Vol. 13, No. 4 (2024): 1344 – 1351 http://dx.doi.org/10.23960/jtep-l.v13i4.1344-1351

JURNAL TEKNIK PERTANIAN LAMPUNG

ISSN 2302-559X (print) / 2549-0818 (online)
Journal homepage : https://jurnal.fp.unila.ac.id/index.php/JTP

Energy Analysis in the Production of Purple Sweet Potato Crackers

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Article History:

Received : 24 September 2024
Revised : 17 October 20234
Accepted : 07 November 2024

Keywords:

Energy consumption.
Energy flow,
Production costs,
Production process,
PSP Crackers.

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ABSTRACT

The production process of purple sweet potato (PSP) crackers involves several stages, including peeling, washing, boiling, kneading, grinding, cutting, frying, and packaging. This study aims to analyze the energy flow and production costs associated with each stage of processing sweet potatoes into crackers at the Azizah Crackers Production House in Padang City. The types of energy considered in this study included human labor, fuel gas, electricity, and raw materials (PSP, cooking oil, and supporting materials). Results showed that the total input energy for the production of PSP crackers was 784,629.95 kJ with average output energy of PSP crackers 803,880.00 kJ. The energy output of PSP crackers was 1.02 times the energy input. The cutting and frying activity required the largest input energy of 46.18% (362,310.15 kJ), while packaging activity required the smallest energy of 0.38% (2,992.33 kJ). Based on the energy type, raw materials contribute the largest energy, amounted to 85.83% (674,822.86 kJ), and the smallest type of energy was electrical energy, which was 0.74% (5,839.72 kJ).

1. INTRODUCTION

Purple sweet potato is one of the staple food substitutes that has a high level of carbohydrates. Sweet potatoes have an important role in alternative food sources besides rice and as industrial raw materials. The sweet potato commodity is expected to play a role as an alternative local food crop in supporting national food security to reduce the amount of community dependence on rice and flour by increasing the consumption pattern of tubers (Ekafitri & Faradilla, 2011). According to Central Bureau of Statistics, the per capita consumption level of sweet potatoes in West Sumatra province in 2021 was 1.809 kg/cap/year, this consumption level increased from 2020 with a value of 1.438 kg/cap/year. The sweet potato commodity can be cultivated to add value to a product and help the community in the economic field. In supporting the economy of the Indonesian people, the utilization of purple sweet potatoes is a great prospect to be developed into a household-scale or large-scale industry (Rijal *et al*., 2019). Increasing public consumption of sweet potato commodities can be done by promoting sweet potatoes as a functional and healthy food (Ginting *et al*., 2011).

Efforts to improve the quality and public consumption of purple sweet potatoes need post-harvest processing to produce superior agro-industry products. Energy consumption is required for every process of running an agro-industry of processed products. The agroindustry plays a role in increasing people's income and in increasing the added value of a product so that it can be competitive with other products. Purple sweet potato agro-industry can be processed into a variety of processed products, such as flour, noodles, ice cream, jam, sauce, sweet potato sticks, crackers (Ginting *et al*., 2011), dyes, and carbonated drinks using purple sweet potatoes as raw materials, producing anthocyanins (Qinah, 2009).

Many processed agricultural commodity products produced by small-scale industries and households in rural areas are processed snacks in the form of purple sweet potato crackers (Mutiara, 2020). Researched the energy consumption used in producing coffee beans into ground coffee at the "Cap Teko" ground coffee factory in Sawahlunto city (Syahrun, 2022) .Based on the results of the study, it was found that it takes 6,834.38 kJ of energy to process each kilogram of coffee beans with a moisture content of 12.23 ± 0.12% into ground coffee. The largest energy use is in the roasting process, which is 97.30%, or 6,649.78 kJ/kg, while based on the type of energy used, the largest is firewood, which is 95.62%, or 6,534.73 kJ/kg. The smallest energy use is in the packaging process, which is 0.59%, or 40.12 kJ/kg, while based on the type of energy used, the smallest is the use of human energy, which is as much as 1.12%, or 80.42 kJ/kg.

Researched the energy audit of the CTC (Crush, Tear, Curl) black tea processing process at the PTPN VIII Tea Factory Rancabali Garden, Patenggang District, West Java Province (Ramanda *et al*., 2021). The use of energy in processing one ton of tea leaves into black tea is 3,930.66 MJ/ton, with the largest energy consumption occurring in the drying process at 1,424.67 MJ/ton, or 36.24%. Energy is one form of analysis commonly used to calculate the energy efficiency of a production system and its impact on the environment (Putri *et al*., 2022). Energy auditing is a technique for improving energy efficiency (Rehiara *et al*., 2023). An energy audit (EA) is a crucial step in enhancing factory energy efficiency and achieving certification for cleaner manufacturing (Al Momani *et al*., 2023). One way to lower electrical energy consumption is through energy conservation (Wardhana & Damarwan, 2023). Implementing an energy audit and its control elements in energy management greatly benefits the organization, promoting the rational use of energy resources and enhancing energy efficiency (Tomaskova *et al*., 2023). By adopting energy-efficient practices, businesses can actively contribute to more sustainable future and align their operations with global environmental goals (Tomaskova *et al*., 2023).

Conducted research on energy analysis in the process of making shrimp crackers at PD (Sugandi *et al*., 2018). Sri Tanjung Indramayu Regency, West Java Province, and obtained an overall energy use of 7,312.148 MJ/ton of shrimp crackers. The total human energy used was 151.154 MJ/ton of shrimp crackers, the total direct energy was 1,992.062 MJ/ton of shrimp crackers, and the total indirect energy used was 5,168.932 MJ/ton of shrimp crackers. The purpose of this study is to analyze the amount of energy flow and production costs in each production process of processing purple sweet potato into purple sweet potato crackers at the ABC Crackers Production House.

2. MATERIALS AND METHODS

The tools needed in this study are stationery, a stopwatch, Garmin Connect software, Garmin Forerunner 35, a heart rate monitor (HRM) (Putri *et al*., 2020), scales, a lux meter, and a digital thermometer. The materials needed in this research are:

a. Primary data in the form of data obtained directly at the research location by conducting a process of observation, measurement, and calculation, including the number of workers, time during production activities, types of tools/machines used, and the amount of fuel consumption.
b. Secondary data in the form of literature sources or references such as the value of the energy equation. Describing the materials and tools used Chemicals, material specifications, and equipment used are mentioned brand.

One of the production houses in Padang City that processes PSP into crackers is the Azizah Cracker Production House. The Azizah Cracker business activities are engaged in the business of snacks and selling products, including original onion crackers, spicy onion crackers, soybean onion crackers, scissor onion crackers, purple sweet potato crackers, potato sticks, and other snack products. The Azizah Cracker agro-industry has been running since 2009, but the use of machines began in 2015, and until now, the processing carried out in the production house as a whole is still done manually and using machines. In the process of making PSP crackers at the Azizah Cracker, there has been no analysis of the use and level of energy consumption required in the production process of purple sweet potato crackers. The process of making PSP crackers at the Azizah Cracker production house includes raw material preparation, peeling, washing, boiling, kneading or mixing PSP with other supporting materials, dough milling, dough cutting, frying, and packaging.

The research method used to direct observation of the field to make observations of energy in the Azizah Cracker business and conduct interviews. Several stages carried out in this research include primary data study and secondary data study. This research conducted several energy analyses including human energy, fuel energy, and electrical energy. Furthermore, the research stages carried out data collection, preparation of tools and materials, measurement, and energy analysis. Data collection in this study comes from various sources and these references are used as references in research. Preparation of tools and materials includes borrowing tools, purchasing materials, and availability of materials in the production house. Measurement and analysis include measurements of purple sweet potato mass and fuel, as well as the electrical power used in each production process of purple sweet potato crackers. The equation used in calculating the input energy source is as follows:

2.1. Human Labor Energy

The human labor energy can be known by using equation 1 below:

$$E_{Human} = \text{calorie value x } 4.20 \tag{1}$$

where the value of 4.20 is the conversion value from kcal units to kJ units (Setiawan, 2022).

2.2. Purple Sweet Potato Energy

The energy value of purple sweet potato can be known by using equation 2 below:

$$E_{PSP} = Mu \times Pu \tag{2}$$

where E_{PSP} is the energy value of purple sweet potato (kJ), Mu is the mass of purple sweet potato (kg), and Pu is purple sweet potato energy conversion factor (3,444.00 kJ/kg) (fatsecret, 2024).

2.3. Fuel Energy

The fuel energy from LPG was calculated according to Equation (3):

$$E_G = M \times NKbb \tag{3}$$

where E_{Gas} is energy used (kJ), *M* is mass of fuel gas used (kg), and *NKbb* is calorific value of fuel (kJ/kg).

2.4. Electrical Energy

The electrical energy can be known by using equation 4 below:

$$E_L = P \times t \tag{4}$$

where $E_{Electric}$ is electrical energy (kJ), *P* is engine power (watts), and t is milling time (s)

2.5. Cooking Oil Energy

The cooking oil energy (E_{CO}) can be known by using equation 5 below:

$$E_{CO} = Mg \times Pg \tag{5}$$

where *Mg* is mass of cooking oil used (kg), and *Pg* is cooking oil energy conversion factor (32,604.00 kJ/kg) (Maulana & Saputra, 2023).

2.6. Energy from Supporting Materials

The energy associating to supporting materials (E_{SM}) was calculated using Equation (6):

$$E_{SM} = (Mf \times Pf) + (Mcc \times Pcc) + (Ms \times Ps) + (Mss \times Pss) \tag{6}$$

where *Mf* is mass of flour (kg), *Pf* is flour energy conversion factor (13,986.0 kJ/kg), *Mcm* is mass of coconut milk (kg), *Pcm* is coconut milk energy conversion factor (9,572.20 kJ/kg), *Ms* is mass of sugar (kg), *Ps* is sugar energy conversion factor (16,164.06 kJ/kg), *Mss* is mass of sesame seeds (kg), and *Pss* is sesame seeds energy conversion factor (23,951.40 kJ/kg).

2.7. Total Energy Input

The total energy input (Ei) was calculated by using Equation (7):

$$E_i = E_H + E_{PSP} + E_G + E_L + E_{CO} + E_{SM} \tag{7}$$

2.8. Total Energy Output

The total energy output (E_o) was calculated from amount of crackers produced (Yk) and energy value (Fk) of the cracker using Equation (7). In this case energy specific for cracker is 23,100.00 kJ/kg (Darely, 2020).

$$E_o = Yk \times Fk \tag{8}$$

2.8. Energetic Performance

Energetic performances of Azizah PSP cracker was evaluated using different parameters, including energy ratio, energy intensity, energy productivity, and net energy. These parameters were defined as the following:

a. Energy ratio ER, obtained by comparing the total output energy value (E_o) with the total input energy value (E_i).
b. Energy intensity EI (kJ/kg), obtained by comparing the total value of input energy (kJ) with the amount of crackers produced (kg);
c. Energy productivity EP (kg/kJ), obtained by comparing the production value of crackers produced (kg/day) with the total input energy value (kJ/kg);
d. Net energy NE (kJ), obtained by subtracting the total value of input energy E_i (kJ) from the total value of output energy E_o (kJ).

3. RESULTS AND DISCUSSION

The research data collection process can be seen in Table 1. Energy consumption analysis based on the production activity process consists of peeling, washing, boiling, kneading, grinding cutting, frying and packaging activities. Overall, there are 6 resources used to produce PSP crackers and contributing to energy utilization, namely main material (PSP), supporting materials, cooking oil, human labor, electricity, and LPG. Based on energy sources, the energy consumption in each step for PSP cracker production is summarized in Table 2.

Table 1. Process, input energy, time required, and output of PSP cracker production

No	Process	Input Energy*					
		Human (man × h)	PSP (kg)	LPG (kg)	Sup. Maters (kg)	Electricity (W × h)	Cooking oil (kg)
1	Peeling and Washing	1 × 0.52	12				
2	Boiling			0.57			
3	Kneading	2 × 0.68			25.2		
4	Milling	2 × 3.07				370 × 3.07	
5	Cutting and Frying	1 × 1.50		1.53			8.9
6	Packaging	1 × 1.21					

Table 2. Energy consumption (kJ) for PSP cracker production based on the processing steps and energy resources

No	Processing Steps	Energy Sources*						Total
		Human	PSP	LPG	Sup. Maters	Electricity	Cooking Oil	
1	Peeling and Washing	273.0	41,328					41,601.00
2	Boiling			26,658.42				26,658.42
3	Kneading	723.8			343,319.26			344,043.06
4	Milling	2,930.2				4,094.8		7,025.0
5	Cutting and Frying	1,632.4		72,134.55			290,175.6	362,310.15
6	Packaging	1,247.4				1,744.9		2,992.3
	Total	6,806.8	41,328	98,792.97	343,319.26	5,839.7	290,175.6	786,262.33

*) Average value from three measurements at different days

3.1. Input Energy Distribution Based on Activities

The distribution of input energy in the production activities of purple sweet potato crackers involves six types of activities, namely washing, peeling, boiling, kneading, grinding, cutting, frying, and packaging. The distribution of input energy based on activities can be seen in Table 2. The percentage of energy in each activity can be seen in Figure 1. The activity that produces the most energy is in the cutting and frying process by 46.18% (362,310.15 kJ). The second largest energy consumption is in the kneading process by 43.85% (344,043.06 kJ).

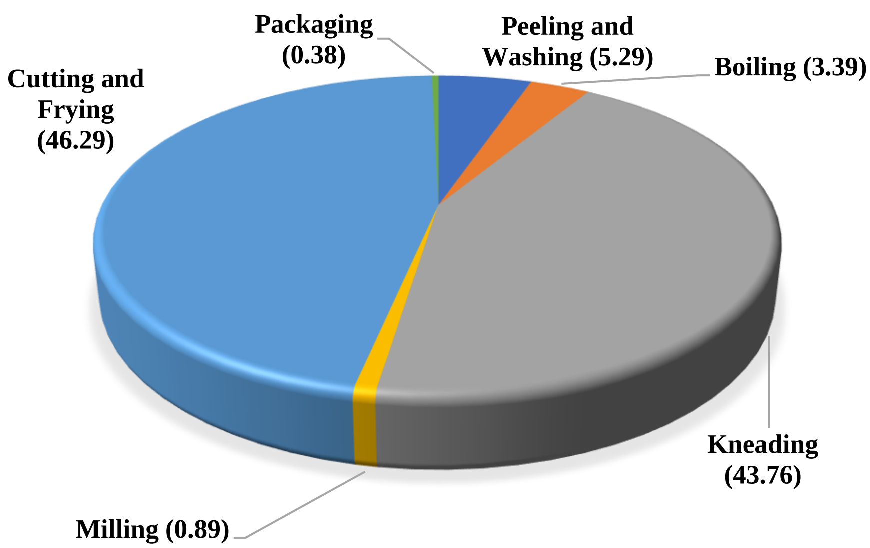

Figure 1. Input energy consumption data based on production activities (numbers are in %)

Purple sweet potato peeling and washing activities are carried out by one person in the process, who takes turns every day. Based on the obtained data, we conclude that the total energy value of the peeling and washing activities is 41,601.00 kJ/kg, with the energy value of the raw materials, purple sweet potatoes, surpassing human energy. This is due to the large conversion factor of purple sweet potato energy, so that the energy consumption value of purple sweet potato becomes greater than human energy.

Energy consumption in the boiling process is 26,658.42 kJ and account for only LPG. Human energy was employed for this process, but it is excluded in this calculation. This because human labor for boiling process at the same time also handle other process, and it had been considered in the other process.

Based on the energy data obtained, the total energy consumption in the kneading process is 344,043.06 kJ, with human energy of 723.80 kJ and supporting energy of 343,319.26 kJ. It is concluded that the value of supporting energy is greater than human energy. This is due to the amount of use of supporting raw materials that is more than human energy and also due to the conversion factor of supporting material energy, so that the energy consumption value of supporting raw materials becomes greater.

Based on the energy data, the total energy consumption in the milling process is 7,024.99 kJ with human energy of 2,930.20 kJ and electrical energy of 4,094.8 kJ. It is concluded that the value of electrical energy is greater than human energy in the milling process. Factors affecting electrical energy are greater because grinding requires two units of machinery to produce a longer working time as well. Based on the energy data obtained, the total energy consumption in the cutting and frying process is 362,310.15 kJ with human energy of 1,632.40 kJ, gas energy of 72,134.55 kJ, and cooking oil energy of 290,175.60 kJ. The use of cooking oil energy value is greater than human energy and gas energy in the cutting and frying process. This is due to the conversion factor which is a factor that affects the value of energy consumption in cooking oil. Last, energy consumption in the packaging process is the smallest 0.38% (2,992.33 kJ).

3.2. Analysis of Energy Consumption by Type

Input energy consumption data based on energy type can be seen in Table 3. The largest energy consumption is in raw material energy as much as 85.83% (674,822.86 kJ), and the smallest energy is in electrical energy and human energy as much as 0.74% (5,839.72 kJ) and 0.87% (6,806.80 kJ), respectively.

Table 3. Input energy consumption data based on energy type

Types of Energy	Energy (kJ)	Percentase (%)
Human	6,806.80	0.87
Gas	98,792.97	12.56
Electricity	5,839.72	0.74
Raw material	674,822.86	85.83
Total	786,262.35	100.00

3.2.1. Human energy

The largest use of human energy to produce purple sweet potato crackers is in the milling process at 43.05% (2,930.20 kJ), and the smallest use of human energy is in the peeling and washing process at 4.01% (273.00 kJ) of the total human energy. The reason human energy consumption is higher during the milling process compared to other processes is because more than two people are required, and it takes a considerable amount of time (Putri *et al*., 2020). Human energy consumption can be seen in Table 4.

The use of human energy is influenced by different body conditions that produce different energy and work times. Meanwhile, the large use of electricity is strongly influenced by the number of crackers to be packaged, so the need for electricity will also increase, and vice versa, the use of electricity will decrease if the material or crackers to be packaged are small.

Table 4. Human energy consumption during PSP cracker production

Process	Energy (kJ)	Percentase (%)
Peeling and Washing	273.00	4.01
Kneading	723.00	10.62
Milling	2,930.20	43.05
Cutting and Frying	1,632.40	23.98
Packaging	1,247.40	18.33
Total	6,806.80	100

3.2.2. Gas Energy

The total fuel gas energy required during the cracker production process is 98,792.97 kJ consisting of LPG used for boiling and frying. The largest value of fuel gas energy in the frying process amounting to 72,134.55 kJ. The gas energy required in the frying process is greater than in the boiling process.

3.2.3. Electrical Energy

The average consumption of electrical energy is 5,839.7 kJ, comprising of energy used in the milling process being 4,094.8 kJ or 70%, and for packaging of 1,744.9 kJ or 30%. This is because there is a difference in the time of use of the grinding machine with the packaging sealer. Also because grinding requires two grinder with two workers.

3.2.4. Raw Material Energy

Raw material energy consumption can be seen in Table 5. The largest use of input raw material energy to produce purple sweet potato crackers is in supporting energy by 50.88% (343,319.26 kJ), and the smallest use of raw material energy is in purple sweet potato energy by 6.12% (41,328.00 kJ). Supporting material consists of flour, sugar, coconut milk, and sesame.

Table 5. Input material consumption

Type of supporting materials	Energy (kJ)	Percentase (%)
Purple sweet potato	41,328.00	6.12
Cooking oil	290,175.60	43.00
Supporting material	343,319.26	50.88
Total	674,822.86	100

3.3. Output Energy

Based on the data, it can be seen that the average value of energy output obtained from the purple sweet potato cracker production process is 803,880.00 kJ, with an average production weight per day of 34.80 kg.

3.4. Energetic Performances

Table 6 presents a summary of PSP cracker production at Azizah Cracker House along with energetic performances in terms of energy ratio, energy intensity, energy productivity, and net energy. The energy ratio value obtained is 1.02, indicating that the value is already efficient. According to Kosemani & Bamgboye (2020), an energy ratio value above 1 indicates that energy is used efficiently, and a high energy ratio is associated with lower input energy usage. The energy intensity value generated in the production of purple sweet potato crackers is 22,593.75 kJ/kg. This indicates that the energy used is already efficient, as the energy output value is greater than the energy input value. According to Kartiasih *et al*. (2012), the less energy required to produce one unit of output, the more efficient the energy usage is. Conversely, the more energy needed to produce one unit of output, the less efficient the energy usage. The energy productivity value obtained is 0.000044 kg/kJ. This indicates that to produce 0.000044 kg of PSP cracker, 1 kJ of energy is used.

Table 6. Energy ratio analysis data

No	Description	Notation	Unit	Value
1	Yield weight	Y	kg	34.80
2	Input energy	E_i	kJ	786,262.33
3	Energy output	E_o	kJ	803,880.00
4	Energy Ratio	$ER = E_o \div E_i$	--	1.02
5	Energy Intensity	$EI = E_i \div Y$	kJ/kg	22,593.75
6	Energy Productivity	$EP = Y \div E_i$	kg/kJ	0.000044
7	Net Energy	$NE = E_o - E_i$	kJ	17,617.67

4. CONCLUSION

Based on the data obtained during the research, it can be concluded that the total average input energy value required during the production process of purple sweet potato crackers is 784,629.95 kJ, and the total average output energy value obtained during the production process of purple sweet potato crackers is 803,880.00 kJ. The energy gain obtained in the production of purple sweet potato crackers is 1.02 times the energy input. With the net energy obtained of 17,617.67 kJ. The cutting and frying activity requires the largest input energy of 46.18% (362,942.55 kJ), and the packaging activity requires the smallest input energy of 0.38% (2,992.33 kJ). Based on the type of energy, the largest energy is found in raw material energy, which requires an input energy of 85.83% (674,822.86 kJ), and the smallest type of energy is found in electrical energy, which requires an input energy of 0.74% (5,839.72 kJ). The energy productivity obtained is 0.000044 kg/kJ, and the energy intensity is 22,546.84 kJ/kg. This indicates that the energy used is already efficient, as the energy output value is greater than the energy input value.

REFERENCES

Al Momani, D., Al Turk, Y., Abuashour, M.I., Khalid, H.M., Muyeen, S.M., Sweidan, T.O., Said, Z., & Hasanuzzaman, M. (2023). Energy saving potential analysis applying factory scale energy audit – A case study of food production. *Heliyon*, 9(***3***), e14216. https://doi.org/10.1016/j.heliyon.2023.e14216

Darely, P. (2020). *Kusuka Keripik ubi*. NilaiGizi.com. https://nilaigizi.com/gizi/detailproduk/1629/Kusuka-keripik-ubi . Diakses Pada 03 Maret 2024

Ekafitri, R., & Faradilla. F. (2011). Pemanfaatan komoditas lokal sebagai bahan baku pangan darurat. *Pangan*, ***20***(2), 153–161.

Fatsecretindonesia. 2024. Mobile.fatsecret.co.id. https://www.fatsecret.co.id/kalori-gizi/superindo/ubi-ungu/100g?frc=True. Diakses Pada 03 Maret 2024

Ginting, E., Utomo, J.S., Yulifianti, R., & Jusuf, M. (2011). Potensi ubi jalar ungu sebagai pangan fungsional. *Iptek Tanaman Pangan*, ***6***(1), 116–138.

Kartiasih, Fitri., Syaukat, Yusman & Anggraeni, Lukytawati. 2012. Determinan Intensitas Energi di Indonesia. *Jurnal Ekonomi dan Pembangunan Indonesia*, 12(2), 192-214.

Kosemani, B. S. & Bamgboye, A. I. 2020. Energy Input- output Analysis of Rice Production in Nigeria. *Jurnal Pre-proof*. https://doi.org/10.1016/j.energy.2020.118258.

Maulana, M.D, & Saputra, R.A. (2023) Simulasi prosedur pengeluaran barang jadi (minyak goreng) pada PT. Wina 3. [*Internship Report*]. Semen Indonesia International University.

Mutiara, D. (2020). Analisis nilai tambah home indutri stik ubi ungu di Kabupaten Oku Timur. *Jurnal Bakti Agribisnis*, ***6***(2), 7–16. https://doi.org/10.53488/jba.v6i02.90

Putri, R.E., Fadhilah, R., Cherie, D., & Novianda, A.W. (2020). Analysis of energy consumption and performance test on rice planting using rice transplanter: A case study in West Sumatera Province, Indonesia. *Journal of Applied Agricultural Science and Technology*, ***4***(1), 12-25. https://doi.org/10.32530/jaast.v4i1.152

Putri, R.E., Lubis, M.I.A., Hasan, A., & Arlius, F. (2020). Realtime measurement of human labor energy for primary tillage operation in paddy cultivation. *IOP Conference Series: Earth and Environmental Science,* ***583***, 012031. https://doi.org/10.1088/1755-1315/583/1/012031

Putri, R.E., Santosa., Cahyani, G.A., Fahmy, K., Arlius, F., & Hasan, A. (2020). Comparison of performance and total energy requirement for several harvesting method of Indonesian Farmers. *IOP Conference Series: Earth and Environmental Science*, ***515***, 012004. https://doi.org/10.1088/1755-1315/515/1/012004

Qinah, E. (2009). Pengaruh Konsentrasi Gula Pasir dan Tepung Ketan Terhadap Sifat Kimia, Organoleptik serta Daya Simpan Dodol Ubi Jalar Ungu. [*Master Thesis*]. Fakultas Kesehatan Masyarakat, Universitas Sumatera Utara, Medan.

Ramanda, M.R., Nurjanah, S., & Widyasanti, A. (2021). Audit energi proses pengolahan teh hitam (CTC) dengan sistem pengambilan keputusan metode space. *Jurnal Teknik Pertanian Lampung*, ***10***(2), 183–192. https://doi.org/10.23960/jtep-l.v10i2.183-192

Rehiara, A., Musa, A.Y., & Stepanus, J.B. (2023). Energy auditing and electricity saving opportunities in BPOM Laboratory of Manokwari. *Social, Ecology, Economic for Sustainable Developmeny Goals Journal*. ***1***(1), 1–17. https://doi.org/10.61511/seesdgj.v1i1.2023.22

Rijal, M., Natsir, N.A., & Sere, I. (2019). Analysis of nutrient content in purple sweet potato flour (*Ipomoea Batatas* Var Ayumurasaki) with sunlight and oven drying. *Jurnal Biotek*, ***7***(1), 48–57.

Setiawan, A. (2022). Studi audit energi dan ekonomi budidaya tanaman bawang merah (*Allium cepa*) di Nagari Salayo Tanang, Kabupaten Solok, Sumatera Barat. [*Thesis*]. Faculty of Agricultural Technology. Andalas University.

Sugandi, W.K., Nurjanah, S., & Aji, R.P. (2018). Analisis energi pada proses pembuatan kerupuk udang (Studi kasus di PD. Sri Tanjung, Kabupaten Indramayu, Jawa Barat). *Teknotan*, ***12***(1), 87–95. https://doi.org/10.24198/jt.vol12n1.10

Syahrun, A. (2022). Studi aliran energi produksi kopi bubuk di pabrik kopi bubuk "Cap Teko" Kota Sawahlunto. [*Thesis*]. Faculty of Agricultural Technology. Andalas University.

Tomášková, T., Duda, D., Abrhám, V., Yanovych, V., & Uruba, V. (2023). The concept, approach and benefits of energy auditing and its impact on the environment. *MATEC Web Conference*, ***383***(00020). https://doi.org/10.1051/matecconf/202338300020

Wardhana, A.S.J., & Damarwan, E.S. (2023). Identification of energy saving potential through energy audit at PT. ABC. *Jurnal Edukasi Elektro*, ***7***(1), 63–74. http://dx.doi.org/10.21831/jee.v7i1.61657