Effect of Partial Substitution of Fish Meal with Sunflower Meal on Feed Utilization, Intestinal Digestive Enzyme, Hematological Indexes, Intestinal, and Liver Morphology on Juvenile Turbot (*Scophthalmus maximus* L.)

Huihui Zhou#, Chaoqun Li#, Fuyun Bian, Mingsan Man, Kangsen Mai, Wei Xu, Gen He*

Key Laboratory of Aquaculture Nutrition and Feed, Ministry of Agriculture, and the Key Laboratory of Mariculture, Ministry of Education, Ocean University of China, Qingdao 266003, P. R. China

# These authors contributed equally to this study and share first authorship

**Keywords:** turbot; sunflower meal; replacement of fish meal; growth performance; hematological antioxidant defense system; intestinal and liver morphology

**Abstract**

A 70-day feeding trial was conducted to evaluate effects of partial substitution of fish meal (FM) by sunflower meal (SFM) on juvenile turbot (*Scophthalmus maximus* L.). Five isonitrogenous and isoenergetic diets were formulated with 0%, 15%, 25%, 35%, and 45% replacement of FM protein with protein from SFM. Triplicate groups of juvenile turbot (30 fish per group), were hand-fed twice daily to apparent satiation. Final body weight (FBW), specific growth rate (SGR), and weight gain rate (WGR), were not significantly influenced by type of plant protein at the 15% level (*P* > 0.05), while higher levels showed significant reduction of FBW, SGR, WGR. Feed efficiency ratio (FER) and feed intake (FI) were significantly influenced when FM protein was replaced up to 45% (*P* < 0.05). Body composition parameters were not affected by SFM substitution but body crude lipid was lowest and ash was highest at 45% (*P* < 0.05). Trypsin and diastase values did not vary with experimental diets but lipase activity was significantly reduced (*P* < 0.05). Catalase (CAT) values were significantly lower than the control (*P* < 0.05) when substitution level reached or exceeded 35%; no significant differences were observed in total antioxidant capacity (T-AOC) and malondialdehyde (MDA) values (*P* > 0.05). In the SFM diet groups, all superoxide dismutase (SOD) values were significantly higher than the control (*P* < 0.05); villi length and enterocytes were significantly reduced (*P* < 0.05), but there was no significant difference (*P* > 0.05) in microvilli height between diets; parenchyma structure of liver was severely damaged; smaller hepatocyte areas and areas with high levels of hepatocyte vacuolization and disorganization were present. All results indicated that SFM protein can partially replace FM protein in juvenile turbot diets without adverse effects.

*Corresponding author: Gen He, Tel/Fax: +8653282031589, email: hegen@ouc.edu.cn