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Nutritive value of soybean meal after solid state fermentation with *Saccharomyces cerevisiae* for Nile tilapia, *Oreochromis niloticus*

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ABSTRACT

Commercial soybean meal (CSBM) was fermented with *Saccharomyces cerevisiae* using the solid-state fermentation (SSF). Yeast fermentation increased the protein content of CSBM by 13.65%, increased the total of hydrolyzed amino acids by 16.27% and decreased phytic acid and tripsin inhibitor. A feeding trial was conducted to investigate the effect of yeast fermented soybean meal (YFSBM) on the growth, feed utilization, hematological and biochemical blood parameters of Nile tilapia *Oreochromis niloticus*. Five isonitrogenous (295 g/kg crude protein and isocaloric 19.5 MJ/kg gross energy) practical diets were formulated by replacing 0% (D-0), 25% (D-50), 75% (D-75) and 100% (D-100) of protein from fish meal with YFSBM. Each diet was fed to three replicate groups of fish with an initial weight 3.49 ± 0.09 g for 84 days. Using polynomial regression the best final body weight (FBW), weight gain (WG), specific growth rate (SGR), protein efficiency ratio (PER) and protein productive value (PPV) were recorded by fish fed D-25. Based on FCR, broken-line model estimated the optimum level of YFSBM to replace FM is at 37.4%. The best apparent digestibility coefficients (ADCs) were recorded by fish fed the D-25 followed by D-50 using a linear model. Best fit was obtained using a linear model for chemical composition. Body protein and ash contents tended to be higher and reached a plateau in fish fed D-25 and D-50. However, fit linear model showed that the lowest dry matter (DM), lipid and gross energy (GE) contents occurred at 0% replacement. Using linear regression analysis, non-significant effect of YFSBM inclusion level on Htc and Hb was found. The same pattern was observed in WBCs, RBCs, IGF-I, C3 and GH increased and ALT and AST decreased with D-25 and D-50, respectively and the best fit of the data were obtained using polynomial regressions.

Abbreviations: ALT, alanine aminotransferase; ANFs, anti-nutritional factors; ADCs, apparent digestibility coefficients; AST, aspartate aminotransferase; CSBM, commercial soybean meal; DM, dry matter; DE, digestible energy; FBW, final body weight; FM, fish meal; GE, gross energy; GH, growth hormone; IGF-I, insulin-like growth factor-I; PER, protein efficiency ratio; PPV, protein productive value; RBCs, red blood cells; SGR, specific growth rate; SBM, soybean meals; SSF, solid-state fermentation; WBCs, white blood cells; YFSBM, yeast fermented soybean meal.

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1. Introduction

Finding novel sustainable protein sources has become a major drive in the aquaculture sector in order to reduce dependency on fish meal (FM) as the main protein component in aqua feeds. The current fishmeal usage in aqua feeds is becoming unsustainable as aquaculture production continues to expand. Cost is also a major constraint to production with greater requirements for more strategic use of this commodity in feeds. This exacerbates pressures on wild fisheries which cannot be sustained to meet such demands. Traditionally, alternatives to protein meals have been sought from vegetable sources such as soybean meals and cottonseed meals due to their wide spread availability, relatively favorable amino acid profiles, reduced cost and sustainable nature (Hardy, 2010). However, the inclusion of plant based proteins in aquafeeds provides a number of problems which include the occurrence of anti-nutritional factors (ANFs), reduced digestibility, issues of palatability and limitations of certain essential amino acids (Oliva-Teles and Gonçalves, 2001). The ANFs in soybean meals (SBM) can cause pathomorphological changes in the distal intestine of fish (Yamamoto et al., 2010), that can reduce the absorptive capacity for nutrients (Nordrum et al., 2000). Heat-labile anti-nutritional factors like proteinase inhibitors and agglutinating lectins are largely deactivated by the toasting step when producing solvent extracted soybean meal (Maenz et al., 1999). However, several of the anti-nutritional factors are heat stable.

Solid-state fermentation (SSF) is defined as any fermentation process performed on a non-soluble material that acts both as a physical support and a source of nutrients in the absence of free flowing liquid (Pandey, 2003). Solid-state fermentation has a long history of the production of traditional foods using different organisms. It was reported that in SSF, the production of metabolites, such as enzymes, antibiotics etc. were higher than that in the submerged fermentation (Hölker and Lenz, 2005).

Techniques including heat treatment (Peres et al., 2003), and microbial fermentation (Liang et al., 2008) have been used to eliminate or reduce anti-nutritional factors. The fermentation of soybean was reported to be able to enhance nutrient digestibility and nutritional value, contributing important nutrients such as calcium and vitamin A (Kim et al., 1999). A little information is available on the effects of fermented soybean meal in fish feeds (Refstie et al., 2005). The nutritional value of a fermented soybean meal was regarded as a new protein resource, which has been improved after fermentation with mould and could lead to a reduction in trypsin inhibitor content and an increase in small-sized peptide concentration (Hong et al., 2004). However, little information is available on using this technique for fish feeds. Therefore, the aim of this study was to determine the effect of soybean meal fermented by *Saccharomyces cerevisiae* on anti-nutritional factors, nutritive values, growth performance, feed utilization, hematological and biochemical blood parameters of Nile tilapia, *Oreochromis niloticus*.

2. Materials and methods

2.1. Preparation of a yeast-fermented Soybean meal

A commercially defatted soybean meal (CSBM) was purchased from a local company (Heliopolis-Cairo, Egypt) and ground to a particle size (<500 μm) by screen diameter. Three replicate fermentation were performed by a modification method of Yabaya et al. (2009). Each replicate, 2 kg CSBM, 60.5 mg of commercial dry yeast, *S. cerevisiae*, with a cell density of 3×10^6 cell/g (Fermipan®, GB ingredients, china) and 1.1 L of distilled water (50% moisture) was homogenized in a Hobart food mixer for 15 min. This provided a yeast density of 1×10^3 cell/g meal. Each replicate was conducted for 48 h in a 10 L glass jar covered with aluminum foil and incubated at 40 °C which is the optimal growth temperature for *S. cerevisiae.* The yeast fermented soybean meal (YFSBM) was dried to constant weight at 70 °C. In the beginning (0 h) and after 48 h of fermentation, 10 g of YFSBM were sampled to analyze the anti-nutritional factors and chemical composition. Crude protein lipids, ash and crude fiber were determined following the methods of the AOAC (1995) (Table 1).

Table 1
Chemical composition and anti-nutritional factors of commercial soybean meal and yeast fermented soybean meal.

Items	CSBM*	YFSBM**
Crude protein (g/kg)	440	500
Crude lipid (g/kg)	43	48
Ash (g/kg)	61	71
Crude fiber (g/kg)	63	32
Nitrogen-free extract[a] (g/kg)	393	349
Phytic acid (g/100 g)	0.56	0.04
Trypsin inhibitor (IU/mg protein)	2080	1902

Data are presented as means ($n = 3$).
* (CSBM) Commercial soybean meal.
** (YFSBM) Yeast fermented soybean meal.
[a] Nitrogen-free extract = 100 − (crude protein + crude lipid + ash + fiber).

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