Original Research Article

Growth performance of Tilapia fingerlings fed with phytoadditives from fruit wastes (pineapple, citrus and banana) for aquaculture

ABSTRACT

Aims: This study aims to determine the effects of the different fruit wastes (banana, citrus and pineapple peel) on the zootechnical parameters (weight gain (WG), length, specific growth rate (SGR), feed conversion ratio (FCR) and survival of tilapia fingerlings (*Oreochromis* sp.) and to select which feed supplement is suitable for tilapia fingerlings.
Study design: Feeding study was conducted and growth in terms of weight gain and length were analyzed.
Place and Duration of Study: College of Fisheries and Aquatic Science Hatchery Laboratory from January 2019 to March 2020.
Methodology: Tilapia fingerlings (*Oreochromis* sp.) samples were used in this study. The treatments used for this experiments were consisted of; commercial feeds (control), 2%, 5% and 10% levels of pineapple, citrus, and banana waste respectively.
Results: Results showed that weight gain and FCR were significantly affected by the treatments and that treatment contained 2% levels of pineapple, citrus and banana waste showed superior growth and FCR than other treatments. Fish length and survival did not show any significant difference at $P \leq 0.05$.
Conclusion: Although the weight gain was significantly affected by the treatments studied but the length of tilapia fingerlings didn't effect when fed with fruit waste. Better FCR and survival rate was observed when fingerlings fed with 2% banana peel however, no found significant difference in cases of 2% citrus or pineapple wastes. Besides, values of water parameters were at a normal level (temperature, dissolve oxygen (DO), and pH) and they did not significantly affect these treatments.

Keywords: Weight gain, FCR, feed supplementation, tilapia fingerlings

1. INTRODUCTION

The quality and healthfulness of the food products are reported to be some of the crucial factors that influence the choice of consumers when purchasing the food items. As consumers are getting more health-conscious, they select food that has positive health benefits.

Interest in the use of plants and various phytochemicals as dietary additives for poultry and livestock has increased in recent years; due to the potential health benefits to these farmed animals that result in better and healthier meat quality. However, conflict in addressing food security issues arise because most of the plants that are used as feed ingredients are also those that are produced primarily for human consumption such as corn, wheat, barley, soybean rice and many others. As such, novel sources of animal feeds have to be explored to avoid competition with providing sources of food for the human population [1]. An example of a novel alternative source of animal feed is fruit waste and by-

products. Currently, approximately 1.3 billion tons of food is lost and wasted annually, and fruits form a substantial part of this loss [2].

There is a change in the cropping pattern from cereals to more lucrative fruit and vegetable crops in several developing countries [2]. This shift in the farming system will potentially generate huge quantities of fruit and vegetable wastes in the future. These wastes and by-products have the potential to be recycled and brought back to the food chain by converting them to aquaculture feeds [1]. In addition, some of these waste products could be sources of some beneficial bioactive compounds that are added to aquaculture feeds to improve the health and growth performance of the aquaculture species (Table 1).

Table 1. Commonly used fruit wastes and by-products as feed additives or ingredients in the animal feed industry.

Common Name	Scientific Name	Parts Utilized
Banana	*Musa acuminata*/*Musa paradisiaca*	Peels
Cinnamon	*Cinnamomum spp.*	Bark
Citrus	*Citrus spp.*	Peels and pulp/rind
Papaya	*Carica papaya*	Peels
Passion fruit	*Passiflora edulis*	peels and rind
Pineapple	*Ananas comosus*	peels and core

Olusola et al. [3] and Steiner & Syed [4].

On a global scale, there is an increasing demand for food including fruits and vegetables [5]. The annual fruit and vegetable wastes that are generated in India is 1.81 million tons, The Philippines 6.53 million tons, China 32.0 million tons, and USA with 15.0 million tons [2]. The feed cost can be as high as 70% of the total cost in producing fish and livestock, and through the use of these wastes, it is likely to reduce the cost of feeding, resulting in a higher profit to the fish and livestock producers.

Plants are being utilized by the food industry as sources of spices, condiments, and culinary herbs. Plant-based additives are also used as preservatives for some food preparations because they have antimicrobial properties [6].Further, the food additives upon addition to food result in preservation of flavor and enhancement of taste and appearance [7]. Because of these benefits, plants have been used to develop healthy and safe food for humans as well as feeds for livestock, and also these are potential alternatives to the use of synthetic antimicrobials in animal feeds [8, 9].

The content of processed fruit waste is highly dependent on the type of fruit and the part of the fruit that forms the main mass of the waste [10]. The presence of these bioactive compounds from fruit wastes results in the stimulation of immune responses of the fish [1, 11] and at the same time contributes to the quality of the carcass. A good quality fish flesh will also contribute to a healthier source of food for the consumers.

Present study aimed to determine the effects of the different fruit wastes (banana, citrus and pineapple peel) on the zootechnical parameters (weight gain (WG), length, specific growth rate (SGR), feed conversion ratio (FCR) and survival of tilapia fingerlings (*Oreochromis* sp.) and to select which feed supplement is suitable for tilapia fingerlings. Result of this study could be used as reference in developing fish feed supplement from fruit waste and can be used as a model in Tilapia culture.

2. MATERIAL AND METHODS

2.1 Study site

The study was conducted at the Aquatic Science Laboratory of the College of Fisheries and Aquatic Sciences of the Western Philippines University – Puerto Princesa. Freshwater tilapia (*Oreochromis* sp.) was used as a model species to test this proof of concept.

2.2 Feed preparation and treatments

The raw materials (banana, citrus, and pineapple peel) were gathered from the fruit vendor in a local market of Puerto Princesa City, Palawan. The collected fruit peel were washed trice using tap water and distilled water were used for final wash. The washed fruit peel were then sundried for seven days at 60°C. The sundried fruit waste samples were ground into fine pieces using a mortar and pestle. The ground fruit wastes were then sieve using fine mesh net and were supplemented to the commercial feeds at 2, 5, and 10% of the total feed weight. The feeds added with fruit waste were

fed to the Tilapia fingerlings at initial rate of 5% of the body weight for 30 days during the month of January to March in year 2020. Adjustments in the feeding rate were calculated every 15 days.

2.3 Experimental setup

A randomized design was used in setting twelve tanks (diameter 7 inches x height 12 inches) that were used for this experiment. Tanks, air stones, and hoses that were used in this experiment were disinfected using chlorine (2ppm) prior to the conduct of the feeding trial. All treatments in this study were replicated three times. Tanks and water containers were filled with 3 L of water and stocked with 10 fish.

2.4 Sampling and monitoring

Water were change at a rate of fifty percent (50%) volume every 15 days. Siphoning of feces was done daily and lost water during siphoning was replaced with the filtered one thereafter. The water parameters such as pH, ammonia, and temperature were determined using a test kit and thermometer.

Sampling of fish was conducted every 15 days. Weight gain (WG), length, survival rate, feed conversion ratio (FCR), and SGR were the biological performance of Tilapia that were recorded and analyzed in this experiment.

The following formulas were used in computing the biological performance of fish in this experiment:

$$Survival\ rate\ (\%) = Total\ fish \frac{survived}{number\ of\ fish\ stocked} x\ 100$$

$$FCR = \frac{Amount\ of\ feed\ fed}{Fish\ weight\ gain}$$

$$SGR = (Final\ weight - initial\ weight) x \frac{100}{Number\ of\ days}$$

2.5 Statistical analysis

The results obtained for WG, length, FCR, SGR, and survival rate of the fish were subjected to a non-parametric one-way ANOVA with multiple comparisons. Differences among means were identified by Tukey's test with $P < 0.05$.

3. RESULTS AND DISCUSSION

(Please, show the results for the first experiment (6 fish\tank) and the second experiment 2 (10 fish \tank as you mentioned in the experimental setup part)

Table 2. showed the biological performance of fingerling Tilapia sp. fed with different inclusion of fruit waste in the diet for 30 days. Results show that weight gain was significantly affected by the treatments but not the length of tilapia fingerlings when fed with fruit waste incorporated diets. Better FCR and survival rate were observed when fingerlings were fed with 2% banana, pineapple and citrus peel.

The WG showed a significant difference but not the length (Table 2). The WG was highly significant in treatment with 2% banana (8.70±0.25). The treatment containing 10% pineapple had significantly high FCR (1.08±0.05) while the lowest FCR was observed in treatment contained 2% banana (0.73±0.02). Significantly high SGR (0.29±0.01) was found in treatment contained 2% banana. No significant difference was observed for the survival rate of fish.

The DO ranged from 10-15mg/l in all treatments and no sudden fluctuation was observed in all treatments. The temperature was at 24°C while pH was maintained at 7.5 in all treatments throughout the experimental trial.

Table 2. Biological performance of Tilapia fingerlings in treatments fed with different inclusion of fruit waste in the diet for 30 days. (n=3)

Treatment		Initial	WG (g)	Length (inch)	FCR	SGR	Survival (%)
Control 1		2.13±0.19	5.99±0.27^{a}	1.87±0.36	1.06±0.05^{a}	0.20±0.01^{a}	90±0.33
Pineapple	2%	1.46±0.12	7.02±0.57^{a}	2.37±0.2 0	0.91±0.07^{a}	0.24±0.02^{a}	100±0.00
	5%	1.70±0.12	6.24±0.38^{a}	2.27±0.2 4	1.02±0.06^{a}	0.23±0.01^{a}	100±0.00
	10%	1.48±0.10	5.78±0.28^{a}	2.17±0.19	1.08±0.05^{ab}	0.21±0.00^{a}	90±0.33
Citrus	2%	1.65±0.10	7.10±0.53^{a}	1.60±0.2 0	0.89±0.07^{a}	0.25±0.01^{a}	100±0.00
	5%	1.77±0.18	7.01±0.54^{ab}	1.73±0.32	0.92±0.07^{a}	0.26±0.01^{a}	100±0.00
	10%	1.81±0.12	6.80±0.35^{a}	1.80±0.3 6	0.94±0.05^{a}	0.24±0.00^{a}	100±0.00
Banana	2%	1.87±0.2 4	8.70±0.25^{a}	2.07±0.33	0.73±0.02^{a}	0.29±0.01^{b}	90±0.33
	5%	1.37±0.0 9	7.06±0.35^{ac}	1.87±0.12	0.89±0.05^{a}	0.25±0.00^{a}	100±0.00
	10%	1.68±0.0 9	7.40±0.57^{ac}	2.27±0.43	0.86±0.07^{a}	0.26±0.01^{a}	100±0.00

Factors such as the size of fish, water quality, and the nutrient content of the formulated feeds affect the growth of fingerlings tilapia [12, 13] which was also observed in the present experiment. Although some of the parameters in this experiment such as the proximate analysis of feeds, and fish body, nutrient content of feeds and another important water parameter such as ammonia were not analyzed due to the limitation of resources, time, and situation.

The phytogenic are plant-derived products that are added to the feed to improve the health and growth performance of the animal. These are widely tested as additives in the manufacture of feeds for livestock, and recently; these are being evaluated in the diets for fish and crustaceans in aquaculture [8, 14, 15, 16]. The mode of action of most phytogenics is still not fully elucidated [17], but these plant-based products possess antioxidant, antimicrobial, anticarcinogenic, analgesic, insecticidal, antiparasitic properties, growth promoters, appetite enhancement, stimulant of bile secretion and digestive enzyme activity [18, 19].

Different size of tilapia requires a different amount of protein for growth. A fingerling tilapia of 0.02 to 10 g in weight requires 35-40% protein in their diet [20, 21]. Although protein content in the diet was not analyzed in the current study, the protein content of the pineapple peel ranged from 5.11 to 8.8% [22, 23], banana peels vary whether they are ripe or unripe and the protein content ranged from 6.86% to 8.51% [24], and the citrus peel (*Citrus maxima*) at 0.42% [25]. Hence also one of the factors why Tilapia fingerlings in this study showed different growth rate depending on the kind of fruit waste fed to them.

As mentioned above, fruit waste contain anti-nutritional factor. In pineapple peel, the level of anti-nutritional factors such as oxalates, hydrogen cyanides, alkaloids, and phytates, and total phenolics contents were 129.06 mg %, 71.50 mg %, 16.19 mg %, 1.99 mg %, and 1.42 mg %, respectively [22]. Citrus peel has a high amount of Alkaloids (3498.37 mg/100g) and has also a high amount of antinutritional factor in the form of phytic acid (444.11 mg/100g) [25]. In general, the oxalates level of banana peel is 280.88 mg %, 116.26 mg % of hydrogen cyanides, 6.88 mg % alkaloids, 6.02 mg % of phytates, and total phenolics of 7.40 mg % [22]. The presence of antinutritional factors in fish feeds results in poor palatability, poor food intake, interference with feed utilization, alteration of gut morphology, high FCR, and slow growth of fish [26, 27, 28].

The unripe banana peel has a higher content of anti-nutritional factors present than the ripe banana peel [24, 29]. An increased in the incorporation of banana peel from 5-15% in the diet decreased the weight gain of Tilapia [29] which was similar to the result of this study. Banana peel has a high fiber load, and when fed to fish could accumulate to

increase cell wall materials and non-soluble polysaccharides which limit the digestion and absorption of nutrients resulting to a decline in the growth of fish [24, 30].

The water parameters including salinity, DO, temperature, pH, and ammonia can affect the growth and survival of Tilapia [13, 31, 32]. The poor quality of water especially the higher nitrite concentration can affect the growth of tilapia, and it was observed that the wide range tolerance of tilapia in high acidity did not affect the growth and survival rate [33, 34], hence water quality both physical and chemical property, should be kept within the optimum level as well as the biological properties to ensure good growth in Tilapia [35].

The optimal range temperature of the water is 25°-30°C for growth of juvenile tilapia and 21°-28°C for food conversion [36], however according to Ibañez et al. [37], fish can still live for two weeks at 35°-40°C. Pandit et al. stated that temperatures above 32°C may significantly decrease the survival and growth rate of tilapia and reduced growth performance that could be attributed to the low food intake and high rate of gastric evacuation [38]. Dissolved oxygen level of 5mg/l support optimum growth of Tilapia but DO level as high as 40mg/l and as low as 3mg/l inhibit growth of Tilapia [39]. As for the pH level, optimum growth of Tilapia is attained at pH level of 7.0- 7.5 [34].

4. CONCLUSION

The weight gain was significantly affected when fed with fruit waste, but this is not true for Tilapia length. Better FCR and survival rate was observed when fingerlings were fed with 2% banana peel but had no significant difference with 2% citrus or pineapple. Water parameters were at a normal level (temperature, DO, and pH) and did not significantly affect the treatments. Conduct a similar study and longer period (3-4 months) of culture using a 0.15 g of tilapia is recommended. Trials on how to Improve the quality of fruit waste to be used as feed additives by lowering the amount of anti-nutritional factor present in the fruit wastes should also be conducted. Further, the possible effect on the flesh and carcass when fish were fed with fruit waste should also be examined.

CONSENT (WHERE EVER APPLICABLE)

All authors declare that 'written informed consent was obtained from other approved parties for publication of this research. A copy of the written consent is available for review by the Editorial office/Chief Editor/Editorial Board members of this journal.

ETHICAL APPROVAL (WHERE EVER APPLICABLE)

All authors hereby declare that "Principles of laboratory animal care were followed, as well as specific national laws where applicable. All experiments have been examined and approved by the appropriate ethics committee.

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