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Brewer's spent grains (BSGs) as feedstuff for striped catfish, *Pangasianodon hypophthalmus* fingerlings: An approach to transform waste into wealth

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ABSTRACT

The surging demand for conventional fish feed ingredients resulted in rising cost of fish feed, which is considered as a limiting factor for the expansion of aquaculture industry. There is need of alternative protein sources, especially those are by-products, and not suitable for human consumption and having the environmental concern of their safe disposal such as brewer's spent grains (BSG). An experiment was conducted to assess the effect of substitution of soybean meal with brewer's spent grains on growth, survival, nutrient utilization efficiency in *Pangasianodon hypophthalmus* fingerlings. Five iso-nitrogenous (365 g protein. kg^{-1} diet) and iso-caloric (20.44 MJ kg^{-1}) experimental diets were formulated with different graded level of brewer's spent grains like 0%, 25%, 50%, 75% or 100% in replacement for soybean meal and designated as control, T_1, T_2, T_3, T_4 respectively. The BSG contributed 0%, 24.26%, 47.10%, 69.51 and 91.26% of the total protein in the diets. Each diet was randomly assigned to 15 experimental tanks containing 20 fish in triplicates and fed to satiation twice daily at 09:00 h and 17:00 h. At the end of the feeding trial, weight gain percentage (WG%), specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER) and apparent net protein utilization (ANPU) parameters were found significantly ($p < 0.5$) higher at 50% brewery waste level but also found non-significant with control and 25% brewery waste level fed group. Fat retention, body indices, and survival rate were found non-significant ($p > 0.5$) among different dietary treatments. Significantly higher moisture content ($p < 0.5$) was recorded in fish fed with 0% dietary BSG group (control). Maximum crude protein content was found to be significantly higher ($p > 0.05$) in fish fed with 50% BSG level compared to the other BSG fed groups. Total ash and ether extract content did not change within treatment groups. Overall, this study suggests that brewer's spent grains can serve as an alternate protein source with 50% level substitution of soybean meal without any adverse effect on growth, nutrient utilization and feed conversion. The finding could help in reducing the environmental concern of disposal of an agro-industrial waste by transforming a waste in the feed for commercially important fish species of aquaculture.

1. Introduction

Brewer's spent grains are the main by-products (80–85% of total) of beer manufacturing industries (Tang et al., 2009; Mussatto, 2014) and widely available throughout the world (Essien and Udotong, 2008). BSGs are rich in protein and have 30% essential amino acids of total protein (Mussatto, 2014; Hassan et al., 2016). After beer production, the different left-over forms of brewer's waste are the potential environmental hazard because they require around 30–60% oxygen demand for complete oxidation (Hang et al., 1975), and their safe disposal as a major environmental concern for the industry. Many attempts have been made for safe

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Abbreviations

BSG	Brewer's spent grains
SBM	Soybean meal
DORB	De-oiled rice bran
BHT	Butylated hydroxytoluene
WG (%)	Weight gain percentage
SGR	Specific growth rate
FCR	Feed conversion ratio
FER	Feed efficiency ratio
PER	Protein efficiency ratio
ANPU	Apparent net protein utilization
FR	Fat retention
HSI	Hepatosomatic index
VSI	Vicerosomatic index
IPF	Intraperitoneal fat index
°C	Degree centigrade
cm	Centimetres
mg	Milligram
g	Gram
kg	Kilogram
hrs	Hours
L	Liter
MJ	Mega joule
mm	Millimetres
min	Minutes
psi	Pound -force per square inch
%	Percent

disposal of brewer's waste, for example, feeding of wet or dry BSG to cattle or as an energy source by installing a combustion chamber or a substrate for production of fuel ethanol or as a nutrient source for yeast cultivation, but none of them has been implemented so far at the industrial scale (Mussatto, 2014). Presently, the consumption of beer among alcoholic beverage ranks first, approx. 200 billion L per year (Ambrosi et al., 2014; Stack et al., 2016) and the annual production has reached more than 196 billion L in 2016 (Statistica, 2016). The worldwide annual production of BSG has been estimated as approximately 38.6 million tonnes (Mussatto, 2014). These low prices, underexploited resources are available throughout the year and their valuable chemical composition makes them a substrate of great interest for use as animal feed. However, the utilization of this by-product for poultry (Oh et al., 1991; Gondwe et al., 1999) and pigs (Yaakugh et al., 1994; Dung et al., 2002) feed is well established worldwide. Moreover, in recent past several attempts were carried out to exploit its beneficial use in aquafeed (Kaur and Saxena, 2004; Zerai et al., 2008; Levic et al., 2010; Hassan et al., 2016), biochar production for carbon sequestration and polymer production (Balogun et al., 2017), wastewater remediation (Zhang and Wang, 2016) and the enhancement of biogas production after hydrodynamic cavitation (Albanese et al., 2017; Montusiewicz et al., 2017) and as human food (Lynch et al., 2016).

Aqua feed is a vital component of fish culture worldwide and the protein ingredients are considered as most expensive constituents. Nowadays, the use of fishmeal has become a limiting factor in the expansion of aquaculture because of the progressive decline in the supply of fish meal which has resulted in the increase of the feed cost (Wu et al., 1999). The basic protein feed ingredients are soybean meal, groundnut oil cake, cotton meal, and mustard oil cake and fish meal.

Competition from other animal feed industry for common feed ingredients such as soybean meal, fish meal, rice bran and oilcakes limited their availability. This has resulted in surging the price of fish feed and thereby low returns affecting sustainability of the enterprise. The inclusion of these protein sources has to be considered not only to support better growth and feed conversion but also from the economics and local availability point of view as well (El-Sayed and Teshima, 1992). Thus, the quest for alternative protein sources has become a necessity for the sustainable aquaculture production including inland open water fisheries. In particular, the need arises to explore the good quality, cheaper and readily available alternative resources *i.e.,* agro-industrial waste and by-products to replace the costly ingredients in the fish feed. The reason for the use of agro-industrial wastes and by-products in animal feed is the severe unsustainability of the competition between animal-based and plant-based proteins in the human diet as well as in animal diet, as the global costs of producing equivalent amounts of animal-based proteins for the human diet from intensive farming is much higher in comparison with a human diet based on plant source proteins in terms of area and water demand (2.4–33 times), and greenhouse gases emissions (2.4–240 times) (Di Paola et al., 2017). The main reason for such difference lies in the very low conversion efficiency of plant protein into animal protein production *i.e.,* only 15% of plant protein could be converted into animal protein source (Albanese et al., 2018). Therefore, there is a need to use the agro-industrial waste and by-products to feed livestock to minimize the global cost of production. The Indian fisheries sector is experiencing a boost in fish production through pond and cage farming of introduced catfish species, *Pangasianodon hypophthalmus* possibly during 1997 from Bangladesh (Lakra and Singh, 2010). The special impetus was given by the Ministry of Agriculture, Govt. of India for cage farming of this species in vast 3.5 million hectare reservoir resources of the country to supplement the protein need of the nation. This species has many advantages over carp cage culture such as tolerance to high stocking density, fast growth, resistance to diseases and easy acceptance of supplementary feed. Due to its own advantages, the species became a popular candidate species among farmers for cage culture and pond culture in South Asian countries including India.

With its introduction, there was a rapid development in feed industries across the globe. It is estimated that over 200,000 tonnes per year of *P. hypophthalmus* catfishes are produced in India (Singh and Lakra, 2012). This species requires a huge tonnage of feed for its faster growth in enclosure and pond culture due to its dependency on supplementary feed, as opposed to pond culture of carps. Consequently, a great pressure has mounted on common feed ingredients available in the country, leading to search for alternative protein sources to reduce dependence on costly and unsustainable ingredients such as soybean meal.

Keeping this in view, this study aimed to find the level of possible substitution of soybean meal by brewer's waste without compromising the growth, survival and feed conversion efficiency and suggesting an environmental friendly feed formulation. As well, this study could contribute to the effort of alleviating the competition between animal-source and plant-source proteins in the human diet.

2. Material and methods

2.1. Experimental design

Fish were reared in indoor flow through plastic tanks of 150 L