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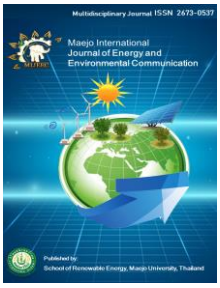

ARTICLE

Waste to wealth: A sustainable circular bioeconomy approach of chicken manure powder for increasing productivity of Lanchester's freshwater prawn (*Macrobrachium lanchesteri*)

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ABSTRACT

A biorefinery is ideal because it can combine many processes to produce multiple bio-products from organic solid waste. Moreover, in view of socially rising energy demands and biodiversity conservation, biorefinery contributed as a sustainable strategic tool for the emerging circular bio-economy. In this research objective was to study some techniques to increase the productivity of Lanchester's freshwater prawn in earthen ponds. The experiment using a completely randomized design was conducted. In six Nattearthen ponds, different amounts of chicken manure were applied to produce different amounts of phytoplankton (green algae). The first pond was control, then, the 2nd to 6th ponds were applied with chicken manure in 30, 60, 90, 120 and 150 kg/rai/week, respectively. The prawns were fed twice daily with 5% of total body weight using 40% protein diet. The results of the study showed that feeding with different densities of phytoplankton (green algae) affected the productivity of Lanchester's freshwater prawn significantly. The highest productivity of Lanchester's freshwater prawn was 566.30 ±4.88 g from the pond applied with chicken manure of 120 kg/rai/week. The productivity of Lanchester's freshwater prawn applied with 90, 30, 60, 150 and 0 kilograms/rai/week of chicken manure was 416.53 ± 9.89, 295.43 ± 5.46, 281.13 ± 4.63, 275.39±4.78 and 265.86 ±4.79 g, respectively. In conclusion, the effect of different densities of phytoplankton (green algae) increased the productivity of Lanchester's freshwater prawn (*Macrobrachium lanchesteri*).

1. Introduction

Prawn (*Macrobrachium lanchesteri* de Man) or commonly called Lanchester's freshwater prawn, is a type of small-sized prawn that thrives in marshes and with prominent features that differ from the giant freshwater prawn or other types of prawn wherein its upper part has big 4-7 teeth and its lower part has 1-2 teeth (Wichiansan, 1980). It thrives at the flowing water sources with depth not exceeding one meter and hides in the stones, in between water plants, in still water with an oxygen content of 4.5 – 5.8 milligram per liter, and turbid water than clear water, due to scarcity of food in the clear water. The turbidity is between 180-

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250 FTU and DO value of 4.5 – 5.8 mm at 9:00 to 10:00 hours which is enough for the prawns to survive. The experiments of Maktoon (1980) reported that the average increased body weight per unit per day of the prawns produced at the density of stocking rate 10 g/m^3 has high value and different from the density stocking rate 30 and 50 g/m^3 and was statistically significant. Thus, the rate density of the prawns that continue to increase will need low investment. They usually eat decaying food found on top of the stones, according to Sriputinibondh and Chongyotha (1997), who found that the stomach of the prawns contained diatoms, Navicula and Diatoma as 53.5 %; algae, Phacus and Euglena as 19.1% and insects as 9.7% belonging to Chironomus Cladocera group, Moina genus.

The Lanchester's freshwater prawn is an aquatic animal widely accepted for its high nutritive value in protein and calcium content and a prevalent dish in dining places. The nutritive value of the freshwater prawn is composed of protein 15.8 g, carbohydrate 1.0 g, fat 1.2 g, the energy of 78 calories, calcium 9.2 g, phosphorus 2.69 g, iron 0.08 g, and moisture content 78.7 g/d weight. At present, water sources are decaying, becoming shallow, and illegally invade, making them less inhabitable for the prawns, so that these types of prawns are declining in populations in their natural habitats (Thanchalan, 1961). Furthermore, the market price of the freshwater prawn has gone up to 200-300 baht/kg. Besides being a human food, the prawn is also a part of the ecosystem serving as food for all types of fishes and especially the food at the nursery stage of the fishes of economic value such as the sand goby, grey and spotted featherback. They could also be processed as prawn paste and dried prawn.

Nomenclature and Abbreviation

BCG	Bio-Circular-Green Economic Model
DO	Dissolved Oxygen
mg/L	Milligram Per Litre

Natural enemies of the young prawns are the frog and fishes that can enter the culture pond of the young prawns leading to low prawn production in nature (Ahmed et al., 2018). In addition, the prawn is a type of animal that is mindful of its habitat area and needs space for hiding, especially during shedding its skin which is considered the main problem in producing them in dense populations in ponds. Thus, the farmers fail in the prawn production in ponds (Arpornchayanan, 1999). Therefore, the study of prawn production in the ponds with various densities of the green water will develop the suitable green water density for the maximum growth of the prawn that inhibits the stress and cannibalism and will show the index or indicator for the prawn. Thus, there is a necessity to conduct the study in order to know the guideline for increased production to meet the market demands and for the commercial production of the prawn by the farmers. Because of industrialization, global urbanization, and economic development, solid waste generation is increasing rapidly, which requires immediate and practical solutions (Whangchai et al. 2020).

Several scientific efforts in response to this challenge were established in order to create new uses for waste materials, which is key factor for the emerging circular bioeconomy concept. Climate change, energy, and food are interconnected global concerns that require practical effort to prepare for adaptation. Furthermore, the bioeconomy, also known as the biobased economy, is based on the concept of maximizing the productivity of biological resources in the agricultural sector. Which is the real driver (engine), but the original production must go on a new creative challenge. 'Value Added' can be created by combining local expertise with technology and innovation to generate income across the production chain (D'Amato et al., 2017).

Along with assistance in resolving issues in the agriculture industry, which has historically been treated like crops (non-value added) with erratic prices and little revenue. Waste reduction assumes that all resources are fully utilized in producing completed goods, resulting in as little waste as possible during the product's life cycle. Therefore, in this study, Lanchester's freshwater prawn (*Macrobrachium lanchesteri*) culture adopted a sustainable circular bioeconomy approach of chicken manure powder for increasing productivity.

2. Methodology

Applying a completely random design for the study, there were six trials with three replicates each:

Trial 1: no fertilizer or control
Trial 2: addition of chicken manure at rate of 30 kg per rai per week
Trial 3: addition of chicken manure at rate of 60 kg per rai per week
Trial 4: addition of chicken manure at rate of 90 kg per rai per week
Trial 5: addition of chicken manure at rate of 120 kg per rai per week
Trial 6: addition of chicken manure at rate of 150 kg per rai per week

The six ponds measuring 100 square meters each were emptied of water, sprinkled with lime, dried under the sun for two weeks, and filled with water. Eighteen floating baskets containing fish measuring 1.25x1.25x1.0 m each were prepared and placed in the ponds at three baskets per pond. Oxygen was made available in the floating basket by putting rubber tubing and air stone. Before putting the prawns in the ponds, they were placed in the resting pond supplied with oxygen and the prawns were trained to eat processed food for three days and then weighed afterward. Finally, the prawns weighing 200 g was released in each floating basket. Feeding was given twice daily in the morning and the evening with ten percent of total body weight using a 40% protein diet.

Data collected from checking the growth rate every two weeks regarding body length and weight were analyzed statistically using SPSS (version 11.5) program. Water quality was examined every two weeks by measuring the following: 1) temperature, 2) pH, 3) DO values, 4) the amounts of ammonia, nitrite, nitrate, and phosphorus, 5) density of phytoplankton, and 6) clarity of the water.

3. Results and discussion

From the study on the effect of green water on the productivity of the freshwater prawn produced at ponds added with chicken manure at varying concentrations, it was shown that increasing the concentrations of the chicken manure also gave corresponding increased prawn production. The pond added with 120 kgs of chicken manure per rai per week had the highest production, which was statistically significant from the 30, 60-, 90-, 150- and 0-kilograms chicken manure per rai per week. This also conformed to the experiments done by the Department of Fisheries (1997), which showed that the productivity of freshwater prawns is higher in green water ponds than in clear water ponds. However, in this study, the prawns were placed in the floating basket and regularly feeding. The effect of other food in nature, such as mosquito larvae, insects, and phytoplankton, on the productivity of the prawns, was negligible (MacGibbon, 2008; Duangsawat and Somsiri, 1985).

The study showed the effect of green water on the productivity of the Lanchester's freshwater prawn inside the floating basket placed in each pond with various concentrations of chicken manure. Prawns that were initially placed in the ponds were sized as 2.80 centimeters long and weighing 0.0045 g on average. Sixty days later, the effects of the various concentrations of chicken manure that also gave various yields or production were statistically significant (P<0.05), wherein the yield of prawn in the ponds added with 120 kgs of chicken manure gave the highest yield of 566.30±4.88 g followed by the concentrations of 90, 30, 60, 150 and 0 kgs; and chicken manure per rai per week that gave a yield of 416.53 ± 9.89, 295.43 ± 5.46, 281.13 ± 4.63, 275.39 ± 4.78 and 265.86 ± 4.79 g, respectively (Figure 1).

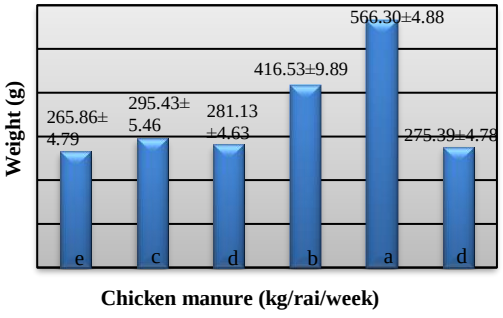

Figure 1 Average body weights of the prawns produced in ponds added with various concentrations of chicken manure

3.1. Growth Efficiency of Lanchester's freshwater prawn

The study also showed that the differences in the length of the prawns produced in the ponds applied with various concentrations of chicken manure were not statistically significant, although it seemed that increasing the amount of chicken manure resulted in increased body length of the prawns (Aquaculture and Experimental subdivision, 1963, Boyd, 1982). Thus, the application of 150, 90, 120, 60, and 0 kilograms chicken manure per rai per week gave the following body length in average as 2.93 ± 0.12, 2.91 ± 0.05, 2.88 ± 0.07, 2.86 ± 0.10, 2.86 ± 0.09 and 2.80 ± 0.04 cm, respectively (Figure 2). Differences in the rates of food conversion ratio of the prawns produced in ponds added with varying concentrations of chicken manure showed that they were not statistically significant. Ponds added with 30, 120, 90, 0, 150, and 60 kgs of chicken manure per rai per week had rates of food conversion ratio at 1.04 ± 2.08, 0.68 ± 1.36, 0.58 ± 1.16, 0.57 ± 114, 0.50 ± 1.00 and 0.48 ± 0.96, respectively.

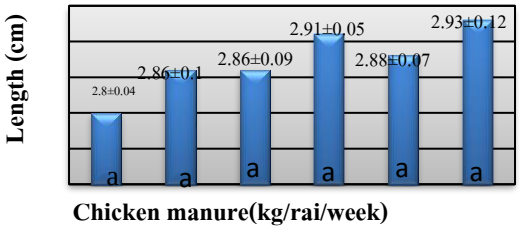

Figure 2 Average body lengths of the prawns produced in ponds added with various concentrations of chicken manure

3.2. Phytoplankton quantity

In the ponds for producing prawns added with various amounts of chicken manure, the differences in phytoplankton were statistically significant (P<0.05). For example, the pond wherein 120 kilograms of chicken manure was added per rai per week had the highest amount of phytoplankton at 196,012.5 ± 9,839.24 cell/ml, followed by the rates of 150, 0, 60, 30 and 0 kgs of chicken manure per rai per week that produced the amounts of phytoplankton at 182,975 ± 4,278.73, 181,100 ± 15,568.40, 47,687.5 ± 2,751.48, 13,075 ± 630.48 and 7,500 ± 3,470.83 cell/ml, respectively (Figure 3).

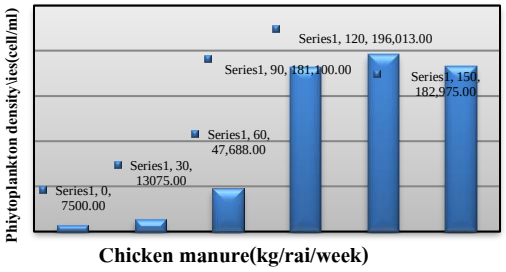

Figure 3 Amount of phytoplankton produced in ponds added with various concentrations of chicken manure

The productivity of the prawns was dependent on the density of the green water, especially on the pond added with 120 kg chicken manure that gave the highest yield than the pond added with 150 kg chicken manure per rai per week because it had the appropriate phytoplankton density. Chaiwongkiat (2001) reported that the density of the phytoplankton had an effect on the survival rate of the prawns since decreased stress and cannibalism. Cannibalism occurred when overpopulation and food insufficiency was leading to the low survival rate of the prawns (Hargreaves, 1999). Cannibalism was the outcome when there was a dense population of the prawn and especially when the prawns were shedding their skin, not at the same time, wherein the prawn that was not shedding its skin ate the prawn that was shedding its skin (Spotte, 1979). The

study showed no statistical significance in the average body length and weight of the prawns, but the increased productivity could be attributed to the increased survival rate of the prawns.

3.3. Water quality

In the study of the amount of phytoplankton in the ponds for producing prawns with chicken manure at varying concentrations, the water quality was analyzed both physically and chemically (Chatvijitkul et al., 2017). In physical terms were temperature and clarity, while in chemical terms were pH, alkalinity, DO, ammonia, nitrogen and phosphorus values. Temperature differences in the ponds for producing prawns with the addition of varying concentrations of chicken manure showed that they were not statistically significant wherein the highest temperature was 27.72 1.09ºC at the pond with 150 kilograms of chicken manure followed by 60, 120, 90, 30 and 0 kilograms chicken manure added per rai per week which had temperatures of 27.72 ± 1.09, 27.62 ± 0.74, 27.62 ± 0.96, 27.57 ± 1.03, 27.42 ± 0.87 and 27.35 ± 0.87 ºC, respectively.

The differences in the degree of light penetrability in the ponds for producing prawns added with varying concentrations of chicken manure were statistically significant (P<0.05), wherein the pond with 0 amount of chicken manure added had the highest degree of light penetrability at 46.11± 1.89 centimeters. This was followed by concentrations of 30, 60, 90, 120, and 150 kilograms of chicken manure added per rai per week which showed the degree of light penetrability at 37.64 ±1.15, 27.29 ± 0.80, 11.61 ± 0.75, 10.63 ± 1.20, and 8.41 ± 0.63 centimeters, respectively.

The differences in pH values of the water in the ponds for producing prawns added with varying concentrations of chicken manure were statistically significant (P<0.05), wherein the pH value in the pond added with 120 kilograms of chicken manure per rai per week gave the highest pH value of 9.03± 0.43. This was followed by ponds added with chicken manure at concentrations of 150, 90, 60, 30 and 0 kgs per rai per week that gave pH values of 8.99 ±0.22, 8.95 ± 0.41, 8.91 ± 0.58, 8.72 ± 0.39 and 7.79 ± 0.46, respectively. The differences in pH values in the ponds for culturing prawns added with various concentrations of chicken manure were statistically significant wherein the pond added with 120 kilograms of chicken manure per rai per week had the highest pH value at 9.03 ± 0.43 and the pond without chicken manure had the lowest pH value at 8.72 ± 0.39.

The differences in the degree of alkalinity in the ponds for producing prawns added with varying concentrations of chicken manure were not statistically significant. The pond added with 150 kilograms of chicken manure had the highest degree of alkalinity at 160.25 ± 12.31 mg/l. Ponds followed this with added chicken manure at concentrations of 60, 120, 90, 30 and 0, which had the degree of alkalinity as 157.50 ± 29.83, 157.25 ± 16.76, 154.75 ± 19.75, 147.50 ± 12.12 and 134.00 ± 9.63 mg/L, respectively.

The differences in the rate of dissolved oxygen (DO value) in the ponds for producing prawns added with varying concentrations of chicken manure were statistically significant (P<0.5) wherein the highest DO value was 13.76± 0.57 milligram per liter at the pond added with 150 kilograms chicken manure per rai per week. This was followed by ponds added with chicken manure at the concentrations of 120, 90, 60, 30, and 0 kg/rai per week, which gave DO values of 13.12 ±0.97, 12.91 ± 0.94, 12.42 ± 1.15, 11.91 ± 1.15, and 10.53 ± 0.97 mg/L, respectively. The differences in DO values or dissolution of oxygen in the pond for culturing prawns added with various concentrations of chicken manure were statistically significant wherein the pond added with 150 kilograms of chicken manure per rai per week had the highest DO value at 13.76 ± 0.57 milligram per liter and the pond without chicken manure had the lowest DO value at 10.53 ± 0.97 mg/L. The differences in penetrability to light in the ponds for culturing prawns added with various concentrations of chicken manure were statistically significant wherein the pond without chicken manure had the highest penetrability to light at 46.11 ± 1.89 mm and the pond added with 150 kilograms of chicken manure per rai per week had the lowest penetrability to light at 8.41 ± 0.64 mm. The differences in temperature, alkalinity, nitrate and phosphorus values in the ponds for culturing prawns added with various concentrations of chicken manure were not statistically significant.

The differences in the amount of ammonia in the ponds for producing prawns added with varying concentrations of chicken manure were statistically significant (P<0.05), wherein the amount of ammonia in the pond added with 150 kilograms of chicken manure had the highest amount of ammonia as 0.128 ± 0.025 mg/L. This was followed by ponds added with 120, 90, 60, 30, and 0 kilograms chicken manure per rai per week that had the amount of ammonia as 0.089 ± 0.019, 0.071 ± 0.038, 0.066 ± 0.027, 0.060 ± 0.022 and 0.029 ± 0.013 mg/L, respectively. The differences in the amount of nitrite in the ponds for producing prawns added with varying concentrations of chicken manure were statistically significant (P<0.05), wherein the highest amount of nitrite was in the pond added with 150 kilograms of chicken manure as 0.366 ± 0.261 mg/L. This was followed by ponds added with 30, 90, 120, 60, and 0 kilograms chicken manure per rai per week that had the amount of nitrite as 0.195 ± 0.011, 0.179 ± 0.149, 0.147 ± 0.117, 0.083 ± 0.047 and 0.045 ± 0.014 mg/L, respectively.

The differences in the amount of nitrate in the ponds for producing prawns added with varying concentrations of chicken manure were not statistically significant, wherein the highest amount of nitrate was 0.207 ± 0.164 in the pond added with 120 kilograms of chicken manure. This was followed by ponds added with 30, 150, 90, 60, and 0 kilograms chicken manure per rai per week that had the amount of nitrate as 0.177 ± 0.051, 0.133 ± 0.043, 0.107 ± 0.011, 0.103 ± 0.034 and 0.081 ± 0.046 mg/L, respectively.

The differences in the amount of phosphorus in the ponds for producing prawns added with various concentrations of chicken manure were not statistically significant. The pond added 150 kilograms of chicken manure per rai per week had the highest amount of phosphorus as 0.864 ± 0.579 mg/L. This was followed by ponds added with 120, 90, 60, 30, and 0 kgs chicken manure per rai per week that had the amount of phosphorus as 0.656 ± 0.645, 0.617 ± 0.487, 0.474 ± 0.500, 0.426 ± 0.478 and 0.070 ± 0.107 mg/L, respectively. The livestock living quarters must be positioned close to or above the fish/shrimp pond in order to use animal manures through livestock integration.

The benefits of combining cattle and aquaculture production are numerous and include the following: because losses of nitrogen and energy due to natural wastage, fermentation, evaporation, and non-reversible coagulation are prevented, the nutritional content of the manure and feed residues is preserved (Fair and Fortner, 1981). Wastes from animal feeding (such as uneaten feed residues) can be absorbed directly by farmed fish or shrimp (Tansutapanit and Paengpairee, 1981). Manure collection, storage, and transportation costs are no longer an issue. Saving land (which can be valuable or in short supply) that would otherwise be used for manure-producing cattle, and hence an increase in land/water productivity. Providing an alternative to land-based or sea-based manure waste disposal, hence decreasing the environmental pollution (Bao et al., 2019). Animals that produce manure will have a better environment. The on-farm supply of fertilizer (manure) and feed (uneaten feed residues) inputs lowers the operating expenses of fish or shrimp production. Therefore, the waste to wealth concept and BCG approach of chicken manure powder experimental results were shown the increasing productivity of Lanchester's freshwater prawn.

4. Conclusion

The highest production of prawns was achieved by adding 120 kg of chicken dung per rai per week. Lanchester's freshwater prawn culture with chicken manure added improved the density of phytoplankton, increasing the density of phytoplankton contributed to increased prawn productivity. The variations in prawn body length and food conversion ratio in ponds containing chicken dung were not statistically significant. The pond for culturing prawns with 150 kg of chicken manure per rai each week had the highest concentration of ammonia at 0.128 0.025 mg/L, whereas the pond without chicken manure had the lowest concentration at 0.029 mg/L. A pond with 150 kg of chicken manure per rai each week had the highest concentration of nitrogen (0.366 mg/L) and a pond without chicken manure had the lowest (0.045 mg/L).

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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