJusadi[1] and Yutaka Haga[3]
[1]Department of Aquaculture, Faculty of Fisheries and Marine Science, Bogor Agricultural University, Jalan Lingkar Kampus, IPB Darmaga, Bogor, Jawa Barat-16168, Indonesia
[2]Assessment and Applied Technology Agency, State Ministry of Research and Technology
[3]Department of Aquatic Bioscience, Tokyo University of Marine Science and Technology, Tokyo, Japan

Abstract: A feeding trial was performed in floating net cages located in Cirata Reservoir, West Java, Indonesia to evaluate the use of high levels of distillers dried grains with soluble as in practical diets of red tilapia. Red tilapia *Oreochromis* sp. with an initial average body weight of 31.59±1.07 g was randomly distributed into 12 units of floating net cage (2 x 2 x 1.5 m) at a density of 25 fish/m^2 and fed to satiation 3 times daily for 120 days of culture period. Isonitrogenous and isocaloric experimental diets with 3 different levels of DDGS inclusion, i.e., 20, 30 and 40% were prepared at average protein and energy levels of 28% and 424 kcal/100 g of feed, respectively. A commercial feed with a protein level of 30% and energy level of 408 kcal/100 g of feed was used as a control diet. Fish survival in treatments C with 40% DDGS inclusion level (93.67%) was significantly higher ($p<0.05$) than other treatments except treatment D (88.90%). There was no significant difference observed in fish final weight, weight gain, as well as specific growth rate in between treatments, however feed efficiency and protein retention of DDGS treatments were significantly higher than the control. This study demonstrates that diets without fishmeal with DDGS inclusion levels up to 40% provides good growth performance and is economically viable for red tilapia cage production.

Key words: Red tilapia, distillers dried grains with soluble, growth, feed efficiency

INTRODUCTION

The Food and Agriculture Organisation (FAO) reported that world aquaculture production has been steadily increasing since the 50's, with an annual growth rate of more than 8% (FAO, 2012). The increasing aquaculture production resulted in higher demand of formulated feed. Fishmeal is the main protein source in most of aquaculture feed which is produced by processing wild capture fish such as anchovy, herring, etc. The use of fishmeal in aquaculture has become a special concern and has made aquaculture being considered as an un-environmentally friendly and unsustainable. Therefore, exploring alternatives to substitute fishmeal in fish nutrition is of important in the development of aquaculture production.

The study of fishmeal substitution in aquaculture feed has been focusing on finding a potential replacement which not only meet the nutritional requirement of the aquaculture species but also adequate in term of quantity and quality in particular at industrial level and economically viable. With the aforementioned criteria, research of aquaculture feed ingredients have been focusing on utilizing agro-industrial waste or by products such as poultry by product (Samocha *et al*., 2004), meat bone meal (Sugiura *et al*., 2000) and distiller dried grain with soluble (Schaeffer *et al*., 2010; Lim and Yildirim-Aksoy, 2008; Abo-State *et al*., 2009), which are inexpensive, available in bulk quantity and are not in competition with human. Distillers dried grain with soluble (DDGS), which is a co-product of ethanol industry, has been considered as a promising feed ingredients that can replace or substitute fishmeal as the protein source in aquaculture feeds (Lim and Yildirim-Aksoy, 2008). DDGS contains considerable level of protein at a range of 27-44%, minimum anti-nutritional factors (Lim and Yildirim-Aksoy, 2008; Li *et al*., 2011; Zhou *et al*., 2000; Schaeffer *et al*., 2010) and have been studied as an alternative feed ingredients in various aquaculture species including tilapia (Li *et al*., 2011; Lim *et al*., 2007; Schaeffer *et al*., 2010), rainbow trout (Lim and Yildirim-Aksoy, 2008) and channel catfish (Lim *et al*., 2009; Zhou *et al*., 2000).

Tilapia production in Indonesia is mostly performed in ponds and floating net cages located in lakes and reservoir (FAO, 2006). Apart from a good feeding management, the application of tilapia in floating cage culture requires a good quality of feed that can efficiently be utilized by the fish and minimally produce waste

Corresponding Author: Muhamad Agus Suprayudi, Department of Aquaculture, Faculty of Fisheries and Marine Science, Bogor Agricultural University, Jalan Lingkar Kampus IPB Darmaga, Bogor, Jawa Barat-16168, Indonesia

(low pollution) to the surrounding water. DDGS has been reported to be a potential feed ingredient for tilapia feed with an inclusion level up to 30%. Shelby *et al*. (2008) suggested that the level of DDGS in tilapia feed can be increased up to 60% by lysine supplementation.

In the present study, DDGS was used to replace fishmeal as the protein source in combination with other plant based and by product based feed ingredients. The study aimed at finding the least cost feed which support an optimal growth and production of tilapia in cage culture.

MATERIALS AND METHODS

Experimental setup: To assess the effect of dietary corn DDGS level on red tilapia production performance, a complete randomized experimental design comprised of 5 feed treatments in triplicates was applied. Red tilapia *Oreochromis* sp. with an initial average body weight of 31.59±1.07 g was obtained from a commercial hatchery in West Java, Indonesia and randomly distributed in 12 units of floating net cages with a dimension of 2 x 2 x 1.5 m located in Cirata Reservoir, West Java, Indonesia. Fish were stocked at a density of 25 fish/m^2 and fed to satiation at a feeding frequency of 3 times daily for 120 days of culture period. Every 30 days of culture, fish was starved for 24 h, weighed and counted to determine total biomass and survival. At the same time, net replacement was also conducted to maintain good water quality within the net cage. Net cleaning and brushing was also daily performed to ensure sufficient water circulation.

Experimental diet: Isonitrogenous and isocaloric experimental diets with 3 different levels of DDGS inclusion, i.e., 20, 30 and 40% were prepared according to the formulation presented in Table 1, with a commercial feed (28% crude protein content) as a control diet. Proximate composition of experimental diets in this experiment is presented in Table 2.

Data collection and chemical analyses: Growth and feeding performance of red tilapia of each treatment including survival, specific growth rate, feed consumption and feed efficiency were determined on the termination of experimental period and calculated according to Huisman (1987). The data of all parameters were further statistically analyzed using SPSS 17.0 software. F test was conducted to evaluate any significant difference among treatments ($p<0.05$).

Fish and feed proximate analyses including crude protein, crude lipid, crude fibre, ash, water and nitrogen free extract (NFE), were performed according to the procedures described in Takeuchi (1988). A complete proximate analysis of fish was carried out at the initial and closing day of experiment.

RESULTS

At the conclusion of the 4 months feeding experiment, fish survival in treatments C with 40% DDGS inclusion level (93.67%) was significantly higher ($p<0.05$) than other treatments except treatment D (88.90%) which showed no significant difference with treatment C as well as with treatment B (82.54%) and C (82.69%). There was no significant difference observed in final weight, weight gain and specific growth rate in between treatments. Feed efficiency and protein retention of DDGS treatments were significantly higher than the control ($p<0.05$).

DISCUSSION

Fish survival in treatment A and B were significantly lower than treatment C; but they did not significantly different from control treatment. The high survival in treatment C on the other hand may indicate a better fish health condition. It was reported that DDGS contained 17.6 g β-glucan/kg (Li *et al*., 2011) and administrating 0.1-0.2% of β-glucan in feed was sufficient to enhance tilapia immune system (Cain *et al*., 2003; El-Boshy *et al*., 2010). Further research is however still needed to comprehend the immunostimulatory effect of β-glucan as well as other polysaccharides available in DDGS.

No significant difference was observed in fish final weight and growth. This result is different from previous

Table 1: Practical diet formulation

	Experimental diet		
Ingredients	A (20% DDGS)	B (30% DDGS)	C (40% DDGS)
DDGS	20.0	30.0	40.0
Soybean meal	19.0	16.0	14.0
Rice bran and homini feed	29.0	23.5	17.5
Meat bone meal	6.9	6.0	5.0
Copra meal	5.0	5.0	5.0
Kapok seed meal	5.0	5.0	5.0
Corn gluten meal	1.6	1.0	-
Shrimp head meal	5.0	5.0	5.0
Cassava meal	2.0	2.0	2.0
Fish oil	0.5	0.5	0.5
Crude palm oil	1.0	1.0	1.0
Vitamin and mineral premix	5.0	5.0	5.0

Table 2: Proximate composition of experimental diets

	Experimental diet			
Proximate composition (in dry weight)	A (20% DDGS)	B (30% DDGS)	C (40% DDGS)	Commercial feed
Crude protein (%)	27.87	28.67	28.57	29.8
Crude lipid (%)	8.79	10.06	9.28	9.48
Ash (%)	9.59	9.36	9.59	11.77
Crude fiber (%)	9.02	10.01	9.1	11.82
NFE (%)	44.73	41.9	43.46	37.13
GE (kcal/100 g)*	422.09	426.91	425.41	408.23
C/P ratio (kcal/g protein)	15.14	14.89	14.89	13.70
EAAI (%)**	71.82	72.12	70.88	

*GE: Gross energy and calculated according to Watanabe (1988)

** $EAAI = \sqrt[n]{aa_1 / AA_1 \times aa_2 / AA_2 ..... \times aa_{11} / AA_{11}}$

Table 3: Growth and feeding performance of red tilapia *Oreochromis niloticus* fed with different levels of corn dried distiller grain soluble (DDGS)

	Experimental diet			
Parameter	A (30% DDGS)	B (40% DDGS)	C (50% DDGS)	Commercial feed
Survival (%)	82.54±1.59^{b}	82.69±2.51^{b}	93.67±2.51^{a}	88.90±4.32^{ab}
Final weight (g)	265.67±32.50	242.00±33.18	278.00±29.87	245.67±25.38
Weight gain (g)	232.80±33.30	211.47±32.45	245.43±27.86	214.37±23.77
SGR (%/day)	1.75±0.13	1.75±0.10	1.80±0.04	1.72±0.04
Feed efficiency (%)	64.91±2.75^{a}	64.91±2.40^{a}	63.12±0.86^{a}	58.30±0.70^{b}
Protein retention (%)	31.09±1.55^{a}	30.44±1.48^{a}	33.87±2.69^{a}	27.49±1.04^{b}
Lipid retention (%)	70.17±19.17	77.31±9.67	84.06±2.50	69.04±8.46

Table 4: Diet cost and cost of gain

	Experimental diet			
	A (20% DDGS)	B (30% DDGS)	C (40% DDGS)	Commercial feed
Diet cost ($/kg)	0.53	0.51	0.51	0.61
Cost of gain ($/kg gain)	0.82±0.03^{a}	0.79±0.03^{a}	0.78±0.01^{a}	0.94±0.01^{b}

Cost of gain = diet cost ($/kg) x 100/feed efficiency

studies in DDGS inclusion in tilapia diet, which showed that 40% DDGS level in fish diet resulted in lower growth and feeding performance (Li *et al*., 2011; Schaeffer *et al*., 2010). Li *et al*. (2011) pointed out that 40% inclusion level of DDGS resulted in lower tilapia growth and feed efficiency than control, whereas Schaeffer *et al*. (2010) reported that the most optimum level of DDGS in replacement of fishmeal in tilapia diet was 17.5%. Nonetheless, the present result is comparable to those reported by Li *et al*. (2011) and Abo-State *et al*. (2009) where lysine and phytase supplementation in DDGS feed significantly improved the fish growth performance. Feed efficiency and protein retention of fish with DDGS treatments were 8-11% higher and significantly different ($p<0.05$) from the control. Though the difference was only 13%, the lower carbohydrate level of the reference diet than that of DDGS diets could be suggested to contribute to the difference in feed efficiency. Shiau and Peng (1993) noted that carbohydrate in tilapia diet contributed in protein sparing in the diet. At the same quantity of feed, the diets with DDGS contained more energy to support maintenance and growth than the reference diet.

Protein retention represents the level of protein that can be utilized for fish metabolism and growth (Halver, 2002). The result of this study show that the increasing level of corn DDGS in the diet up to 40% did not reduced protein retention as what have been observed in hybrid tilapia (Coyle *et al*., 2004) and Nile tilapia (Abo-State, 2009). Protein retention of a feed by fish is strongly related to protein level, protein-energy ratio and its essential amino acids composition (Suprayudi *et al*., 1999, 2000). The experimental diets (Diet A, B and C) in this study were designed to be isonitrogenous and isocaloric with a balanced amino acids composition at an EAAI range of 70.88-72.12%. Therefore, it can be expected that protein retention in between experimental diets would not be different significantly. Furthermore, it was also reported that the essential amino acids composition of diets containing up to 40% DDGS were sufficient to meet the requirement of tilapia nutrition and comparable to the diets with fishmeal and soybean meal as the protein source (Lim and Yildirim-Aksoy, 2008; Li *et al*., 2011).

To our knowledge the present experiment is the first experiment which evaluates the effect of corn DDGS supplemented diet in red tilapia cage culture. The experiment was located in a reservoir where tilapia production commonly performed by the farmers, therefore the experimental environmental condition was similar to those in commercial cage culture farms.

Cost of feed per unit of fish gain in the present study was significantly lower than the commercial feed used as the control (Table 4). The data also indicate that 40% is the most effective and economical level of DDGS inclusion in tilapia diet. The use of agro-industrial by products feed ingredients such as copra meal, kapok seed meal, shrimp head meal and meat bone meal in the experimental diets was an incentive in obtaining a least cost feed formulation. Though still need to be further confirmed, the use of these by products in this particular study may also contribute to the nutrient enrichment in the diet and improve red tilapia production performance. Results of the current study demonstrate that corn DDGS level up to 40% efficiently support an optimal growth of red tilapia and is economically effective for cage culture production. It can be suggested that a total replacement of fishmeal can be attained by using a combination of DDGS with other agro-industrial by products based ingredients including kapok seed meal, copra meal, meat bone meal and shrimp head meal.

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