Alternative protein source for fish meal production focusing on the protein contents of cockroach

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ABSTRACT

Fish meal is primarily used as a protein supplement in the production of fish feed. Cockroaches are considered a suitable ingredient from a nutritional and palatability perspective to replace fish meal and other high protein ingredients in aqua feed. In the present study, cockroach powder was produced intended to replace the fish meal in fish feed production. The experiment was conducted from August 2019 to March 2020. The wild cockroaches were collected from food stores, kitchens and restaurants. The collected cockroaches were dried and ground into powder form. The nutritional value of cockroach powder was determined and used as the insect meal to produce fish feed. Fish feed including cockroach dried-powder was formulated and treated to the catfish *Pangasius hypophthalmus* to examine the growth performance of fish. A total of 58.81% of the protein was used from cockroach powder for fish feed. The highest growth performance and feed utilization was calculated in terms of Weight Gain, Daily Growth Rate, Specific Growth Rate, Feed Conversion Ratio, and Percent Weight Gain. The water temperature was measured with a thermometer daily at experimental and control sites. The concentration of dissolved oxygen (DO) and pH of the water were measured using on oxygen meter and pH meter respectively. Three sets of experiment were carried out to compare cockroach meal feed and other commercial pellets. This study will focus on replacing fish meal in fish feed production and reducing the cost of fish meal.

Keywords: Cockroach, Insect fish meal, Nutritional value, Aqua feed, *Pangasius hypophthalmus*

INTRODUCTION

Insects are a good source of nutrients and are comparable to the conventional animal source with high protein content. In general, insects can supply protein (20-70 percent of raw protein), amino acids (30-60 percent), fats (10- 50 percent), minerals and vitamins important for human health. Insects are especially rich in phosphorus, potassium, iron, copper, zinc, manganese, sodium, vitamin B1 and B2 and niacin (Nutrition Division 1992). Nutritional values vary according to the species and how they are prepared for consumption. Several studies have established reference nutritional values for various edible insect species (Klinhom *et al*. 1984; Lewvanich *et al*. 1999; Lumsa-ad 2001; Sungpuang and Puwastien 1983).

Insects are nutrient-efficient compared to other meat sources. The insect protein content is comparable to most of the meat products. Likewise, the fatty acid composition of edible insects is comparable to fish lipids, with high levels of polyunsaturated fatty acids (PUFAs). In addition, all parts of edible insects are efficiently used whereas some parts of conventional livestock are not directly available for human consumption. The nutritional contents of insects vary with species as well as within species, depending on their metamorphic stage, habitat, and diet. For instance, the lipid composition of insects is largely dependent on their diet and metamorphic stage. Insects are abundant in other nutrients.

Nutrition is one of the most important factors influencing the performance of cultured fish and is influenced by factors such as behaviour of fish, stocking density, quality of feed, daily ration size, feeding frequency and water temperature. Aquaculture requires optimization of nutrition to efficiently raise fish for the purpose of food production. Fish nutrition is the study of nutrients and energy sources essential for fish health, growth and reproduction.

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Good nutrition in animal production systems is essential to the economical production of a healthy, high-quality product. In fish farming (aquaculture), nutrition is critical because feed typically represents approximately 50 percent of the variable production cost. Fish nutrition has advanced dramatically in recent years with the development of new, balanced commercial diets that promote optimal fish growth and health.

Diet supplementation and selection of appropriate species for culturing environment are important criteria in aquaculture. Catfish (*Pangasius hypophthalmus*) is a widely-cultured species all over the world, as it is easily spawned, has tolerance to handling, resistance to disease, efficient conversion of natural and prepared feeds, controllable reproduction and good marketability, tolerates poor water quality and grows rapidly at a warm temperature. Since the feed cost accounts for approximately 50% of the operating costs in intensive culture systems, the economic viability of the culture operation depends on the appropriate use of feed.

Nutritional food sources of fish may be quite costly, especially for many people in developing countries with lower incomes. Fish meal is primarily used as a protein supplement in compound feed. Insects have obvious advantages in nutritional value. Their nutritional compositions are quite similar to those of traditional animal foods (Raubenheimer & Rothman, 2013). They have enormous potential as a source of nutrients and active substances not only for human but also for poultry and aquaculture. Insects at all life stages are rich sources of animal protein. Cockroaches and other insects are quite nutritious and have high proteins. They are plentiful and cheap when compare to meat. Using cockroaches and insects as feed and as an alternative source of protein is being promoted by some researchers and nutritionists. It is much cheaper to farm insects than it is to raise beef or chicken or pork. Cockroaches are a suitable ingredient from a nutritional and palatability perspective to replace fishmeal and other high protein ingredients in aqua feed. The nutritional value of cockroach is important and had to know in calculating the amount of cockroaches needed to feed the fish. In recent years, the demand for alternative protein sources, more sustainable from an environmental point of view, has significantly increased (Cappelli *et al*. 2020c). The present study was conducted to investigate the nutrient content of cockroach powder and to formulate the fish feed using cockroach powder. The study was conducted to examine how effectively fish grow after being provided a diet that contained cockroach meal.

MATERIALS AND METHODS

Study sites and Study period

Cockroaches were collected from the store and old buildings of the University of Yangon campus. The preparation of cockroach meals as fish feed was conducted in the fish nutrition laboratory, fisheries and aquaculture. The research was carried out from August 2019 to March 2020.

Preparation of cockroach meal

Cockroaches were firstly sundried and dried in the oven at a temperature of 100˚ C for about 30 minutes. The dried cockroaches were ground into powder form. Their nutritional values such as crude protein, fat, carbohydrate, moisture, ash, fiber, calcium and phosphorus were measured at the laboratory in UMFCCI (Union of Myanmar Federation of Chambers of Commerce and Industry) (Table .2).

Fish feed formulation

The cockroach meal pellet was produced based on the feed formula for catfish. The experimental diet was formulated to contain 58.81% crude protein of cockroach powder including locally available materials such as wheat flavor, Cassava, Vitamin C, Carboxymethyl

cellulose (CMC), Butylated Hydroxytoluene (BHT), Guar gum and fish oil. The average analyzed proximate nutritional compositions of food types are listed in (Table 1). All ingredients were mixed with a mixer. Cockroach meal pellets were made by handmade (plate 1). Then, these cockroach meal pallets were fed as fish feed and explored the growth performance of fish. Three experimental groups with different fish meals such as Cockroach meal pellets, Commercial floating pellets and Commercial sinking pellets. The treatments of C1 and C2 were fed extruded feed from cockroach meal, G1 and G2 were fed commercial floating pellet and control group P1 and P2 were fed control sinking pellets. Each of the experiments was duplicated to calculate the mean values of this research.

Table1. Ingredients for fish meal pellet

Sr.no	Ingredients	Percentage (%)
1	Cockroach powder	33.61
2	Wheat flour	54.14
3	Cassava	7.4
4	Vitamin C	2
5	CMC	0.33
6	BHT	0.02
7	Guar gam	0.5
8	Fish oil	2
	Total	100

A. Dried cockroach

B. Grinded Cockroach powder

C. Ingredients for experiment fish feed pellet

D. Cockroach powder mixed with ingredients

E. Pellets were made by handmade

F. Cockroach meal pellets

Plate1. Procedure of cockroach meal pellet

Preparation of experimental tanks

To investigate the behaviors of fish, two types of tanks: glass tanks and fiber tanks were prepared for each experiment. Three fiber tanks (4 x 3 x 1.5 ft) and three glass tanks (2 x 1 x 1.5ft) were prepared with an aeration system in the Aquatic Bioscience Laboratory, University of Yangon to maintain fish. Each tank was named C (cockroach meal), G (commercial floating pellet), and P (commercial sinking pellet) respectively. A total of 180 fingerlings of *Pangasius hypophthalmus*, catfish were collected from Hlawgar fish hatchery, Yangon. Fish were divided into six groups for the experiment. Immediately arriving at the laboratory, the fingerlings were transported to experimental cages by plastic barrels half-filled

with lake water. The total length and total weight were measured. Juveniles (30 fingerlings) were stocked in three glass tanks (C1, G1, P1) and three fiber tanks (C2, G2, P2) in a completely randomized manner. Fish have been fed twice a day (10:00 AM and 16:00 PM) with 5% of body weight (plate 2).




A. Fish transportation B. *Pangasius hypophthalmus* C. Fiber tank D. Glass tank

Plate 2. Fish firming trial

Analysis of the growth rate of fish

Growth performances and feed utilizations were calculated in terms of Weight Gain, Daily Growth Rate, Specific Growth Rate, Feed Conversion Ratio, and Percent Weight Gain. The weight gain (g) was calculated as given below followed by Lugert *et al.,* (2016).

Weight Gain (WG)

$$\text{Final weight (g)} - \text{Initial weight (g)}$$

Specific Growth Weight (SGR)

$$SGR\ (\%) = \frac{(\ln Wt - \ln W0)}{D} \times 100$$

Percent Weight Gain (PWG)

$$PWG(\%) = \frac{(\text{Final Wt} - \text{Initial Wt})}{\text{Initial Wt}} \times 100$$

Feed Conversion Ratio (FCR)

$$FCR\ (\%) = \frac{\text{Weight of food gain (g)}}{\text{Weight gain of fish (g)}}$$

Daily Growth Rate (DGR)

$$DGR = \frac{\text{Final Weight} - \text{Initial Weight}}{\text{Cultured days}}$$

Water quality analysis during the culture period

Water temperature was measured with a thermometer daily at 25 cm below the surface of the water at experimental and control sites. The concentration of dissolved oxygen (DO) and pH of the water was measured using an oxygen meter and pH meter respectively. The fish length and weight were measured using a measuring board and digital balance respectively and recorded. At the end of the experiment, the fish were counted; the weight and length of all the fish were measured.

RESULTS

The nutritional compositions of cockroach powder were measured. In this result, the crude protein content of 58.81% is the highest and followed by fat content 17.63%, fiber 12.63%, moisture 7.99% and ash content of 5.73%. The Energy value is 398 kcal (Table.2).

Table 2. The nutrient compositions by % of cockroach powder

No.	Test Parameter	Result
1	Moisture	7.99%
2	Ash	5.73%
3	Crude Protein	58.81%
4	Crude fiber	12.63%
5	Crude Fat	17.63%
6	Carbohydrate	0.00%
7	Energy Value (kcal/100g)	398

Table 3. The growth performance of different feeding treatment during experimental period

Food Items	WG	SGR	PWG	FCR	DGR
C1	6.8	3.194871	66.02	1.51	0.11
C2	2.4	1.459115	22.22	4.67	0.04
G1	6.82	3.199766	98.84	1.1	0.11
G2	3.24	1.959289	32.6	3.46	0.05
P1	5.5	2.841247	64.7	1.87	0.09
P2	1.92	1.078505	19.71	5.5	0.03

C1: Cockroach pellet, G1: Floating pellet, P1: Control (sinking pellet) (Experiment in glass tank)

C2: Cockroach pellet, G2: Floating pellet, P2: Control (sinking pellet) (Experiment in fiber tank)

WG: Weight Gain, SGR: Specific Growth Rate, PWG: Percent Weight Gain, FCR: Feed Conversion Ratio, DGR: Daily Growth Rate

According to the results, in glass tanks, comparing the feeding of the cockroach pellet (C1) and floating pellet (G1), the growth rates were not different. The weight gain of the feeding floating pellet was slightly higher than the cockroach pellet. The specific growth rate was similar to the cockroach pellet (C1) and the floating pellet (G1) and the lowest dada was recorded in the sinking pellet (P1). But the growth weight of cockroach meal and floating meal were higher than the control (sinking pellet, P1). The percent weight gain of floating pellet (G1) was the highest and follows by the cockroach pellet (C1) and the sinking pellet (P1). The daily growth rate was recorded as the same as of all the feeding experiments.

In fiber tanks, the weight gain of the feeding floating pellet (G2) was higher than the cockroach pellet (C2) and sinking pellet (P2). But the growth weight of cockroach meal and floating meal were higher than the control (sinking pellet). The specific growth rate was also

higher than the cockroach pellet (C2) and sinking pellet (P2). The percent weight gain of the floating pellet (G2) was the highest and follows by the cockroach pellet (C2) and sinking pellet (P2). The daily growth rate was recorded as the same as of all the feeding experiments.

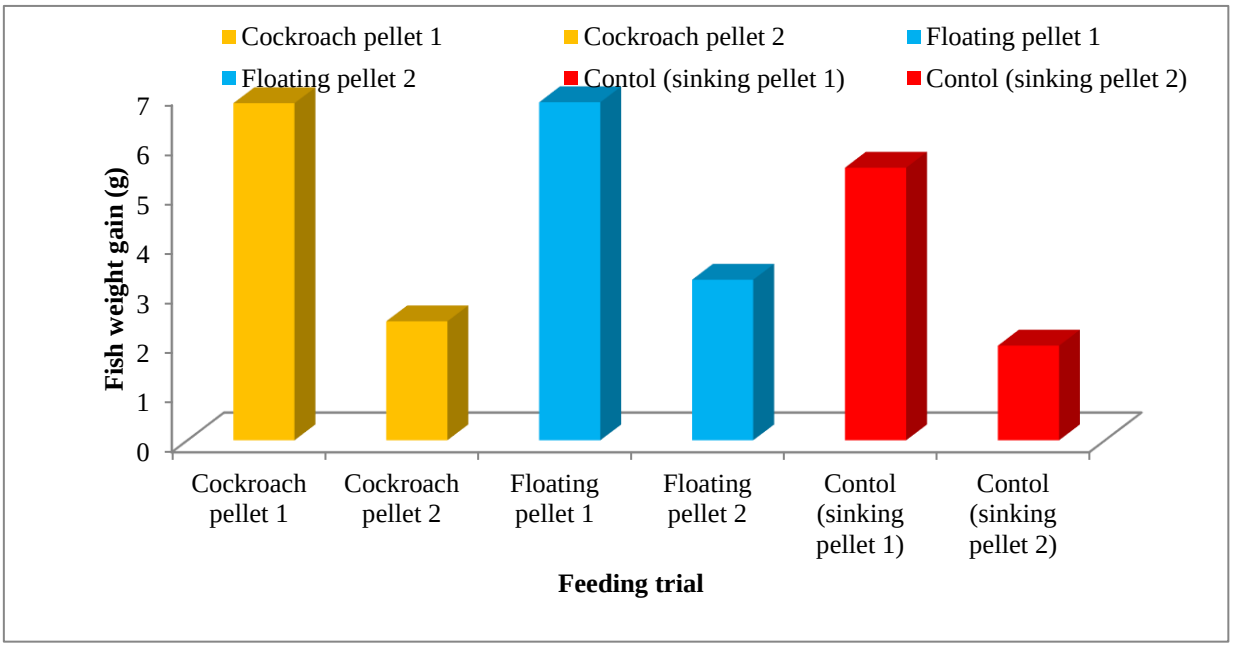

Figure 1. Compare the growth rate (GW) of the studied catfish species during the study period

The recorded growth rate of the floating pellet (G1, G2) and cockroach pellet (C1, C2) were higher than the control pellet (P1, P2). At the start of the experiment, the initial weights were relatively the same as the fish groups in different feeding trials. The highest final weight was recorded in floating pellet P1 and cockroach pellet C1. The lowest final weight was recorded in control pellet 2.

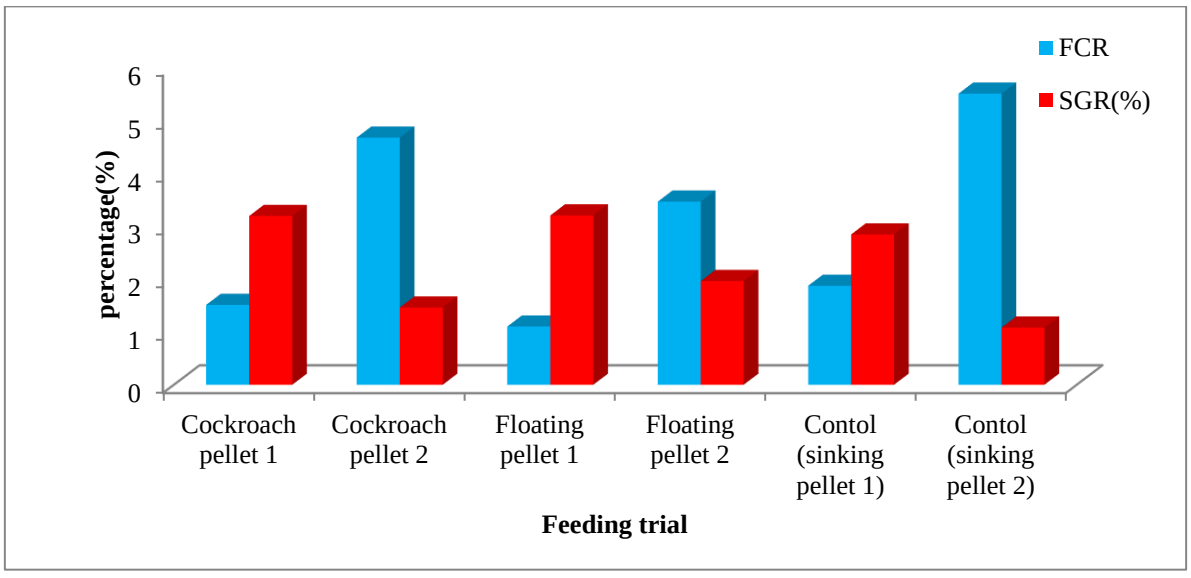

Figure 2.Comparison of Feed Conversion Ratio (FCR) and Specific Growth Rate (SGR)

According to the recorded data, the feed conversion ratio (FCR) was lowest in the floating pellet (G1, G2). The second lowest was recorded in the cockroach pellet (C1, C2). The highest recorded in control (sinking pellet P1, P2).

Table 4. Water parameters of three different feeding test during the experiment

Different diets	Ammonia	pH	Do	Temp
Cockroach pellet (glass tank)	0.2-0.6	5.5-6.5	6-7	22-23.8
Cockroach pellet (fiber tank)	0.2-0.6	5.5-6.5	6-7	22-23.8
Floating pellet (glass tank)	0.6-1	5.5-6.5	6-7	22-23.8
Floating pellet (fiber tank)	0.6-1	5.5-6.5	6-7	22-23.8
Sinking pellet (glass tank)	0.6-1	5.5-6.5	6-7	22-23.8
Sinking pellet (fiber tank)	0.6-1	5.5-6.5	6-7	22-23.8

DISCUSSION

The important challenges of aquaculture are sustainable food resources for large farming. As the population increase, the production of food also increases. The demand for feed for farming increases and the food available decreases. Therefore, people work out the fish meal with other parts of animals that humans cannot need. The cost of feed is expected to rise therefore need to supply low-cost fish meal production.

The present study works out the fish meal from insects. The insect population is higher than that of other living things. Some are edible and some are not. But in a cockroach, the protein composition is high according to the results of the protein test. Most people thought cockroaches are carriers of some diseases, but no one show the evidence. The smell of cockroaches is bad for humans but it was attracted to the fish.

The present research showed the growth rate of cockroach pellet meal and the floating pellet meal was the same. The production of cockroach fish meal is very low cost compared with the floating pellet. Cockroaches can be getting easily from the wild or culture. Their survival rate is higher although their lifecycle takes about 1 or 2 years.

The water quality is not different in the glass tank and fiber tank during the study period. This showed that the growth performance of the experiment was not depending on water quality. A similar discussion was stated in the research of feeding frequency on growth performance and survival of Nile Tilapia (Workagegn *et al*., 2014, Alemayehu and Getahun, 2017).

Firstly, the present research was comparing the growth performance of cockroach pellet C1, floating pellet G1 and sinking pellet P1 in the glass tank. The second comparison was cockroach pellet C2, floating pellet G2 and sinking pellet P2 in the fiber tank. Although 30 numbers of fish were put in separate tanks and the feeding weight of the diet was fed in the same ratio to all tanks, much differences between C1 and C2, G1 and G2, P1 and P2. The reason for the change was the recorded weight gain data was too much different in glass tanks and fiber tanks. But the similar results were recorded in the daily growth rate in all of the tanks. The feed conversion ratio was highest in fiber tank P2.

In cockroach pellet C1, the FCR is 1.51 and SGR is 3.20% were recorded. The data shows feed conversion rate is low and the specific growth rate is high. This means that the cockroach meal affects the growth rate of fish.

The results of the present study showed the different food items and different protein contents did not affect the feed convention rate, daily growth rate and specific growth rate of the study fish. The results of the present study also revealed that all the experiment in different diets was accepted by Workagegn *et al*., 2014. The reason might be caused by the processing of techniques to make pellets.

The present research was the innovative one in Myanmar. Nobody is conducting any research on insect meal for fish. The present study showed that the insects (edible or un-edible) were used as the meal for animals. The insect meals were also performance to growth of animals. People can substitute the source of protein with insect. Of all animals on the planet, insects make up 70% of the population. Some of them are edible and others are not. They can, however, use different sources of protein for both humans and animals. A further benefit is the inexpensive production of insect meals.

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