

## THE USE OF FERMENTED FEATHER MEAL FOR REPLACEMENT FISH MEAL IN THE DIET OF *OREOCHROMIS NILOTICUS*

การใช้ขนไก่ป่นทดแทนปลาป่นในสูตรอาหารเลี้ยงปลานิล

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The suitability of fermented feather meal (FFM) as a replacement of dietary fish meal protein in the diet for tilapia was evaluated. Five diets were formulated in which fish meal (FM) in the control diet (diet 1) was replaced by FFM in the following percentages: 0/100, 25/75, 50/50, 75/25 and 100/0 (FFM/FM). All the diets were contained with 30 % protein. Each diet was proffered to three replicate groups of 60 tilapia (20 per replicate) with average initial body weight  $120.0 \pm 5.0$  g for 12 weeks. Survival was not significantly different among diet formulas (100 %). The individuals fed with 0/100, 25/75 and 50/50 (FFM/FM) did not differ significantly in average weight gain, however, individuals fed with 100/0 (FFM/FM) was significantly poorest than those fed all other diets at the end of experimental periods. The results of the present study indicated that fermented feather meal could be used at 25 % up to 50 % of the diet level for *Oreochromis niloticus* without compromising growth and feed utilization efficiency. However, it's appeared to result in a decrease in weight gain and associated growth parameters with high increasing replacement.

Keywords : tilapia / *Oreochromis niloticus* / feather meal / fish meal

การใช้ขนไก่ป่นทดแทนปลาป่นในสูตรอาหารสำหรับปลานิล (*Oreochromis niloticus*) ต่อผลการเจริญเติบโตและการใช้ประโยชน์จากอาหารของปลา โดยสูตรอาหารมีโปรตีนเท่ากันที่ 30% อาหารสูตรที่ 1 ใช้ปลาป่น 100% โดยใช้ขนไก่ป่นในอัตราส่วนทดแทนระหว่างขนไก่ป่นต่อปลาป่น 0/100 เพื่อเป็นอาหารชุดควบคุม และสูตรที่ 2, 3, 4 และ 5 ใช้ในอัตราส่วนเป็น 25/75, 50/50, 75/25 และ 100/0 ตามลำดับ การทดลองใช้ปลานิล 60 ตัวต่อหนึ่งสูตรอาหาร (20 ตัวต่อหนึ่งซ้ำ) น้ำหนักเฉลี่ยปลานิลเริ่มต้น  $120.0 \pm 5.0$  กรัม ผลการวิจัยพบว่า ปลานิลที่เลี้ยงด้วยอาหารสูตรที่ 1 มีน้ำหนักเมื่อสิ้นสุดการทดลองไม่แตกต่างอย่างมีนัยสำคัญ เมื่อเปรียบเทียบกับสูตรที่ 2 และ 3 และสูตรอาหารที่ 5 (อัตราส่วน 100/0) ให้ผลการเจริญเติบโตและการใช้ประโยชน์จากอาหารของปลานิลน้อยกว่าสูตรอื่นๆ ผลการศึกษาแสดงให้เห็นว่าขนไก่ป่นสามารถทดแทนโปรตีนจากปลาป่นได้ในอัตราส่วนทดแทนระหว่าง 25 ถึง 50 เปอร์เซ็นต์ในสูตรอาหารสำหรับเลี้ยงปลานิล โดยไม่ส่งผลต่อการเจริญเติบโตและการใช้ประโยชน์จากอาหารของปลานิล

คำสำคัญ : ปลานิล / *Oreochromis niloticus* / ขนไก่ป่น / ปลาป่น

### 1. INTRODUCTION

Fish meal is the major protein source that using in artificial fish diet production because of the suitable protein quality, amino acid profile that closely match fish requirement and palatability of fish diet

(NRC, 1993). In the present day, the increasing demand and uncertain availability of fish meal are interested for the nutritionist to studying alternative source of protein for supply dietary protein in artificial fish diets (Kikuchi, 1999; Sargent and Tacon, 1999) such as soybean meal, wheat gluten, corn meal etc. (Kaushik *et al.*, 1995; Watanabe *et al.*, 1998 and Taksin and Somsueb, 2005). Feather meal is the by-product from poultry production. It contains a complex protein (keratin), which can be broken down by hydrolysis to make them digestible. Digestibility of feather meal is directly affected by cooking time and pressure. Feather meal is rich in indispensable amino acids such as cystine, threonine and arginine, and has high level of pepsin digestible protein (75-87 %). The amino acid profile of feather meal is similar to those of investigated for fish meal and soybean meal (Sarmwatanakul and Bamrongtum, 2000 and Sinchermiri *et al.*, 1988). Feather meal has been using with fish and aquatic animals (Langar and Metailler, 1989; Fowler, 1990; Steffens, 1994 and Bureau, 2000). The utilization of feather meal is better in ruminant animals and can be improved when the feather supplemented with urea, but the utilization of feather meal in fish diets are limited due to the keration, the complex protein which has sulfide bonding of 2 molecules of cysteine. The sulfide bonding is hardly digested by monogastric animal. However, Fowler (1990) reported that the feather meal could replaced 15 % of fish meal in diet without different growth and feed utilization efficiency of Chinook salmon. Somseueb and Boonyaratpalin (2001) also reported that the maximum dietary feather meal level for walking catfish (hybrid clarias) was 5 % of fish meal replacement.

The improvement of protein quality in feather meal by fermentation with microorganism has been studied for using substitute fish meal in fish diet. Protein compounds are fermented by enzyme from self-digestion and changed to be poly-peptide, peptide and amino acid under optimum condition before used as nitrogen source in fish diets. Generally, there are some natural keratinophyllic microorganisms in soil and animal skins such as bacteria (*Bacillus*, *Streptomyces*) and fungi (*Mucor*, *Rhizopus* and *Aspergillus*) are active in room temperature and optimum conditions (moisture more than 20 %), and these microorganisms can ferment feathers meal (Grazziotin, 2006).

From the above reasons, the fermentation of feather meal are possible to improve the protein quality in feather meal and more able to be used for partial or total replacement of fish meal in fish diets as major protein source.

## **2. MATERIALS AND METHODS**

The study on replacement of fermented feather meal for fish meal were investigated in diet for tilapia, based on feed quality, growth and feed utilization efficiency. The research was conducted at Experimental Unit of Feed Quality Control and Development Division, Department of Fisheries at Pranakornsri Ayutthaya province, Thailand. Experimental result was analyzed at Laboratory of Feed Quality Control and Development Division, Department of Fisheries.

### Experimental planning

The experiment was carried out with Nile tilapia (*Oreochromis niloticus*), it had five treatments. Each treatment was fed with different diets that were formulated from practical ingredients with 0, 25, 50, 75 and 100 % by weight of fermented feather meal (FFM) replaced fish meal (FM). The diets were crude protein (30 %) and 400 kcal GE/100g diet of gross energy. Experimental fishes were fed with experimental diets in 120 liters glass aquarium in close water flow through systems with aeration, and then experimental diets and fish samples were collected for composition analyzed. The formulas of experimental diets were shown in Table 1.

Table 1 Experimental diet formula of Nile tilapia

Raw material	Diet formula and percentage of fermented feather meal replacement of fish meal				
	Formula 1 (0 %)	Formula 2 (25 %)	Formula 3 (50 %)	Formula 4 (75 %)	Formula 5 (100 %)
Fish meal	25	18.75	12.5	6.25	-
Feather meal	-	4.4	8.8	13.3	17.7
Soybean meal	30	30	30	30	30
Bran rice	15	15	15	15	15
Cassava powder	10	10	10	10	10
Alpha starch	6	6	6	6	6
Vegetable oil	1.3	1.3	1.3	1.3	1.3
Fish oil	1.0	1.4	1.9	2.3	2.7
Lard	-	0.4	0.6	0.9	1.6
Di-calcium phosphate	1.53	1.43	1.63	1.96	2.24
Vitamins & minerals	2	2	2	2	2
Ground husk	7.67	8.82	9.77	10.49	10.96
Bakery yeast	0.5	0.5	0.5	0.5	0.5

**Note:** Five diets were formulated to contain 30 % crude protein and 400 kcal/100 g diet gross energy

### Experimental diets

Preparing fermented feather meal and mixing with other raw materials as followed:

1. Ferment feather meal with cake yeast and cassava powder [x % : 0.5 % : 10 % (x = percentage of feather meal in diet formula)] and then add 30 % water (by weight), stirred every 4 hours for air transfer, fermented for 48 hours.

2. Formulate 5 experimental diets that contained 30 % protein and 400 kcal/100 g diet.

Formula 1 100 % FM : 0 % FFM as control feed

Formula 2 75 % FM : 25 % FFM

Formula 3 50 % FM : 50 % FFM

Formula 4 25 % FM : 75 % FFM

Formula 5 0 % FM : 100 % FFM

Mixed raw materials in homogenous mixture, and then added oil. Subsequently, water around 30 % was added to dry mixture and blended until it became dough like paste.

3. Moistened feed mixture were passed through a meat grinder with die size of 3 mm. and dried in open air then broken into small crumble. Dried pellet diets were stored in airtight plastic bags at -4 °C.

### **Experimental fish culture**

1. All Nile tilapia (*O. niloticus*) with initial average weight  $120.0 \pm 5.0$  g were acclimated about 7 days period before the start of the feeding trial.

2. Twenty fishes were randomly sampled, stocked individual in 120 liters glass aquarium with close water flow through systems and aeration. Fish was fed 2 times a day at 9.00 a.m. and 4.00 p.m. and gradually fed until fish fill in each time. Leftover diets were collected by siphonation, dried and weighed and then minus from eaten diet weight every 2 weeks.

3. Fishes were counted and weighed at every 2 weeks and not fed on morning period of weighing day.

4. Monitoring of water quality in the glass aquarium was conducted. Temperature was measured every day at 9.00 a.m. where as dissolved oxygen (DO) by titration method, pH by pH meter, alkalinity by titration method, hardness by EDTA titration method, ammonia by Indophel Blue Colorimetric method (APHA AWWA WPCF, 1999).

### **Nutrition analysis of experimental diets**

Diets were randomly sampled, dried, blended in size that passed 200 micron mesh sieve. Subsequently homogenize and then stored in airtight containers at -18 °C until analyzed by AOAC (1995).

1. Crude Protein by Kjeldahl Nitrogen

2. Crude Lipid by Ether Extraction

3. Total Ash by Muffle Furnace Combustion

4. Crude Fiber by Weende Method

5. Carbohydrate by % NFE equation

$$\% \text{ NFE} = 100 - (\% \text{ protein} + \% \text{ lipid} + \% \text{ fiber} + \% \text{ ash} + \text{moisture})$$

6. Gross Energy (GE)

$$\text{GE} = (\% \text{ NFE} \times 4.11) + (\% \text{ protein} \times 5.64) + (\% \text{ lipid} \times 9.44)$$

### **Growth performance and composition analysis fish**

Fish growth and feed utilization efficiency of this experiment were measured every two weeks and at the end of all experiments as following Somsueb and Boonyaratpalin, 2001; Jantrarotai *et al.*, 1996; Chuapoechuk, 1999 and Tinnungwatana and Viputhanumas, 2000.

$$1. \text{ Percentage of weight gain (\%)} = \left( \frac{\text{Mean final weight} - \text{Mean initial weight}}{\text{Mean initial weight}} \right) \times 100$$

$$2. \text{ Average daily gain (g/ind/day)} = \frac{(\text{Mean final weight} - \text{Mean initial weight})}{\text{Culture period (day)}}$$

$$3. \text{ Survival rate (\%)} = (\text{Final number of fish} / \text{Initial number of fish}) \times 100$$

$$4. \text{ Feed conversion ratio (FCR)} = \text{Total feed consumed} / \text{Increase mass fish}$$

$$5. \text{ Protein efficiency ratio (PER)} = \frac{\text{Increasing weight in mass fish (g)}}{\text{Protein intake in diet (g)}}$$

$$6. \text{ Apparent net protein retention (ANRP)} = \{[(W_1 \times \% P_1) - (W_0 \times \% P_2)] / P\} \times 100$$

$$W_1 = \text{Mean final fish weight (g)}$$

$$W_0 = \text{Mean initial fish weight (g)}$$

$$P = \text{Protein intake in diet}$$

$$P_1 = \text{Final percentage of protein in fish}$$

$$P_2 = \text{Initial percentage of protein in fish}$$

### 3. RESULTS AND DISCUSSION

#### Quality of experimental diet

All experimental diets had possess same physical characteristics that were cylindrical 3 mm diameter, 5 – 10 mm length, light-brown color, breakable by fingers, suddenly sink in aquarium and stand in water about 5 – 8 minuets. The proximate analysis of experimental diets was presented in Table 2.

The percentages of crude protein in the experimental diet 1, 2, 3, 4 and 5 were similar in all diets with ranging from 28.48 to 30.38 %. The crude lipid, fiber and gross energy in the experimental diets were increased, while ashes in diets were decreased with increasing of fermented feather meal replacement.

Table 2 Proximate composition of Nile tilapia experimental diet with different ratio fermented feather meal replacement of fish meal and commercial feed

Proximate analyses	Formula 1	Formula 2	Formula 3	Formula 4	Formula 5
Protein (%)	29.51	30.38	29.05	29.73	28.48
Lipid (%)	3.48	4.27	4.64	4.81	5.77
Fiber (%)	5.91	5.99	6.42	6.65	6.94
Ash (%)	10.44	9.10	7.73	6.71	5.35
Moisture (%)	15.10	12.94	15.18	14.19	16.15
Gross Energy (kcal/100g diet)	345	365	359	368	368

### Growth and feed utilization efficiency

#### 1) Average weight of nile tilapia throughout the experimental

At the beginning, average initial body weight ranged from 122.81 to 123.68 g. The difference of average weight was begun significantly at the week 10<sup>th</sup> of the feeding period. The body weight of fish fed with diet formula 1, 2 and 3 were significantly higher than other diets ( $P<0.05$ ). At the end of the experimental period (week 12<sup>th</sup>), the average final weight ranged from 192.08 to 224.08 g. The average weight of nile tilapia during the experimental period of 12 weeks was presented in Table 3.

Table 3 Average weight of nile tilapia that fed with different diet every 2 weeks throughout the experiment

Time (week)	Average weight (g.)				
	Formula 1	Formula 2	Formula 3	Formula 4	Formula 5
Initial	123.08±1.67 <sup>a</sup>	122.81±1.43 <sup>a</sup>	123.50±1.03 <sup>a</sup>	123.68±0.57 <sup>a</sup>	123.03±0.26 <sup>a</sup>
2	150.13±4.35 <sup>a</sup>	151.81±2.02 <sup>a</sup>	150.96±3.16 <sup>a</sup>	149.62±6.43 <sup>a</sup>	144.27±4.30 <sup>a</sup>
4	155.36±3.37 <sup>b</sup>	155.30±2.51 <sup>b</sup>	152.82±3.85 <sup>b</sup>	152.21±0.22 <sup>b</sup>	144.29±3.18 <sup>a</sup>
6	173.73±11.11 <sup>a</sup>	175.55±6.77 <sup>a</sup>	170.11±14.66 <sup>a</sup>	163.21±7.49 <sup>a</sup>	159.28±4.52 <sup>a</sup>
8	182.79±12.53 <sup>a</sup>	187.3±10.21 <sup>a</sup>	181.28±15.55 <sup>a</sup>	170.02±6.36 <sup>a</sup>	168.23±3.14 <sup>a</sup>
10	202.14±13.21 <sup>bc</sup>	204.90±9.42 <sup>c</sup>	194.09±14.99 <sup>abc</sup>	184.12±4.16 <sup>ab</sup>	180.77±3.27 <sup>a</sup>
12	224.08±12.64 <sup>a</sup>	222.35±10.98 <sup>a</sup>	206.97±14.53 <sup>ab</sup>	195.97±4.10 <sup>b</sup>	192.08±3.07 <sup>b</sup>

**Note :** Mean with different superscript (a,b,c,d) in the same row were significantly different ( $P<0.05$ )

#### 2) Percentage of weight gain

Percentage of weight gain in fish fed with diets containing 0, 25, 50, 75 and 100 % fermented feather meal were significantly difference ( $P<0.05$ ). According to Table 4, the results showed that percentage of weight gain was highest on fish fed with diet formula 1 (105.88±8.35 %) and lowest on formula 5 (72.97±2.13 %). There were not significantly difference ( $P>0.05$ ) between fish fed with diet formula 1 (105.88±8.35 %), formula 2 (101.22±10.45 %) and formula 3 (86.27±8.55 %), and also no significantly difference ( $P>0.05$ ) between fish fed with diet formula 3 (86.27±8.55 %), formula 4 (75.12±6.78%) and formula 5 (72.97±2.13 %). This result agreed with the study of Bishop *et al.* (1995) on *Oreochromis niloticus* fry reported that tilapia fry fed with diet that replace more than 66 % of fish meal by feather meal had low final weight gain. Fowler (1990) also reported that juvenile fall chinook salmon (*Oncorhynchus tshawytscha*) fed with diets that replaced 15 % of fish meal by feather meal, weight gain did not differ from fed with diets that replaced 0 and 5 % of fish meal by feather meal at the end of experiment.

#### 3) Average daily weight gain

Average daily weight gain in fish feds with diet containing 0, 25, 50, 75 and 100 % fermented feather meal were significantly difference ( $P<0.05$ ) among diet groups. According to Table 4, the

results showed that daily weight gain was highest on fish fed with diet formula 1 ( $1.20 \pm 0.15$  g/ind/day) and lowest on diet formula 5 ( $0.82 \pm 0.03$  g/ind/day). There were not significantly difference between fish fed with diet formula 1 ( $1.20 \pm 0.15$  g/ind/day), formula 2 ( $1.19 \pm 0.13$  g/ind/day) and formula 3 ( $0.99 \pm 0.16$  g/ind/day) and also no significantly difference ( $P > 0.05$ ) between fish fed with diet formula 3 ( $0.99 \pm 0.16$  g/ind/day), formula 4 ( $0.86 \pm 0.04$  g/ind/day) and formula 5 ( $0.82 \pm 0.03$  g/ind/day).

#### 4) Survival rate

Survival rate showed the same value (100 %) on all diet groups.

#### 5) Feed conversion ratio

Feed conversion ratio in fish feds with diet containing 0, 25, 50, 75 and 100 % fermented feather meal were significantly difference ( $P < 0.05$ ) among the groups. The results showed that feed conversion ratio was lowest on fish fed with diet formula 1 ( $1.93 \pm 0.20$ ) and highest on diet formula 5 ( $2.93 \pm 0.19$ ). There were not significantly difference ( $P > 0.05$ ) between fish fed with diet formula 1 ( $1.9 \pm 0.20$ ) and formula 2 ( $1.78 \pm 0.13$ ) and also no significantly difference between fish fed with diet formula 3 ( $2.32 \pm 0.36$ ) and formula 4 ( $2.54 \pm 0.08$ ) but significantly difference from diet formula 5 ( $2.93 \pm 0.19$ ). Feed conversion ratio in fish fed diets containing 0 % and 25 % fermented feather meal was significantly lowest and slightly increased by increasing fermented feather meal level in diets. These results agreed with the study of Tacon *et al.* (1983) on sub-adult tilapia (*Oreochromis niloticus*) and Kikuchi *et al.* (1999) on Japanese flounder (*Paralichthys olivaceus*) reported that the feed conversion ratio was increased by increasing percentage of feather meal replacement of fish meal in fish diet.

#### 6) Protein efficiency ratio

Protein efficiency ratio in fish fed with diets containing 0, 25, 50, 75 and 100 % fermented feather meal were significantly difference ( $P < 0.05$ ) among diet groups. Protein efficiency ratio of fish fed with diet containing 25 % fermented feather meal was highest but not significantly difference from fish fed with diet containing 0 % fermented feather meal but significantly different ( $P < 0.05$ ) from fish fed with diet containing 50 %, 75 % and 100 % fermented feather meal. Protein efficiency ratio was slightly decreased when the fermented feather meal increased in diets. The results showed similarly to the study of Fasakin *et al.* (2005) that presented data on the hybrid tilapia which reported protein efficiency ratio of fish decreased with feather meal partial replacement of fish meal. The study of Tacon *et al.* (1983) on sub-adult Nile tilapia also reported that the 30 % feather meal replacement of fish meal with addition L-methionine or L-histidine or L-lysine or all 3 amino acid together have better protein efficiency ratio than without addition.

#### 7) Apparent net protein retention and Protein intake

Apparent net protein retention in fish feds with diet containing 0, 25, 50, 75 and 100 % fermented feather meal were significantly difference among diet groups. The results showed that apparent net protein retention was highest on fish fed with diet formula 2 ( $31.86 \pm 1.13$  %) and lowest on diet formula 5 ( $23.62 \pm 1.20$  %). There were not significantly difference between fish fed with formula 1

(27.73±1.69 %), formula 3 (27.64±2.67 %) and also no significantly difference between fish fed with diet and formula 4 (24.19±2.57 %) and formula 5 (23.62±1.20 %). Meanwhile, protein intake in fish was not significantly difference among diet groups. The values varied between 57.00±2.64 and 53.25±1.61 g/ind. The apparent net protein retention were highest on fish fed with diet containing 25 % fermented feather meal and were not significantly difference from diet containing 0 % fermented feather meal but higher than diet containing 50 %, 75 % and 100 % fermented feather meal. The different apparent net protein retention indicated the quality of protein that fish obtained from diet. The fermentation of feather meal process may digest the protein to small peptide and free amino acid, which was effected to be absorption in intestine (Hardy *et al.*, 1984). In general, the results that obtained from the experiments contained 0, 25, 50, 75 and 100 % fermented feather meal showed that the growth responses of fish fed with feather meal in term of percentage of weight gain, daily weight gain, survival rate and also feed utilization efficiency such as feed conversion ratio, apparent net protein retention and protein efficiency ratio were reduced by increasing of fermented feather meal in diets. The tilapia fed with diet containing 0 and 25 % fermented feather meal showed similarly the good growth rate and feed utilization efficiency. These were not significantly different ( $P>0.05$ ) from the Nile tilapia that fed with diet containing 50 % fermented feather meal but significantly different ( $P<0.05$ ) from diet containing 75 % and 100 % fermented feather meal. These results agreed with the study of Bishop *et al.* (1995) that the growth of tilapia fry was not compromised by replacement of up to 66 % fish meal and meat and bone meal with feather meal and also Hasan *et al.* (1997) reported that hydrolyzed poultry feather meal could be used up to 50 % for *Labeo rohita* fry without compromising growth and feed conversion

Once the percentage of fermented feather meal in the diet was decreased, the fish growth was increased. That was resulted from the quality of protein from fermented feather meal were lower than protein from fish meal. However, in this study showed that the feather meal fermentation had improved with the percentage of replacement for fish meal.

Table 4 Growth and feed utilization efficiency of Nile tilapia fed with different diets during 12 weeks

	Fermented feather meal replacement for fish meal in Nile tilapia diets				
	Formula 1	Formula 2	Formula 3	Formula 4	Formula 5
Average initial weight (g)	123.08±1.67 <sup>a</sup>	122.81±1.43 <sup>a</sup>	123.50±1.03 <sup>a</sup>	123.68±0.57 <sup>a</sup>	123.03±0.38 <sup>a</sup>
Average final weight (g)	224.08±12.64 <sup>b</sup>	222.35±10.98 <sup>b</sup>	206.97±14.53 <sup>ab</sup>	195.97±4.10 <sup>a</sup>	192.08±3.07 <sup>a</sup>
Survival rate (%)	100±0 <sup>a</sup>	100±0 <sup>a</sup>	100±0 <sup>a</sup>	100±0 <sup>a</sup>	100±0 <sup>a</sup>
Percentage of weight gain (%)	105.88±8.35 <sup>b</sup>	101.22±10.45 <sup>b</sup>	86.27±8.55 <sup>ab</sup>	75.12±6.78 <sup>a</sup>	72.97±2.13 <sup>a</sup>
Average daily weight gain (g/ind/day)	1.20±0.15 <sup>b</sup>	1.19±0.13 <sup>b</sup>	0.99±0.16 <sup>ab</sup>	0.86±0.04 <sup>a</sup>	0.82±0.03 <sup>a</sup>
Feed conversion ratio	1.93±0.20 <sup>a</sup>	1.78±0.13 <sup>a</sup>	2.32±0.36 <sup>b</sup>	2.54±0.08 <sup>b</sup>	2.93±0.19 <sup>c</sup>

Table 4 (Cont.)

	Fermented feather meal replacement for fish meal in Nile tilapia diets				
	Formula1	Formula1	Formula1	Formula1	Formula1
Protein efficiency ratio	1.77±0.17 <sup>bc</sup>	1.85±0.13 <sup>c</sup>	1.51±0.20 <sup>ab</sup>	1.32±0.04 <sup>a</sup>	1.26±0.08 <sup>a</sup>
Apparent net protein retention (%)	27.73±1.69 <sup>b</sup>	31.86±1.13 <sup>c</sup>	27.64±2.67 <sup>b</sup>	24.19±2.57 <sup>a</sup>	23.62±1.20 <sup>a</sup>
Protein intake (g/ind)	57.00±2.64 <sup>a</sup>	54.70±1.93 <sup>a</sup>	55.13±0.72 <sup>a</sup>	53.25±1.61 <sup>a</sup>	54.96±4.93 <sup>a</sup>

**Note:** Mean with different superscript (a,b,c,d) in the same row were significantly different ( $P < 0.05$ )

#### 8) Carcass composition of fish

The proximate compositions of experimental fish at the initial and the end of experiment were presented in Table 5. The carcass compositions of initial fish were observed on crude protein, crude lipid and fiber content as 61.41 %, 19.25 % and 1.23 %, respectively. At the end of experiment, the carcass composition of fish fed diet formula 1, 2, 3, 4 and 5 were composed of crude protein content as 68.67 %, 70.21 %, 70.59 %, 69.48 % and 75.12 %, crude lipid content as 17.21 %, 19.71 %, 19.68 %, 17.78 % and 10.92 % and fiber content as 1.26 %, 1.13 %, 0.98 %, 0.96 % and 1.35 %. The initial fish carcass have lower protein than those of the fish at the end of the experiment. The percentage of protein in experimental fish carcass was related to the percentage of lipid content in carcass.

The body lipid was affected by fermented feather meal. These body lipid content was lowest in the group fed diet containing 100% FFM. These results agreed with the study on Japanese flounder (*Paralichthys olivaceus*), (Kikuchi, 1994) cited by Somserb and Boonyaratpalin (2001) reported that body lipid content were reduced by increasing feather meal in the diets.

Table 5 Chemical composition of the carcass of Nile tilapia fed with the experimental diet for 8 weeks

Composition	Initial fish	Fermented feather meal replacing for fish meal in Nile tilapia diet				
		Formula 1	Formula 2	Formula 3	Formula 4	Formula 5
Protein (%)	61.40	68.67	70.21	70.59	69.48	75.12
Lipid (%)	19.25	17.21	19.71	19.68	17.78	10.92
Fiber (%)	1.23	1.26	1.13	0.98	0.96	1.35

#### Water quality in experiment of Nile tilapia

During the experimental period, the water temperature was monitored everyday. The average temperature ranged from 24.06-24.63 °C. Dissolved oxygen, pH, hardness, alkalinity and ammonia concentrations of water were biweekly monitored. Dissolved oxygen, pH, hardness, alkalinity and ammonia concentrations of water ranged from 5.27-5.68 ppm, 7.79-7.88, 132.50-133.75 ppm, 368.75-390.25 ppm and 0.56-0.79 ppm, respectively, as presented in Table 6. In this study, the water quality

showed no significantly different in all fish diets during experimental periods and were all within the acceptable tolerance or desirable ranges for fish culture (Chuapoehuk, 1999).

Table 6 Water quality in the experiment of Nile tilapia during 12 weeks

Treatment	Water quality parameters (Mean)					
	Temperature (°C)	Dissolved oxygen (ppm)	pH	Hardness (ppm)	Alkalinity (ppm)	Ammonia (ppm)
Formula 1	24.12±0.76	5.58±0.25	7.83±0.07	132.50±1.00	368.75±18.93	0.67±0.32
Formula 2	24.21±1.24	5.38±0.46	7.79±0.32	133.50±1.91	386.25±19.62	0.76±0.20
Formula 3	24.06±0.97	5.68±0.43	7.88±0.20	133.00±1.63	382.50±17.82	0.56±0.24
Formula 4	24.17±0.53	5.45±0.42	7.81±0.26	133.75±1.50	386.25±26.85	0.75±0.27
Formula 5	24.63±1.61	5.27±0.34	7.84±0.17	132.50±1.91	390.25±30.89	0.79±0.16

#### 4. CONCLUSION

The study on replacement of fish meal with different percentage of fermented feather meal was conducted on Nile tilapia. Based on the results obtained from this study, it could be concluded that feather meal which passed the fermentation process by bakery yeast could increase efficiency of feather meal utilization for fish meal replacement in fish diet. Fermented feather meal could be used at 25 % up to 50 % as the replacement of fish meal for tilapia diet containing 28.48 to 30.38 % protein and 345 – 368 kcal/100g diet.

#### 5. REFERENCES

- AOAC (1995). **Official Methods of Analysis**. Association of Official Analytical Chemists. Washington DC.
- APHA AWWA WPCF (1999). **Standard methods for the examination of water and wastewater**. The 20<sup>th</sup> Edition. American Public Health Association American Water Works Association and Water Pollution Control Federation. Washington DC.
- Bishop C. D., Angus R.A. and Watts S.A. (1995). **The use of feather meal as a replacement for fish meal in the diet of *Oreochromis niloticus* fry**. Bioresource Technology 54:291-295.
- Bureau D.P., Harris A.M., Bevan D.J., Simmons L.A., Azevedo P.A. and Cho C.Y. (2000). **Feather meals and meat and bone meals from different origins as protein sources in rainbow trout**. Aquaculture 181:281-291.
- Chuapoehuk V. (1999). **Aquatic animals nutrition and feeding**. Faculty of Fisheries, Kasetsart University. Kasetsart University Press, Bangkok.
- Fowler L.G. (1990). **Feather meal as a dietary protein sources during parr-smolt transformation in Fall Chinook salmon diets**. Aquaculture 1.89:301-314.
- Fasakin E.A., Serwata R.D. and Davies S.J. (2005). **Comparative utilization of rendered animal derived products with or without composite mixture of soybean in hybrid tilapia (*Oreochromis niloticus* x *Oreochromis mossambicus*) diet**. Aquaculture 249:329-338.

- Grazziotin A., Pimentel F.A., de Jong E.V. and Brandelli A. (2006). **Nutritional improvement of feather protein by treatment with microbial keratinase.** Anim. Feed Sci. Technol. 126 (1),135-144.
- Hardy W., Shearer D. and Spinelli J. (1984). **The nutrition of co-dried fish silage in rainbow trout (*Salmo gairdneri*) dry diet.** Aquaculture 38:35-44.
- Hasan M.R., Haq M.S., Das P.M. and Mowlah G. (1997). **Evaluation of poultry-feather meal as a dietary protein source for Indian major carp, *Labeo rohita* fry.** Aquaculture 151: 47-54.
- Jantrarat W., Viputhanumas T. and Somsueb P. (1996). **Partially Replacing Fish Meal with Corn Gluten Meal Improve Growth and Flesh Coloration of Hybrid *Clarias* catfish (*Clarias macrocephalus* X *Clarias gariepius*).** Technical Paper No.178. National Inland Fisheries Institute, Department of Fisheries. Bangkok.
- Kaushik, S.L., Cravedi J.P., Lalles J.P., Sumpter J., Fauconneau B. and Laroche M. (1995). **Partial or total replacement of fish meal by soybean protein on growth, protein utilization, potential estrogenic effects, cholesterolemia and flesh quality in rainbow trout, *Oncorhynchus mykiss*.** Aquaculture 133:257-274.
- Kikuchi, K. (1999). **Use of defatted soybean meal as a substitute for fish meal diets of Japanese flounder *Paralichthys olilaceus*.** Aquaculture 179:3-11.
- Langar H. and Metailler R. (1989). **Use of some protein from animal origin for European sea bass (*Dicentrarchus labrax* L.) feeding.** In: Aquaculture Europe'89. Short communications and abstracts of review paper.
- NRC, (1993). **Nutrient Requirement of Fish.** National Research Council. National Academy Press, Washington DC.
- Sargent J.R. and Tacon A.G. (1999). **Development of farmed fish: a nutritionally necessary alternative to meat.** Proc. Nutr.Soc. 58:377- 383.
- Sarmwatanakul A. and Bamrongtum B. (2000). **Aquarium Fish Nutrition.** Extension paper No. 1/2000. Ornament Fish Research and Public Aquarium. Bangkok.
- Sinchermiri D., Harnbunchon A. and Boaban R. (1988). **A Study on Native Value of Hydrolyzed Feather Meal Product in Thailand.** In : The proceeding of 42<sup>nd</sup> Kasetsart University Annual Conference. Kasetsart University. Bangkok.
- Somsueb P. and Boonyaratpalin M. (2001). **Use of Feather meal in Hybrid *Clarias* catfish Feed (*Clarias macrocephalus* X *Clarias gariepius*).** Technical Paper No.5/2001. Feed Quality Control and Development Division, Department of Fisheries. Bangkok.
- Steffens W. (1994). **Replacing fish meal with poultry by product meal in diet for rainbow trout, *Oncorhynchus mykiss*.** Aquaculture 124:27-34.
- Tacon A.G.J., Jauncey K., Falaye A., Pantha M., MacGowan I. and Stafford E.A. (1983). **The use of meat and bone meal, hydrolyzed feather meal and soybean meal in practical fry and fingerling diets for *Oreochromis niloticus*.** In: International Symp.on Tilapia in Aquaculture Nazareth, Israel, Tel Aviv University, Israel. 356-365.

- Taksin Y. and Somsueb P. (2005). **Partial Replacement of fish meal by corn gluten meal for frog (*Rana rugulosa* Weigmann) cage culture.** Thai Fisheries Gazette 58:159-168.
- Tinnungwatana W. and Viputhanumas T. (1995). **Feeding of Thai Silver Barb, *Burbotodes gonionotus* (Bleeker) with Brewery Activated Sludge.** Technical paper No.12/2000. Phetchaburi Inland Fisheries Center. Phetchaburi.
- Watanabe T., Verakunpiriya V. K., Watanabe K., Viswanath K. and Satoh S. (1998). **Feeding of rainbow trout with non-fish meal diets.** Fish. Sci. 1.63:258-266.

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