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Research

VACUUM FRYING FOR JACKFRUIT : PROCESSING, FINANCIAL, AND SWOT ANALYSIS

Rizal Alamsyah, Arief Budhiono, Yang Yang Setiawan, and Herry Rinaldi

Institute for Research dand Development of Agro-Based Industry (IRDABI)
Jl. Ir. H. Juanda No.11, Bogor 16122, Indonesia.

ABSTRACT.: This study described about analysis of processing, financial and SWOT (strength, weakness, opportunities, and threats) for jackfruit vacuum frying processing. For vacuum frying of jackfruit, the frying condition (pressure and temperature), frying rate, and organoleptic test were investigated. The jackfruit are submerged in heated solid frying oil to induce vaporization of the water from the jackfruit. This was conducted under vacuum pressure of -70 cm Hg, and temperature level of 75°C and 80° C. Such condition was done to minimize the heat used and therefore reduce changes in composition, color, taste, and flavor of the jackfruit. The results showed that the product has low moisture content of 3.58 % (wet basis) with the taste, flavor, color, and volume similar to the fresh jackfruit. This experiment was conducted using 3 kg of jackfruit, the yield of the product was 22 % and the total water removal was 2510 ml. It Financial analysis was conducted to evaluate the financial viability of jackfruit processing. Financial analysis of the jackfruit production capacity of 30 kg per day showed that NPV (Net Present Value) was Rp 52.391.000 which was bigger than investment cost, IRR (Internal Rate Return) was 51% and PBP (Pay Back Period) was 1.95 years. It can be concluded that jackfruit processing was viable to be established.

Keywords : *Vacuum frying technology, vacuum frying of jackfruit processing, vacuum frying analysis, financial analysis, and SWOT analysis, fruit processing.*

INTRODUCTION

Vacuum technology play an important role in modern food industry. One of the vacuum technology is vacuum frying that is intended first of all to keep all natural food substances. Taste of vacuum fried food is very close to natural, because frying temperature is less than 90°C (Clary, 1996). In addition, there are at least three others benefits as the most useful method of cooking foods e.g. firstly, it is a method that can maintain some initial characteristics of the food such as taste, flavor, color, and appearance (Numata and Sugano, 1980). Secondly, it can prolonged the product life due to lower moisture content which are required by producers. Finally, frying also imparts a characteristics flavor which is different to that obtained by other methods of cooking.

Recently, fried fruit and vegetable products which processed by vacuum frying, have just spread all over the world. They have just been invented in some developed countries and have been favored in America, Japan, France, and Canada. These fried product after absorbing water will become nearly same as the original fresh fruits and vegetables. It is very important to develop the dry fruit and vegetable products by the vacuum fry technology. If this new technology is applied, the economic value of fresh fruits and vegetables will be changed.

Vacuum frying has been implemented by IRDABI in West Java such as Tasikmalaya and Sukabumi area (Djubaedah *et al* 2000). It would be very beneficial to use vacuum frying as food processing in Indonesia since it is a tropical country where various kind of fruits and vegetables are produced. The use of vacuum frying for fruit and vegetable should be taken into account since their production are very high year by year. For some fruits such as jackfruit, mango, tomato, and others frequently could not be processed when the peak production come. As a consequence their price would decrease. The economic value of these products actually can be increased when this new technology is applied. Besides, the income of fruits and vegetables producers will be relatively higher because of the price. On the other hand the snack food producers will obtain more profit because of this new vacuum frying products.

One of the Indonesian popular and preferred fruit is jackfruit (*Artocarpus integra.sp.*). This fruit has typical taste and flavor which are liked by many people. Normally people consume such fruit naturally or in fresh condition. The observation conducted by Alamsyah *et al* (2001) showed that the vacuum fried fruit or related product usually were sold in relatively high price and were available in many supermarkets in Indonesia. It would be better and considerable when jackfruit are consumed in fried and

crispy condition without loosing its flavor. Other advantages is that the product is more convenient and has long shelf life due to low moisture content. These can be achieved when jackfruit is processed by vacuum fry technology and to obtain the best condition of process and results, some works have to be analyzed.

The objectives of the experiments was to investigate the characteristics of vacuum frying of jackfruit using vacuum fryer unit. It was conducted by analyzing the best condition process (pressure and temperature level), by measuring and calculating vacuum frying rate as well as vacuum frying time, and finally by evaluating organoleptic test. The other objectives were to conduct financial and SWOT analysis, and those two factors were very important since it can give some descriptions and guidance to establish small scale jackfruit processing.

MATERIALS AND METHODS

Materials

Vacuum frying experiments were conducted at Food Processing Laboratory in Cikaret, Bogor and such experiments were done using local jackfruit variety called *Salak Nangka* and obtained from local market in Bogor, Indonesia. These material have typical flavor and yellow color characteristics. The initial moisture content of the jackfruit was about 75.3 % (wet basis) and it was in mature condition. The kernels of the materials were separated before frying and it was cleaned from outer and inner skin. The weight of clean jackfruit in every run was 5 kg.

The oil used in vacuum frying was the solid frying oil, and this was used since it can give better crispiness and long shelf life product due to low free fatty acid (FFA) value (Anonymous, 1993). The solid frying oil was produced by PT. Sinar Meadow International Indonesia, Jakarta.

Methods

1. Vacuum fryer :

A vacuum fryer with water jet system was used in the analysis of vacuum frying for jackfruit (Djubaedah *et al*, 2000). Figure 1 shows the diagram of vacuum frying unit and it is basically consist of cylindrical column or chamber which attached with internal basket where materials will be fried and the component was made from 1 mm stainless steel. Vacuum pressure inside the chamber was resulted from a circulation of water that generated from induction motor of 1 hp (horse power) and 1 phase. Heat source come from gas burner completed with thermostat and selenoid which was connected to the frying chamber to control temperature level inside. A valve was used to control the vacuum pressure in the chamber. To observe the drying rate of jackfruit, a glass jar connected with frying chamber. A vacuum system of water was employed using cones and circulation of water.

2. Water Removal :

The measurements of frying rate or water removal rate of jackfruit were conducted using big glass jar with 2 liters volumes. The results of water removal rate were presented in figure 2. The moisture removal was measured and observed every 10 minutes: A thermocouples was installed to measure the temperature of the frying oil temperature in cylindrical column. The temperature level of the oil was maintained by installing thermostat inside the column, meanwhile heat source which come from gas burner (Elpiji) was completed with the selenoid to control the flow of the gas in order to get constant temperature.

At the start of the experiment the frying oil was heated until temperature about 80°C. It was conducted in the atmosphere pressure and occurred about 45 minutes. The jackfruit was weighed using a 10 kg balance before feeding. Conditioning of jackfruit in the chamber took place about 5 minutes. The feeding gate was then fully closed and the jackfruit started to be immersed in frying oil so that the chamber pressure started decreasing up to - 50 cm Hg and occurred about 10 minutes to reach stable or minimum pressure condition of - 70 cm Hg.

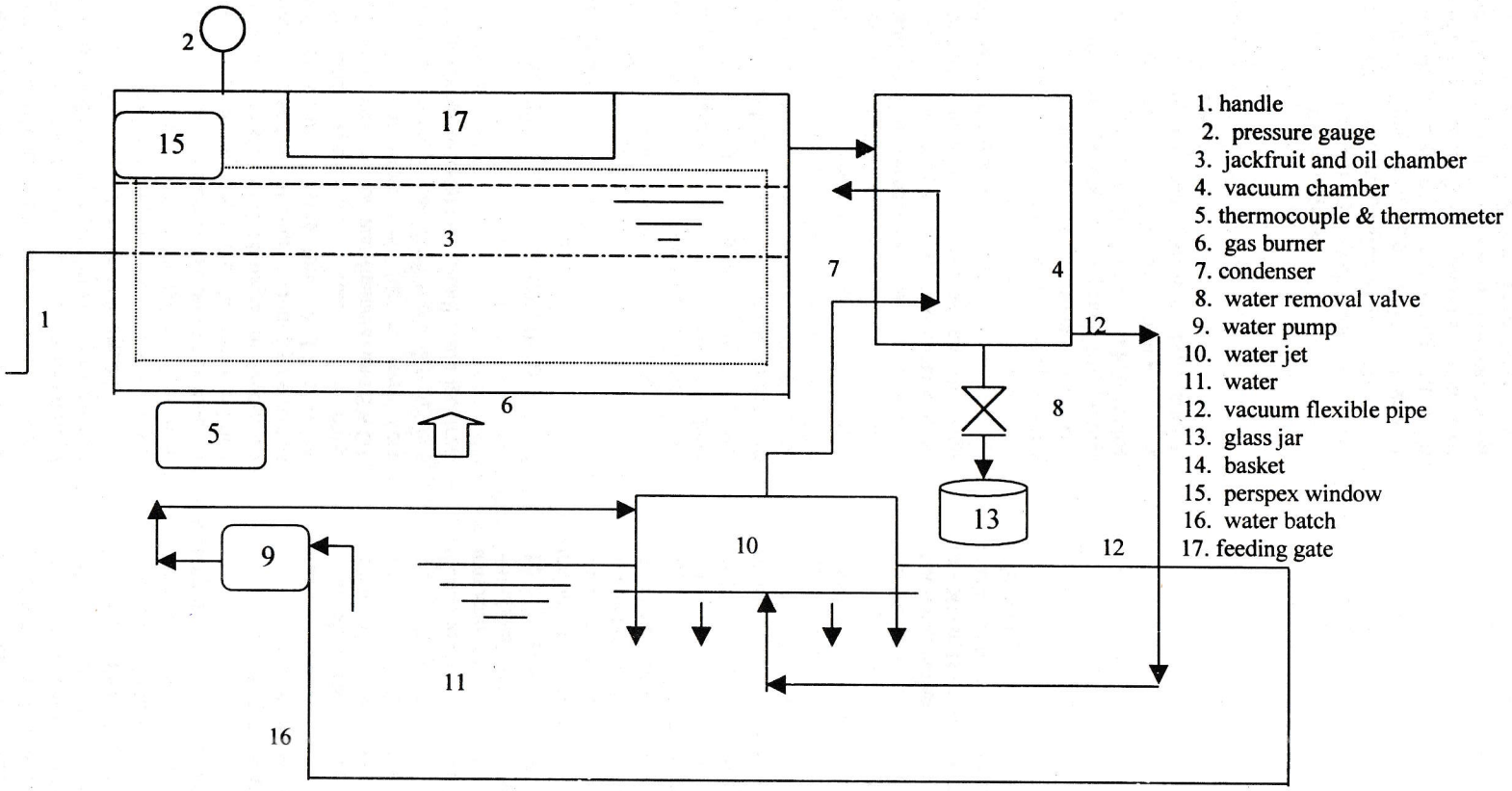

Figure 1. Diagram of vacuum frying equipment for jackfruit

3. Pressure and Temperature :

The experiments were also designed to confirm the relationship between pressure and frying temperature in cylinder (vacuum frying chamber). Three experiments of vacuum frying were operated with different level condition of temperature. Each experiment that consist of two runs was operated at different temperature and pressure e.g. (1) 75°C and - 70 cm Hg, and (2) 80°C and - 70 cm Hg. At the run three the tempering were conducted every 30 minutes to find out the tempering treatment effect to the product. Each process was stopped when there were no frying oil bubble and moist where both can be observed from perspex window. The pressure of vacuum frying was measured and monitored using pressure gauge which located on the chamber with cm Hg scales.

3. Moisture Content :

Measurements of moisture content of the jackfruit were conducted before feeding and after frying finished at 100 minutes. Vacuum frying experiments were conducted with 100 minutes frying time. Such measurements were applied for both runs with temperature of 75°C and 80°C. Meanwhile measurements of the jackfruit with tempering treatment were at 0 (for initial moisture content), 30, 60, and 100 minutes. The measurements of both initial and final moisture content were conducted by xylena method.

5. Organoleptic Test :

The products were tested on some criteria e.g. appearance, color, taste, flavor, and texture (crispiness). Such organoleptic test was employed to 25 panelist and the scale of criteria for appearance, color, taste and flavor covers (1) strongly dislike, (2) dislike, (3) tend to be like, (4) like, and (5) strongly like. Meanwhile for texture or crispiness, its value related to (1) very tough, (2) little bit tough, (3) little bit crispy, (4) crispy, (5) very crispy .

6. Financial analysis :

Data required for financial analysis consist of:

- Investment which is for land, building, equipment, and capital cost,
- Operational cost which comprise of raw materials, frying oil, packaging materials, gas, fuel, electricity, and water cost, and
- Revenue.

Based on the above data, financial analysis was conducted to evaluate financial parameter which consist of IRR (Internal Rate of Return), NPV (Net present value), and PBP (Pay back Period) as presented by Kadariah *et al* (1978).

7. SWOT Analysis :

SWOT analysis was conducted to analyze the position and condition of small scale vacuum frying industries for a projection which can be used as basic considerations in developing such industries. To know the position of vacuum frying industries, all elements of internal factors of strength-weakness and external factors of opportunities-threats should be classified. After that a matrix of strategy of SWOT analysis was constructed which consist of (Anonymous, 2001) :

- Strategy for strength–opportunities (S - O),
- Strategy for strength – threats (S - T),
- Strategy for weak – opportunities (W - O), and
- Strategy for weak – opportunities (W - O).

RESULTS AND DISCUSSIONS

Moisture Content

The moisture content and vacuum frying time of jackfruit product were presented in Table 1. The moisture content of jackfruit product that processed at 80 ° C was 3.58 % wet basis (wb) and it was less than those which fried at 75 ° C that was 3.98 % wb in the same frying time of 100 minutes. Such moisture content were low enough so that they can influence the shelf-life of the product as long as the products were packed in hermetic packaging. Meanwhile the product that fried at 80 ° C with tempering treatment exhibits high final moisture content i.e. 26,0 % wb and pliable appearance so that it was not recommended to produce.

Table 1. Moisture content, yield, and frying time

Tempera-ture (°C)	Moisture content		Yield (%)	Frying time (minutes)
	Mo (%,wb)	M (%,wb)		
75	70.30	3.98	22.00	100
80	70.30	3.58	23.00	100
80 (tempering)	70.30	26.00	unrecommended (pliable)	100

Where : Mo is initial moisture content
M is final moisture content
Wb is wet basis

Based on these results, the temperature level of 75°C and 80°C exhibits small effects on the final moisture content. On the other hand, it was significantly effected when the jackfruit was fried with tempering treatment which has

effect of pressure in vacuum frying that gives discontinuity of air removal from internal part of the jackfruit to the air.

With the frying time of 100 minutes for each run, the yield of the product obtained from vacuum frying experiments with two level temperature of 75°C and 80°C were 22.0 % and 23.0 % respectively. Although the yield was not so high, the volume of the product was not significantly changed compared with the fresh jackfruit before frying. This is due to the air space inside of the jackfruit was filled by the air that can slightly effect of volume change.

Water Removal (Frying rate)

Moisture removal was calculated from the condensate volume. These moisture removal data from every run were used to determine the frying rate. The relationship between moisture removal and time were presented in figure 2. At the beginning, the results exhibits relatively high averages frying rate of 38,5 ml per minute and it occurred until the first twenty minutes, but after that the frying rate decrease gradually up to 90 minutes of frying time. The above frying rate happened for the experiments with the temperature of 80 °C. The air removal showed limit to be zero when the frying time nearly 100 minutes. The above water removal happened due to drying of the materials which is at first the materials will exhibits high water removal rate or constant rate drying period and continued by falling rate drying period. Such drying period will happened until critical moisture content was reached. After critical moisture content was reached, the air removal occurred with capillary mechanism where the removal will be long and this condition was showed by the product which has final moisture content of 3.58 % wet basis (Nishiyama, 1987 and Brooker *et al*, 1974). The results of vacuum frying experiments with the temperature of 75°C exhibits similar curve.

The total condensate volume of those with 75°C and 80°C were 1900 ml and 2510 ml respectively. Meanwhile the final weight of products were 1150 grams and 1100 grams respectively. The final weight of the product were slightly different. The differences of condensate volume and final weight of product could happen due to some possible factors such as the loss of condensate and product when doing weight measurements.

Pressure and Temperature

The estimation of the minimum pressure in vacuum frying is necessary to predict the power requirements for vacuum frying. The results of 2 (two) runs of experiments are displayed as graphical representations of vacuum pressure inside the chamber (cm Hg) versus time (minute) as presented in Figure 3. All figures showed both increasing and decreasing pressure. At the end of process the pressure showed stable condition. Based on those curves, the vacuum pressure in the chamber that can be achieved was - 70 cm Hg and this was resulted by the induction motor of 1 hp used in circulation of water. To obtain higher vacuum pressure in the chamber, it has to use the power of induction motor more than 1 hp.

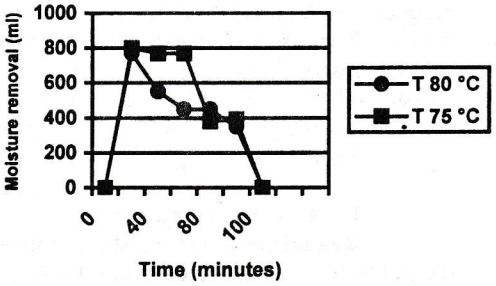

Figure 2. Moisture removal versus time

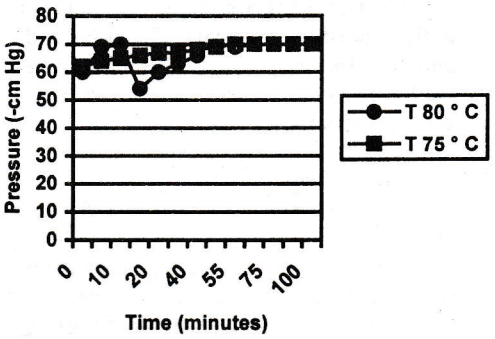

Figure 3. Pressure versus time

Organoleptic Tests

The results of organoleptic test which were applied to some criteria e.g. appearance, color, taste, flavor, and texture (crispiness) have been conducted. Test of texture or crispiness of jackfruit fried with temperature level of 80°C showed better score than those fried with temperature level of 75°C. The test results of appearance and color of jackfruit that was fried with both temperature of 75°C and 80°C showed relatively the same score and exhibits insignificant effect on them. Meanwhile the higher test results of taste and flavor was attributed to the fried product fried at 80°C than those which fried at 75°C.

On the other hand, the product that fried at 80 °C with the tempering treatment

shows pliable and greasy appearance. Actually the test results of color, taste and flavor of this product shows the similar to fresh materials of jackfruit. The worst score of this product implied to the appearance or crispiness criteria, and this could happen due to the higher moisture content. Based on the result of organoleptic test, this product was not recommended to produce.

Financial Analysis

To evaluate the feasibility of jackfruit small scale processing, a financial analysis have been conducted. Some factors were involved which comprise of some important data namely:

- Daily input production capacity was 30 kg jackfruits (21kg without kernels),
- Yield or product resulted was 30 % (7 kg per day),
- Working hour was 9 hours per day (300 days per year and 25 days per month),
- Labors employed was 2 persons, and,
- The price for product was Rp 50,000,- per kg.

It was assumed that such small scale industries was located in 50 m^2 buildings and 100 m^2 land area and it was located in West Java. It was also assumed that the capital was not provided from banks, but was invested by producers himself. The operational cost consist of fixed cost (maintenance, depreciation, insurance, and unpredictable cost) and unfixed cost (raw materials, labor wages, electricity, fuel, and packaging materials). Depreciation was calculated from 10 % of equipment value.

Based on the above data, financial analysis was calculated and the result analysis was presented on table 2. From calculation resulted it can be concluded that jackfruit small scale industry was feasible to set be up since some indicators financial gave feasible value e.g net revenue was Rp 24.70 million per year. and pay back period was 19.1 months. Also the other financial parameters showed feasible results such as break event point (BEP) was on Rp 35.19 million, internal rate of return (IRR) was 45.81 which is bigger than the existing interest rate, and net present value (NPV) was 61.70 (at discount rate of 20 %).

Table 2. Financial analysis for small scale jackfruit processing industry

Financial parameters	Value (Rp)
A. Investment	
1. Land 100 m2 @ Rp 100,000	10,000,000
2. Building (raw material, processing, and storage room) 70 m2 @ Rp 125,000	8,750,000
3. Equipment (vacuum frying unit and others)	22,500,000
Investment	41,250,000
B. Working capital (for two months)	
1. Raw materials,50 days, 30kg, @ Rp 5000	7,500,000
2. Wages, 3 persons	2,800,000
3. Frying oil, 4 ltr, 50 days, Rp 6000	1,200,000
4. Fuel, 3kg, 50 days @ Rp 30,000	400,000
5. Elctricity and water 50 days @ Rp 3000	150,000
Total working capital	12,050,000
Total Investment (A+B)	53,300,000
2. Operational cost	
A. Fixed cost	
1. Wages (1x 12xRp 600,000, 2x12xRp400,000)	16,800,000
2. Maintainenance (4 % x building budget)	2,132,000
3. Depreciation (10 % x equipment budget)	2,250,000
4. Insurance (0,5 % x building and equipment budget)	156,250
5. Quality control and promotion	1,000,000
6. Others (10 % x wages)	1,600,000
Total fixed cost	23,938,250
B. Unfixed cost	
1. Raw materials 300 days x 30 kg x Rp 5000,-	45,000,000
2. Plastics packaging (0.5 kg plastics/day)	1,500,000
3. Cartoon packaging (4 boxes/day @ Rp 1000,-)	1,200,000
4. Gas, fuel, electricity, and water	6,600,000
Total unfixed cost	54,300,000
Total Operational cost (A+B)	78,238,250
C. Sales (21 x 0,3 x 300 x Rp 60,000)	113,400,000
D. Production cost: Operational cost	78,238,000
E. Gross Revenue	35.162.000
F. Tax (20 % x Gross revenue)	7,453,000
Net revenue	27,709,000
NPV	52,391,000
IRR (%)	51
PBP or Payback period- (fixed capital/net revenue x 1 year)	1.95 years
Production cost per kg: [D : (21x 0.3 x 300)]	37,260

Sensitivity Analysis

Sensitivity analysis was conducted to obtain data related to the price and cost changes for viability of jackfruit processing industry. Sensitivity analysis was conducted by changing the value of investment, product price and raw materials price. Sensitivity analysis on investment was not significant since by increase of 10 % investment resulted 46 % of IRR value. It means that only gave 9.8 % changes of IRR value. By decrease of 10 % of investment also gave insignificant IRR value e.g 57 % or indicated changes of 11,7 % IRR.

Raw materials price also was not significant on sensitivity analysis, these indicated by increase of 20 % of raw material price, it was only resulted 45 % of IRR value or gave changes of 11 % IRR. Meanwhile product price showed significant on sensitivity analysis. It can be seen by increase 20 % of product price, the IRR value was 94 % or provide changes of 84 % IRR. In general the effect investment, product price and raw materials changes on IRR value were r epresented on figure 4.

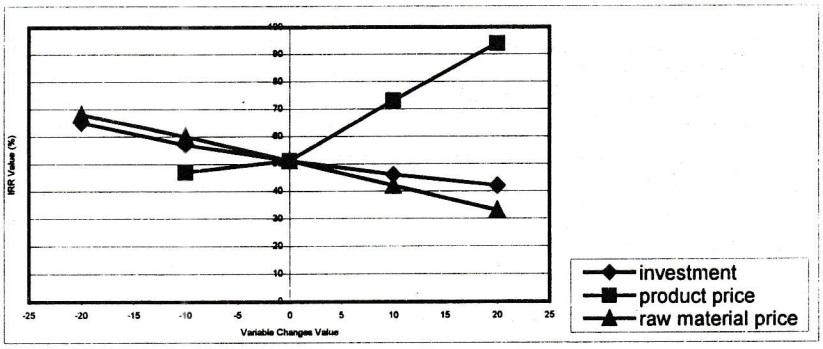

Figure 4. The effect of investment, product price and raw materials changes on IRR value

SWOT Analysis

It is very important to do some analysis for the application of vacuum frying unit in snack food producers, since it can provide many useful information due to the presence possibilities of constrains especially in facing global market. Also these analysis can be strategic in solving problem comprehensively. One of the methods which can be employed is SWOT analysis (strength, weakness, opportunities, and threats).

Basically each element of SWOT analysis can comprise of some aspects or crucial points. In general the SWOT analysis for producing of vacuum fried fruits was presented in table 3 below.

Based on the analysis of internal and external factors which can affect the implementation of vacuum frying unit, some necessary steps or strategies that might be provided in setting the development of vacuum frying business were reviewed. Such strategies were addressed into matrix in order to obtain specific guidance. Table 4 below presents SWOT analysis matrix in developing vacuum frying enterprises.

Table 3. Internal and external identification of SWOT

Strength (Internal factor)	Opportunities (External factor)
❑ Convenient food which preferred by people ❑ Availability of raw materials ❑ Simplicity of process and equipments which is appropriate for small scale entreprises ❑ Typical products ❑ Low cost capital ❑ High demand of product	❑ There is high demand of local market ❑ It can create new work opportunity ❑ It is low competitiveness ❑ Vacuum frying equipment can be used for frying other fruits and vegetables ❑ There is a chance in marketing for global market
Weakness (Internal factor)	**Threats (External factor)**
❑ The lack of access in marketing ❑ Relatively high price products ❑ Low motivation of doing business when dealing with technical problems (troubles) ❑ High operational cost ❑ High electricity consumption	❑ Similar product from other countries through global market ❑ The requirements of high quality and food safety ❑ Strict product standards ❑ High price of raw materials

Table 4. Matrix for strategy of SWOT analysis

Strategy (S - O)	Strategy (S - T)
❑ Create competitive product in term of price and quality ❑ Increase production capacity ❑ Maintain continuity of raw materials with consistence of quality ❑ Find out access of market by business dialogue or internet media	❑ Follow the development of the trends of technology and market requirements ❑ Observe product competitiveness the from local, and regional market, ❑ review product come from abroad, ❑ implement national and international standard
Strategy (W - O)	**Strategy (W - T)**
❑ Make business contract with customer, exporter, and buyers ❑ Provide business and high work motivation by training , ❑ Improve processing method and machinery capacity, ❑ Obtain loan from banks for investment , ❑ Investigate and review equipments in order to obtain those which have moderate electricity consumption	❑ Create access of national, regional, and international market, ❑ Provide training for quality standard and food safety, ❑ Implement and increase quality management, ❑ Increase management capabilities of human resources, ❑ Adopt new technology for vacuum frying when necessary

CONCLUSION AND RECOMMENDATIONS

Pressure and temperature played important role in moisture content, appearance, color, texture, and flavor on the vacuum frying of jackfruit. Under condition of frying temperature of 80°C and 75°C and pressure of - 70 cm Hg, the product was similar with the natural jackfruit especially in taste, flavor, and color. Tempering treatment was not recommended since it resulted in pliable appearance.

Future work will be addressed to elaborate vacuum frying analysis especially for operation under lower pressure and temperature than the previous work, characteristic of dried product, shelf life stability, and economics analysis.

Vacuum frying industry was feasible to be conducted and these were indicated by financial parameters e.g IRR, NPV, and PBP. Such production will be acceptable as long as it was supported by production management, the continuity of raw materials , trained labor, and good quality standard.

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