ADAPTATION OF ARROWROOT (*MARANTA ARUNDINACEA*) PROCESSING TECHNOLOGIES IN TYPHOON PRONE MARGINAL AREAS IN BICOL

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Abstract: Adaptation of the arrowroot processing technologies developed by BUCAF, Guinobatan, Albay in 2004, and tested in the Province of Marinduque in 2006, is conducted in typhoon prone marginal areas in Bicol. Mr. Jimmy Ibarreta of Bgy. Morera, Guinobatan, Albay was the farmer cooperator of the project.

Planting of local varieties of arrowroot was done at BUCAF, Guinobatan, Albay. Production ranges from 1.7 to 2.5 kg/m^2 for shaded and open areas respectively. The size of rhizomes is smaller than that of the Marinduque variety by 20% in length and in diameter. Processing Plant analysis showed a capacity of 1000 kg/day with starch recovery of 12-14%, machine efficiencies ranges from 86 to 99%. The operational cost of the processing system was at P7.00/kg to include P2.00/kg from washing to water removal, drying at 1.50/kg, and buying price of P5.00/kg for fresh tubers. Economic analysis resulted to an ROI of 41.53% at 960 hours annual use. Added value per kg of processed arrowroot is at P2.20/kg excluding by-products. The processing arrowroot is technically and economically feasible in producing quality starch. Commercialization of the technology shall be done in Bicol and Laguna marginal areas.

Keywords: Arrowroot, Machines, Marginal areas, Mechanized Technologies, Processing

RATIONALE

Bicol region is frequently visited by typhoon at an average of ten (10) typhoons a year. This situation needs a viable agricultural production program that would provide emergency response food source for its constituents if devastated by such calamity. Development and adaptation of technologies that would provide potential crops as food source should be explored. One of the potential crop is the arrowroot whose rhizomes are readily available source of food energy.

Arrowroot (Maranta arundinacea) locally known as ‘‘uraro’’ is one of the crops that abundantly grow in the buffer zone communities in the country. Most of the time, this crop is not domesticated but just grows wildly in the different parts of the mountain. However, if given the necessary care and management, this crop can produce a yield ranging from 27-29 tons per hectare. When planted under coconut or intercropped with fruit trees, arrowroot produced at least 65 % of what it normally yields (Gonzaga, 1988). Arrowroot strains in Bicol, Quezon and Palawan have almost same characteristics which yielded 17 tons of tubers under partial shading (Tabinga, 1982). Some of the residents are aware of its potential, but the lack of information and

technologies hinders the development of the commodity.

Arrowroot flour is the secret ingredient for making delicious biscuits and other pastries and as a substitute for wheat. It is both a spice and a vegetable with a variety of uses as extenders, thickeners in noodles, soup, sausages and meat products It is nutritive, and is used as an agreeable, non-irritating diet in certain chronic disease during convalescence from fevers, in irritation of the alimentary canal, pulmonary organs, or of the urinary apparatus, and is well suited for infants to supply the place of breast milk for a short time after having weaned them.. As poultry feed, the flour can substitute for 25 % of yellow corn while its stems, leaves and wastes are feeds for ruminants (Jimenez, 1996).

Marinduque and Laguna are the two provinces known for the production of arrowroot food products. In a market study conducted by Bicol University, information gathered revealed that starch & flour production is very tedious and time consuming. It requires 3 to 11 days to produce dried starch especially during rainy days. Semi-mechanized process yielded to a very low starch recovery ranging from 9-10 %. This is the major problem faced by Marinduque as reported by its Department of Agriculture and affirmed by the respondents from Nagcarlan and Liliw, Laguna. This resulted to the collaborative project between DA-Marinduque, the Bicol University College of Agriculture & Forestry & TROPICS-Naga City on the development of mechanization process for arrowroot starch and flour production.

In the Bicol Region, the research team validated the availability of arrowroot crops in the different provinces. It was noted that the rootcrop is not very popular like the cassava, sweet potato and ube, however sporadic plantation in the upland hills of Albay, Camarines Sur & Sorsogon were noted. In these areas, there are considerable diversity of opinion as to the best type of uraro and its time of harvesting. Although the rhizomes are often harvested 8 months after planting, starch manufacturer suggested that harvesting should take place when the plants are 17 – 19 months old, but that becomes increasingly difficult to prepare good quality starch as the rhizomes aged. This resulted to the study on the collection of germplasm to determine the variety that would yield the optimum results in terms of starch recovery. This is an on-going study by the arrowroot commodity team of BU.

In 2003, the development of mechanization technologies for arrowroot processing was initiated by BU when DA Marinduque visited BUCAF in search for the mechanized technology in processing the commodity hearing the multicrop extruder of BU. The researchers of the Agricultural Engineering of BUCAF were tapped to assist them in this endeavor paving way to the development of technologies in processing arrowroot. In the manufacturing group, KOLBI was tapped to assist in the manufacture of the equipment 2004. DA Marinduque was very vigilant in piloting the technology in the Province considering the wide area grown to arrowroot at around 75 hectares cultivated by 300 farmers.

The crop is indigenous in Bicol area where growing sporadically in the upland and island barangays of Bicol. Considering that the region is frequently visited by typhoon. The need to identify crops that could be grown in the marginal areas should be done. The crop should be a potential source of additional income to the farmers. Likewise, technologies that could process the crop should be available. This resulted to the conceptualization of the adaptation of arrowroot processing technologies in typhoon prone marginal areas in Bicol, as such this project.

REVIEW OF LITERATURE

The arrowroot plant is an erect, smooth dichotomously branched perennial herb, 0.4 to 1.0 meter high and growing from freshly fusiform rootstock. The leaves are ovate-oblong, 10 to 20 centimeters long, thin petioled, acuminate, rounded at the base and green. The inflorescent is terminal lax, divaricate and few flowered. The flowers are white and about 2 centimeters long and very sparingly produced. Rhizomes are with white flesh, cylindrically elongated and nodded. It is fibrous and similar to corn in taste when boiled.

Uraro is widely cultivated in the Philippines for its starchy rhizomes. It is a native of Tropical America.

Analysis of arrowroot reveals the following contents: Starch (27.17 percent); fiber fat, albumen, sugar, gum, ash and water (62.83%). Arrowroot starch is white, odorless and tasteless either in the form of powder or in more or less aggregate masses which rarely exceed a pea in size. The bitter resinous substance in the skin of the rhizome can be removed in the preparation of starch during peeling

Arrowroot is an edible starch obtained from the rhizomes or underground stems of several tropics herbs. The perennial plant, produce a genuine arrowroot in large of 20 – 40 cm or 9 – 14 inches rhizomes. It is usually grown in a loamy type soil and the climatic requirements are warm and moist. It requires 8 – 10 months to grow before it is harvested.

Arrowroot is a effective substitute for corn in broiler ration. A 25% level of arrowroot meal formulation proved to be the best ration for broiler replacing 69% of the yellow corn in poultry ration.

Figure 1: Arrowroot plant

Figure 2: Rhizomes of the arrowroot plant

Processing Technology reported that the rhizomes are washed and the skin scales carefully peeled from the white fleshy core, otherwise they impart a bitter taste to the final product. The peeled rhizomes are washed again and grated into a coarse pulp. The pulp is then mixed with a large quantity of clean water and the mixture passed over a series of sieving to separate fiber. The liquid is allowed to stand and the starch out on long tables. The starch is removed from the tables mixed with more water and resettled overnight. The lumps of starch are placed on racks to air-dry, a process which can take from 4 – 14 days according to the weather and which can result in the material becoming discolored. After drying lumps of starch are pulverized and prepared for marketing in different grades according to viscosity ratings. It is packed in moisture proof bags.

In the large scale processing, the arrowroot tubers are thoroughly washed in special tanks. They are then cut into small pieces, rasped and crushed into a pulp. The pulp is then passed in a continuous flow of water into a series of three vibrator sieves. The starch milk then passes to the separator. The residues remaining on the sieves are crushed and sieved twice more to effect the maximum extraction of starch the resultant starch milk is passed to the separator. The separator divides the starch from the water within four minutes and it is next mixed with fresh water, passed through a fine sieve of 120 mesh wire cloth and recentrifuge. The starch is then mixed with fresh water, treated with sulphuric acid and fed into settling tanks. After the starch has settled, the supernatant liquid is run off and the upper layers of sediment are washed away by vigorous hosing to remove as much as possible of the residual fibrous tissue. The starch is then dried in low temperature 131 -150ºF (55 – 60ºC) driers for 4-11 days to a moisture content of approximately 17 percent or slightly less. When dry, the starch is pulverized and packed.

Information gathered revealed that small rasping equipment were developed in Laguna. Small grinders are used to pulverize the dried clumps of “uraro”. All other operations are manually done to include washing, crushing & juice extraction, and drying.

OBJECTIVES

The general objective of this study is to adapt the mechanized technologies for processing arrowroot into starch and flour in typhoon prone marginal areas using locally available varieties.

SPECIFIC OBJECTIVES

(a) To identify sites and cooperators in the conduct of the adaptation of processing technology for arrowroot; (b) To collect and plant locally available arrowroot varieties to produce the raw materials for the adaptation project (c) To evaluate the processing system in terms of recovery, efficiency, losses and power requirement using locally available varieties; and (d) To determine the technical and economic feasibility of the system.

METHODOLOGY

The following methodologies were employed in the adaptation of technologies for arrowroot processing:

Site Selection and Identification of Cooperator

The selection of the site and cooperator was based on the criteria such as area planted to arrowroot, accessibility, and willingness to participate in the project.

Local Variety Collection

Local variety of arrowroot was selected and collected in three different sites. These varieties were planted and become the source of raw materials in the adaptation of the arrowroot technologies.

Planting of Arrowroot

Three local varieties of arrowroots were planted in plots. It has four replication and two planting conditions.

Fund Sourcing and Machine Procurement

Fund sourcing was done to support the project during adaptation testing of the equipment. Three (3) Machines were provided by DOST-TECHNICOM to include the mechanical washer, the extruder, and micro mill. The other three (3) machines were provided by KOLBI to include the granulator, the filter centrifuge and the dryer.

Processing Plant and Machine On-site Installation

Processing plant was established at BUPC, Polangui, Albay. Machine on-site installation was done by KOLBI with the support of the cooperator and BU.

Harvesting

The arrowroot was harvested using the traditional method. Yield of every plot was recorded and was put in separate sacks with marks of its plot number, variety and replicate.

Processing of Arrowroot

The arrowroot was brought to Bicol University Polangui Campus and was process using the six different machines. Evaluation of the arrowroot processing equipment was done.

Data Generation and Evaluation

Tests were conducted to generate data as to the operational condition of the machines to include cash and non-cash data for analysis and evaluation

Economics of the Adapted System

The economics of the adapted system was determined in the operation of the individual machines. Actual costs were used as the basis in coming-up with the economics of the integrated system. This is to determine the cost of production of the products and by-products.

Data Analysis and Report Writing

Data analysis was conducted and the report of the study was prepared.

RESULTS AND DISCUSSION

Site Selection and Identification of Cooperator

The Province of Albay was identified as the site for adaptation of the arrowroot processing technologies. One cooperator was selected for the technology adaptation. Mr. Jimmy Ibarreta was selected as the cooperator of the project due to its experience in planting "uraro" products and its eagerness to engage in the processing of arrowroot. The selected site was located at BUCAF, Guinobatan, Albay cultivalted by Mr. Ibarreta. Mr. Ibarreta planted three arrowroot varieties which were from "Malabnig", "Mauraro" and "Mapaco", all in Guinobatan, Albay.

Local Variety Collection

Mr.Jimmy Ibarreta and the researchers selected three arrowroot varieties which were collected from Malabnig, Mauraro and Mapaco, all in Guinobatan, Albay. This was done to obtain raw materials for processing arrowroot to produce starch and flour.

Planting of Arrowroot

The arrowroot was planted on a 14m x 28 m Area with 16 plots of 3.5 m x 7m dimension. It was planted 50 cm between hills and 30 cm between rows in BUCAF type of soil which is sandy loam. Arial-based planting was used and tested for shaded area and open to sunlight. The production cost for planting arrowroot is P 7.10/m^2.

Harvesting of Arrowroot

Ten (10) months after planting, the arrowroot was harvested. May 2008 – March 2009. The Arrowroot plantation yielded 2.5 kg/m^2 or 25 tons/ha in open area. Less yield was noticed on shaded area of 1.7 kg/m^2 or 20 tons/ha. The harvested arrowroot was smaller than varieties which was harvested in Marinduque in terms of dimension.

Processing Plant and Machine On-site Installation

The processing plant was established at BUPC, Polangui, Albay. The plant was installed with six (6) machines. The results of the machine performance adaptation test result are presented below.

Results of Machine Performance

Mechanical Washer

Testing of the machine for washing arrowroot showed an average washing capacity of 200 – 300 kg/hr with washing efficiency 97.44%. The machine which is manually fed has a rotating washing drum with center brush assembly. The machine is run by a 1 hp electric motor.

Multi-Crop Crusher, Juice Extractor, and Mill

The machine is composed of five major parts; the hopper, the extracting chamber, the stand/frame, the transmission, and the prime mover. Testing of the machine for arrowroot juice extraction showed an average extracting capacity of 50-60 kg/hr for whole and chopped rhizomes and 100 kg/hr for grated rhizomes. The overall extracting efficiency of the machine is 86.90 %. The juice extraction rate is 300 ml/min with juice recovery of 51.40%. Machine is run by a 1.5 hp electric motor.

Granulator

This grating equipment is used to decrease the size of the tubers for ease of juice extraction. This process increases the capacity of extruding and the starch recovery from 10% to 14%. The machine has a capacity of 200 kg/hr and run by a 1 hp motor.

The centrifuge

This machine is used to remove the excess water from the washed starch. Reduction in the water content of starch decreases the time of drying by 4 hours. It has a capacity of 12 kg per 12 min of centrifugation of the dripping wet starch. The machine includes the provision of a 14" diameter basket made of cloth. It is run by a 1.5 hp electric motor.

Multicrop Tray Type Batch Dryer

The KOLBI drying equipment is a tray type dryer with a capacity of 120 kg per batch of drying for 5 – 6 hours. Drying temperature ranges from 55 ºC to 65 ºC. It is an LPG fuelled dryer which could be converted to rice hull fired burner.

Multicrop microwill

This machine is used to mill the starch. The milling capacity is 30 kg/hr. Its milling efficiency is 99% for starch. It is run by a 1.5 hp electric motor. The Machine cost is Php 36, 000.00.

Figure 3: Mechanical washer

Figure 4: Multi-Crop Crusher, Juice Extractor, and Mill

Figure 5: Granulator

Figure 6: The centrifuge

Figure 7: Multicrop Tray Type Batch Dryer

Figure 8: Multicrop micromill

Table 1: Performance Evaluation of the Arrowroot Processing Equipment

System Components	Cost	Capacity	Efficiency	Recovery	Power Requirement	Cost /kg
Washing	58, 000.00	200 kg/hr	70% (tubers with sheet) 97.44 % (without sheet)	93 %	1 kwhr	
Grating	15, 000.00	200 kg/hr	92 % 86.90 %	98%	0.5 kwhr	P 2.00
Extraction	45, 000.00	100 kg/hr	97 %	98%	1.5 kwhr	
Settling	16, 000.00	1 batch/ 2 hours @100kg/batch		98%		
Spinner for MC Removal	47, 000.00	12 kg/10 min	98 %	99%	1.5 kwhr	
Dryer	85, 000.00	120 kg wet/ 4 - 6 hr	99 %	99%	1 kwhr	P 1.50
Bldg and Accessories	200, 430.00					

Table 2: Cost of Operation of the Processing Plant per Batch at 1 ton Capacity per Day

Material Cost	1000kg x P 3.50	3, 500.00
Operational Cost		
Washing to Centrifuge	1000 kg x P 2.00	2, 000.00
Drying	1000 kg x P 1.50	1, 500.00
Total Operational Cost		**7, 000.00**
Flour Starch Recovery	170 kg x 60.00	10, 200.00
Gross Income		**3, 200.00**
Other Expenses (Bldg. and Other)		1, 000.00
Net Income		**2, 200.00** **---------- = 2. 20/kg** **1000 kg**
2,200.00 **ROI = ---------- x 100** **7, 000.00**		**31.42%**

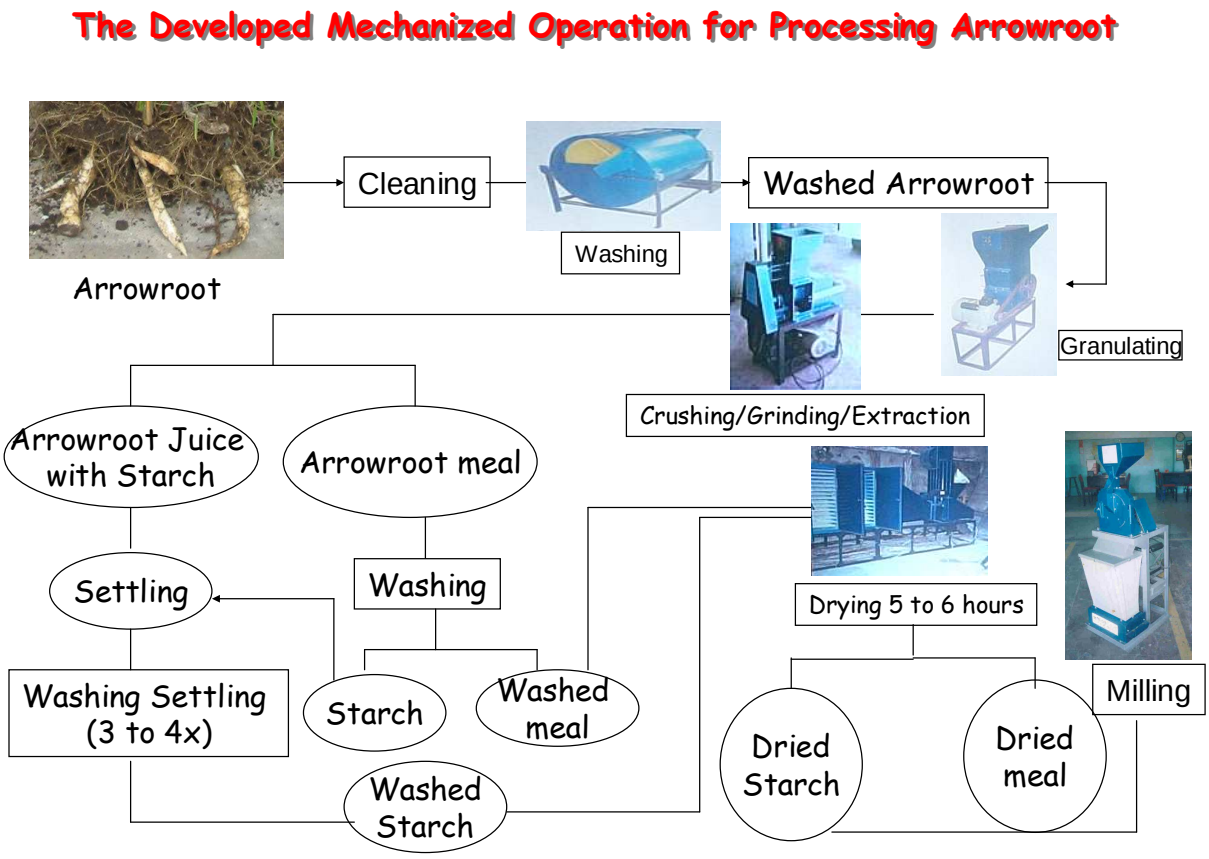

Figure 9: The Developed Mechanized Operation for Processing Arrowroot

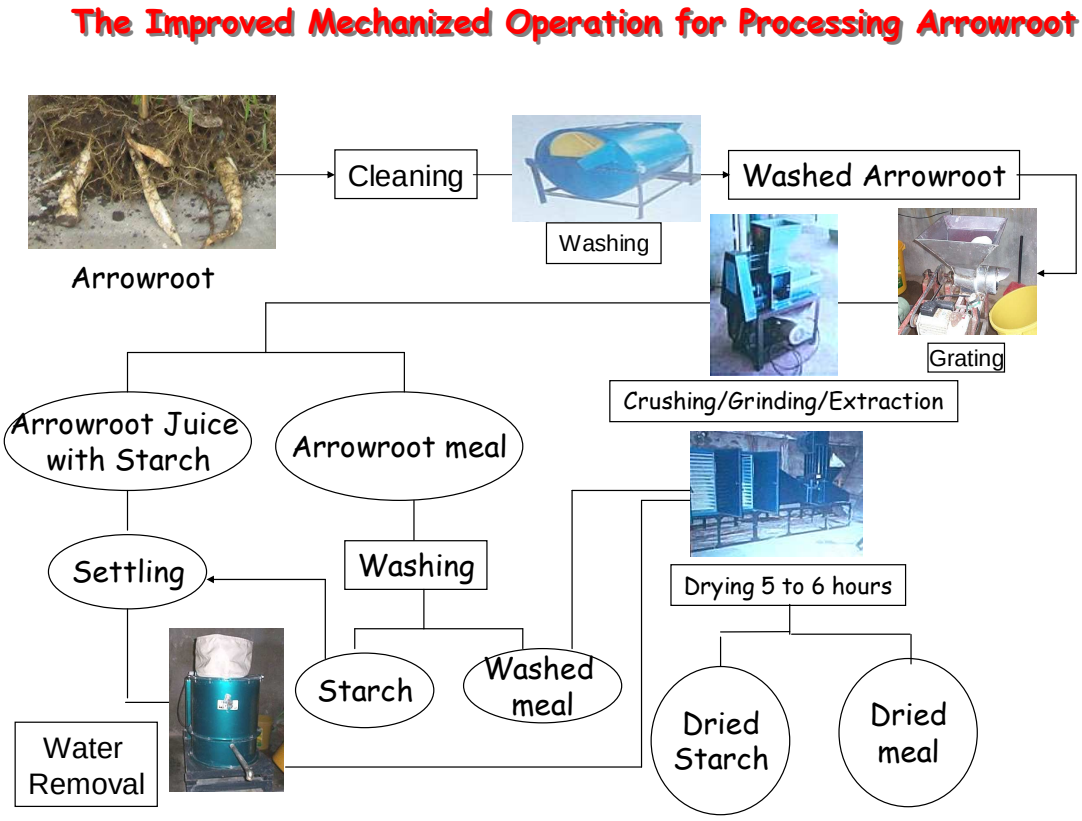

Figure 10: The Improved Mechanized Operation for Processing Arrowroot

Attachment 1: Notes on Economics of Utilization of Processing Equipment for Arrowroot (excluding the dryer).

Acquisition cost ₱ 166, 000.00 (with electric motor)
A. Fixed Cost
Depreciation [1] ₱ 29, 880.00 /yr
Interest[2] ₱ 29, 880.00 /yr
Accessories(1.5%) ₱ 2, 490.00/year
TIS (2%) ₱ 3, 320.00/year
Sub –Total ₱ 65, 570.00 / year
B. Variable cost
4. Labor cost [3] ₱ 36, 000.00
5. Power Cost [4] ₱ 38,400.00/yr
6. Fuel and Oil [5] ₱ 1, 920.00/yr
7. R and M [6] ₱ 7, 632.00/yr
SUB. TOTAL. P 83, 952.00 / year
Total Opening Expenses =Fixed cost(FC) + Variable costs (VC)
=FC + VC = P 65, 570.00/yr + P 83, 952.00/yr = P 149, 522.00/yr
P 149, 522.00/yr
Processing/operational Cost/kg = ---------- = P 1.25/kg
120,000 kg / year
Operational cost with Mark – up = P 2.00 / kg
Gross Income = P 2.00/ kg x120,000 kg / year = P 240, 000.00
Net Income = P 240, 000.00 -P 149,522.00 = P 90, 478.00
P 90, 478.00
ROI = ------- ---------x100= 60.51 %
P 149, 522.00
P 166, 000.00
Payback Period = ---------- = 1.84 years
P 90,123.00
Note: The cost of operation will be affected by the annual use. Any adjustment would change the production cost and to include the ROI and payback period.

Basic Assumptions

[1]Depreciation = $\frac{AC - SV}{\text{Life Span}}$ = P 29, 880.00 /yr Where : Salvage Value(SV) is 10% Life Span 5 years

[2]Interest on Capital : 18% ; I = (0.18) (P 166, 000.00) = P 29, 880.00/yr

[3] Annual use : 8 hours / day for 5 days/ x 4 weeks/ x 6 mo./
week mo. yr
= 960 hours / year x 125 kg/hr
= 120,000 kg / year

[4]Labor Cost : P 18.75./hr x 960 hr/ year = P 18,000.00 / yr x 2 laborers = P 36, 000.00
[5] Power Cost : P 40.00/ hr x 960 hr/yr = P 38,400.00/yr
[6] Fuel and Oil : 5% of Power Cost (0.05 x 38,400.00) = P 1, 920.00/yr
[7] R and M : 10% of Operating Expenses = (0.10) (76, 320.00)= P 7,632.00/yr

Attachment 2: Notes on Economics of Utilization of Dryer for Arrowroot Starch

Acquisition cost ₱ 85, 000.00 (with electric motor)
C. Fixed Cost
Depreciation [1]₱ 15, 300.00 /yr
Interest[2] ₱ 15, 300.00 /yr
Accessories(1.5%) ₱ 1, 275.00/year
TIS (2%) ₱ 1, 700.00/year
Sub –Total ₱ 33, 575.00 / year
D. Variable cost
4. Labor cost [3] ₱ 27, 000.00
5. Power Cost [4] ₱ 9, 360.00/yr
6. Fuel and Oil [5] ₱ 18, 720.00/yr
7. R and M [6] ₱ 3, 823.20/yr
SUB. TOTAL P 58, 903.20 / year
Total Opening Expenses =Fixed cost(FC) + Variable costs (VC)
=FC + VC = P 33, 575.00/yr + P 58, 903.20/yr = P 92, 478.00/yr

$$\text{Processing/operational Cost/kg} = \frac{\text{P 92, 478.00/yr}}{\text{120,000 kg / year}} = \text{P 0.77/kg}$$

Drying cost with Mark – up = P 1.10 / kg
Gross Income = P 1.50/ kg x 120,000 kg / year = P 180, 000.00
Net Income = P 180, 000.00 - P 92,478.00 = P 39, 522.00

$$\text{ROI} = \frac{\text{P 39, 522.00}}{\text{P 92, 478.00}} \times 100 = 42.74\ \%$$

$$\text{Payback Period} = \frac{\text{P 85, 000.00}}{\text{P 39, 522.00}} = 2.15 \text{ years}$$

Note: The cost of operation will be affected by the annual use. Any adjustment would change the production cost and to include the ROI and payback period.

Basic Assumptions

[1]Depreciation $= \frac{AC - SV}{\text{Life Span}} = \text{P 15, 300.00 /yr}$ Where : Salvage Value(SV) is 10% Life Span 5 years

[2]Interest on Capital : 18% ; I = (0.18) (P 85, 000.00) = P 15, 300.00/yr

[3] Annual use : 12 hours / day for 5 days/ week x 4 weeks/ mo. x 6 mo./ yr
= 1440 hours / year x 500 kg/6hr
= 120,000 kg / year

[4]Labor Cost : P 18.75./hr x 1440 hr/ year = P 27, 000.00 / yr
[5] Power Cost : P 6.50.00/ hr x 1440 hr/yr = P 9, 360.00/yr
[6] Fuel and Oil : 200% of Power Cost (2 x 9,360.00) = P 18, 720.00/yr
[7] R and M : 10% of Operating Expenses = (0.10) (38, 232.00)= P 3, 823.20/yr

Processing Plant testing and Data Gathering

Processing plant tests were conducted at full capacity and continuous operation. Table 1.0 presents the results of the evaluation with efficiencies and recovery obtained ranging from 86 to 99%.

During the tests, all of the machines showed excellent performance in processing arrowroot.

Economics of Mechanical Processing of Arrowroot

For a hectare of land planted to arrowroot which had yielded 20, 000 kg harvest. If this was sold fresh would only gain about Php.100,000.00. If the arrowroot is processed manually would costs ₱ 33.00/kg excluding drying which is done intermittently. Manual processing can be sold for only Php. 144, 000.00 due to its starch recovery of about 9 percent. In the mechanical processing system, the cost of operation was computed at P2.00/kg from washing to water removal through centrifuge, and a drying cost of 1.50/kg of fresh tubers. The starch and flour which can be produced can be sold for a minimum Php. 192, 000.00 in which the operational cost amounted to 7.00 pesos at a buying price of P5.00/kg of fresh arrowroot tubers. Simple economic analysis resulted to an ROI of 41.53% with 960 hours annual use. Added value per kg of processed arrowroot is at P2.20/kg in the pilot operation. The processing of by-product or the dried meal was not included in the cost. Table 2.0 presents the computation of the Economics of mechanical processing of arrowroot. Attachment 4.0 presents the notes on economics of utilization of processing equipment for arrowroot

CONCLUSIONS

The following conclusions were drawn by the project: (a) The yield of locally grown arrowroot varieties produced comparable yield with that of other localities. (b) The mechanized processing systems in processing arrowroot showed positive economic results at 1 ton/day capacity with 120 to 140 kg starch recovered (c) The improved mechanized processing system for arrowroot is economically viable and technically feasible in the selected site and cooperator (d) The pilot plant provides an alternative system in processing arrowroot into starch by increasing the recovery and improving the quality of the product.

RECOMMENDATIONS

The following were the recommendations of the project: (a) Further collection of indigenous arrowroot be done in Bicol for starch and flour recovery screening (b) By-products development for arrowroot fiber and juice be studied (c) Promotion and commercialization of technologies through TAPI and concerned agencies be considered in marginal areas in the country (d) Evaluate and develop appropriate size of the machine to address the need of small and medium enterprises in the countryside.

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We dedicate this piece of work to the ALMIGHTY, to the farmers and to our families.

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