Analysis of Technological Feasibility in The Development of Potato Chips Business with Cabinet Type Greenhouse Effect Dryers

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Abstract. Small and Medium Enterprises (SMEs) "Rama" is one of the potato chips producers in Batu City with a production capacity of 210 kg per day with the trademark "Rama Djaya". Drying of potatoes in SMEs "Rama" is done by drying in direct sunlight. Drying with drying has several disadvantages, including drying is very dependent on the weather, so it takes innovation of dryer technology to overcome this, namely ERK Cabinet Dryer (Greenhouse Effect) with a capacity of 200-300 kg. The performance of ERK dryers is not optimal, so it is necessary to analyze the feasibility of ERK cabinet dryer technology. The purpose of this study is to analyze the efficiency of the use of ERK cabinet dryers, economic feasibility and added value using hayami method for the development of SME potato chips business "Rama". The ERK dryer performance test was conducted five experiments. The results of the ERK dryer feasibility test showed the cabinet type ERK potato dryer has an average efficiency of 83.81% so that this dryer is feasible for use. Economically the use of ERK dryers is more efficient than manual drying and the added value generated by using an ERK dryer can increase the added value of potato chips. Proposed repair of ERK dryer is modification of heat distributor between blower and dryer room where the material chips, arrangement or reduction of the number of fans/blowers so that the hot air contained in the dryer room.

Keywords: Drying Efficiency, Economic Analysis, ERK Cabinet Dryer.

1 Introduction

Batu City has a agricultural area that has potential as an Agropolitan city with a variety of horticultural crops, including fruits (apples, oranges, jackfruit), vegetables and ornamental plants. According to [1] in 2015-2017 the number of potato production in Batu City was 78,009, respectively; 88,270; and 93,878 (quintals), which shows that potato productivity continues to increase. The increase in potato productivity has caused many business actors to innovate to increase the added value of potatoes as raw material for making potato chips.

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Small Medium Enterprises (SMEs) "Rama" is one of the potato chip producers in Batu City with a production capacity of 210 kg of potatoes per day with the brand "Rama Djaya". The raw material for potatoes comes from the Mandiri Mitra Cooperative, which has collaborated with them. Increasing market demand causes potato chip business actors to try to increase their sales revenue. Business development is an organized activity or activity to produce goods and services in meeting the needs and desires of the community [2]. So far, potato chip producers drying potatoes by drying them directly in the sun has a weakness, namely during the rainy season, drying cannot be carried out. Greenhouse Effect Dryer (ERK) is a dryer that utilizes solar energy using a transparent cover on all parts of the dryer building wall which is made of fiberglass [3].

Drying potato chips at SMEs "Rama" manually depends on weather conditions. Drying by drying under direct sunlight is carried out for 8 hours starting from 06.00-14.00 for 2 days during the summer and 3-7 days during the rainy season. Manual drying requires a relatively long drying time, quite a lot of labor, depending on weather conditions and requires a large area. Technological innovation of cabinet type Greenhouse Effect Dryer (5.5 m x 4.5 m x 2.3 m) with a capacity of 200-300 kg/process. In the drying room, there are 11 cabinet shelves made of angled iron (100 cm x 60 cm x 180 cm). Each cabinet shelf consists of stacked shelves with an upright distance of 10 cm to facilitate the entry of materials with 10 shelves in one cabinet. The ERK cabinet dryer that has been designed and used at UKM Rama is used for 14 hours starting from 06.00-20.00 in a greenhouse for 2 days using LPG fuel and a fan.

According to [4] the efficiency of the dryer is the good or bad performance of the dryer to dry the material. Feasibility of technology in business units, can provide real added value to the sustainability of its business. According to [5] added value is the value contained in the product because of the processing and activities that are appropriate to provide satisfaction to consumers. In an effort to increase the added value of the product, the business unit requires a good source of funds, so an economic analysis of a business unit is needed. The economic analysis is an analysis to determine the ability of a business unit to manage its sources of funds in generating maximum profits with low production costs and an efficient level of efficiency in the production process.

Technology feasibility analysis is used to perform performance tests on tools and machines used to produce a product. Technological feasibility aims to assess the technical capability of a business unit to produce high productivity. Technology feasibility analysis is closely related to economic analysis to determine the ability of a business unit economically. Economic analysis is an analysis to determine the allocation of costs incurred to obtain optimal profits. The purpose of this study is to determine the efficiency of the use of cabinet type ERK dryers, analyze the economic feasibility of using ERK dryers and analyze the added value generated in SMEs “Rama”.

2 Research Methods

The research was carried out at the SMEs “Rama” as potato chip producer in Batu City with following methods.

2.1 Analysis of the efficiency of using ERK Dryer

Daily Solar Irradiation (Ih)

$$Ih = 0.5\,\{(t_1 - t_0)(I_1 + I_0) + (t_2 - t_1)(I_2 + I_1) + \ldots + (t_n - t_{n-1})(I_n + I_{n-1}) \quad (1)$$

Information:
Ih = daily irradiation (W/m^2)
I_0, I_1, I_n = irradiation on t_0, t_1, t_n
t_0, t_1, t_n = 0, 1^{st}, n^{-th} time

Drying chamber temperature and distribution. This temperature measurement is done using a digital thermometer. The temperature measured is the ambient temperature and the drying room temperature.

Drying time. Drying time is the total time required to dry the product to the desired moisture content. Drying will be stopped when the mass of the material is constant. The measurement of air humidity includes the humidity of the air on the outside and inside of the dryer, carried out simultaneously with the temperature measurement.

Air humidity. Air humidity is measured, namely the humidity of the ambient air and the humidity of the air in the drying room. Air humidity data obtained from the wet bulb temperature and dry bulb temperature using graphic theory with psychometric charts.

Air velocity. Air velocity is measured using an anemometer. Measurement of air velocity includes air inlet (inlet) in the drying chamber, air in the drying chamber and air outlet (outlet) in the dryer.

Fuel energy requirement. Energy requirements of the fuel to dry the material during drying.

Electrical energy. Electrical Energy used during drying to drive fans, room thermometers. The amount of electrical energy used can be calculated by the equation:

$$Q_{total} = Q_1 + Q_2 \quad (2)$$

Information:
Q_{total} = total of electrical (kJ)
Q_1 = electrical used for the fans (kJ) = 3,6 Pk. t
Q_2 = electrical energy used for room thermometer (kJ) = 3,6 Pt. t
P = electrical power (W)
T = duration of use (hour)

2.2 ERK Dryer Economic Analysis

Total Cost

$$TC = TVC + TFC \tag{3}$$

Information:
TC = Total Cost (IDR)
TVC = Total Variabel Cost (IDR)
TFC = Total Fix Cost (IDR)

Fixed Cost. Fixed costs are costs whose amount is fixed and is not influenced by the amount of output or production volume in a certain period. Parameters in fixed costs, i.e.:*Shrinkage*

$$D=\frac{P\text{-}S}{N} \tag{4}$$

Information:
D = t-year depreciation,
P = Purchase price of tools/machines
N = Depreciation life of the tool/machine (years)

Investment Cost and Capital Interest

$$I= \frac{i(p)(n+1)}{2n} \tag{5}$$

Information:
I = Total interest on capital and insurance (Rp/year),
i = Total interest rate on capital and insurance (% year),
p = Initial purchase price of tools/machines (Rp),
n = Economic life (years).

Variable cost. Variable costs are costs whose amount depends on the volume of production carried out [6]. Consist of:*Repair and Maintenance Cost*

$$PP = 1{,}2\% \, x \frac{P-S}{100} x \, t \tag{6}$$

Information:
PP = Repair and maintenance costs (Rp/year),
P = Equipment purchase price (Rp),
S = Final value (Rp),
t = Working hours a year (hours/year)

Fuel Cost

$$\mathrm{BB} = \mathrm{FC \; x \; Fp} \tag{7}$$

Information:
BB = Fuel cost (Rp/day)
FC = Fuel consumption (kg/day)
Fp = Fuel price (Rp/kg)

Labor Wages

$$BT = Wop/Wt \tag{8}$$

Information:
BT = Labor cost (Rp/hour)
Wop = Daily labor wages (Rp/day)
Wt = Working hours per day (Hours/day)

Electricity cost

$$BL = P\ x\ t \tag{9}$$

Information:
BL = Electricity cost (Rp/hour)
P = Electric power used (kwh)
t = Electricity usage time (hours)

3 Results and Discussion

SMEs "Rama" is one of the potato chip producers in Batu City since 2004. The raw material used for potatoes comes from the Mitra Mandiri cooperative in Batu City with a production capacity of them ± 210 kg per day and the number of workers is 7 people consisting of 3 permanent workers and 4 temporary workers. The potato chips produced in this SMEs are divided into 3 qualities, namely quality 1 and 2 which are obtained from the first to sixth sliced potatoes sold to gift shops, while for quality 3, they are obtained from the seventh to the last slice of potato, with the same size. smaller and sold to small shops. Potato chips produced by them are marketed in Batu, Malang, Sidoarjo, Surabaya, Pasuruan, Probolinggo and Bogor, and are starting to try to export.

3.1 Performance Test of Cabinet Type Greenhouse Effect (ERK) Dryer

The performance of the dryer used can be seen from the efficiency of energy use by measuring several parameters, namely changes in solar irradiation, drying temperature, air humidity, wind speed, electrical energy and additional heating energy.

3.2 Changes in Solar Irradiation on Drying Time

Measurement of solar irradiation is carried out every 1 hour using a luxmeter. The experiment was carried out 5 times. Measurements using a luxmeter produce values in lux units, which are then converted into W/m2 units (see Fig. 1). Based on [7], 1 lux = 0.0079 W/m^2. Drying of potatoes at SMEs "Rama" is generally carried out at 09.00 until finished for 1 day 1 night when the weather is hot and when the weather is cloudy or rainy the drying can last for 3-4 days.

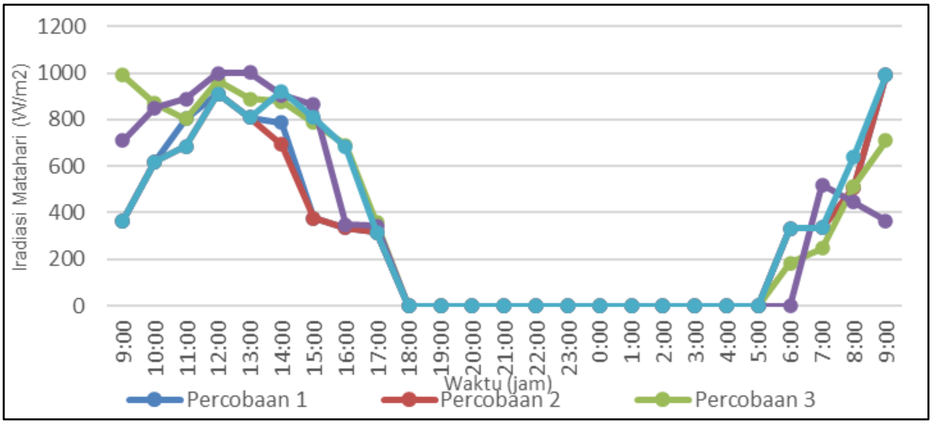

Fig. 1. Solar Irradiat*i*on Profile of Each Experiment Solar Irradiation Profile of Each Experiment

Figure 1 shows fluctuating results with hot weather conditions during the drying process. These fluctuations are influenced by the intensity of the sun and changing cloud conditions. The higher the irradiation value, the higher the solar intensity obtained. In each experiment there are differences in the minimum, maximum and average values of the solar intensity (see Tab. 1) due to changes in the level of solar radiation and the geographical location of an area. In general, the average solar intensity obtained during the experiment is greater than the average solar irradiation reception in Indonesia. The average solar irradiation rate in Indonesia is 562.5 W/m2. According [8] Asia has a high level of solar irradiation which is widely used for processing agricultural products for drying, because the costs incurred are relatively low. This is because when drying is carried out when the weather is sunny and hot, the average solar irradiation received by the dryer is high.

Table 1. Minimum, Maximum, and Average Values of Solar Irradiation.

Test	Minimum (W/m$^{2)}$	Maximum (W/m$^{2)}$	Average (W/m$^{2)}$
1	316	911.66	576.457
2	316	990.66	559.93
3	182.49	990.66	683.84
4	344.44	1000.93	686.97
5	316	990.66	647.86

3.3 Changes in Temperature Against Drying Time

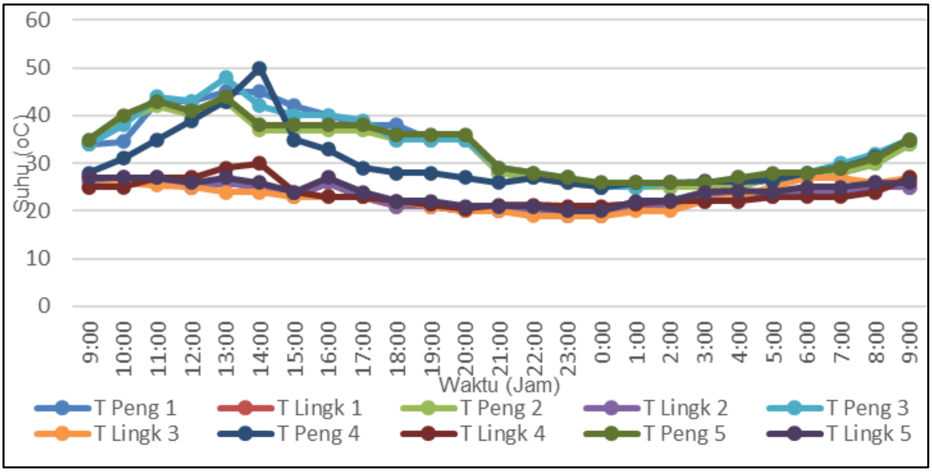

Fig. 2. Graph of Changes in Dryer Room Temperature and Environment for Each Experiment.

The temperature in the drying chamber and the environment fluctuates (see Fig. 2) due to the unstable heat of the sun so that there is a difference in temperature in each of the experiments carried out. The temperature of the drying room fluctuates is influenced by the ambient temperature and the absorber as a heat absorber of solar radiation and heat from the LPG gas stove located in the drying room. The average temperature in the drying room from all experiments was 32.48°C. According to [9] the temperature used for drying potatoes for food needs, especially potato chips, is 40°C - 60°C with a maximum temperature of 50°C. The temperature measurement for each experiment is smaller because the heat in the drying chamber has not been used optimally but has been removed by the fan. According to [10] during the day the air temperature in the drying chamber is affected by fluctuations in solar irradiation, while at night the temperature in the drying chamber is influenced by additional heating. The higher the temperature or the greater the difference between the temperature of the heating medium and the temperature of the material, the greater the difference in saturated vapor pressure between the surface of the material and the environment, so that the evaporation of water in the dried material will be faster and more abundant.

3.4 Changes in Air Humidity (RH)

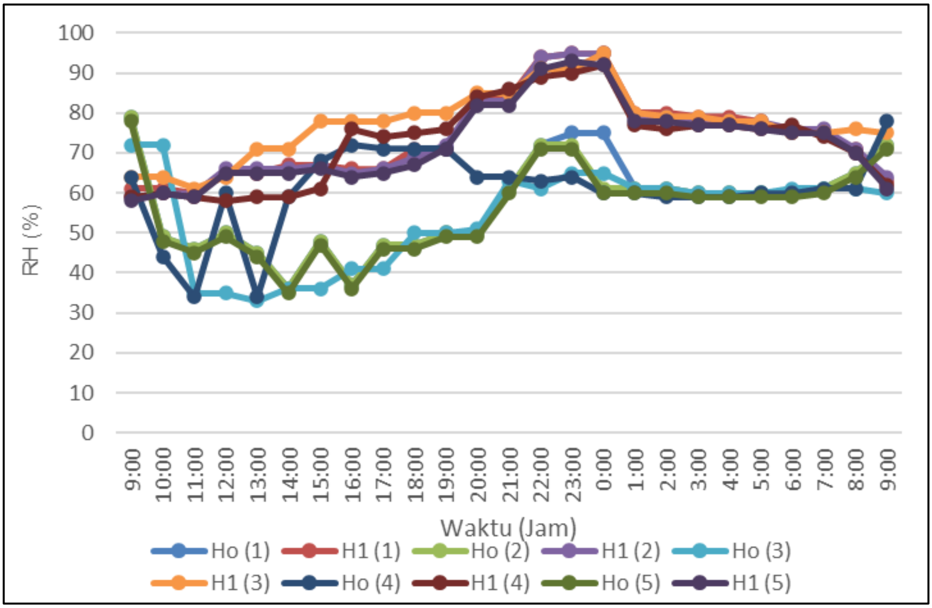

Fig. 3. Dryer RH Chart and Environment.

The average RH of the dryer ranged from 54-57.08% and the average RH of the surrounding environment of the dryer ranged from 72.5-77.2%. High RH can cause mold to appear on the material. According to [11] bacteria and fungi cannot grow in the 40-60% RH range. So the level of RH must be kept stable. Air flow occurs due to the difference in pressure between the drying chamber and the environment [12]. According to the magnitude of the RH value is affected by temperature, the relationship between temperature and RH is inversely proportional to that if the temperature increases, the RH will decrease. The hot air in the drying chamber will slowly heat and evaporate the mass of water contained in the potatoes. The water vapor will not directly come out of the drying chamber but will saturate the air around the material. Increasing RH at constant temperature will decrease the drying rate of the material [13]. RH affects the transfer of liquid or water vapor from the material to the drying air, the lower the RH of the drying air, the greater the ability to absorb moisture from the surface of the material, so the faster the drying rate [14].

3.5 Airflow Velocity Change

The speed of the incoming air flow is obtained from the pressure of the fan contained in the drying chamber which functions to remove water vapor and spread heat in the drying chamber. The average air flow velocity can be seen in Table 3.

Table 2. Average velocity of air in and air out.

Test	Average Inlet Airflow Speed (m/s)	Average Outlet Airflow Speed (m/s)
1	1.07	1.87
2	1.08	2.11
3	1.01	1.90
4	1.02	1.41
5	1.08	2.12

The high air rate causes the drying process to be faster in materials that have a high moisture content such as potatoes. According to [15] at the beginning of the drying process for agricultural products with high moisture content, an air velocity of at least 0.5 m/s is required, while for products with low moisture content the drying rate is more influenced by low humidity and high temperature. the average air flow rate out/outlet is greater than the inlet/inlet flow rate. According to [16] the outflow/outlet air flow is greater than the inlet/inlet airflow rate, resulting in the heat that should be used to dry the material by the exhaust fan before being used to its full potential.

3.6 Electrical energy

The electrical energy in the drying process is only used to drive the exhaust fan to remove the material vapor in the dryer to the environment so as to reduce high humidity in the dryer, especially in drying agro-industrial products that have high moisture content. This fan serves to spread, level, replace and remove air in the drying chamber which contains moisture from the material being dried [17]. The use of electrical energy in the ERK dryer used at them for 2 inlet fans (110 Watt) and 4 outlet fans (3 Watts), so that the electrical energy used is 20044.8 kJ.

3.7 Additional Heater

Additional heating is an important part of the ERK dryer because solar energy is erratic, and additional heating is used to generate energy to assist the drying process. The additional heater used in this cabinet type ERK dryer is a gas heater (LPG gas burner) made of aluminum in the form of a square box that is not easy to rust. The LPG gas needed to dry potatoes in one drying process is 2-3 LPG gas. The advantages of using LPG gas because it does not produce smoke or combustion residues that can contaminate potatoes and LPG gas is easy to find and the heating level can be adjusted. The placement of the stove in the drying room has a few obstacles, namely the worker's space is not free and reduces the capacity of the dryer. According to Mahardian (2014), the placement of the stove or burner on the dryer is very important to ensure that the heat from the burner can be channeled thoroughly in the drying chamber to dry the material.

3.8 Energy Efficiency

The efficiency is important because it relates to the use of existing resources, environmental issues and equipment operational costs. The use of thermal energy is usually greater than the use of mechanical energy, so both energies must be available in sufficient quantities for the drying process to take place properly . The average efficiency of the ERK dryer from the five experiments conducted was 83.81%. The value of lightening efficiency in this study is high. Based on the research of [18] that drying red chili using a greenhouse dryer can increase drying efficiency by almost 90% and also based on [19] that using a greenhouse dryer can overcome external factors such as rain, dust, insects and dried products are of high quality compared to manually. The high drying efficiency is due to the available energy input, the dryer is able to dry materials in large quantities and in a fairly short time. The greater the room temperature for drying the material, the greater the drying efficiency which results in reduced humidity [20].

3.9 Quality of Drying Results

Fig. 4. ERK Drying Results.

Fig. 1. Manual Drying Results.

The potato chips that were dried using the ERK dryer had a slightly bright yellow color, while the dried potato chips were pale white in color. The results of the appearance of potato chips are influenced by temperature and the length of the drying process, where with the ERK dryer it takes 2 days 1 night with hot sunny weather conditions so that the material can dry, while manual drying only takes half a day with hot sunny weather conditions so that the material can be dried manually and also the temperature in the ERK drying chamber is higher than that of manual drying during the drying process. The higher the temperature and the drying time will affect the appearance of the product to be slightly yellow and brownish, while the low temperature and drying time will produce a white product. The high temperature causes a decrease in the brightness of the material due to the non-enzymatic browning reaction occurring during the heating process or often called the Maillard reaction.

3.10 Economic Analysis

The economic analysis is an analysis carried out to find out the financial aspects of the business unit as a whole through the calculation of costs and profits that can be obtained by comparing expenses and income. Some of the basic parameters used as the basis for the operation of machines/tools are production capacity, equipment, number of workers, technology used and projected prices [21]. Assumptions of Economic Analysis of ERK Dryer can be seen in Table 3.

Table 3. Economic Analysis Assumptions of ERK Dryer.

No.	Parameter	Value
1.	Price of ERK Dryer Equipment and Components Cabinet type (P), Rp/unit	Rp. 60.000.000
2.	Tool Life (N), years	10
3.	The final price of the tool (S), Rp/unit	Rp. 6.000.000
4.	Bank interest rate (I), decimal	0,04
5.	Labor Wage (L), Rp/day	Rp. 120.000
6.	ERK Dryer Capacity, kg	300
7.	Working hours per day	8
8.	Total hours worked per year	1456

Table 4. Economic Analysis of ERK Dryer and Manual Drying.

No.	Parameter (ERK dryer)	Value	Parameter (Manual Dryer)	Value
	Fixed cost			
1.	Depreciation Cost (D),	Rp. 5.400.000		
2.	Interest capital cost (I),	Rp. 1.320.000		
4.	Capital interest rate (I),	Rp. 1.320.000		
	Variable cost			
1.	Repair and maintenance costs,	Rp. 9.434.000	The number of workers	7
2.	Labor cost	Rp. 120.000	Working hours per day	8
3.	Electricity Cost, days	Rp. 8.044,1	Wage/day, Rp/day	60.000
4.	Fuel cost	Rp. 474.000	Production capacity	180

Amount	Rp 17.356.924	Rp. 75.600.000

In calculating the fixed cost of using ERK dryer with the price of the tool and its components is Rp. 60,000,000,-. The residual value is Rp. 6,000,000 obtained assuming 10% of the price of the tool. Residual value is an estimate of the value of assets received by the company if the assets are resold at the end of their useful lives [22]. Depreciation cost of Rp. 5,400,000 assuming the economic life of the tool is 10 years. variable costs of operating the ERK dryer obtained repair and maintenance costs of Rp. 9.434.880.-. Repair and maintenance costs include repair costs due to unexpected factors, replacement of worn out components or parts, and labor costs for repairing special components. The average repair cost for agricultural tools or machinery is 1.2% of the initial price per 100 hours. Operator/worker fee of Rp. 120,000.The cost of workers or operators is the cost that is obtained based on the receipt of workers' wages per day divided by the number of hours worked each day. the total cost of using the ERK dryer is Rp. 17,356,924, while the basic cost manually is IDR. 75.600.000,-.

The calculation of the basic cost of drying manually is assumed to ignore the costs of tools and labor costs incurred. where this value is smaller than manual drying. This means that drying with an ERK dryer is more efficient than manual drying and can overcome the problems that exist in SMEs “Rama”. The difference between ERK and manual dryers is due to the larger capacity of the dryer and fewer workers and the drying can take place even if the weather is cloudy or rainy. One of the advantages of using tools and machines is to reduce production costs incurred by business units. The advantages obtained using a dryer are more effective work because it does not require large land, less labor, more practical in storage and more hygienic [23] and during the rainy season the production process can still be carried out [24].

4 Conclusion

1. Based on the experimental results of the performance of drying potato chips with a cabinet type ERK dryer with solar energy and additional heating in the form of an LPG gas burner, several conclusions can be drawn as follows:
   a. The temperature of the drying chamber in all experiments was greater than the temperature of the outside environment around the dryer which ranged from 30.56-33.52oC while the ambient temperature ranged from 23.02-24.02oC with an average RH of the dryer ranging from 54-57.08%. and the average RH of the environment around the dryer ranges from 72.5 to 77.2%.
   b. The average solar irradiation in all experiments was 576.46 W/m2, respectively; 559.93 W/m2; 683.84 W/m2; 634.13 W/m2 and 647.86 W/m2.
   c. The air flow velocity was obtained from the inlet and outlet fan pressure, the average inlet air flow velocity for each experiment was 1.07 m/s; 1.08 m/s; 1.01 m/s; 1.02 m/s and 1.08 m/s, while the average outlet air flow velocity is 1.87 m/s; 2.11 m/s; 1.90 m/s; 1.41 m/s and 2.12 m/s. The outlet airflow is greater than the inlet airflow which results in the heat that should be used to

dry the material already removed by the exhaust fan before being used to its full potential.

d. This ERK dryer is able to dry the material in all experiments (experiments 1-5) as much as 210 kg of wet potatoes to 21 kg of krecek takes 2 days and 1 night with hot sunny weather conditions using a solar dryer energy source that comes from three sources, namely solar irradiation, LPG and electricity. Electrical energy is used to drive 110 Watt inlet fans (2 pieces) and 3 Watt outlets (4 pieces) so that for all experiments, the use of electrical energy is 20044.8 kJ. The energy from the use of LPG gas burner in all experiments is 0.392 kJ.

e. The drying energy efficiency achieved in all experiments was 87%, respectively; 81.95%; 84.32%, 83.04% and 82.75%, so that the average drying efficiency of all experiments is 83.81%.

2. Economic analysis of the total cost of using the ERK dryer is Rp. 17,356,924, and the calculation of the cost of drying manually obtained a total of IDR. 75.600.000,-. The value of the ERK dryer is smaller than manual drying, which means that drying with the ERK dryer is more efficient than manual drying and can overcome the problems that exist in SMEs "Rama".

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