Philippine Journal of Social Sciences and Humanities
Volume 25, 58-71 (2020) University of the Philippines Visayas

Assessment of the Potential Economic Viability of Using Algal Paste on Selected Prawn Hatcheries in Panay, Philippines

Louie Marie T. Eluriaga[1], Rodelio F. Subade[1], Soledad S. Garibay[2], Macy Esmilla[1]*

[1]Division of Social Sciences, College of Arts and Sciences, University of the Philippines Visayas, Miagao 5023, Iloilo

[2]Institute of Aquaculture, College of Fisheries and Ocean Sciences, University of the Philippines VIsayas, Miagao 5023, Iloilo

ABSTRACT

The use of live microalgae poses constraints and problems in the prawn hatcheries. To address this issue, research efforts have been initiated to develop a locally produced algal paste as a substitute to live microalgae. This study was an attempt to determine the possible economic viability of using algal paste as natural food input to eight selected prawn hatcheries in Panay, Philippines. Since algal paste is a new feed technology, an economic viability assessment is essential to gauge its potential in improving profitability of prawn hatcheries. Cost and return analysis was used to evaluate the viability of using algal paste. The potential economic viability of using algal paste was determined using production data of hatchery operations and results of the laboratory experiments and product testing of algal paste conducted by the College of Fisheries and Ocean Sciences (CFOS), University of the Philippines Visayas. As for the basis of pricing for the algal paste, a shadow price and selling price were used. Results of the cost and return analysis showed that prawn hatcheries operate profitably. Pure economic profit was positive at PHP 366.73 per ton using algal paste based on CFOS selling price but lower compared to the use of live microalgae. Continuous effort to bring down the operating cost of algal paste production will prove to be effective in making algal paste more profitable to use as food input for prawn hatcheries.

Keywords: potential economic viability, algal paste, selected prawn hatcheries, Panay

Based on the 2014 data of the Bureau of Fisheries and Aquatic Resources (BFAR), there were 271 prawn farms in the country. Of this total number, black tiger shrimp (*Penaeus monodon*) was cultured in 48% of the farms. Some of these were polycultured with milkfish (Vergel, 2017). According to Corre (1993), one of the factors that make prawn industries vulnerable in the country is its dependence on the shrimp hatcheries for the supply of fry. This underscores the importance of having a steady supply of fry in the success of the prawn industries.

Many factors determine the success of the hatchery production. Among these factors, food input is of primary importance. Natural food input used in hatcheries is one of the determinants of larval nutrition (Muller-Fuega, 2000) and survival, making it a crucial input in every production (Dhert & Sorgeloos, 1995).

In the Philippines, prawn hatcheries use live microalgae as a primary food input. Live microalgae contain phytonutrients essential for marine larvae (Lavens & Sorgeloos, 1996; Das et al., 2012). However, the use of live microalgae inevitably poses constraints to hatchery production (Robert & Trintignac, 1997). These constraints include the risk and cost associated with its use and production. Feeding of live microalgae may introduce pathogens to the culture. Live microalgae culture is often the common source of Vibrio spp., fungi and protozoa in the larvae culture (FAO, 2007) that may cause diseases among larvae resulting to mortality. Live microalgae culture is also sensitive to weather condition where a sudden rain may cause for the collapse of the culture (Aji, 2011). This is one of the problems faced by hatchery operators in the country, which often results to a high mortality rate of larvae (SEAFDEC, 1988). It is also recognized that live microalgae culture is both labor intensive and expensive (Lavens et al., 1995). Coutteau and Sorgeloos (1992) found that the cost of live microalgae culture in a bivalve hatchery covers 30% of the total operating cost. This high cost is associated with the expensive equipment used such as inoculums, test tubes, and tissue culture tanks (Aji, 2011).

Given the aforementioned constraints in the use of live microalgae culture, the College of Fisheries and Ocean Sciences (CFOS) of the University of the Philippines Visayas (UPV) in coordination with Southeast Asian Fisheries and Development Centre (SEAFDEC), and with funding support from the Department of Science and Technology (DOST) has undertaken a research on the development of a local algal paste. It is a liquid formula formed after a mass culture of algae and is highly concentrated. Methods used to achieve concentration included centrifugation, flocculation (Brown, 2002), filtration, and foam fractionation (Ugoala, 2012). Preservatives or additives are sometimes added to lengthen its shelf life and may be stored for a certain period of time by freezing or refrigeration (Aji, 2011).

Algal paste has several advantages as an alternative feed diet. It is more cost-effective for hatcheries to use concentrated algae because it is a ready-to-use food input (Brown, 2002) minimising cost associated with live microalgae production. Using algal paste also lowers the presence of bacteria and viruses compared with live microalgae (Heasman et al., 2001) and has stable nutritional content (Zelaya et al., 2007).

Several studies had been conducted in evaluating the potential of algal paste as food input compared to live microalgae and other substitutes (e.g., Ponis et al., 2008; Knuckey et al., 2006; Nunes et al., 2009; Aji, 2011) but very few if none of these studies determined the economic viability of algal paste as substitute food input for live microalgae. Coutteau and Sorgeloos (1992) mentioned that based on a survey among commercial hatcheries, cost effectiveness is one of the attributes of a feed substitute to be considered in the decision of utilizing it. Most of the studies, however, on the use of algal paste focus only on its biological viability as substitute food input. If most of these developments in feed technologies targets commercial hatcheries, then it is also important to consider the economic aspect of algal paste as feed substitute. Even when commercially available microfeeds were not yet produced in the country, Basa (1988) already highlighted the importance of assessing the economic feasibility of using these imported feeds. Rizwan et al. (2015) found that in seeking the optimal design of microalgae-based biorefinery, gross operating margin was most sensitive to the cost of feed which included the cost of carbon dioxide, water and nutrients. Their study results underlined that the processing of microalgae residue was an important and promising aspect of microalgal biorefinery, ad technological improvement in the field can create a huge impact on the economics of microalgal biorefinery. Molina Grima et al. (2003) examined the economics of monoseptic production of microalgae in photobioreactors and the downstream recovery of metabolites. They found that it was influenced significantly by the cost of producing the biomass, the metabolite content in the biomass, and the cost of purification

Previous studies used cost and return analysis to evaluate economic feasibility of an agribusiness venture. Then, different indicators (e.g., profit, break-even points, return on investment) are used to gauge economic performance. For instance, Wakibia et al. (2011) used cost and return analysis to evaluate the economic viability of using two commercial eucheumoid algae. The study used net income and payback period as indicators of economic performance. The results showed that *K. alvarezii* earned the highest profit and required only 0.3 years to recover the initial investment.

In the Philippines, Corre et al. (2011) assessed the profitability of an integrated milkfish broodstock and hatchery production. Using the data from BFAR-National Integrated Fisheries Development Center and the Jamandre Hatcheries Inc., cost and return analysis showed positive net operating profit for both hatcheries. Other economic indicators like return on working capital, return on investment, and payback period also showed that both hatcheries operated profitably.

Since there is not enough information on the economic viability of using algal paste as a substitute food input to prawn hatcheries, this paper primarily assessed the potential economic viability of using the locally produced algal paste for prawn hatchery production. This is to determine whether the use of this new food input is indeed profitable to use among prawn hatcheries. Revenue and profit of using algal paste as food input was compared with that of using live microalgae. Results of this study could provide hatchery operators, aquaculture technologist, and potential investors vital information and consideration of the potential profitability for the development of algal paste as food input in hatchery production.

MATERIAL AND METHODS

This study was conducted in Iloilo and Aklan, Philippines to test the economic viability of algal paste among prawn hatcheries. This section describes the study sites where the research was conducted. The research design is discussed, by identifying the data sources, describing the variables measured and the data analysis employed.

Description of the Study Sites

This study was conducted in Iloilo and Aklan provinces located in Western Visayas region in Central Philippines (Figure 1) where most of the prawn hatcheries in the region are situated. Markets of fry coming from these two provinces are not only limited to the region since these hatcheries also supply fry in other provinces in Mindanao. These two provinces were selected given their close proximity to UP Visayas where the algal paste is being formulated. The province of Aklan, with 17 coastal and upland municipalities, is in the northwestern part of Panay island.

Makato and Numancia are just two of the coastal municipalities in the province of Aklan. Most of the residents are either engaged in hatchery, aquaculture, or fishing as a means of livelihood in which hatchery has been a profitable venture. According to Altamirano (2010), the area of Makato is just near the Batan estuary believed to be ecologically fit for fish and shrimp culture that eventually led to the expansion of hatchery operation in 1980's.

The province of Iloilo is situated in the southeastern portion of Panay island. According to the Bureau of Agriculture and Statistics (2014), fishing industry plays a major role in the local economy of Iloilo. From 2011 to 2013, the province has been among the top 10 fish-producing provinces in different fishery sectors including the inland municipal, ranking 9th. Guimbal is just one of the coastal municipalities in Iloilo province with a coastline of nine kilometres facing the Panay Gulf. Residents are mainly dependent on fishery and farming as their means of livelihood (Somo,2013).

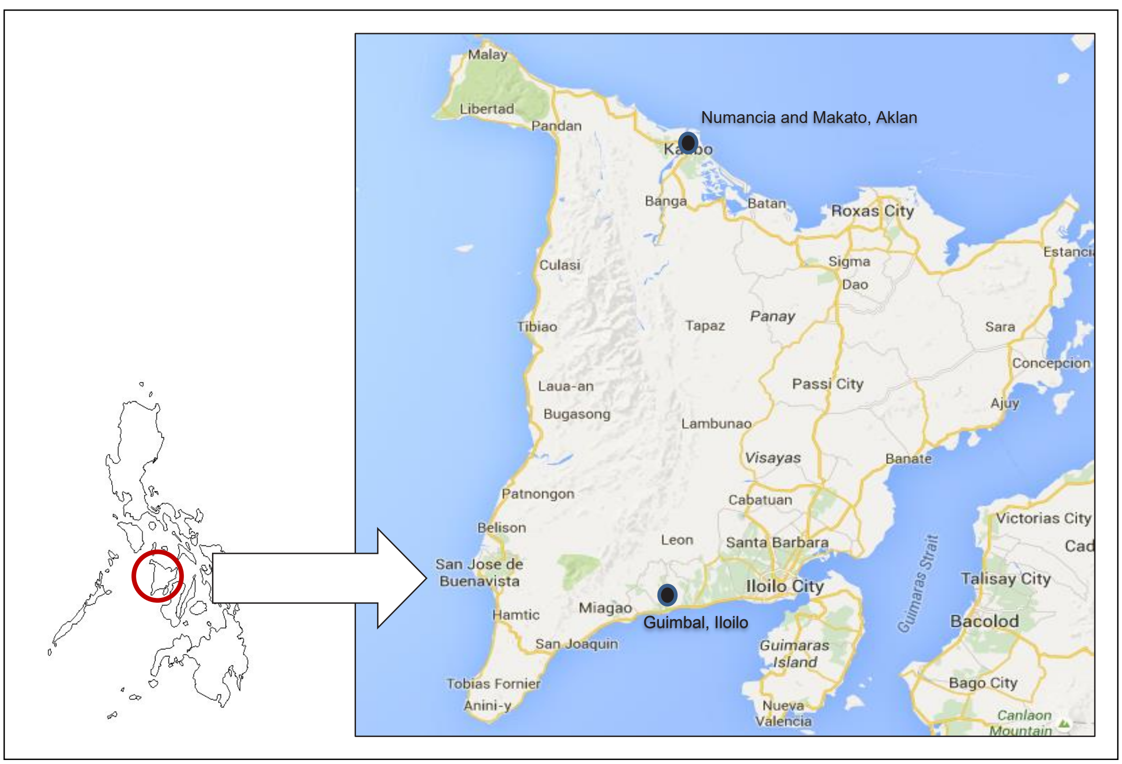

Figure 1. Location Map of Panay Island (Google Maps 2016)

Research Design

To test for the economic viability of using algal paste, this study required a product testing. The list of hatcheries that could possibly participate in field testing of algal paste from the two provinces was taken from the Bureau of Fisheries and Aquatic Resources (BFAR) and respective Municipal Agriculture Office (MAO). The list showed a total of 11 prawn hatcheries in the province of Aklan and three in the municipality of Guimbal, Iloilo. Sampling was supposed to be complete enumeration due to the small number of hatcheries. However, this study only considered operational hatcheries during the study period and from which only eight were operational. The remaining three hatcheries were greatly affected by typhoon Yolanda thus they were not operational at the time of the study. It must be noted that the result of this study is only applicable to the prawn hatcheries covered and will need verification with other hatcheries to be studied.

Field visits and consultation were undertaken among the hatcheries. Hatchery owners and operators were interviewed to gather profile data for hatcheries and their production, cost structures and profitability indicators. During the initial visit, they were also asked whether they would be interested to try an alternative food input to live microalgae. All hatchery owners and supervisors agreed so a product introduction and demonstration were done during the next visit.

Product testing and demonstration was conducted together with the personnel from CFOS. This went well so product testing was expected to follow. In this regard, several liters of algal paste were sent to the aforementioned prawn hatcheries. However, instead of using it as a direct food input, hatchery owners used it as starter for their live microalgae culture. Their reason was to see whether the paste was indeed viable and safe. Since all the prawn hatcheries were small-scale, operators were afraid to take risks. Some would agree to use the algal paste throughout the whole cycle only if there is a representative from CFOS who would monitor the entire duration of production which was difficult to comply given the long distance of these hatcheries from UP Visayas.

Data Sources

Primary data used for this study were gathered through personal interviews with the hatchery owners or operators. All the hatchery participants were small-scale prawn hatcheries. The survey instrument contained four sections; (1) socioeconomic characteristics; (2) hatchery profiles; (3) cost and production profiles; (4) problems encountered in the prawn culture. Other primary data were gathered through key informant interview with the CFOS personnel involved in the algal paste project or from government agencies (e.g., BFAR and MAO). On the other hand, secondary data including prices of algal paste and interest rates were taken from different online sources.

Variables Measured

Different variables were collected during the survey. These variables were mostly related to the operation and production of the hatcheries. Costs structures that were collected during the survey include fixed, variable and opportunity costs.

Fixed costs are input requirements whose costs are independent on the level of output produced. In the case of prawn hatcheries, fixed costs include depreciation, rent, tax, spawners, and permanent workers.

Variable costs are input whose costs vary with the level of output. This includes hired labor, feeds, electricity, fertilizer, transportation, miscellaneous, and other input costs.

Opportunity costs are foregone opportunities. This was computed for family labor, owned capital used as investment in the hatchery, and owned land. The cost of land was based on PHP 150/ m^2. The opportunity cost of capital was based on the assumption that the invested capital was rather saved in the bank. The current savings rate in Landbank of the Philippines is at 0.25% per annum. Family labor was computed based on the prevailing minimum wage for agriculture in Western Visayas.

Table 1. Variables for the cost and return analysis

Variables	Variables measured	Sources
Fixed Cost	Costs that do not vary with the level of output (e.g., depreciation, maintenance, spawners, and others), expressed in PHP	Survey with the study participants
Variable Costs	Costs that vary with the level of output (e.g., hired labor, electricity, feeds, fertilizers, supplies, transport, and others), expressed in PHP	Survey with the study participants
Opportunity Costs	Foregone opportunities	Survey with the study participants and website for the data on wage rate and savings rate
Production	Quantities of fry (pcs)	Survey with the study participant
Price of fry	Price of fry per piece	
Price of algal paste	Price per liter of algal paste in PHP	Key informant interview with the CFOS personnel for the selling price; Reed mariculture website for the shadow price

Data Analysis

Economic assessment studies are usually conducted to determine whether the production of a product is viable or not. Economic viability pertains to the financial viability of an enterprise. Determining whether an economic activity is viable can provide rationale for the use of resources or in investing in the said venture. Cost and return analysis were used in this study to evaluate economic performance of using algal paste in prawn hatcheries. There are three steps involved in conducting a profitability analysis: (1) estimation of the production costs, (2) estimation of the revenues, and (3) economic analysis (Shang, 1990).

Total economic cost (or the total hatchery production cost) is the sum of both explicit and implicit costs or the summation of fixed, variable, and opportunity cost such that total cost was computed as follows:

$$TC = FC + VC + OC \quad (1)$$

Gross revenue is the total value of the hatchery's production in a certain period of time, such that revenue was computed as follows:

$$R = Quantity \times Price \quad (2)$$

This include the total amount sold, the total value of what was consumed, total value that was given away, and total value that was used as in-kind payment (Shang, 1990).

Several economic indicators can be used to evaluate hatchery performance and the viability of using algal paste. This study used profitability indicators such as pure economic profit, break-even points, and return on investment to validate economic viability of using algal paste. Pure economic profit is the difference between total cost and total revenue. The break-even point is the point at which revenue is exactly equal to costs. Although profit is zero at the break-even point, no losses are incurred. Return on investment measures the return relative to the cost of the investment. The use of algal paste is considered viable if pure economic profit is positive, break-even points are attained, and return on investment is positive.

RESULTS

Majority of the study participants were the owners or financers (62.50%), while the rest (37.50%) were operators or technicians since the owners were not staying in the area. Only one of the eight participants was female, indicating that prawn hatchery is a male-dominant entrepreneurial activity. All study participants were married, and majority (62.50%) of them aged from 40 to 65 years. The remaining 37.50% aged from 30 to 40 years. Likewise, study participants had been in the hatchery business for more than 10 years and they considered the hatchery business as their primary source of income.

Seven out of the eight hatcheries were from Aklan while the other one is from Iloilo province. On average, one production cycle lasted for 29 days. However, in a year, hatcheries were able to produce five to seven times since after a production cycle, tanks had to be cleaned. While all the hatcheries were producing

Table 2. Socioeconomic characteristics of the survey participants, Aklan and Iloilo, 2015

VARIABLE	Prawn	
	No. (n=8)	Percentage (%)
Position		
Owner/ Manager	5	62.50
Operator/ Technician	3	37.50
Sex		
Male	7	87.50
Female	1	12.50
Civil Status		
Single	0	0
Married	8	100
Widowed	0	0
Age		
40-65	5	62.50
30-40	3	37.50
Employment to hatcheries		
Primary	8	100
Years in business/ working in hatchery		
>10	8	100

commercially, hatchery production were small-scale scale. These hatcheries were mostly managed by family members and workers were mostly immediate family members.

Table 3. Prawn Hatcheries in Aklan and Iloilo, 2015

	No. (n=8)	Percentage (%)
Location		
Iloilo	1	17%
Aklan	7	83%
Type		
Commercial	8	100%
Scale of production		
Small-scale/ backyard type	8	100%
Production per year		
12 (every month)	0	0
8-11 times	1	14%
5-7 times	7	86%
2-4 times	0	0
Days of culture (mean)	29	-

The study initially analyzed the farm performance of prawn hatcheries using live microalgae. Summarized in Table 4 are the cost requirements of the prawn hatcheries in one production cycle. All the cost requirements are expressed in per ton and for the whole hatchery.

The total fixed cost per ton of production amounted to PHP 500.74, which is equivalent to PHP 58,786.88 for the whole hatchery. Among the fixed inputs, cost of spawners had the biggest percentage share, followed by rent and maintenance cost. The depreciation cost was computed for all the equipment and structures in the hatchery.

Furthermore, total variable cost per ton of production amounted to PHP 1,329.88. For the whole hatchery, this is equivalent to PHP 166,235.59 in one production cycle. Among the variable inputs, hired labor accounted for the biggest percentage share (34%) of the total cost. The corresponding high cost on labor can be attributed to the culture of live microalgae. Live microalgae culture is labor intensive because of the high tendency of live microalgae culture to crash. Hence, live microalgae production must be under the supervision of a specialist (Heasman et al., 2001). Cost and return analysis of bivalve hatchery also showed that live microalgae culture accounted for the biggest share in the operating cost. In prawn hatcheries, the diatom *C.calcitran* is the commonly live feed used by the hatcheries. The second biggest cost was for feeds. Live microalgae are fed from protozoea stage to Post Larvae 1 stage. Thereafter until the harvest days, a commercial feed is used as feed input. Electricity cost is the third biggest variable cost incurred in the operation of prawn hatcheries.

Table 4. Average Total Operating Cost of Selected Prawn Hatchery Production (PHP) from Aklan and Iloilo per production cycle, 2015.

Item	Per ton (PHP)	Standard deviation	Per hatchery (PHP)	Standard deviation	Percentage share on Total Cost (%)
Fixed Cost *(FC)*					
Depreciation	12.61	11.55	1,513.20	1, 443.64	0.56
Rent	77.98	75.38	9,357.60	9,422.08	3.46
Tax	0.29	0.70	34.80	87.48	0.01
Spawners	387.51	0.75	45,200.00	15,885.21	16.73
Maintenance	22.35	17.87	2,785.71	2, 233.79	1.03
Total Fixed Cost	500.74		58,786.88		21.81
Variable Cost *(VC)*					
Hired Worker	775.48	147.62	93, 057.60	18, 451.90	34.45
Electricity	126.86	82.08	15, 223.20	10, 259.89	5.644
Supplies	14.16	11.43	1,699.20	1, 428.46	0.63
Fuel	35.48	25.17	4,257.60	3, 145.63	1.58
Feeds	267.40	98.30	32,088.00	12, 287.33	11.88
Repair	5.72	2.36	686.40	294.99	0.25
Food Allowance	72.35	39.17	8, 682	4,895.67	3.21
Miscellaneous	20.66	7.04	2,479.20	879.88	0.92
Transportation	8.85	6.66	1,062.00	832.99	0.39
Fertilizers	2.62	127.8	314.40	93.63	0.12
Starter	0.30	0.84	36.00	104.98	0.01
Total variable Cost	1,329.88		166,235.59		61.68
Opportunity Cost *(OC)*					
Capital	12.92	19.45	1,550.40	2, 430.03	0.57
Land	363.49	424.26	43,618.80	53, 033.01	16.15
Labor	43.76	27.11	5,251.20	3, 388.15	1.94
Total Opportunity Cost	420.17		44,472.03		16.50
Total Cost *(TC)*	2, 250.79		270,094.80		100

This study also computed the opportunity costs of land, family labor, and initial capital. Total opportunity cost per ton of production amounted to PHP 420.17 or PHP 44,472.03 for the whole hatchery. Together, the total cost per ton of production was PHP 2,250.79 or PHP 270,094.80 for the whole hatchery. Other inputs that are not reflected here such as water are used freely.

Table 5 below shows the different biological conditions and economic indicators of selected prawn hatcheries. The prawn hatcheries interviewed had an average stocking density of 118, 571 per ton, with an average survival rate of 34%. The selling price of fry was PHP 0.11 per piece. Markets for fry are not only limited to the region since some hatcheries also supply fry to prawn farms in Mindanao.

Hatchery owners earned an average revenue per ton of PHP 3,529.14. Given the price, this resulted to a pure economic profit of PHP 1,278.35 per ton. For the whole hatchery, pure economic profit was estimated at PHP 171,648.40.

The results of the cost and return analysis showed that prawn hatcheries operated profitably. However, several problems were raised by the hatchery owners and operators that constrained their operation. One of the mostly cited problem was the sudden changes in weather condition. Both prawn fry and live microalgae culture are very sensitive to sudden changes in weather condition. Live microalgae are essential in prawn hatcheries since this is the major food input in production. However, this concern could be addressed with the use of algal paste. This new feed technology is a ready to feed algae that can be kept viable for months under refrigerated conditions, easy to apply and could be feed directly.

Economic Viability of Using Algal Paste on Prawn Hatcheries

Since algal paste is a new technology, it is important to assess the economic viability of using this as a food input substitute to live microalgae culture.

Table 5. Biological conditions and economic indicators per production of selected prawn hatcheries from Aklan and Iloilo, 2015

Indicators	Per ton	Per Hatchery Production
Average stocking density (pcs/ton)	118, 571	-
Survival rate (%)	34	-
Revenue (PHP) *R= Quantity x Price*	3,529.14	423,496.80
Pure Economic Profit (PHP) *PEP= R-TC*	1,278.35	153,402.00
Break-even price (PHP) *Bprice= (FC+VC)/Production*	0.05	0.05
Break-even production (pcs) *Bproduction= (FC+VC)/Price*	16,642	16,642
Return on Investment (ROI) *ROI=Profit/Total cost * 100*	56.80	56.80

Two prices for the algal paste were used in computing the total cost of prawn hatchery production. These were the selling price of PHP 2,000.00 and shadow price of PHP 3,173.00 per kilogram. The selling price was determined by the CFOS based on the operating cost of algal paste production. This price was higher than the break-even price of algal paste production, thus profit was already incorporated.

However, since this product is not yet being sold in the local market, a shadow price was also used in the economic analysis. This shadow price was based on the international market price of algal paste based on the pricing of Reed Mariculture Inc. Reed Mariculture Inc. in Campbell, California, USA is one of the world's largest producers of algae products (Reed Mariculture Inc., 2011). The pricing of algal paste per liter bag is $75 which was converted to Philippine Peso using the purchasing power parity exchange rate of PHP 42.31 to $1 U.S. (Worldbank, 2015).

However, several assumptions with the use of algal paste were held, such as follows:

(1) Algal paste consumption was from early Protozoea to Post Larvae 1 stage only (11 days).

(2) 50, 000 cells of *Chaetoceros sp.* /ml of larvae

The first assumption indicated the length of time in which algal paste is used as food input. *C. calcitran* feed diet is given only from the 3rd up to the 13th day of the larvae, that is 11 days (Platon, 1978). After this stage until harvest, a commercial feed diet is commonly used.

The second assumption pertains to the amount of algal paste needed to feed for the prawn larvae. Accordingly, larvae are fed with *Chaetoceros sp.* having a density of 50,000 algal cells per ml (Kungyankij, 1985). Consequently, algal paste *C.calcitran* contains 3.34 X 10^8 cells per ml. Thus, a one-liter pack algal paste has a total of 3.34 X 10^{11}cells and one ton (one cubic meter) of larvae culture consumes 5 X 10^{10} cells every day. This assumption then holds that one kilogram of paste is enough to feed one ton (one cubic meter) of larvae culture for 6.68 days. Likewise, this means that for 11 days the total amount of algal paste needed is 1.65 kgs.

Since collaboration with prawn hatcheries did not materialize, cost of hatchery production using algal paste was estimated using the preliminary data and the operating cost of prawn hatchery operation using live microalgae (see Tables 4 and 5). Using the operating cost from the prawn hatcheries and by holding some assumptions, cost structures of using algal paste were derived under the selling and shadow prices. Table 6 presents the cost comparison of using live microalgae and algal paste in prawn hatchery production. The average total cost for live microalgae culture per ton of fry production amounted to PHP 517.52. This amount covers the cost for labor, electricity, fertilizer, and starter. In the whole hatchery, the total cost of labor per ton of production amounted to PHP 775.48 because prawn hatcheries hire a technician responsible solely for the culture of live microalgae and half of labor (PHP 387.74) cost goes to this technician.

On the other hand, the corresponding cost for the use of algal paste was PHP5,235.45 and PHP 3,300.00 using shadow and selling price, respectively. Total fixed, variable, and opportunity costs are the same for both live microalgae and algal paste as these costs covers the prawn hatchery operation. It can be inferred that the use of live microalgae yields the lowest total cost (PHP 2,250.79), followed by the algal paste valued using the selling price (PHP 5,033.27), and finally algal pasted valued using the shadow price (PHP 6,968.72).

Given the cost structures of using live microalgae and algal paste, different economic indicators were derived to validate the economic viability of using algal paste. Indicators such as stocking density, survival rate, and production of using live microalgae were based on the selected prawn hatcheries operation but indicators of using algal paste were based on the experiment conducted by CFOS (see Tables 5 and 7). In the latter case, the algal paste was tested on a one cubic meter prawn culture. Result showed that using algal paste led to a higher survival rate than the use of live microalgae at 60% and 34%, respectively.

Table 7 shows that higher revenue was obtained using algal paste rather than using live microalgae. This was primarily because higher survival rate signifies higher fry production assuming all biological conditions are favorable. However, pure economic profit was highest with live microalgae at PHP 1,278.14. Using the selling price, pure-economic profit of using algal paste was positive amounting to PHP 366.73. On the other hand, negative pure economic profit was obtained using algal paste with the shadow price. Other economic indicators such as the break-even price and break-even production showed that the use of live microalgae is the most profitable food

Table 6. Average cost per 1 ton of using live algae and algal paste in one production cycle in selected prawn hatcheries in Iloilo and Aklan, 2015 (in PHP).

Cost of Hatchery Production	Live Microalgae	Algal Paste	
		Shadow price	Selling price
Total cost of live microalgae culture:	517.52	-	-
Labor	387.74		
Electricity	126.86		
Starter	0.30		
Fertilizer	2.62		
Algal Paste	-	5,235.45[1]	3, 300.00[2]
Total Fixed Cost	500.74	500.74	500.74
Total Variable Cost	812.36	812.36	812.36
Total Opportunity Cost	420.17	420.17	420.17
Total Cost	2, 250.79	6, 968.72	5, 033.27

Legend: [1]Price based on Reed Mariculture Inc. selling price at 1.65 kgs for 11 days feeding
[2]Price based on CFOS selling price at 1.65 kgs for 11 days feeding

Table 7. Biological conditions, revenue and profit comparison (per ton) between algal paste and live algae in one production cycle for selected prawn hatcheries in Iloilo and Aklan, 2015.

Indicators	Live Microalgae	Algal Paste	
		Shadow price	Selling price
Stocking (pcs/ton)	118,571	100,000	100,000
Survival Rate	34%	60%	60%
Production (pcs)	40,314	60,000	60,000
Average Price (PHP)	0.09	0.09	0.09
Revenue (PHP)	3, 529.14	5, 400	5, 400
Pure Economic Profit (PHP)	1,278.47	-1, 568.72	366.73
Break-even price (PHP)	0.05	0.12	0.08
Break-even production (pcs)	16,642	77,430	55,922
Return of Investment (%)	56.80	-22.51	7.29

input. Likewise, corresponding values with the use of algal paste under the selling price is also profitable but lower than compared with the live microalgae. In terms of the return of investment, positive rates were obtained from the use of live microalgae (57%) and algal paste valued using the selling price (7%).

Sensitivity Analysis

To further assess the viability of using algal past, a sensitivity analysis was conducted. Two scenarios were assumed – an increase in the price of algal paste by 10% and 20%. Both scenarios were applied for the selling and shadow prices. Assuming a 10% increase in the price of algal paste resulted to PHP 2,200 and PHP 3,490.30 for selling and shadow prices, respectively. A 20% increase in price resulted to PHP 2,400 and PHP 3,807.60 selling and shadow prices, respectively.

Table 8 shows the results of the sensitivity analysis of economic viability of using algal paste for the prawn hatcheries. The same values for revenue and production were used in the sensitivity analysis (see Tables 4 and 5). Given the new prices of algal paste, corresponding values of the total cost changed. Despite the 10% increase in the price of algal paste, pure economic profit is positive when algal paste is valued using the selling price. However, when price increased by 20%, the use of algal paste is no longer profitable.

DISCUSSION

Results showed that positive pure economic profit was achieved with algal paste using the CFOS selling price though lower compared with that of live microalgae. Although algal paste is economically viable to use, this is not the best option to choose compared with live microalgae at the present time of prawn hatchery operation. This cost-comparison analysis takes only the possible cost reduction on operating cost although the use of algal paste can also lead to a decrease cost on capital investment especially for infrastructure, equipment and space. This is an important consideration because some of the tanks used in the culture of live microalgae can be converted for the larvae culture, implying an increase in production capacity of the hatchery. Despite some advantages of using algal paste as food input in prawn hatchery, continuous effort on the improvement of algal paste in terms of biological aspect and application of the most cost-effective production technique are crucial in achieving higher profitability and attracting possible hatchery operators and investors.

Food inputs are crucial in the hatchery production (Lavens & Sorgeloos, 1996). Laboratory experiment by the CFOS showed that using algal paste as food input for larvae has higher survival rate compared with live microalgae used by the prawn hatcheries. This is

Table 8. Sensitivity analysis of economic viability of using algal paste in one production cycle for prawn hatcheries (in PHP).

Indicators	Shadow price		Selling price	
	Increase by 10%	Increase by 20%	Increase by 10%	Increase by 20%
Revenue	5400	5400	5400	5400
Production	60000	60000	60000	60000
Total Cost	5,759.00	6,282.54	5,363.27	5,693.27
Pure Economic Profit	-359.00	-882.54	36.73	-293.27
Break-even Price	0.09	0.10	0.08	0.09
Break-even Production	48,534.82	53,294.27	44,937.27	47,937.27
Return on Investment	-6.23	-14.05	0.68	-5.15

because the high mortality rate in larvae culture using live microalgae is often associated with bacteria and viruses (Heasman et al., 2001). The use of algal paste lowers the presence of pathogens in hatchery production because methods of production of algal paste like flocculation and centrifugation minimizes bacterial growth (Aji, 2011).

In hatcheries, production of live algae particularly the photosynthetic species is highly dependent on favorable conditions (i.e., light intensities, temperature). Hence, in cases of unpredictable weather conditions, algae production has become a challenge. Algal paste is therefore an option to such growing issues of algal production that demands for a continuous supply of live algae for the local industry.

This study determined the profitability of a locally produced algal paste if it will be made available for the industry. The decision whether the use and local production of algal paste is reasonable depends primarily on its economic viability. If the use of algal paste as food input is more profitable for the partnered hatcheries, then adoption of this new food input in other prawn hatcheries would simply follow.

CONCLUSION

Based on the result of the cost and return analysis, prawn hatchery operation using live microalgae was profitable. Despite some constraints with live microalgae culture, economic indicators were positive. On the other hand, pure economic profit of using algal paste with the CFOS selling price is positive but lower compared with the use of live microalgae. However, the results do not necessarily disregard the fact that the use of algal paste simplifies hatchery production and there are corresponding advantages of using it as food input that provide a rationale for continuous effort on further improvement in the production of this product. Given the huge potential of algal paste in the prawn hatchery industries, efforts should be made in bringing down its selling price and shelf life.

Since the profitability assessment of using algal paste was based only on the testing conducted by the UP Visayas research team, it is suggested that there must be an actual testing of algal paste on commercial hatcheries. A team member can stay in the area to monitor and ensure that proper protocol of using the algal paste is followed by the hatchery owners. The actual testing of algal paste on commercial hatcheries will provide better information on the economic viability of using this new feed technology.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the UPV DOST Aquafeeds Program A-Project 2 and the Small Budget Research Grant of the Office for the Vice Chancellor for Research and Extension, UP Visayas for the funding support. Thanks also to Ms. Ana Liza A. Subade for technical editing and finalization of this paper.

REFERENCES

Aji, L. (2011). The use of algal Concentrates, Dried Algae and Algal Substitutes to Feed Bivalves. Makara, Sains, 15(1), 1-8.

Altamirano, J.P. (2010).Stock Enhancement of Tiger Shrimp (*Peneaus monodon*): Studies and Assessment for Batan Estuary in Northern Panay, Central Philippines. Tokyo, Japan: University of Tokyo.

Basa, S. (1988). Feeds and feedstuffs for aquaculture use in the Philippines. Report of the workshop on shrimp and finfish development. ASEAN/UNDP/FAO/ Regional Small-scale Coastal Fisheries Development Project. Philippines: Manila.

Brown, M. (2002). Nutritional Value and Use of Microalgae in Aquaculture. CSIRO Marine Research GPO Box 1538, Hobart, 7001 Australia.

Bureau of Agriculture and Statistics. (2014). Fisheries Situationer. Retrieved September 20, 2014, from http://www.bas.gov.ph/?ids=downloads_view&id=754.

Corre, V. (1993). The shrimp farming industry in the Philippines. Proceedings of the Aquaculture Workshop for SEAFDEC/AQD Training Alumni. SEAFDEC Aquaculture Department, Iloilo, Philippines.

Coutteau, P. & Sorgeloos, P. (1992). The Use of algal Substitutes and the Requirement for Live Algae in the Hatchery and Nursery Rearing of Bivalves Mollusks: An International Survey. Journal of Shellfish Research, 2 (2), 467-476.

Das, P., Mandal, S., Bhagabati, S.K. & Akhtar, M.S. (2012). Important Live Food Organisms and their Role in Aquaculture. Frontiers in Aquaculture, pp. 69-86.

Dhert, P. & Sorgeloos, P. (1995). Live Feeds in Aquaculture. Aquaculture Towards the 21st Century: Proceedings of INFOFISH-AQUATECH "94, International Conference on Aquaculture, pp. 209-219.

FAO. (2007). Improving *Penaeus monodon* Hatchery Practices Manual based on experience in India. FAO Fisheries Technical Paper 446.

Google Maps. (2016). Philippines and Panay Island. Retrieved January 16, 2016, from https://www.google.com.ph/maps/@11.0926293,122.1459007,200365m/data=!3m1!1e3?hl=en.

Heasman, M.P., Sushames, T.M., Diemar, J.A., O'Connor, W.A. & Foulkes, L.A. (2001). Production of Micro-algal Concentrates for aquaculture Part 2: Development and Evaluation of Harvesting, Preservation, Storage, and Feeding Technology. NSW Fisheries Final Report No. 34.

Knuckey, R., Brown, M., Robert, R. & Frampton, D.M.F. (2006). Production of microalgal concentrates by flocculation and their assessment as aquaculture feeds. Aquacultural Engineering, 35(3), 300-313.

Kungyankij, P., Tiro Jr., L. B., Pudadera Jr., B.J., Potestas, I.O., Corre, K.G., Borlongan, E., Talean, G.A., Bustilo, L.F., Tech, E.T., Unggui, A. & Chua, T.E. (1985). Shrimp hatchery design, operation, and management: Training Manual. Bangkok, Thailand: Network of Aquaculture Centres in Asia.

Lavens, P., Sorgeloos, P., Dhert, P. & Devresse, B. (1995). Broodstock management and egg and larval quality. Blackwell Science Ltd, p.373-397.

Lavens, P. & Sorgeloos, P. (1996). Manual on the Production and Use of Live Food in Aquaculture. FAO Fisheries Technical Paper No. 361. Retrieved September 12, 2014, from http://www.fao.org/fishery/topic/12314/en.

Muller-Fuega, A. (2000). The role of microalgae in aquaculture: situation and trends. Journal of Applied Phycology, 12(3-5), 527-534.

Nunes, R., Pereira, A. Ferreira, J.F. & Yasumaru, F. (2009). Evaluation of the Microalgae Paste Viability Produced in a Mollusk Hatchery in Southern Brazil. Journal of the World Aquaculture Society, 40, 1.

Platon, R. (1978). Design, operation, and economics of a small-scale hatchery for the larval rearing of sugpo, Penaeus monodon Fab.Tigbauan, Iloilo, Philippines: Aquaculture Department, Southeast Asian Fisheries Development Center.

Ponis, E., ChiniZittelli, G., Lavista, F., Robert, R. & Tredici, M.R. (2008). Pavlova lutheri: Production, preservation and use as food for Crassostreagigas larvae. Aquaculture, 282(1-4), 97-103.

Reed Mariculture Inc. (2010). Instant Algae applications. Retrieved April 26, 2015, from https://dl.dropboxusercontent.com/u/24096529/Documents/Products/instant_algae_applic ations.pdf

Robert, R. & Trintignac, P. (1997). Substitutes for live algae in mariculture: a review. Aquatic Living Resource, 10, 315-327.

SEAFDEC AQD. (1988). Biology and Culture of Penaeus Monodon. Tigbauan, Iloilo, Philippines. 94 p.

Shang, Y. (1990). Aquaculture Economic Analysis. The World Aquaculture Society: Louisiana State University, Baton Rouge, LA 70803.

Somo, M.R. (2013). Guimbal, Iloilo. Retrieved December 16, 2014, from http://www.iloilo.net.ph/guimbal-iloilo/

Ugoala, E., Ndukwe, G.I., Mustapha, K.B. & Ayo, K.I. (2012). Constraints to large scale biomass production. Journal of Algal Biomass Utilisation, 3(2), 14-32.

Vergel, J.C.V. (2017). Current trends in the Philippines' shrimp aquaculture industry: A booming blue economy in the Pacific. Oceanography & Fisheries, 5(4), 555668.

Wakibia, J.G., Ochiewo, J. & Bolton, J.J. (2011). Economic analysis of Eucheomoid algae farming in Kenya. Western Indian Ocean Journal of Marine Science, 10(1), 13-24.

Worldbank. (2015). Price Level Ratio of PPP to market exchange rate. Retrieved May 24, 2015, from http://data.worldbank.org/indicator/ PA.NUS. PPPC.RF.

Zelaya, O., Davis, D.A. & Rouse, D.B. (2007). The influence of Artemia and algal supplements during the nursery phase of rearing pacific white shrimp, *Litopenaeus vannamei.* Journal ofthe World Aquaculture Society, 38, 486–496.

Author:

Louie Marie T. Eluriaga, Division of Social Sciences, College of Arts and Sciences, University of the Philippines Visayas, Miagao 5023,Iloilo; lteluriaga@up.edu.ph

Rodelio F. Subade, Division of Social Sciences, College of Arts and Sciences, University of the Philippines Visayas, Miagao 5023,Iloilo; rfsubade1@up.edu.ph

Soledad S. Garibay, Institute of Aquaculture, College of Fisheries and Ocean Sciences, University of the Philippines Visayas, Miagao 5023,Iloilo; ssgaribay@up.edu.ph

Macy Esmilla, Division of Social Sciences, College of Arts and Sciences, University of the Philippines Visayas, Miagao 5023,Iloilo; _@up.edu.ph