Techno-economic and Supply Chain Analysis of Nano Tea Made from Mangosteen Peel as Functional Food

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Abstract. This study aims to examine the availability of raw material to produce the Mangosteen Peel Nano Tea and to validate the economic value of it on a business scale. In Indonesia, Mangosteen is mostly produced in the West Java Province. As for the process of utilizing mangosteen peel into nano tea, it requires at least seven processes in production. We used five methods to find the economic value, namely Payback Period (PP), Average Rate of Return (ARR), Net Present Value (NPV), Internal Rate of Return (IRR), and Profitability Index (PI). The results of this study are PP was one year and 11 months; ARR was 137%; NPV was IDR 3,079,664,331; IRR was 38.35% which is greater than the rate of return; and PI worth 1.36. These results show that the utilisation of mangosteen peel can be a profitable business.

1. Introduction

Indonesia is an agricultural country that has not maximized its utilization of horticulture. Based on research, most of people in Indonesia has a low level for consumption for horticulture products. Almost the consumption of horticulture product less than 50% for every age group [1]. From this fact, shows that low-level consumption has correlation in how much the product of horticulture can be utilize. One of the horticulture product has a chance to utilize more specific is mangosteen. Mangosteen production in this sub-sector has long been cultivated in Indonesia. The value of exports in the horticultural sector has increased by 19.9% per year, with the mangosteen community as one of the largest export contributors. Mangosteen production in Indonesia The second highest production growth after mangoes, in 2010 as many as 84,538 tons, in 2011 as many as 117,595 tons, in 2012 as many as 190,287 tons, in 2013 there were 139,602 tons, in 2014 as many as 113,096 tons, in 2015 as many as 144,957 tons, and the production target for 2016 was 147,566 tons [2].

The mangosteen production is increasing, keeping up with its increasing demand for processed fruit products. One of the drivers of this rise in demand is that consumers nowadays tend to choose natural foods and beverages that contain no additional chemicals substances [3]. If the community used only to use mangosteen flesh, mangosteen peel is now also recorded. The mangosteen peel contains active substances such as xanthones, anthocyanins, tannins, and compounds [4]. It also contains bioactive substances such as phenolic acids and flavonoids [5]. Besides, the mangosteen peel is considered capable of preventing degenerative diseases such as coronary heart disease, cancer, diabetes, hypertension, stroke, and Alzheimer's disease [6].

Furthermore, other researchers have shown that the mangosteen peel has pharmacological activities as an antioxidant, anticancer, anti-inflammatory, antibacterial, and antifungal [7]. Compounds contained in the mangosteen peel are also mentioned to contain chemical compounds alkaloids,
flavonoids, glycosides, saponins, tannins and steroids or triterpenoids [8] where these compounds are considered capable of preventing oxidative damage or cell damage due to free radicals in the body such as damage to components such as DNA, lipids, proteins, and carbohydrates that can cause various biological disorders such as atherosclerosis, cancer, diabetes, and other diseases [9].

Other research also determine the other function of the mangosteen peel in healthy function. Mangosteen peel has a function to prevent the degenerative diseases such as coronary heart disease, cancer, diabetes, hypertension, stroke, and Alzheimer’s disease [6]. With these potential, supply chain analysis needed to see the potential of mangosteen peel to be use as raw material for products. Some are the quantity of mangosteen production and mangosteen peel each year, the distribution of raw material productivity in Indonesia and the sustainability of raw materials as the main ingredients in the process of making mangosteen tea Nano products. Also, the business feasibility from the economic (investment) needs to be done to see the economic potential of processed mangosteen peel products. The feasibility study will be used as a basis for considering investors to see the potential projection of profits that can be obtained in a certain period.

2. Literature Review

2.1 Supply Chain of Mangosteen

Marshall Fisher vide Pujawan [10] classifies supply chains into two, namely (1) market mediation activities and (2) physical activities. Market mediation activities aim to find common ground between consumer desires and the availability of goods made and sent by the supply chain. This market mediation activity can be in the form of a market survey to get tangible types of goods preferred by consumers, design products that consumers want and make projections of demand for products. Hence, physical activities are more about activities to get raw materials, convert raw materials into finished products and do product distribution to consumers. In addition, effective chain operations must also be complemented by a logistics information system with the aim of gathering, utilizing company data as a basis for decision making regarding the strategies to be carried out [10].

Based on data regarding Static Annual Fruit and Vegetable Plants in Indonesia [2], mangosteen is a commodity with a high level of productivity. The potential of this mangosteen is proportional to the level of public awareness of the benefits of the mangosteen fruit itself and the processed products.

Table 1. Annual productivity of mangosteen fruit compared to other fruits in Indonesia

| No. | Commodity/Species (Tons) | Tahun/Year | Perkembangan/ Growth 2016 over 2015 (%) |
|-----|--------------------------|------------|----------------------------------------|
| 1   | Manggo/Mango              | 2,078.2    | 2,125.078                            |
| 2   | Jeruk/Orange              | 64.00      | 64.00                                 |
| 3   | Jujur/Pepper              | 112.00     | 112.00                                |
| 4   | Rambutan/Rambutan         | 1,680.00   | 1,702.00                              |
| 5   | Durian/Durian             | 700.00     | 700.00                                |
| 6   | Manggo/Mango              | 112.00     | 112.00                                |
| 7   | Bawang/Banana             | 45.00      | 45.00                                 |
| 8   | Dadon/Dodo                | 112.00     | 112.00                                |
| 9   | Jeruk/Orange              | 64.00      | 64.00                                 |
| 10  | Jujur/Pepper              | 112.00     | 112.00                                |

Mangosteen production tends to fluctuate every year. Even so, several provinces in Indonesia make mangosteen one of the agricultural commodities. West Java is the province with the highest production rates from 2012 to 2016 [2, 11].

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Table 2. Annual productivity of mangosteen fruit by provinces in Indonesia

| No | Province                        | 2012  | 2013  | 2014  | 2015  | 2016  | Growth 2016 over 2015 (%) |
|----|---------------------------------|-------|-------|-------|-------|-------|--------------------------|
| 1  | Aceh                            | 1,153 | 695   | 632   | 557   | 658   | 9.03                     |
| 2  | Sumatera Utara                  | 6,591 | 6,168 | 5,435 | 3,974 | 3,663 | -3.91                    |
| 3  | Sumatera Barat                  | 5,937 | 5,976 | 7,457 | 10,170| 11,645| 0.31                     |
| 4  | Riau                            | 1,309 | 1,804 | 897   | 1,798 | 1,930 | 3.69                     |
| 5  | Jambi                           | 1,960 | 755   | 1,094 | 1,134 | 2,489 | 21.22                    |
| 6  | Sumatera Selatan                | 548   | 349   | 510   | 1,451 | 711   | -18.66                   |
| 7  | Bengkulu                        | 1,975 | 1,796 | 2,331 | 2,710 | 1,437 | -0.50                    |
| 8  | Lampung                         | 3,349 | 1,858 | 2,078 | 735   | 1,240 | -27.15                   |
| 9  | Kepulauan Bangka Balitung       | 666   | 354   | 981   | 735   | 529   | -14.05                   |
| 10 | Kepulauan Riau                  | 108   | 80    | 159   | 96    | 169   | 38.09                    |
| 11 | DKI Jakarta                     | 3     | 0     | 0     | -     | -     | -                        |
| 12 | Jawa Barat                      | 39,722| 14,877| 10,55 | 34,657| 24,540| -14.60                   |
| 13 | Jawa Tengah                     | 9,860 | 5,260 | 3,929 | 6,095 | 5,540 | -4.54                    |
| 14 | DI Yogyakarta                   | 1,369 | 894   | 1,061 | 1,083 | 1,077 | -0.28                    |
| 15 | Jawa Timur                      | 4,196 | 7,209 | 4,803 | 14,874| 9,623 | -17.66                   |
| 16 | Banteng                         | 9,938 | 10,552| 4,573 | 4,880 | 3,208 | -17.14                   |
| 17 | Bali                            | 2,063 | 2,109 | 2,868 | 5,330 | 3,172 | -20.24                   |
| 18 | Nusa Tenggara Barat            | 363   | 1,777 | 1,288 | 3,539 | 3,373 | -2.35                    |
| 19 | Nusa Tenggara Timur            | 17    | 15    | 10    | 4     | 3     | -0.02                    |
| 20 | Kalimantan Barat               | 410   | 486   | 472   | 498   | 411   | -8.70                    |
| 21 | Kalimantan Tengah              | 516   | 726   | 910   | 380   | 301   | -10.45                   |
| 22 | Kalimantan Selatan             | 282   | 361   | 389   | 709   | 719   | 0.67                     |
| 23 | Kalimantan Timur               | 113   | 82    | 74    | 252   | 256   | -                        |
| 24 | Kalimantan Utara               | -     | -     | -     | 30    | 11    | -31.51                   |
| 25 | Sulawesi Utara                 | 354   | 319   | 375   | 594   | 1,243 | 54.70                    |
| 26 | Sulawesi Tengah                | 562   | 507   | 821   | 790   | 738   | -3.31                    |
| 27 | Sulawesi Selatan               | 1,120 | 3,729 | 2,706 | 2,645 | 1,228 | -26.78                   |
| 28 | Sulawesi Tenggara              | 47    | 62    | 74    | 37    | 76    | 52.84                    |
| 29 | Gorontalo                       | -     | -     | -     | 10    | -     | -                        |
| 30 | Sulawesi Barat                 | 40    | 571   | 378   | 431   | 922   | 57.05                    |
| 31 | Maluku                          | 60    | 114   | 136   | 156   | 216   | 19.41                    |
| 32 | Maluku Utara                   | 511   | 319   | 323   | 195   | 299   | 26.50                    |
| 33 | Papua Barat                    | 3     | 2     | 1     | 1     | 0     | -35.00                   |
| 34 | Papua                          | 4     | 2     | 4     | 4     | 0     | -47.34                   |

*Indonesia 95,144 69,801 57,378 101,550 81,431 -9.91*

The selection of mangosteen peel to be extracted by antioxidants in addition to producing natural antioxidant products namely xanthones also aims to optimize the utilization of agricultural waste in the form of mangosteen peels which weigh more than 50% for each mangosteen fruit. Based on data from the Central Horticultural Statistics Agency, mangosteen production in Indonesia reached 162,862 tons [12].

In addition, mangosteen has also become an export commodity of high value in terms of the country's foreign exchange amounting to USD 20,220,359 in 2016. Most mangosteen fruits are exported to countries such as Vietnam, Malaysia and Hong Kong [13].
2.2 Techno-economic Analysis

The techno-economic analysis is an analysis that discusses in detail related to economic viability, which consists of market analysis, technology and financial feasibility [14]. This technique of analysis has been widely used in previous agricultural studies [15-17]. Market feasibility includes demand, product trends related to new technology, and competitive advantage. This analysis can be seen from the availability of raw materials in accordance with the potential in certain regions. The results of this analysis can also be used as input data for the future cash flow of technology and as an analysis of the position of competitors in similar fields. Another aspect that is also seen in the techno-economic analysis is that which is related to technological feasibility. The feasibility of technology aims to test the utility and competitiveness of new technologies for the company compared to other companies, as well as the production capability and development process. The feasibility of this technology generates costs that arise with production capabilities, as input data for flow technology futures from financial feasibility [18].

![Figure 1. Techno-economic analysis](image)

The income-based method measures the potential income from an IP asset in the future. This income stream is discounted back to the date of the valuation to give a present value for the technology. There are many income-based valuation methods, each with variations according to the reason for valuation and the type of industry. Approaches such as the discounted cash flow (DCF) method calculate the potential future cash flows from the IP asset and appropriately discount these. The DCF approach attempts to determine the value of the IP by computing the present value of cash flows, attributable to that piece of IP, over the useful life of the asset. Unlike an enterprise DCF valuation, terminal values are rarely used, as the useful life of a patent is typically a finite period.

The benefits of the DCF method are its ability to compare values among different patents, likely availability of many of the required inputs from the firm’s financial statements and market information [19]. A drawback of DCF is that it does not capture the unique independent risks associated with patents. All risks are lumped together and are assumed to be appropriately adjusted for in the discount rate and the probability of success, rather than being broken out and dealt with individually (i.e., such as legal risk, technological risk, piracy, etc.) Further, often, DCF fails to consider dependencies on properties held by others.

3. Methods

This research was conducted using the mixed method approach [20], namely by using quantitative and qualitative methods through descriptive analysis [21]. Both of these approaches are used to complement one and the other results so that they are expected to provide more objective results, especially in analyzing investment feasibility, technology valuation, and marketing of Mangosteen Peel Nano Tea products. The data sources that will be used are primary data sources and secondary data sources. Primary data is data obtained directly from the field, based on direct observation through interviews.
with expert opinion approaches such as expert research on this product and also other speakers who are driven in the field. While secondary data is data obtained from reading materials that are literature studies, both online and offline, which can support this research activity.

In this research, there are several aspects discussed. Some are the condition of national availability of raw materials, demographic and geographical availability of raw materials. Besides that also discussed the factors that affect the productivity of raw materials, analysis of production costs, investment, costs profit and loss, cash flow, and feasibility of investment analysis shown in the five main variables, namely variable Payback Period (PP), Net Present Value (NPV), Average Rate of Return (ARR), Internal Rate of Return (IRR), and Profitability Index (PI).

1. **Payback period (PP)**
   The PP is a method used to calculate the period needed to return the invested money from the cash flow (proceeds). If the proceeds are equal each year, the PP of an investment can be calculated by dividing the number of investments with annual proceeds, according to Suliyanto [22]. The formula used to calculate the PP is as follows:
   \[
P = \frac{a_{in}}{n} x 12 \ m \ h \ f
   \]
   If PP < the maximum time, the project proposal is feasible, and if PP > the maximum time, the project proposal is not feasible. The evaluation criterion is that if the PP is shorter than the maximum PP, the investment proposal is feasible.

2. **Net Present Value (NPV)**
   The NPV method carried out by comparing the present value of the net cash flow (proceeds) with the present value of outlays. The formula used to calculate the NPV is as follows:
   \[
   NPV = \sum_{t=1}^{n} \frac{A_t}{(1 - k)^t}
   \]
   With the \( K \) is discount rate, \( A_t \) is cash flow in a certain period, and \( n \) is the last period in which cash flow is expected. Where are if NPV > 0, the investment is feasible, and if the NPV < 0, the investment is not feasible.

3. **Average Rate of Return (ARR)**
   The ARR is a way of measuring the average return on interest by comparing the average Earning After Tax (EAT) to the average investment [14].
   \[
   A = \frac{a_{o \ in}}{a_{o \ in}} x 100\%
   \]

4. **Internal Rate of Return (IRR)**
   This method used to calculate the interest rate that can equalize the present value of all cash inflows with cash flow out of project investment, according to Suliyanto [22]. The formula used to calculate the IRR formula for interpolation is:
   \[
   IRR = P_1 - C_1 = \frac{P_2 - P_1}{C_2 - C_1}
   \]
   Note: \( P_1 \) = interest rate 1; \( P_2 \) = interest rate 2; \( C_1 = NPV \) 1; \( C_2 = NPV \) 2
The evaluation criterion is that if the IRR obtained turns out to be a larger Rate of return determined, then the investment can be received.

5. Profitability Index (PI).

The method of PI can be search by calculating the ratio between the present value of net cash receipts in the future (proceeds) and the present value of investment (outlays) according to Suliyanto [14]. The formula used to calculate Profitability (PI) is as follows:

$$PI = \frac{\text{Proceeds}}{\text{Outlays}}$$

If PI > 1 the project is feasible, but if the PI < 1 the project is not feasible.

The investment feasibility criteria from the financial aspect can be implement if the feasibility test of the PP, NPV, IRR, and PI meet the eligibility criteria. From this analysis will provide recommendations related to the potential feasibility of raw materials and analysis of the projections of profits / losses that will be obtained if the Mangosteen Peel Tea Nano business is carried out. This recommendation document is usually used to convince investors in developing the product business.

4. Results and Discussion

The results of this study are twofold, namely the results of the supply chain analysis and the results of the techno-economic analysis.

4.1. Supply Chain Analysis

4.1.1. Utilization of Mangosteen.

Mangosteen fruit contains calories and water content that is quite high. Traditionally the mangosteen fruit can be used as a cure for cancer sores, haemorrhoids and wounds. The peel of the fruit used as a dye, including for textiles and the cooking water used as traditional medicine [23].

Table 3. The nutritional content of mangosteen per 100 grams.

| Nutritional content   | Amount   |
|-----------------------|----------|
| Calorie               | 34.0 kcal|
| Water                 | 87.6 %   |
| Soluble amount        | 15 – 19 %|
| Protein               | 0.6 g    |
| Fat                   | 1.0 g    |
| Carbohydrate          | 5.6 g    |
| Fibre                 | 5.1 g    |
| Ash                   | 0.1 g    |
| Calcium               | 7.0 mg   |
| Phosphorus            | 13.0 mg  |
| Iron                  | 1.0 mg   |
| Natrium               | 7.0 mg   |
| Potassium             | 45.0 mg  |
| Vitamin B1            | 0.03 mg  |
| Vitamin B2            | 0.03 mg  |
| Niacin (Vitamin B3)   | 0.3 mg   |
| Vitamin C             | 4.2 mg   |

Source: Rukmana [23]
At present, the utilization of mangosteen is not only traditional medicine, but also developed into a processed product by utilizing the contents of the mangosteen peel. Various research results show that the mangosteen peel is rich in antioxidants, especially anthocyanin, xanthones, tannins, and phenolic acids [24]. In addition, extracts from mangosteen peel have the potential to be antioxidants [25]. Antioxidants are substances that the body needs to neutralize free radicals and prevent damage caused by free radicals to normal cells, proteins and fats [26].

The use of mangosteen peel into extracts can be produce as raw material for making mangosteen peel tea. Several studies have been conducted to make mangosteen peel tea products based on experimental methods of Randomized Block Design (RBD). This method uses two factors. The first factor is the type of tea (black tea and green tea) and the second factor is the proportion of mangosteen peel powder added (20, 30 and 40% b / b) with repeated three times. Repetition conducted to guarantee the taste has a same results and to prevent the imperfect mixing. The proportion 20, 30, and 40% b / b chosen in order to consider the level of the tea concentration in the end process of the formulating product. Besides that, it also to see the best formulation in order to get the optimum formulation to prevent the bitter taste of tea. The results of this experiment showed that the best formula obtained in tea with raw materials of black tea as well as the addition of 20% mangosteen peel b / b with the characteristics of water content quality of 5.65%, and IC50 value of 62.87 ppm.

4.1.2. Process of Mangosteen Peel Nano Tea.

The process of making mangosteen peel nano tea in broad outline can be done using raw material of still mangosteen skin and extracted mangosteen peel. The process of making mangosteen peel nano tea is done using wet mangosteen peel, beginning with the collection of raw materials to be chopped. After enumeration, the mangosteen peel will be drying using an oven. Drying using the oven considered more effective than drying using direct sunlight. The results of drying the mangosteen peel mashed then using a blender to obtain the appropriate size of the dried mangosteen peel.

The mashed mangosteen skin generally has a bitter taste and a plate on the final day later. To reduce the bitter and concentrated taste, the mangosteen skin that been added finely was cyclodextrin. The next process is to change the mangosteen peel into nano-sized particles. In this process, the Planetary Ball Mill (PBM) method used, which has a capacity of around 500grams for a one-time use of the tool.

![Figure 2. Flow of the Process of Making Mangosteen Peel Nano Tea](image-url)

Supply Chain analysis or supply chain analysis for the manufacture of Mangosteen Peel Nano Tea in Indonesia has enormous potential and almost spread throughout Indonesia, even though to date the concentration of mangosteen productivity in Indonesia has been exported directly to abroad and to commercialization of the needs in the country. Until now, the significance of the use of mangosteen peels is still not too much. Therefore, this is a big opportunity in the commercialization of Mangosteen Peel Nano Tea in Indonesia.
2.3 Techno-Economic Analysis

Techno-economic analysis is a method to analyze and calculate the feasibility of investment study in order to develop and produce some products in mass scale. From this method, the producer can provide the requirements and fulfill all the requirements needed to establish the production in economic scale. Besides that, the techno-economic analysis also can provide the investment feasibility by predicting the amount of profit in some period time to convincing the investor involved in that business. Many ways to know about this feasibility, some are Payback Period (PP), Net Present Value (NPV), Internal Rate of Return (IRR), and Profitability Index (PI).

From the results of the analysis, it founded that the Principal Price of Production of Mangosteen Peel Nano Tea was IDR 40,671 so that the profit margin of 135% taken from the cost of production with a selling price of IDR 55,000 / kg. If this Mangosteen Peel Nano Tea will be packaged in the form of 200 grams of packaging, then the selling price for packaging is 200 gram IDR 11,000.

Table 4. The Economic Inputs of Mangosteen Peel Nano Tea Production

| Source: Primary and secondary data, processed |

| *Value in IDR, other units are mentioned |

| Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|------|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|
| Sales Revenue | - | 1,974,720,000 | 2,090,880,000 | 2,207,040,000 | 2,323,200,000 | 2,323,200,000 | 1,161,600,000 |
| Investment capital | (968,941,200) | - | - | - | - | - | - |
| Working capital | (738,747,600) | (738,747,600) | - | - | - | - | - |
| Total Capital | (968,941,200) | (738,747,600) | - | - | - | - | - |
| Cost | - | 1,168,215,010 | 1,236,933,540 | 1,305,652,070 | 1,274,370,600 | 687,185,300 | 1,161,600,000 |
| Production cost | - | 216,026,719 | 228,734,173 | 241,441,627 | 254,149,081 | 198,236,283 | 198,236,283 |
| Operational cost | - | 216,026,719 | 228,734,173 | 241,441,627 | 254,149,081 | 198,236,283 | 198,236,283 |
| Financial cost | - | 45,083,077 | 48,154,300 | 51,225,523 | 54,296,746 | 54,296,746 | 54,296,746 |
| Total Cost | - | 1,429,324,806 | 1,515,822,013 | 1,513,822,013 | 1,513,822,013 | 912,044,653 | 912,044,653 |
| Net Cash Flow | (968,941,200) | (193,352,406) | 577,057,987 | 608,720,780 | 640,383,573 | 249,555,347 | 249,555,347 |
| Net Cash Flow (Accumulated) | (968,941,200) | (1,162,293,606) | (585,235,619) | 23,485,161 | 663,868,734 | 5,885,649,166 |
| NPV | 3,079,664,331 | - | - | - | - | - | - |
| ARR | 137% | - | - | - | - | - | - |
| PP | 1.9 | - | - | - | - | - | - |

Source: Primary and secondary data, processed

*Value in IDR, other units are mentioned
From the DCF analysis, it is also analysed that the NPV value is IDR 3,079,664,331 (positive value), which means that this investment is feasible. In terms of the value of the PI worth 1.36 (where the value > 1) is considered to be also worth investing. In terms of the IRR, it is worth 38.35% (greater than the rate of return), so it is considered that the development business of Mangosteen Peel Tea Nano is feasible to be developed. From the value of ARR of 137% which shows the investment in Mangosteen Peel Tea Nano business has a good prospective profit. Concerning the PP value of the investment that can be returned for 23 months, which means that the investment in commercializing Mangosteen Peel Nano Tea products does not require a long time to reverse the investment.

5. Conclusion
This study aimed to investigate the potency of Mangosteen Peel on the production of Nano Tea and to quantify its economic value in a business scale. The results of this study are PP was 23 months; ARR was 137%; NPV was IDR 3,079,664,331; IRR was 38.35% which is greater than the rate of return; and PI worth 1.36. These results show that the utilization of mangosteen peel can be a profitable business. Further evaluative studies are needed to corroborate the findings of this study.

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