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Optimizing Profit from Coconut Sap-based Products at Different Investment Levels

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ABSTRACT

The coconut industry is one of the important sectors in the economy of the Philippines. Nonetheless, its decline in farm yield in the past years has been discouraging to farmers. Given its richness in vitamins, minerals, nutrients, and low glycemic index, coconut sap has emerged as a promising ingredient. Therefore, this study focuses on value-adding activities for coconut sap-based products. Since it is crucial to determine the optimum level of production to generate optimal operating profit, this study aimed to optimize the income of coconut sap farmers by producing wines, sweeteners, or vinegar at different investment levels.

Through linear programming, results revealed that the optimal operating profit will be generated when a farmer invests in *bahalina*. Particularly, at PhP60,000, PhP156,000, PhP222,000, PhP432,000, and PhP600,000 investment levels, the profit that could be generated is PhP137,301, PhP356,981, PhP508,012, PhP988,564, and PhP1,373,006, respectively. If producing *bahalina* is not possible since selling this requires high storage capacity, *lambanog* would generate optimal profit. Finally, results showed that if a farmer prefers not to sell liquors, the production of coconut vinegar could generate optimal profit.

It is recommended that this study be replicated to develop mathematical models that will take advantage of the economies of scale while considering the capacity of tappers. Moreover, it was suggested that farmers consider value-adding activities to increase returns and maximize profits. In addition, a market analysis may be conducted to define market preferences. Reaching out to several agencies may be opted to access programs for support.

Keywords: coconut, farmer, *bahalina, lambanog,* vinegar

INTRODUCTION

Coconut is one of the significant crops in the Philippines, as the country is recognized as the world's second-largest coconut exporter after Indonesia. Coconut, next to banana, corn, and rice, is a major export, as it contributes to the country's gross value added (GVA) of about 3.6 percent (Castillo & Ani 2019). About USD 2 to USD 3 billion annual revenues was generated from coconut export (Rivera 2023). The country's primary coconut-producing regions include Northern

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Mindanao, Davao, Zamboanga Peninsula, and CALABARZON.

About 69 out of 82 provinces in the country produce coconut. The coconut industry has been recorded to cover about a third of the country's total farmland. To be specific, this is about a total of 3.62 million hectares. Moreover, the coconut industry has been providing significant employment and income to the Philippine economy (Calungsod & Ramoneda 2020). It was estimated to contribute about 2.5 million farmers with employment. As of 2018, the Philippines had a total approximate production of 14.7 million metric tons (MT) of coconut from 347 million fruit-bearing trees (Villegas 2022).

However, despite these figures, the coconut industry has been in a constant state of stagnation in the country (Castillo & Ani 2019). Among the identified problems include the susceptibility of the product to the fluctuations of prices worldwide, an unorganized supply chain, low farm productivity, low budget allocation on research and development, and the lack of economies of scale that results in the inability to apply modern farm machinery and technology (Villegas 2022). For this reason, farm consolidation has been advocated as one of the key pillars in promoting agricultural development in the leadership of the Department of Agriculture (DA).

Moreover, the high poverty incidence among millions of coconut farmers indicates that the industry is an orphan in the country's agriculture due to poor investments (Villegas 2022). Eastern Visayas suffers from one of the highest poverty incidences in the Philippines (Villegas 2022). It was the third region in 2018 and the fifth region in 2021, with 30.7 percent and 28.9 percent poverty incidence among population, respectively(ECongress, 2022). In 2023, being predominantly a coconut-producing region, this demonstrates that coconut farmers in the area are among the poorest of the poor in the country. Hence, to generate additional income and employment for various sections of the population and further improve the economic conditions of the farmers in the country, value-adding activities have been tremendously stimulated, such as producing coconut sweeteners (Castillo & Ani 2019).

The country's largest international trade exhibition on food last 2019 emphasized that a value-added supply chain could help shift the Region's coconut sector from a main subsistence farming community into a sustainably lucrative agribusiness industry (Philippine Star 2019). This included processing raw coconut materials into food products like organic sugar, coconut water or juice, and tuba.

Indeed, the coconut tree has been offering many potentials which can be utilized in augmenting the farm-level income of coconut farmers. In the study of Joseph et al., (2021), coconut sap was tackled to be rich in various vitamins, such as B1, B3, B5, B7, B8, and B9; minerals, such as potassium, calcium, magnesium, phosphorus, copper, and zinc; and nutrients, like biotin, choline, and polyphenols. With the increasing threats of obesity, hypertension, diabetes, and heart diseases due to high consumption of sugar in beverages, food, and confectionery products, coconut sap was found the potential to produce sweeteners having low glycemic index (Asghar et al 2019; Joseph et al 2021). Hence, coconut sap products were the focus of this study.

Nevertheless, an inadequate strategy for sustainable profit maximization may result in the liquidation of assets and/or organizations, principally small-scale processing enterprises (Oyekan & Gabriel 2019). Thence, to mitigate the constant state of stagnation of the coconut industry and high poverty incidence among millions of coconut farmers in the country, a profit maximization study on coconut value-added products was conducted to: 1.) determine the production cost of coconut sap-based products; 2.) identify optimum product and its production level that will generate maximum income, find out the volume of coconut sap necessary to be processed; 3.) know the number of trees to be tapped in a year to arrive at the optimal operating profit, and 4.) present the marketability of the optimal product alternatives; such that the production level is bound to the supply of coconut sap, investment capacity of the farmer, revenue must not be less than the total production costs, and the production level that must be greater than or equal to zero.

Conceptual Framework

In a farm, it was shown that income is the result of varying factors. The social-economic capacity of the farmers is a contributing factor that affects profit (Granada & Ongy 2017). This entails the availability of monetary resources, the availability of land, and the actual revenue to cover the cost were determinants of the profit. This information was used to show or to find the optimal alternatives and to designate what products are most optimal. Recommendations were derived from these to arrive at an optimized income.

In The Impact of Demand and Price Expectations on the Behavior of Prices (Maccini 1978), demand was mentioned to have a relatively weak influence on prices. The empirical work that produced these results was dominated by the use of markup models that presume prices are set as a markup over unit cost. Unit cost was the total expenditure incurred by the farmer to produce, store, and sell one unit of a particular coconut sap-based product (Young, Estevez & Logan 2021). On the other hand, unpaid inputs were also sources of profits (Hinton 2022). An example of these was the ecological and social inputs and impacts that are essential in economic processes when the ecological and social stakeholders in the process are not compensated for their contributions. It was illustrated that sources of profits could be any of the following: marking-up prices through contributions known to willing consumers, and exploitation of consumers, communities, and society; price-fixing, collusion, and cartels which may end up competitors to agree with the prices defined to be profitable by one firm rather than offering the market with more competitive prices to compete; programmed obsolescence, wherein people spend their money on products that become outdated needlessly; more efficient techniques to increase productivity and efficiency; buying in bulk to achieve the economies of scale; suppressing wages and benefits; disregarding taxes and regulations; and profit-seeking strategies that do not hurt the customers, such as by promoting a social benefit that makes the informed customers willing to pay extra.

This model in Figure 1 shows how the socio-economic capacity of farmers affects organizational performance in terms of profit. In coconut farming activities, the availability of monetary capital that funds farming activities, in terms of raw materials, equipment, transportation, and other necessary expenses, along with the demand was taken into account to determine the pricing strategy to be adopted that will further shape the revenue. This was where the linear programming (LP) tool is used.

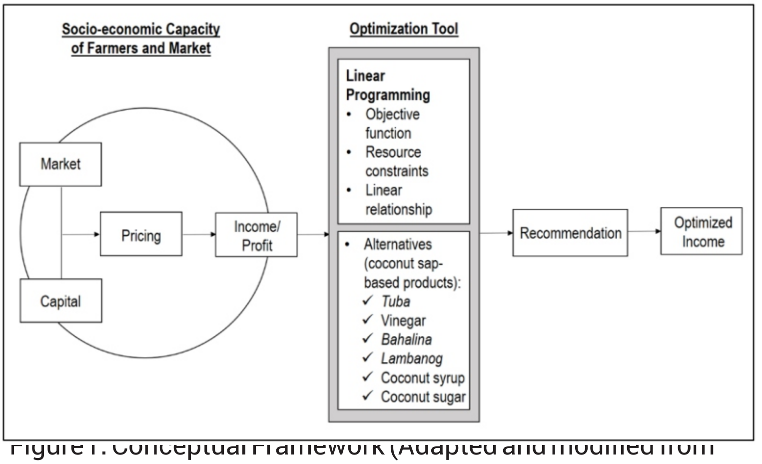

Figure 1. Conceptual Framework (Adapted and modified from Granada & Ongy 2017)

To optimize the operation, since resources are limited, the researcher was able to identify the maximum profit of the farmers per level of investment in coconut sap-based products subject to several constraints. Furthermore, the analyst was able to investigate which product will provide optimal operating profit based on different levels of investment, and their optimum production level. Hence, to prevent, rule out, or influence undesirable consequences or situations, appropriate recommendations were cited.

METHODOLOGY

Data Collection

Primary data of this study were gathered by conducting a semi-structured interview with the coconut sap processors in the provinces of Leyte, Northern Samar, and Batangas. Region VIII, also known as Eastern Visayas, has been one of the top producers of coconut in the Philippines. This study was primarily conducted in the biggest producer of coconuts in Region VIII—Leyte (Food and Agriculture Organization [FAO] 2023; DA-R8 2010). Leyte followed by Northern Samar has the largest area of coconut farms—258,632 hectares and 179,503 hectares, consecutively (Philippines Statistics Authority [PSA] 2004). Northern Samar formed Northern Samar Coconut Industry Council and held a provincial coconut summit (Tan 2019). This could serve as a model to have for the entire region. On the other hand, Southern Tagalog Region has been one of the centers of coconut production and a significant coconut-growing region (Lindsey 1993). In this area, Batangas came out to be the top coconut producer in the country with its coconut wine production (Batangas-Philippines.Com 2012). Thus, subjective sampling or purposive sampling was conducted in these areas, wherein, the primary members of the population that participated in the survey are upon the judgment of the researcher; for the reason that the number of coconut sap processors was limited. The respondents with complete profiles were about seven (7) processors and/or traders of *tuba*, six (6) processors of vinegar, two (2) processors/traders of *bahalina*, one (1) *lambanog* processor, one (1) farmer selling plain raw coconut sap, one (1) farmer selling coconut sap juice, one (1) producer of coconut syrup, and one (1) processor of coconut sugar. On the other hand, the secondary data were collected from the processors' one (1) to three (3) years' available records that are allowed for access and the national and international published works of literature over the internet.

Problem Formulation

This study used descriptive analysis using the Simplex Method approach to solve LP to identify the maximum profit of the farmers per level of investment in producing either coconut sugar, coconut vinegar, coconut syrup, coconut wine (*bahal*, *bahalina*, and *lambanog*), or coconut juice subject. About three (3) runs of computation, using the application package LINDO software, were performed was assessed at different levels of investment to get the optimum alternative if one (1) or more products are not an option for production.

The goal of this model in this study was to find the quantity that generates the highest outcome or profit for a farmer at a level of investment, hence, the objective was to maximize the profit Z, which will be limited to several constraints.

One of the constraints known to the processing of goods is the scarcity of resources. In this study, this was the level of investment or the available funds a farmer is willing and able to fund this operation. Thence, based on the investment of the existing farmers in the study, it was assumed that levels of investment vary from PhP60,000.00 to PhP600,000.00. This was based on the possible revolving fund of the farmers as micro-entrepreneurs that could support the initiation of the products made from coconut sap determined through costing and analysis.

The price of each commodity was referred to as the minimum prevailing price in the region, disregarding the economies of scale, to generate a conservative solution. In this study, one of the recognized limitations to maximize profit was the amount of the breakeven sales, in which the product of the price of the commodity and the production level must be greater than or equal to the level of Micro-enterprise's investment—to avoid performance below the break-even points.

Moreover, the coconut sap supply necessary to generate the optimum production capacity per investment level poses another limitation to the solution. Since there are only limited number of available trees in the locality for tapping, the volume of coconut sap required per level of investment was determined and was recognized as a constraint in the LP model. This was expressed in terms of the amount of coconut sap necessary to produce the optimal solution. Nonetheless, the potential income from coconut sap products may convince farmers to explore the production of coconut sap.

Finally, the decision variable of an LP model must be positive whether the net present value of the activity or objective function is aimed to be minimized or to maximize.

Parameters

Let

$i = i; i = 1, i = 2, \ldots n;\ where\ n\ is\ the\ coconut\ sap\ commodity\ produced$

$1 = Tuba/Bahal$

$2 = Bahalina$

$3 = Lambanog$

$4 = Coconut\ vinegar$

$5 = Coconut - sap\ juice$

$6 = Coconut\ syrup$

$7 = Coconut\ sweetener/sugar$

$p_i = Profit\ per\ commodity\ per\ unit$

$c_i = Total\ cost\ per\ commodity\ per\ unit$

$P_i = Price\ per\ commodity$

$S_i = Supply\ or\ the\ value\ of\ the\ procured\ coconut\ sap$

$MCS_{investment} = Maximum\ coconut\ sap\ supplied\ per\ level\ of\ investment$

$I = Invesment\ level$

$r = Recovery\ rate$

Decision Variable

$X_i = level\ of\ production\ of\ each\ product\ per\ year$

Objective Function

$$Maximize \sum_{i=1}^{7} p_i X_i$$

$$Maximize\ (p_1X_1) + (p_2X_2) + (p_3X_3) + (p_4X_4) + (p_5X_5) + (p_6X_6) + (p_7X_7)$$

Constraints

1. Maximum cost of produce per level of investment

   a. $\sum_{i=1}^{7} c_i X_i \leq 60{,}000$

   $$(c_1X_1) + (c_2X_2) + (c_3X_3) + (c_4X_4) + (c_5X_5) + (c_6X_6) + (c_7X_7) \leq 60{,}000$$

   b. $\sum_{i=1}^{7} c_i X_i \leq 156{,}000$

   $$(c_1X_1) + (c_2X_2) + (c_3X_3) + (c_4X_4) + (c_5X_5) + (c_6X_6) + (c_7X_7) \leq 156{,}000$$

   c. $\sum_{i=1}^{7} c_i X_i \leq 222{,}000$

   $$(c_1X_1) + (c_2X_2) + (c_3X_3) + (c_4X_4) + (c_5X_5) + (c_6X_6) + (c_7X_7) \leq 222{,}000$$

   d. $\sum_{i=1}^{7} c_i X_i \leq 432{,}000$

$$(c_1X_1) + (c_2X_2) + (c_3X_3) + (c_4X_4) + (c_5X_5) + (c_6X_6) + (c_7X_7) \leq 432{,}000$$

e. $\sum_{i=1}^{7} c_iX_i \leq 600{,}000$

$$(c_1X_1) + (c_2X_2) + (c_3X_3) + (c_4X_4) + (c_5X_5) + (c_6X_6) + (c_7X_7) \leq 600{,}000$$

2. Minimum revenue to avoid loss per level of investment

a. $\sum_{i=1}^{7} P_iX_i \geq 60{,}000$

$$(P_1X_1) + (P_2X_2) + (P_3X_3) + (P_4X_4) + (P_5X_5) + (P_6X_6) + (P_7X_7) \geq 60{,}000$$

b. $\sum_{i=1}^{7} P_iX_i \geq 156{,}000$

$$(P_1X_1) + (P_2X_2) + (P_3X_3) + (P_4X_4) + (P_5X_5) + (P_6X_6) + (P_7X_7) \geq 156{,}000$$

c. $\sum_{i=1}^{7} P_iX_i \geq 222{,}000$

$$(P_1X_1) + (P_2X_2) + (P_3X_3) + (P_4X_4) + (P_5X_5) + (P_6X_6) + (P_7X_7) \geq 222{,}000$$

d. $\sum_{i=1}^{7} P_iX_i \geq 432{,}000$

$$(P_1X_1) + (P_2X_2) + (P_3X_3) + (P_4X_4) + (P_5X_5) + (P_6X_6) + (P_7X_7) \geq 432{,}000$$

e. $\sum_{i=1}^{7} P_iX_i \geq 600{,}000$

$$(P_1X_1) + (P_2X_2) + (P_3X_3) + (P_4X_4) + (P_5X_5) + (P_6X_6) + (P_7X_7) \geq 600{,}000$$

3. Maximum available supply of coconut sap per level of investment

a. $\sum_{i=1}^{7} S_iX_i \leq MCS_{60{,}000}$

$$(S_1X_1) + (S_2X_2) + (S_3X_3) + (S_4X_4) + (S_5X_5) + (S_6X_6) + (S_7X_7) \leq MCS_{60{,}000}$$

b. $\sum_{i=1}^{7} S_iX_i \leq MCS_{156{,}000}$

$$(S_1X_1) + (S_2X_2) + (S_3X_3) + (S_4X_4) + (S_5X_5) + (S_6X_6) + (S_7X_7) \leq MCS_{156{,}000}$$

c. $\sum_{i=1}^{7} S_iX_i \leq MCS_{222{,}000}$

$$(S_1X_1) + (S_2X_2) + (S_3X_3) + (S_4X_4) + (S_5X_5) + (S_6X_6) + (S_7X_7) \leq MCS_{222{,}000}$$

d. $\sum_{i=1}^{7} S_iX_i \leq MCS_{432{,}000}$

$$(S_1X_1) + (S_2X_2) + (S_3X_3) + (S_4X_4) + (S_5X_5) + (S_6X_6) + (S_7X_7) \leq MCS_{432{,}000}$$

e. $\sum_{i=1}^{7} S_iX_i \leq MCS_{600{,}000}$

$$(S_1X_1) + (S_2X_2) + (S_3X_3) + (S_4X_4) + (S_5X_5) + (S_6X_6) + (S_7X_7) \leq MCS_{600{,}000}$$

4. Minimum produce for each product

   a. $X_1 \geq 0$

   b. $X_2 \geq 0$

   c. $X_3 \geq 0$

   d. $X_4 \geq 0$

   e. $X_5 \geq 0$

   f. $X_6 \geq 0$

   g. $X_7 \geq 0$

Data Used in the Analysis

To solve for the optimal operating profit of the farmers per level of investment, specific values, and accurate coefficients were requisite to the operations. Nonetheless, there might be a selectivity bias in determining the average number of inputs (Ray 1985). To address this, simple random sampling was applied. The operating profit is the net income obtained from the production's main operations after meetings the operating costs or the gross profit gained before paying taxes (Square Up 2023). These were determined by analyzing the total production cost; wherein all the costs incurred in production, including the direct costs and overhead costs, were tracked and analyzed, along with its sales (Burjorjee 2010). Hence, the production costs of the processors were examined to assess and determine the current technologies and practices adopted by the processors or farmers. The summary of these processors' operation is summarized in Table 1. The product costing per commodity was compared with the published profitability analysis of several agencies in determining the interval of coefficients. This made it unnecessary to accommodate multiple respondents per product type.

Based on the recent environmental conditions of coconut palms, a typical coconut palm has been producing around 1.5 L to 2.5 L of sap per day or an average of about 2 L per day. The average number of palms a coconut sap tapper can climb each day is about 10 palms. Nonetheless, this study was not bound to a maximum of 25 trees per tapper since a family with an available investment fund may not be composed of only one (1) single tapper. In a week, most of the coconuts tappers, simply set forth the seventh day of harvest to the owner of the tree as payment for harvesting coconut sap from their trees; while 10 percent of the respondents pay PhP250.00 per tree every month instead of giving-off plain coconut sap to the tree owner. Derived values were cross-checked and compared with the existing works of literature and studies. Nonetheless, average recent prices of the supplies and commodities were employed to generate conservative results.

Objective Function

The objective function was the maximization of the operating profits generated from the profits of each coconut sap-based product (Table 1).

Table 1. Respondents' summary of the operation

ID NO	PRODUCT	MAJOR ACTIVITY	REVOLVING CAPITAL (PHP)	ANNUAL NET PRODUCE		*RECOVERY (%)	TAPPED TREES	ANNUAL REVENUE	ANNUAL INVESTMENT	ANNUAL INCOME	AVE. PRICE PER UNIT		AVE. COST PER UNIT		AVE. PROFIT PER UNIT	
				UNIT				(PHP)	(PhP)	(PhP)						
1	*Tuba*	Farming	6,240	2,088.40	gallons/ year	0.75	11	254,786	29,985.45	224,800.57	122	PhP/ gallon	14.36	PhP/ gallon	107.64	PhP/ gallon
2	Vinegar	Farming	460	18	gallons/ year	0.95	11	1,080	92	988	60	PhP/ gallon	5.11	PhP/ gallon	54.89	PhP/ gallon
3	*Tuba*	Farming	1,740	1,349.20	gallons/ year	0.94	19	160,553	24,963.39	135,589.12	119	PhP/ gallon	18.5	PhP/ gallon	100.5	PhP/ gallon
4	Vinegar	Farming	180	72	gallons/ year	0.95	19	4,320	60	4,260.00	60	PhP/ gallon	0.83	PhP/ gallon	59.17	PhP/ gallon
5	*Tuba*	Trading	2,410	469.6	gallons/ year	0.9	N/A	103,311	86,162.80	1,429.05	220	PhP/ gallon	183.48	PhP/ gallon	36.52	PhP/ gallon
6	*Tuba*	Farming	3,790	460.5	gallons/ year	0.83	5	90,636	56,512.47	34,124.53	196.82	PhP/ gallon	122.72	PhP/ gallon	74.1	PhP/ gallon
7	Vinegar	Farming	110	25	gallons/ year	0.95	10	2,500	110	2,432.86	100	PhP/ gallon	2.69	PhP/ gallon	97.31	PhP/ gallon
8	*Tuba*	Farming	4,287	1,150.00	gallons/ year	0.82	10	226,787	57,893.46	168,895.19	197.21	PhP/ gallon	50.34	PhP/ gallon	146.86	PhP/ gallon
9	Raw Coconut sap	Farming	110	221.8	gallons/ year	1	10	22,175	169	22,006.42	100	PhP/ gallon	0.76	PhP/ gallon	99.24	PhP/ gallon
10	*Lambanog*	Processing	50,000	3,650.00	gallons/ year	0.36	N/A	1,056,777	575,539.93	481,237.16	289.53	PhP/ gallon	157.68	PhP/ gallon	131.85	PhP/ gallon
11	*Tuba*	Trading	2,952	220	gallons/ year	0.85	N/A	44,016	26,614.00	17,402.31	200	PhP/ gallon	120.93	PhP/ gallon	79.07	PhP/ gallon
12	Vinegar	Processing	4,920	126	gallons/ year	0.95	N/A	94,782	53,042.50	41,739.62	752.24	PhP/ gallon	420.97	PhP/ gallon	331.27	PhP/ gallon
13	Vinegar	Processing	1,407	121	gallons/ year	0.95	5	15,423	12,081.91	3,341.96	128.53	PhP/ gallon	100.68	PhP/ gallon	27.85	PhP/ gallon
14	*Bahalina*	Trading	4,167	40	containers/ year	0.91	N/A	52,500	39,377.98	13,122.02	262.5	PhP/ gallon	196.89	PhP/ gallon	65.61	PhP/ gallon

Table 1 continued ..

	Trading	20,833	381.8	gallons/ year	0.91	N/A	208,750	156,889.88	51,860.12	208.75	PhP/ gallon	156.89	PhP/ gallon	51.86	PhP/ gallon
ar	Trading	1,235	99	gallons/ year	0.95	N/A	13,860	10,570.00	3,290.00	140	PhP/ gallon	106.01	PhP/ gallon	33.23	PhP/ gallon
ıut Sugar	Processing	300,000	64.8	kilos/ year	0.47	N/A	51,813	49,481.18	2,331.57	800	PhP/ kilo	764	PhP/ kilo	36	PhP/ kilo
Coconut	Farming	3,300	152.1	gallons/ year	0.33	1	24,333	19,417.18	4,916.15	160	PhP/ gallon	127.67	PhP/ gallon	32.33	PhP/ gallon
ıut syrup	Processing	2,500	168	bottles/ year	0.18	N/A	24,563	23,046.30	1,516.46	146.21	PhP/ bottle	137.18	PhP/ bottle	9.03	PhP/ bottle
ina	Processing	10,000	3,956.60	gallons/ year	0.8	N/A	1,530,000	1,222,526.45	307,473.55	386.69	PhP/ gallon	308.98	PhP/ gallon	77.71	PhP/ gallon

**Recovery- percentage of the total volume of coconut sap recovered. It is calculated by dividing the total volume recovered from the volume utilized in the production*

Table 2. Summary of annual operation from 10 coconut sap palms per commodity

	TUBA/ BAHAL (X_1)	*BAHALINA* (X_2)	*LAMBANOG* (X_3)	COCONUT VINEGAR (X_4)	COCONUT SAP JUICE (X_5)	COCONUT SYRUP (X_6)	COCONUT SUGAR (X_7)
Revolving capital (PhP)	31,618.27	50,011.37	47,447.84	20,188.61	11,633.71	13,348.13	45,049.40
Net Produce (gal/year)	1,404.86	1,149.43	590.74	1,573.09	545.84	100.93	256.54
Recovery rate (%)	85	69.55	35.74	95.18	33	6.11	15.52
Annual Revenue (PhP)	222,670.70	496,517.48	272,440.86	341,003.23	87,334.32	281,593.83	388,936.30
Profit (PhP)	76,331.93	345,524.25	162,570.84	186,527.46	9,083.14	61,874.60	178,304.48
Annual Production Cost (PhP)	146,338.77	150,993.23	109,870.02	154,475.76	78,251.18	219,719.23	210,631.81
*Average Profit per Gallon (PhP)	80.07	300.6	275.2	118.57	16.64	613.07	695.02

$*Profit_{Xi} = Total\ Revenue - Total\ Cost$

Profit (see Table 2) was expressed by subtracting costs from revenues (Equation 1). Meanwhile, coefficients in the left-hand-side (LHS) of the profit (Equation 2) of each coconut sap commodity were derived from the quotient of the annual operating profit and the annual net production volume.

LHS: PR=R-C (1)

where:
Pr are profits gained from processing coconut sap-based products from 10 coconut palms annually (PhP)
R are revenues generated from the sales of producing coconut sap commodities from 10 coconut palms annually (PhP)
C are costs incurred from producing coconut sap commodities from 10 coconut palms annually (PhP)

$$p_i = \frac{Pr}{V} \quad (2)$$

where:
p is the profit per unit gained from processing each coconut sap-based product from 10 coconut palms (PhP)
Pr is the profit gained from processing a coconut sap-based product from 10 coconut palms annually (PhP)
V is the annual net production volume for producing a coconut sap-based commodity from 10 coconut palms (PhP)

Variation of prices from the primary data was based on the current market price depending on the location. Bahal ranged from PhP15.00 to PhP50.00 per liter. Nevertheless, the usual price was PhP20.00 per liter (Pacho 2010), but this study utilized the most recent prices of the commodities from the respondents.

The total production cost in a year for the *tuba* was subtracted from the anticipated annual sales revenue of PhP222,670.70. The difference was divided by the recovered produce of 1,404.86 gallons with about an 85 percent recovery rate. This resulted in about PhP80.07 profit per gallon of *tuba*.

In the production of *bahalina*, the expected annual sales revenue was about PhP496,517.48 from a net production of 1,149.43 gallons of *bahalina* at a 70 percent recovery rate. From these, the total annual production cost was found to be about PhP150,993.23. Hence, the profit for each gallon turned out to be about PhP300.60.

In producing *lambanog*, the total annual production cost of PhP109,870.02 was subtracted from the anticipated annual sales revenue of PhP272,440.86. The difference was divided by the recovered produce of 590.74 gallons with about a 36 percent recovery rate. This resulted in about PhP275.20 profit per gallon of *lambanog*.

For the processing of coconut vinegar, the expected annual sales revenue was about PhP341,003.23 from a net production of 1,573.09 gallons of vinegar at a 95 percent recovery rate. From these, the total annual production cost was found to be about PhP154,475.76. Hence, the profit for each gallon turned out to be about PhP118.57.

In the production of coconut sap juice, the total production cost of

PhP78,251.18 was subtracted from the anticipated annual sales revenue of PhP87,334.32. The difference was divided by the recovered produce of 545.84 gallons with about a 33 percent recovery rate. This resulted in about PhP16.64 profit per gallon of coconut sap juice.

In producing coconut syrup, the expected annual sales revenue was about PhP281,593.83 from the net production of 100.93 gallons of coconut syrup at a six (6) percent recovery rate. From these, the total production cost was found to be about PhP219,719.23. Hence, the profit for each gallon turned out to be about PhP613.07.

Finally, for the processing of coconut sugar, the total annual production cost of PhP210,631.81 was subtracted from the anticipated annual sales revenue of PhP388,936.30. The difference was divided by the recovered produce of 971.13 kg of coconut sugar with about a 16 percent recovery rate. This resulted in about PhP695.02 profit per gallon of coconut sugar conversion.

Constraint 1

The right-hand-side (RHS) of the constraint, which is the PhP60,000 level of investment, was determined by selecting the maximum revolving fund that could start any of the products made from coconut sap. From this level, about 42.92 percent were expected to finance the possible tools and equipment necessary for the farmers to kick off the operation (see Table 3). About 40.44 percent will be used as a revolving capital, while, the 16.65 percent may be spent on licenses, fees, and miscellaneous expenses.

Table 3. Potential investment level of farmers (RHS)

LEVEL OF INVESTMENT (PhP)	MONTHLY INVESTMENT (PhP)	PRODUCTION COST (%)	COST OF FACILITY (%)	LICENSES, FEES, & OTHERS (%)
60,000	5,000.00	40.44	42.92	16.65
156,000	13,000.00	69.05	24.55	6.4
222,000	18,500.00	78.25	17.25	4.5
432,000	36,000.00	50.86	47.5	1.63
600,000	50,000.00	57.15	34.2	8.65

The next level of investment which is PhP156,000, was determined by assuming that the farmer opt to sell coconut wines. Thus, the fund that could accommodate the maximum facility for wines while taking into consideration farmers' availability of funds was selected. From the PhP222,000 investment level, the RHS of the inequality was determined given that the farmers have larger capital. From this level, about 78.25 percent may be used to finance the operating expenses, while, 17.25 percent may be used for the possible tools and equipment necessary for the operation.

Assuming that coconut farmers opt to produce coconut sweeteners, and are planning to acquire the approval of the Food and Drug Administration (FDA) in the future, in this level of investment, the fund must be able to accommodate a facility that may cater further potential product developments inclined to FDA's preferences; thus, farmer-processors may invest PhP432,000. At this point, if the farmer-processor decides to attain this level of investment in a staggered manner, one may opt to invest in the operation about PhP36,000 monthly. About PhP205,220 may be invested in a facility, while about 50.86 percent may be allotted to the operating expenses. Eventually, farmer processors may have larger capital available. From the PhP600,000 investment level, about 57.15 percent may be used to finance the operating expenses, while, the 34.20 percent may be used in the possible tools and equipment necessary for the operation.

The LHS of the first constraint was the product of the unit cost of each coconut sap commodity (see Table 4). The coefficients (Equation 3) of each coconut sap commodity were derived from the quotient of the annual production cost and the annual net production volume.

Table4. Coconut sap-based products and their costs (LHS)

	ANNUAL PRODUCTION COST (PHP)	NET PRODUCE (GALLONS)	COST PER GALLON (*c* VALUE ASSIGNED; PHP)
Tuba/ Bahal (X_1)	146,338.77	1,404.86	78.43
Bahalina (X_2)	150,993.23	1,149.43	131.36
Lambanog (X_3)	109,870.02	590.74	185.99
Coconut Vinegar (X_4)	154,475.76	1,573.09	98.2
Coconut sap Juice (X_5)	78,251.18	545.84	143.36
Coconut Syrup (X_6)	219,719.23	100.93	2,177.04
Coconut Sugar (X_7)	210,631.81	256.54	821.03

where:
c_i is the cost per unit incurred from processing each coconut sap -based product from 10 coconut palms (PhP)
C is the cost incurred annually from processing a coconut sap -based product from 10 coconut palms (PhP)
V is the annual net production volume for producing a coconut sap -based commodity from 10 coconut palms (PhP)

Constraint 2

The RHS of the second constraint was the sales revenue of the processor, which must be greater than its level of investment to ensure greater than break-even performance.

Table 5. Coconut sap-based products and their prices (LHS)

	ANNUAL SALES REVENUE (PHP)	NET PRODUCE (GALLONS)	PRICE PER GALLON (*P* VALUE ASSIGNED; PHP)
Tuba/ Bahal (X_1)	222,670.70	1,404.86	158.5
Bahalina (X_2)	496,517.48	1,149.43	431.97
Lambanog (X_3)	272,440.86	590.74	461.19
Coconut Vinegar (X_4)	341,003.23	1,573.09	216.77
Coconut Sap Juice (X_5)	87,334.32	545.84	160
Coconut Syrup (X_6)	281,593.83	100.93	2,790.11
Coconut Sugar (X_7)	388,936.30	256.54	1,516.06

Meanwhile, the LHS of the second constraint was the product of the average selling price per unit cost of each Coconut sap commodity (see Table 5). The coefficients (Equation 4) of each Coconut sap commodity were derived from the quotient of the annual sales revenue—relative to the potential sizes and variants available, and the annual net production volume.

$$P_i = \frac{S}{V} \qquad (4)$$

where:
P_i is the average price per unit incurred from processing each coconut sap-based product from 10 coconut palms (PhP)
S is the sales generated annually from processing a coconut sap-based product from 10 coconut palms (PhP)
V is the annual net production volume for producing a coconut sap-based commodity from 10 coconut palms (PhP)

Constraint 3

$$MCS_{investment} = \frac{I}{r} \qquad (5)$$

where:
MCS is the maximum available supply of coconut sap per level of investment
I is the investment level of a coconut sap farmer for a commodity (PhP)
r is the recovery rate per type of commodity (%)

The RHS value for each level of investment in the third constraint is determined by dividing the level of investment by the unit cost of the product that requires the most sap per gallon of produce (see Equation 5); and multiplied by its recovery coefficient. In this model, it is the *lambanog* that requires most of the coconut sap among all other products. Hence, each level of investment is divided by its unit cost, which is PhP185.99; and multiplied by its recovery coefficient which is 35.74 percent.

Table 6. Derived maximum coconut sap supply per level of investment (RHS)

LEVEL OF INVESTMENT (PHP)	MAXIMUM COCONUT SAP SUPPLY PER LEVEL OF INVESTMENT ($MCS_{investment}$ VALUE ASSIGNED; GALLONS)
60,000	902.58
156,000	2,346.71
222,000	3,339.56
432,000	6,498.59
600,000	9,025.83

The coconut sap procured for PhP60,000 level of investment must not be greater than the maximum coconut sap supply of 902.58 gallons (see Table 6). For PhP156,000, PhP222,000, PhP432,000, and PhP600,000, the maximum coconut sap supply is 2,346.71 gallons, 3,339.56 gallons, 6,498.59 gallons, and 9,025.83 gallons, respectively. To determine the coconut sap supply required for each commodity, one must divide the volume of production by its recovery rate. Thus, coefficients of the LHS of the constraint were established by dividing one (1) by the recovery rate of each commodity (Equation 6).

$$S_i = \frac{1}{r} \qquad (6)$$

where:
S_i *is the coconut sap supply necessary to produce the optimum level or product of a commodity (gallons)*
r is the recovery rate per gallon of each commodity (%)

Hence, Table 7 summarizes the supply coefficient of the LHS of the third constraint.

Table7. Supply coefficient of the third constraint (LHS)

	RECOVERY RATE (%)	SUPPLY COEFFICIENT (S VALUE ASSIGNED; GALLONS)
Tuba/ Bahal (X_1)	0.85	1.18
Bahalina (X_2)	0.69545	1.44
Lambanog (X_3)	0.35742	2.8
Coconut Vinegar (X_4)	0.95179	1.05
Coconut Sap Juice (X_5)	0.33	3.03
Coconut Syrup (X_6)	0.06106	16.38
Coconut Sugar (X_7)	0.15522	6.44

The Model

Objective Function

$$Maximize \sum_{i=1}^{7} p_i X_i$$

$$Maximize\ (80.07X_1) + (300.60X_2) + (275.20X_3) + (118.57X_4) + (16.64X_5) + (613.07X_6) + (695.02X_7)$$

Constraints

1. Maximum cost of produce per level of investment

   a. $\sum_{i=1}^{7} c_i X_i \leq 60{,}000$ PhP level of investment

   $$(78.43X_1) + (131.36X_2) + (185.99X_3) + (98.20X_4) + (143.36X_5) + (2{,}177.04X_6) + (821.03X_7) \leq 60{,}000$$

   b. $\sum_{i=1}^{7} c_i X_i \leq 156{,}000$ PhP level of investment

   $$(78.43X_1) + (131.36X_2) + (185.99X_3) + (98.20X_4) + (143.36X_5) + (2{,}177.04X_6) + (821.03X_7) \leq 156{,}000$$

   c. $\sum_{i=1}^{7} c_i X_i \leq 222{,}000$ PhP level of investment

   $$(78.43X_1) + (131.36X_2) + (185.99X_3) + (98.20X_4) + (143.36X_5) + (2{,}177.04X_6) + (821.03X_7) \leq 222{,}000$$

   d. $\sum_{i=1}^{7} c_i X_i \leq 432{,}000$ PhP level of investment

   $$(78.43X_1) + (131.36X_2) + (185.99X_3) + (98.20X_4) + (143.36X_5) + (2{,}177.04X_6) + (821.03X_7) \leq 432{,}000$$

   e. $\sum_{i=1}^{7} c_i X_i \leq 600{,}000$ PhP level of investment

   $$(78.43X_1) + (131.36X_2) + (185.99X_3) + (98.20X_4) + (143.36X_5) + (2{,}177.04X_6) + (821.03X_7) \leq 600{,}000$$

1. Minimum revenue to avoid loss per level of investment

   a. $\sum_{i=1}^{7} P_i X_i \geq 60{,}000$ PhP level of investment

   $$(159X_1) + (432X_2) + (461X_3) + (217X_4) + (160X_5) + (2{,}790.11X_6) + (1{,}516.06X_7) \geq 60{,}000$$

   b. $\sum_{i=1}^{7} P_i X_i \geq 156{,}000$ PhP level of investment

   $$(159X_1) + (432X_2) + (461X_3) + (217X_4) + (160X_5) + (2{,}790.11X_6) + (1{,}516.06X_7) \geq 156{,}000$$

c. $\sum_{i=1}^{7} P_i X_i \geq 222{,}000$ PhP level of investment

$$(159X_1) + (432X_2) + (461X_3) + (217X_4) + (160X_5) + (2{,}790.11X_6) + (1{,}516.06X_7) \geq 222{,}000$$

d. $\sum_{i=1}^{7} P_i X_i \geq 432{,}000$ PhP level of investment

$$(159X_1) + (432X_2) + (461X_3) + (217X_4) + (160X_5) + (2{,}790.11X_6) + (1{,}516.06X_7) \geq 432{,}000$$

e. $\sum_{i=1}^{7} P_i X_i \geq 600{,}000$ PhP level of investment

$$(159X_1) + (432X_2) + (461X_3) + (217X_4) + (160X_5) + (2{,}790.11X_6) + (1{,}516.06X_7) \geq 600{,}000$$

3. Maximum available supply of coconut sap per level of investment

a. $\sum_{i=1}^{7} S_i X_i \leq MCS_{60{,}000}$

$(1.18X_1) + (1.44X_2) + (2.80X_3) + (1.05X_4) + (3.03X_5) + (16.38X_6) + (6.44X_7) \leq$ $902.58_{60{,}000}$ gallons of coconut sap

b. $\sum_{i=1}^{7} S_i X_i \leq MCS_{156{,}000}$

$(1.18X_1) + (1.44X_2) + (2.80X_3) + (1.05X_4) + (3.03X_5) + (16.38X_6) + (6.44X_7) \leq$ $2{,}346.71_{156{,}000}$ gallons of coconut sap

c. $\sum_{i=1}^{7} S_i X_i \leq MCS_{222{,}000}$

$(1.18X_1) + (1.44X_2) + (2.80X_3) + (1.05X_4) + (3.03X_5) + (16.38X_6) + (6.44X_7) \leq$ $3{,}339.56_{222{,}000}$ gallons of coconut sap

d. $\sum_{i=1}^{7} S_i X_i \leq MCS_{432{,}000}$

$(1.18X_1) + (1.44X_2) + (2.80X_3) + (1.05X_4) + (3.03X_5) + (16.38X_6) + (6.44X_7) \leq$ $6{,}498.59_{432{,}000}$ gallons of coconut sap

e. $\sum_{i=1}^{7} S_i X_i \leq MCS_{600{,}000}$

$(1.18X_1) + (1.44X_2) + (2.80X_3) + (1.05X_4) + (3.03X_5) + (16.38X_6) + (6.44X_7) \leq$ $9{,}025.83_{600{,}000}$ gallons of coconut sap

RESULTS AND DISCUSSION

Annual profitability analysis of coconut sap-based products

Alternative products were summarized in Table 8. Among the options, *bahalina* was remarkably high in return on investment (ROI), though it was the product that needed the highest revolving fund with its storage inventory of old wines. It could be noticed that with the units of measurement, it was the coconut sugar that has the highest profit in every gallon. This could be translated to about 3.79 kilograms per gallon or about PhP183.61 profit per kilo. Though farmers could raise their profit by selling coconut sugar in smaller packs like 500 grams and 250 grams to add more value, it has also a high unit cost. In an average of 10 coconut trees tapped annually, about PhP388,936 could be generated by selling an average of PhP400.5 per kilo of coconut sugar. In addition, among the seven (7) products, coconut sweeteners have the biggest annual operations cost with their higher cost of labor, the use of liquefied petroleum gas (LPG), and the utilization of packaging materials. On the other hand, *bahalina* is anticipated to produce the highest annual operating profit with the highest ROI; though it does not generate the highest profit per unit, nor the highest volume produced annually.

Table 8. Annual profitability analysis of coconut sap-based products

	TUBA / BAHAL (X_1)	*BAHALINA* (X_2)	*LAMBANOG* (X_3)	COCONUT VINEGAR (X_4)	COCONUT SAP JUICE (X_5)	COCONUT SYRUP (X_6)	COCONUT SUGAR (X_7)
Annual Cost (PhP)	146,339	150,993	109,870	154,476	78,251	219,719	210,632
Revenue (PhP)	222,671	496,517	272,441	341,003	87,334	281,594	388,936
Profit (PhP)	76,332	345,524	162,571	186,527	9,083	61,875	178,304
ROI (%)	102	229	148	121	12	28	85
Revolving Capital (PhP)	31,618	50,011	47,448	20,189	11,634	13,348	45,049
Inventory allowance (months)	2	2	1	1	1	1	1

Farmers may capitalize on *tuba* processing at a minimum investment of PhP31,618.27 (Table 8). This would cater supply of an average inventory of about two (2) months' allowance to avoid stockouts. The annual cost was about PhP146,338.77.

Meanwhile, annual costs in producing *bahalina*, *lambanog*, coconut vinegar, coconut sap juice, coconut syrup, and coconut sugar are anticipated to be about PhP150,993.23, PhP109,870.02, PhP154,475.76, PhP78,251.18, PhP219,719.23, and PhP210,631.81, respectively.

Lambanog was assumed to be fermented at an average of 1.125 years and was sold in one (1) liter, four (4) liters, six (6) liters, and 750 milliliters. Farmers may regular vinegar and spiced vinegar of different sizes: 250 milliliters, 500 milliliters, one (1) liter, and one (1) gallon. On the other hand, processing coconut syrup assumes a variety of 200mL syrup: classic, cinnamon, and pineapple.

Meanwhile, the result of a 16 percent recovery rate from fresh raw coconut sap to kilograms of coconut sugar was consistent with the profitability analysis of PICARRD (2010) on coconut sugar which reported around a 12 to 18 percent recovery rate. Product sizes were assumed to be 10 grams, 100 grams, 500 grams, and one (1) kilogram.

Optimal Operating Profit at Different Levels of Investment

At the PhP60,000.00 level of annual investment, considering all alternative products, it was found that producing *bahalina* was the most optimal. To generate the optimal operating profit of PhP137,300.60, about 456.75 gallons of *bahalina* in a year must be produced (Figure 2). This would require harvesting about 656.76 gallons of fresh raw coconut sap from only about 3.97 or four (4) trees annually.

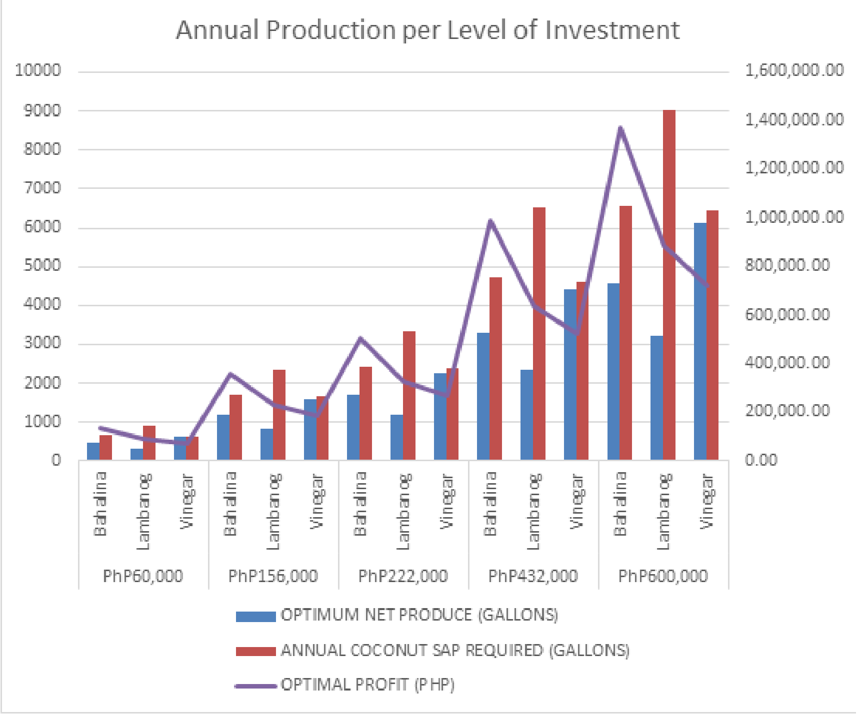

Figure2. Annual Production per Level of Investment

If a farmer does not have enough space for storage, or for any other reasons such that the market for *bahalina* in the locality is not well defined, the results revealed that the next product that will provide optimal operating profit is *lambanog*. Selling about 322.60 gallons of *lambanog* in a year, at its assumed sizes, would maximize the profit by PhP88,779.91 annually, at a PhP60,000.00 level of investment (Table 9). This translates to a harvest of 902.58 gallons of raw coconut sap annually from about 5.46 or six (6) trees. On the other hand, when the farmer does not consider selling liquors, one may seek to produce about 611.01 gallons of vinegar at its assumed variants to generate an optimal operating profit of PhP72,449.22 in a year. This would require a harvest of 641.96 gallons of coconut sap from around 3.88 or four (4) trees. In the Philippine Coconut Industry Roadmap 2021-2040 of DA (2022), a farmer generates an average of only PhP28,512.60 per hectare annually if young nuts are sold at PHP9.00 per kilogram. Nevertheless, congruent to the estimates of Secretaria et al. (2004), the production of sap syrup, vinegar, and beverage, involving simple procedures at the farmers' level, showed higher farmer's net income of PhP 9,100 to PhP 14,800 per month, than that of coconut sugar making (PhP 5,900 per month).

Table 9. Summary table per level of investment

LEVEL OF INVESTMENT	OPTIMUM PRODUCE PER RUN	ANNUAL COCONUT SAP REQUIRED (GALLONS)	OPTIMUM NET PRODUCE (GALLONS)	OPTIMAL PROFIT (PHP)	NO. OF COCONUT PALMS REQUIRED FOR TAPPING
PhP60,000	*Bahalina* (First run; X2)	656.76	456.75	137,300.56	3.97
	Lambanog (Second run; X3)	902.58	322.6	88,779.78	5.46
	Coconut Vinegar (Third run; X4)	641.96	611.01	72,449.21	3.88
PhP156,000	*Bahalina* (First run; X2)	1,707.58	1,187.55	356,981.49	10.33
	Lambanog (Second run; X3)	2,346.71	838.76	230,827.75	14.2
	Coconut Vinegar (Third run; X4)	1,669.09	1,588.61	188,367.96	10.1
PhP222,000	*Bahalina* (First run; X2)	2,430.02	1,689.97	508,012.21	14.7
	Lambanog (Second run; X3)	3,339.56	1,193.62	328,485.72	20.21
	Coconut Vinegar (Third run; X4)	2,375.24	2,260.72	268,062.15	14.37
PhP432,000	*Bahalina* (First run; X2)	4,728.69	3,288.59	988,563.93	28.61
	Lambanog (Second run; X3)	6,498.59	2,322.72	639,215.22	39.32
	Coconut Vinegar (Third run; X4)	4,622.09	4,399.24	521,634.34	27.97
PhP600,000	*Bahalina* (First run; X2)	6,567.63	4,567.49	1,373,005.61	39.74
	Lambanog (Second run; X3)	9,025.83	3,226.01	887,799.14	54.61
	Coconut Vinegar (Third run; X4)	6,419.57	6,110.05	724,492.14	38.84

At PhP156,000.00 level of annual investment, the optimal operating profit of PhP356,981.49 will be generated by producing 1,187.55 gallons of *bahalina* in a year. At a PhP222,000.00 investment level, producing 1,689.97 gallons of *bahalina* would generate the optimal operating profit of PhP508,012.21. Meanwhile, to generate the optimal operating profit of PhP988,563.93, one must produce 3,288.59 gallons of *bahalina* at a PhP432,000.00 investment level. Finally, at the PhP600,000.00 investment level, results showed that producing 4,567.49 gallons of *bahalina* would generate the optimal operating profit of PhP1,373,005.61.

Sensitivity Analysis

Results revealed that the reduced cost (see Table 10), the dual price, and the allowable decrease in the profit per unit of coconut sap-based products remained the same per run or set of alternative products. On the first run—considering all alternative products are an option, the allowable decrease in the profit of *bahalina* per unit is PhP106.23 (Table 11). This means that as long as the profit of producing *bahalina* does not decrease by more than PhP106.23; or the profits of the other product alternatives do not increase by more than its reduced cost, *bahalina* will still be the optimal product.

Table10. Reduced cost per run

	BAHALINA	*LAMBANOG*	COCONUT VINEGAR	*TUBA/BAHAL*	COCONUT SUGAR	COCONUT SYRUP
First run	0	150.4	106.14	99.41	1,183.78	4,368.74
Second run	-	0	26.73	35.98	519.83	2,608.22
Third run	-	-	0	14.63	296.36	2,015.68

Table11. Sensitivity analysis

LEVEL OF INVESTMENT	OPTIMUM PRODUCE PER RUN	DUAL PRICE (PHP)	ALLOWABLE DECREASE IN PROFIT PER UNIT (PHP)	ALLOWABLE INCREASE IN TOTAL SALES (PHP)	ALLOWABLE DECREASE OF THE ANNUAL PRODUCTION COST (PHP)	ALLOWABLE DECREASE IN THE MAXIMUM PROCURED SUPPLY (GALLONS)
PhP60,000	*Bahalina* (First run; X2)	2.29	106.23	137,300.60	41,753.73	245.82
	Lambanog (Second run; X3)	1.48	50.62	88,779.91	35,803.18	0
	Coconut Vinegar (Third run; X4)	1.21	18.32	72,449.22	32,819.77	260.63
PhP156,000	*Bahalina* (First run; X2)	2.29	106.23	356,981.50	108,559.70	639.13
	Lambanog (Second run; X3)	1.48	50.62	230,827.80	93,088.28	0
	Coconut Vinegar (Third run; X4)	1.21	18.32	188,368.00	85,331.40	677.63
PhP222,000	*Bahalina* (First run; X2)	2.29	106.23	508,012.10	154,488.80	909.53
	Lambanog (Second run; X3)	1.48	50.62	328,485.70	132,471.80	0
	Coconut Vinegar (Third run; X4)	1.21	18.32	268,062.10	121,433.20	964.32
PhP432,000	*Bahalina* (First run; X2)	2.29	106.23	988,564.00	300,626.80	1,769.90
	Lambanog (Second run; X3)	1.48	50.62	639,215.30	257,782.90	0
	Coconut Vinegar (Third run; X4)	1.21	18.32	521,634.40	236,302.40	1,876.51
PhP600,000	*Bahalina* (First run; X2)	2.29	106.23	1,373,006.00	417,537.30	2,458.20
	Lambanog (Second run; X3)	1.48	50.62	887,799.10	358,031.80	0
	Coconut Vinegar (Third run; X4)	1.21	18.32	724,492.20	328,197.70	2,606.26

In addition, results indicated that among all the alternatives, it will take about PhP2.29 dual price from the cost of *bahalina* to generate PhP1.00 profit. The same applies to the second and third runs with their respective values. Finally, it could be observed that the reduced cost at all levels of investment showed that during the first run, *tuba/bahal* has the lowest reduced cost of PhP99.41 while coconut syrup has the highest reduced cost of PhP4,368.74.

Marketability of the Product Alternatives

In the Visayas islands, like in Leyte, coconut wine also known as *tuba* and *bahalina* has been a popular drink made from the fermented sap of palm inflorescence (Slow Food n.d.). For the local drinkers, it has been labeled as their symbol of pride, enthusiasm, kindness, and resistance (Co 2022; Woolsey 2023). With the deep-rooted social culture of hospitality, locals present coconut wine as a welcome drink (Woolsey 2023). Remarkably, businessmen from China, Singapore, and India expressed their interest in the native wines. The *tuba/bahalina* has been stated to be prepared in conquering the world markets (Labro 2013). Globally, it has been expected that there would be profitable growth in the market in North America because of the high alcohol consumption rate. Moreover, Latin America and Asia Pacific regions were anticipated to hold a major portion of the global coconut wine market (Allied Market Research 2023).

There are also specific coconut wines that are popular in several local provinces, such as in Southern Tagalog provinces. *Lambanog* has been saleable among the young crowd with its fruity-flavored variants (Zalameda et al., 2016). With its strength and its appearance of sparkling, clear, and white characteristics, it can find a distinct niche market in the world (Esmaquel II et al., 2023).

In the coconut sap vinegar industry, there has been no actual data yet on how much it contributes to the economy of each province in the country since it is yet so small (Tan 2021). Nonetheless, the Department of Science and Technology (DOST) has assisted several producers with acetators to ferment vinegar. Coconut sap vinegar has been found with huge market potential since it has been compared with apple cider vinegar with its health buffs (Tan 2021).

CONCLUSION AND RECOMMENDATION

Results revealed that upon the use of LP, the optimal operating profit will be generated when a farmer invests in *bahalina* rather than investing in other coconut sap-based products, such as *tuba/bahal, lambanog*, coconut vinegar, coconut sap juice, coconut syrup, and coconut sugar. Particularly, at PhP60,000, PhP156,000, PhP222,000, PhP432,000, and PhP600,000 investment levels, the profit that could be generated from bahalina is PhP137,300.56, PhP356,981.49, PhP508,012.21, PhP988,563.93, and PhP1,373,005.61, respectively. Nevertheless, when producing *bahalina* is not possible since selling this requires high storage capacity, *lambanog* would generate the optimal profit. Moreover, the availability of its market is also another consideration, similar to Quezon province. Within that area, *lambanog* has been a common drink, while *tuba* or *bahalina* were seldom drunk. It will yield about PhP88,779.78, PhP230,827.75, PhP328,485.72, PhP639,215.22, and PhP887,799.14, respectively. Finally, results showed that if a farmer prefers not to sell liquors, production of coconut vinegar could generate an optimal profit of about PhP72,449.21, PhP188,367.96, PhP268,062.15, PhP521,634.34, and PhP724492,14 on the mentioned investment levels, respectively. This product was assumed to be added with spices to satisfy the needs of the diverse market.

Since any business enterprise seeks to offer value to its customers, it is crucial to determine the optimum level of production that will yield the optimal operating profit at a given level of investment. Thus, it was suggested that this study be replicated to develop more LP models with more number of respondents, such that costs are adjusted to a bigger production volume to accommodate the amount of supply from more than one (1) coconut tapper and be able to take advantage of the economies of scale, while taking into consideration the capacity of the tappers, in terms of the number of trees tapped per day. The objective function would be the maximization of the operating profits generated from the profits of each coconut sap-based product, such that $i = i; i = 1, i = 2, \ldots n,$ where X_i is the decision variable or the level of production annually, n is the coconut sap commodity produced, p_i is the profit per commodity per unit, c_i is the total cost per commodity per unit, P_i is the price per commodity, S_i is the supply or the value of the procured coconut sap, $MCS_{investment}$ is the maximum coconut sap supplied per level of investment; and I is the investment level.

$$Maximize \sum_{i=1}^{7} p_i X_i$$

$$Maximize\ (p_1X_1) + (p_2X_2) + (p_3X_3) + (p_4X_4) + (p_5X_5) + (p_6X_6) + (p_nX_n) \ldots$$

This is subject to the constraints represented in the equations below: the availability of investment, the availability of supply, and the minimum revenue necessary to be generated to avoid loss.

a. $\sum_{i=1}^{7} c_i X_i \leq I$

$$(c_1X_1) + (c_2X_2) + (c_3X_3) + (c_4X_4) + (c_5X_5) + (c_6X_6) + (c_nX_n) \ldots \leq I$$

b. $\sum_{i=1}^{7} S_i X_i \leq MCS_I$

$$(S_1X_1) + (S_2X_2) + (S_3X_3) + (S_4X_4) + (S_5X_5) + (S_6X_6) + (S_nX_n) \ldots \leq MCS_I$$

c. $\sum_{i=1}^{7} P_i X_i \geq I$

$$(P_1X_1) + (P_2X_2) + (P_3X_3) + (P_4X_4) + (P_5X_5) + (P_6X_6) + (P_nX_n) \ldots \geq I$$

The success of each product does not solely rely on its profitability. Instead, a market analysis may also be conducted to consider the preferences of different customers. One strategy that may increase the sales of coconut sap products is the availability of variants in various sizes and value-adding activities. Farmers may also access agencies for support. Finally, an in-depth study is suggested on the external factors affecting product success in terms of effectiveness, relevance, and viability, to further promote profitability and sustainability.

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