Studies on the utilization of extruded corn gluten and soybean meals in rainbow trout Oncorhynchus mykiss diet

［課程博士・論文博士共通］

博士学位論文内容要旨
Abstract

専　攻 Major	Applied Marine Biosciences	氏　名 Name	Taan Rena Santizo
論文題目 Title	Studies on the utilization of extruded corn gluten and soybean meals in rainbow trout *Oncorhynchus mykiss* diet（ニジマス用飼料におけるエクストルーダー処理コーングルテンミールおよび大豆油粕の利用性に関する研究）		

Nutritional value of fish feed ingredient could be improved through adequate processing of the raw material. Even in aquafeed, heat treatment is one of the common processing techniques used to improve nutritional value of plant ingredients. The process is known to commonly reduce the anti-nutritional factors (ANFs) and gelatinizes carbohydrate which could result to increased digestibility. However, excess heat processing can also negatively affect the overall quality of the raw material such as, protein availability or digestibility may be reduced and the amino acids including lysine, arginine and cysteine may be destroyed. These unwanted effects could be avoided if the raw material is processed to a high temperature (200°C) for only a short time (30-45 s). This heat processing technique that utilizes high temperature in a short time (HTST) is called extrusion cooking. It is a process of heating, mixing, shearing and forcing material through a die. This technique is known to enhance nutritive value of several plant ingredients, and even reduce or inactivate ANFs, and increased digestibility value for proteins, amino acids and nitrogen. This processing technique could be applied to improve the nutritional value of numerous known plant ingredients that could partially or totally replace fish meal in the fish diet. For rainbow trout and many other carnivorous finfish, fishmeal is normally an important protein source in their diet because of its high protein quality that could give the fish optimal growth, high feed efficiency, and good product quality. However, demand for fishmeal is continually rising thus making its availability limited and its price is getting more expensive. With this issue in the aquafeed industry, there is a need to replace fish meal with other less expensive and sustainable protein sources. Plant-based protein sources such as soybean meal (SBM) and corn gluten meal (CGM) are considered candidate ingredients to replace fish meal. SBM particularly is extensively used in animal diet because of its good amino acid profile, high availability, and low cost. Likewise, CGM which is a by-product of starch extraction from corn is also broadly used for salmon and marine fish feeds due to its high protein value, acceptable amino acid profile, and is commercially available. In rainbow trout, the combination of SBM and CGM gives promising result as their combination compensates for the deficiency in essential amino acid of each ingredient which resulted to increased feed utilization and efficiency. To further improved the nutritional value of SBM and CGM, they may undergo extrusion cooking before utilizing it as fish feed ingredients. With this, three studies were conducted with the general objective to investigate the effects of extrusion cooking temperature on soybean meal and corn gluten meal as combined ingredients in the diet for juvenile rainbow trout, in terms of nutritional value, fish growth performance, feed utilization, and apparent digestibility.

In the first experiment, the objective was to determine the nutritional values of soybean and corn gluten meals extruded at 100°C (low temperature, LT) or 150°C (high temperature, HT). SBM and CGM were sourced from Nihon Nosan Kogyo and each ingredient underwent extrusion at 100°C or 150°C. The proximate composition of the four extruded ingredients were obtained and results shows that the crude protein of extruded SBM increased but for CGM, it decreased. It could be because CGM usually contains 12-15% starch which is bound tightly together with protein gelatinized. On the other hand, for the crude lipid, higher values were obtained with ingredients extruded at high temperature, which is true for both SBM and CGM. Four

isonitrogenous (41%, CP) and isolipidic (14%, CL) diets were made to proceed for the 12-week feeding trial. Control group is fishmeal based, NE diet contains non-extruded SBM and CGM, LT diet is composed of low temperature extruded SBM and CGM while HT diet is composed of high temperature extruded SBM and CGM. 240 individuals of rainbow trout with initial average body weight of 12.5 g were randomly distributed to 12 60L aquaria and fed two times a day at satiation for six days a week. Result of the feeding trial shows that the control group had the highest value for final body weight and weight gain which is significantly different ($P<0.05$) with NE and HT group but not with the LT group. Specific growth rate (SGR) of HT group had the lowest value and is significantly different with that of the control. Daily feed intake was not affected by the dietary treatments. Feed conversion ratio (FCR) of the control group is significantly different among all treatments and trend for the protein efficiency ratio (PER) was the same with that of the SGR. The result of the total amino acid composition of the fish body is noteworthy because the methionine level of both the LT and HT group are low which reflects that of the methionine level of the respective diets. Moreover, the methionine level of the diets is below the requirement of rainbow trout to support optimum growth of the fish. The digestibility data had promising result as the protein digestibility was found to be highest for LT and HT group and phosphorus and manganese absorption was also found to be highest in HT group.

The second experiment was done with the same dietary treatments but with methionine supplementation at 0.3%. Result for the digestibility study shows that protein digestibility of LT and HT group were comparable with the control group and significantly different ($P<0$) with the NE group. For the growth performance, final weight and weight gain, values were found to be highest in HT group which is comparable with the control group and significantly higher than NE group. SGR of NE group was significantly lower among other treatments. FCR and daily feed intake were not affected by dietary treatments. Likewise, PER was found to be highest in HT group and significantly lower than NE group. For the nutrient retention, protein retention was found to be significantly higher in LT, HT and control group than in NE group. Values for lipid retention was significantly higher in LT and HT groups than in control and NE groups which is also reflective of the result for the fish body composition. Levels of phosphorus and manganese were still higher in HT group. It seems that remarkable result was observed for the HT group.

In the third experiment, we would like to find out which among the high temperature extruded ingredients (HT SBM or HT CGM) gives good result for fish growth, feed efficiency, digestibility and body composition. Five isonitrogenous and isolipidic diets were formulated. Control is still fishmeal based; NE contains non-extruded SBM and CGM; HTS has HT SBM + NE CGM; HTC has HT CGM+ NE SBM; HTSC has both HT SBM and HT CGM. ADC for dry matter, crude protein and crude lipid of control group and HTSC group are the same and significantly higher than others. Moreover, the phosphorus absorption of HTSC group is significantly higher among all treatments. Growth performance in terms of final weight, weigh gain and SGR shows that control group had significantly higher values among others followed by HTSC group. For feed efficiency, NE group had significantly lower values among others. For nutrient retention, it is noteworthy to mention that HTSC group had highest values for both protein and lipid retention. This study demonstrated that combined high temperature(150ºC) extruded SBM and CGM resulted to improved growth, feed efficiency, nutrient utilization, digestibility and fish body composition. Also, the performance of fish groups fed HTS or HTC are the same.

In general, these studies demonstrated that extrusion cooking could improve nutritional value of SBM and CGM. Diets containing high temperature (150ºC) extruded SBM and CGM enhanced fish growth, feed utilization, nutrient retention, body composition and digestibility in rainbow trout. Extrusion temperature (150ºC) in this study is suitable for the processing of SBM and CGM as feed ingredients for rainbow trout.