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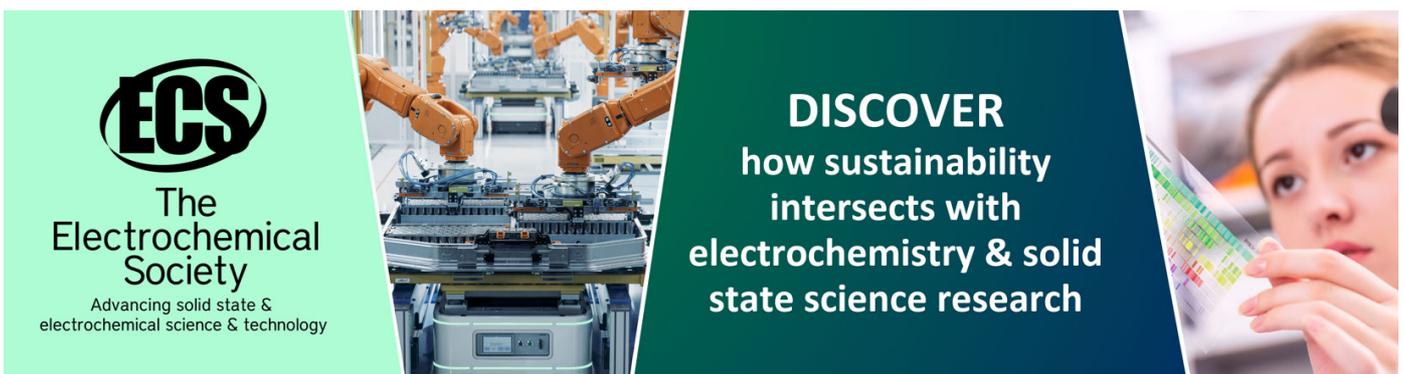
Palm sugar production from Palm tree in Gerenggam village environment, Aceh

To cite this article: M Yuzan Wardhana *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **644** 012018

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Palm sugar production from Palm tree in Gerenggam village environment, Aceh

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Abstract. This study aims to determine internal factors (strengths and weaknesses) and external (opportunities and threats) in increasing the production of brown sugar from palm oil and to formulate alternative strategic priorities in increasing palm sugar production in the palm oil palm sugar home industry. The study was conducted in Gerenggam village, Kejuruan Muda District, Aceh Tamiang Regency, in May 2019. The analysis was carried out using IFE/EFE analysis, SWOT analysis, and QSPM analysis. The results of the study indicate that there are internal factors consisting of five strengths and five weaknesses, external factors consisting of five opportunities, and five threats that affect the increase in production in the palm sugar home industry. The strategy obtained to increase the palm sap production is an aggressive strategy (SO) that is using power to get the opportunities available, the results of the QSPM analysis are the priority strategies that must be implemented to establish and enhance cooperation with the government in the use of room processing machines for efficient use of labor with the highest total TAS of 6.160.

1. Introduction

Aceh is one of the palms oil-producing regions. Palm oil was first introduced in Indonesia by the Dutch colonial government in 1848. At that time there were four palm oil seedlings planted in the Bogor Botanical Gardens, two from Bourbon (Mauritius), and two from Hortus Botanicus, Amsterdam (Netherlands). Oil palm plants began to be cultivated and cultivated commercially in 1911 in Aceh and North Sumatra [1]. The area of oil palm plantations continues to increase from year to year. The first oil palm plantations are located on the East Coast of Sumatra (Deli) and Aceh.

The palm plantations have saved a lot of potentials that have not been explored and utilized maximally by the community or companies, especially at the time of replanting or replanting young oil palm plants to replace oil palm that has not been producing optimally. The potential that can be produced by oil palm plants is quite large in addition to fresh fruit bunches (FFB) that can be processed into oil and cosmetic ingredients, the stems of palm oil plants can also produce juice of palm juice. According to Azanuddin Kurnia "oil palm aged 15 years and over can produce 3-15 L sap per month per 24 hours and is able to extract sap for 2-3 months" [2].

In general, oil palm plants have an average age of 20-25 years. Generally, at the age of 25-30 years, oil palm plants will experience a decline in the production function. This is due to the aging plant, its quality will decrease. Thus, good quality palm oil plants will continue to produce until they reach the age of 25 years. The age of an oil palm can indeed reach one hundred years, but its production age is only 25-30 years. After the age of 25 years, the production of palm oil will decrease. Therefore, after the age of 25 years oil palm plantations need replanting or replanting again [3].

Data from the Aceh Agriculture and Plantation Office [4] based on an Aceh Agriculture and Plantation Service decree with the Republic of Indonesia Directorate General of Plantations No. 61 / Hk.210 / VIII / 2018 states that the quota for replanting oil palm land for Aceh in 2018 reached 12,260 hectares with details: 1,502 ha in Nagan Raya, 950 ha in Aceh Singkil, 1,110 ha in Aceh Barat, 1,650 in



Aceh Utara, 1,200 ha in East Aceh, 2,670 ha in Aceh Jaya and 3,178 ha in Aceh Tamiang. Aceh Tamiang has the highest quota of a number of other regions which will also be carried out a replanting program. The palm sugar home industry currently has a very good prospect to run and is expected to be able to increase the household income of the palm sugar producers themselves and also the surrounding community. Usually, the oil palm plants that have been uprooted are only used as ingredients for fertilizer. Palm juice from palm oil stems is still very rarely used by people in Indonesia because there is no clear research and information about it [5]. So far, the community, in general, is more familiar with brown sugar made from palm sugar palm juice, and still very few people know that brown sugar can also be processed from palm oil palm juice.

One palm oil can produce around Rp. 600,000 for two months from the sale of palm sugar processed from palm oil palm juice with the following calculation, if the sap produced per 24 hours is as much as 5 L from one palm sap bar, then for 2 months (60 days) a palm produces 300 L of sap and can produce 60 kg of sugar or about 20% of the yield of existing sap. The price of brown sugar at the consumer level ranges from Rp. 20,000 - 27,000 / kg, if the price at the producer level is Rp. 10,000 / kg, then for 2 months (60 days) can generate as much as Rp. 600,000 per palm oil. The potential and opportunities are huge, but there is only one producer in the Kejuruan Muda Subdistrict, Aceh Tamiang who has produced palm sugar from the palm oil sap, Mr. Sumarno who is assisted by his wife in the processing process.

The home industry of palm sugar from palm oil palm juice that is run by Mr. Sumarno still has many obstacles including the quality and sustainability of products that are not yet guaranteed, product packaging is still very simple, limited human resources, the processing is still using traditional methods and lack of technology can help the production process, as well as the amount of product, produced decreased from the previous year where the previous year the household industry was able to produce as much as 1 tonne/day of brown sugar production and marketed to the Lhok Nibong region, East Aceh. One of the causes of the decline in the amount of production is due to a decrease in the number of palm oil stems which are taken to be processed into brown sugar.

The existence of constraints and problems in the amount of palm sugar production from palm oil palm juice produced by this home industry, it is necessary to study a strategy that can be applied in order to be able to increase the amount of production so that the palm oil palm household industry is able to meet all market demand in the Aceh Tamiang region.

2. Material and Methods

The flow of research from the formulation of this strategy to increase production begins with identifying the internal environment which includes strengths and weaknesses, as well as the external environment which includes opportunity and threat factors as an input stage, knowing the internal and external conditions are expected to create an appropriate formulation or alternative strategy namely by pouring in internal factors (strengths and weaknesses) and external factors (opportunities and threats) into the SWOT matrix. Identified internal and external factors are then analyzed and used to construct the SWOT matrix as a matching stage and then analyzed by QSPM analysis to obtain priority alternative strategies.

2.1 Data collection

The location of the research was carried out in Sumber Karya Hamlet, Lorong 2, Gerenggam Village, Kejuruan Muda District, Aceh Tamiang Regency. When this research was conducted in May 2019. Primary data were obtained by conducting observations and direct interviews based on a questionnaire against the owners of the palm sugar home industry from palm oil palm juice. Secondary data were obtained from several related institutions, library research, internet, and other information related to this research.

2.2 Data analysis

Data analysis was carried out qualitatively and quantitatively. The collected data were analyzed using IFE / EFE analysis, SWOT analysis, and QSPM analysis. Data obtained from the results of the study were analyzed in stages starting with the weighting of strategic factors that influence, the results of weighting strategic factors were analyzed using a SWOT matrix and then followed by QSPM analysis. The stages of the strategy formulation used are: (1) the input or data entry stage uses the IFE and EFE matrices, (2) stage matching using IE (internal-external) matrix and SWOT matrix, and (3) the decision-making stage.

The SWOT analysis clearly illustrates how opportunities and threats faced by a company or industry can be adjusted to the strengths and weaknesses of the company or industry. In the SWOT analysis, it can be seen where the position of a company or industry is more clearly through a combination of internal and external conditions faced by the company or industry. The SWOT matrix is an important matching tool to help develop a strategy. Through the SWOT matrix, it can be clearly known the strengths and weaknesses of a company or industry is facing external opportunities and threats. The performance of a company or industry can be determined by a combination of internal and external factors of the company or industry, both factors can be considered in a SWOT analysis where SWOT compares between internal and external factors. All internal and external factors are given ratings and weights are then carried out an identification process between ratings and weights, then a sum of the scores of all factors of strengths, weaknesses, opportunities, and threats [6]

The Quantitative Strategic Planning Matrix (QSPM) is a recommended tool for strategists to evaluate objectively alternative strategies based on internal key success factors and external factors that have been previously identified [8]. QSPM analysis aims to determine the priority of the strategy and determine the relative attractiveness of feasible alternative actions [9]. The factors contained in QSPM are alternative strategies, key factors, weight, the value of attraction (AS), the total value of attractiveness (TAS), and total amount of attractiveness (AS). The steps in using QSPM analysis are as follows:

1. Make a list of key internal strengths/weaknesses and opportunities/threats written starting from the left column of QSPM.
2. Write the weights for each key internal and external factor. Weights are presented in the right-hand column of internal and external critical success factors.
3. Check the matrices by matching the values in step two and identifying alternative strategies that must be considered for implementation. The strategy is written on the top line of QSPM.
4. Determine the US score by checking one by one each internal factor and external factor. The scope of the attraction value is 1 = not attractive, 2 = somewhat interesting, 3 = interesting and 4 = very interesting.
5. Calculate the TAS score. The total value of the attraction shows that the relative attractiveness of each alternative strategy by considering the impact of the success factors of the adjacent internal or external crisis. The higher the value of attractiveness, the more attractive the alternative strategy.
6. Add up the TAS in each QSPM strategy column. The number of TAS shows the most interesting strategy in each alternative strategy set. The higher the value of the TAS, the more attractive the strategy is.

3. Result and discussion

Based on the results of the analysis of internal factors, obtained several strengths and weaknesses factors that affect the amount of palm sugar production from palm sap. The internal factors are: (1) having a strategic location, (2) the availability of raw materials, (3) the area of production can be adjusted, (4) the relationship with the suppliers of raw materials is well established, (5) producers have sufficient expertise and experience in processing palm sugar. The weaknesses factors are: (1) capital is still limited, (2) production technology is still simple, (3) limited human resources, (4) management is less effective, and (5) productivity is not stable. Based on the results of the analysis of external factors, several factors

of opportunity and threat are obtained. namely: (1) high market share opportunities, (2) government support, (3) low level of competition, (4) potential supporting regions, (5) training in palm sugar manufacturing. The threat factors that are owned are (1) changing climate conditions, (2) the product is not yet well known by the community, (3) quality standards, (4) raw materials cannot be obtained from their own land and (5) damage to oil palm stems.

3.1 IFE (Internal Factor Evaluation) Matrix

Internal factors in the form of strengths and weaknesses in the home industry of palm sugar from palm oil palm juice are then analyzed through the IFE table consisting of the weight, rating and score values presented in the following Table 1:

Table 1. IFE (Internal Factor Evaluation) Matrix Analysis

No	Internal Factors	Quality	Rating	Score (Quality x Rating)
Strength				
1	Has a strategic business location	0.085	4	0.34
2	Availability of raw materials	0.1	4	0.4
3	The area of production can be adjusted	0.09	3	0.27
4	Relationships with raw material suppliers are well established	0.1	3	0.3
5	Producers have sufficient expertise and experience in processing palm sugar	0.1	4	0.4
Sub Total Strength		0.475		1.71
Weaknes				
1	Limited capital	0.11	2	0.22
2	Production technology is still simple	0.095	2	0.19
3	Limited human resources	0.115	1	0.115
4	Ineffective management	0.11	1	0.11
5	The resulting productivity is not yet stable	0.095	2	0.19
Sub Total Weaknes		0.525		0.825
Total		1		2.54

3.2 EFE (External Factor Evaluation) Matrix

External factors are analyzed through the EFE table consisting of quality, ratings, and scores of opportunity and threat factors that arise from outside the home industry. The following table analyzes external factors s presented in Table 2:

Table 2. EFE (External Factor Evaluation) Matrix Analysis

No	Eksternal Factors	Quality	Rating	Score (Quality x Rating)
Opportunity				
1	High market share opportunities	0.105	3	0.315
2	Government support	0.11	4	0.44
3	Low level of competition	0.09	3	0.27
4	Potential supporting areas	0.11	4	0.44
5	There is training in making palm sugar	0.115	4	0.46
Sub Total Opportunity		0.53		1.925

Threat				
1	Changing climatic conditions	0.095	2	0.19
2	The product is not very well known by the public	0.095	1	0.095
3	Quality standard	0.085	2	0.17
4	Raw materials cannot be obtained from the land itself	0.11	1	0.11
5	Palm oil stem damage	0.085	2	0.17
Sub Total Threat		0.47		0.735
Total		1		2.66

3.3 IE (Internal-External) Matrix

IE matrix is used to map the position of the home industry. The IE matrix is based on the IFE total weight score on the X-axis and EFE weight score on the Y-axis. Total weight scores ranging from 1.00 to 1.99 represent weak internal positions, a score of 2.00 to 2.99 average positions, and a score of 3.00 to 4.00 is a strong position. The IE matrix places the home industry in 9 cells that contain information about the total values that have been weighted from the IFE and EFE matrices. Based on the results of weighting and rating the total score on the IFE owned by the palm sugar home industry is 2.54 and the total score on the EFE is 2.66. Then both the IFE and EFE matrices are attached to the IE matrix and the results are in quadrant V which means that the home industry can implement a hold and maintain strategy. IE matrix can be seen in Figure 1 below:

		Total Score IFE			
			Strong	Average	Weak
		4.00	3.00	2.00	1.00
Total Score EFE	High	3.00	I	II	III
	Midle	2.00	IV	V	VI
	Low	1.00	VII	VIII	IX

Figure 1. Matrix IE

Based on Figure 1. IE matrix above can be seen that the position of the home industry is in quadrant V where in this condition the palm sugar home industry can be managed with a strategy of maintaining and maintaining (hold and maintain). According to David [10], market penetration and product development are two strategies that are suitable for use in home industries that are in this quadrant V.

3.4 SWOT Analysis Diagram

Based on the results of the analysis on the IFE matrix total strength scores (subtotal strengths) were 1.71 and total weakness scores (subtotal weaknesses) were 0.825 and the second difference between the total scores between strengths and weaknesses was 0.885, while on the EFE matrix the total score was obtained opportunity (subtotal chance) is 1,925 and the total value of the threat score (subtotal threat) is 0.735 so that the second difference between the total score between the opportunity and threat is 1.19. Then the two results of the sum analysis are entered into the SWOT analysis diagram. The score on the internal factor becomes a point on the X-axis while the score on the external factor becomes the point on the Y-axis. The meeting between the X-axis point and the Y-axis point is what illustrates the position of the palm sugar home industry of palm oil. The following is a SWOT analysis diagram showing the position of the home industry as shown in Figure 2.

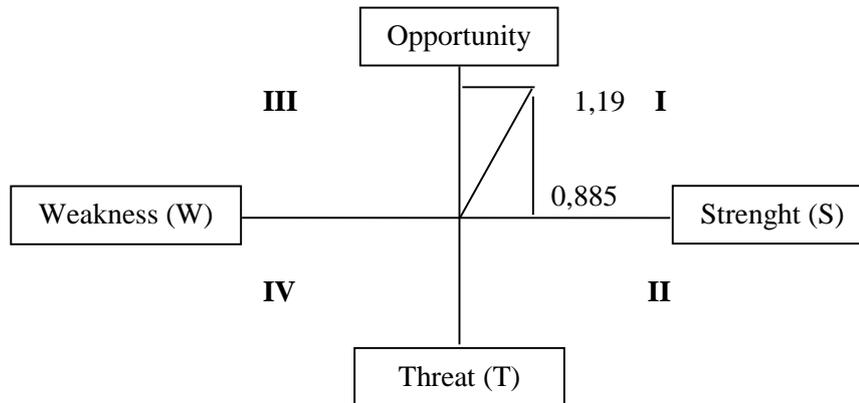


Figure 2. SWOT Analysis Diagram of Palm Sugar Home Industry

Based on the figure, it can be seen that the palm sugar home industry is in quadrant I where the meeting of internal factors with external factors is in the coordinates (0.885: 1.19). The strategy that can be applied is the SO strategy which is a strategy that uses all the power to take advantage of existing opportunities. Aggressive strategies implemented are market development strategies, market penetration, and product development. Marketing strategy is a translation of a competitive strategy, not only considered a function but must be used as a strategic business concept. Marketing strategies must be made with due regard for the entire internal and external environment of the company. The marketing strategy is very specific for each organization, this is because the internal and external factors of the company are different in each company [11]. Product development is an effort to increase sales by developing product appearance or content by reducing, enlarging, replacing, making various products, developing other models and sizes, rearranging existing performances, including developing quality [12].

3.5 SWOT (Strength-Weakness-Opportunity-Threat) Matrix

Various alternative strategies can be formulated based on the SWOT matrix analysis model. Alternative strategies that can be applied based on strengths, weaknesses, opportunities, and threats consist of four types of strategies namely SO (Strength-Opportunity) strategy, ST (Strength-Threat) strategy, WO (Weakness-Opportunity) strategy and WT (Weakness-Threat) strategy. The formulation of strategies with the SWOT matrix is compiled based on the analysis of IFE and EFE by matching the strength and weakness factors with the opportunity and threat factors, the purpose of the SWOT analysis is to collect alternative strategies used by entrepreneurs [13]. The following is a SWOT matrix a shown in Table 3.

Table 3. SWOT Matrix of Palm Sugar Households Industry

Internal	<p>Strength</p> <ol style="list-style-type: none"> 1. Has a strategic business location. 2. The availability of raw materials. 3. The area of production can be adjusted. 4. Relations with the suppliers of raw materials are well established. 5. Producers have sufficient expertise and experience in processing palm sugar. 	<p>Weakness</p> <ol style="list-style-type: none"> 1. Capital is still limited. 2. Production technology is still simple. 3. Limited human resources. 4. Management is less effective. 5. The resulting productivity is not yet stable. 	
External	<p>SO Strategy</p> <ol style="list-style-type: none"> 1. Increase the number of raw materials (S1, S2, S3, S4, S5, O1, O2, O3, O4). 2. Sharpen and improve the ability of producers by participating in training in making palm sugar (S5, O5). 	<p>WO Strategy</p> <ol style="list-style-type: none"> 1. Establish and enhance cooperation with the government in the use of roomie processing machines for efficient use of labor (W1, W2, W5, O2). 2. Enhancing human resources by encouraging communities to strengthen training in palm sugar making (W3, W5, O5). 	
	<p>Opportunities</p> <ol style="list-style-type: none"> 1. High market share opportunities. 2. Government support. 3. Low level of competition. 4. Potential supporting areas. 5. There have training making palm sugar 		
	<p>Threats</p> <ol style="list-style-type: none"> 1. Changing climatic conditions 2. The product is not very well known by the public 3. Quality standards 4. Raw materials cannot be obtained from one's own land 5. Damage to oil palm stems 	<p>ST Strategy</p> <ol style="list-style-type: none"> 1. Expanding the area of sap extraction (S1, S2, S4, T1, T4). 2. Create a Memorandum of Understanding (MOU) between producers and suppliers of raw materials (S4, T4). 	<p>WT Strategy</p> <ol style="list-style-type: none"> 1. Looking for sources of venture capital to improve production (W1, W2, W5, T2, T4). 2. Establish a good management system and best operational standards (W4, W5, T3, T5).

In the table above, it can be seen that there are several alternative strategies obtained from internal factors (strengths and weaknesses) and external factors (opportunities and threats) in the home industry of palm sugar from palm oil palm juice, namely SO strategy to increase the number of raw materials, sharpen and increase the ability of producers to participate in training in making palm sugar. The S-T Strategy expands the area of sap collection and creates an MOU between producers and suppliers of raw materials. W-O's strategy is to establish and enhance cooperation with the government in the use of roomie processing machines for efficient use of labor and to improve human resources by encouraging people to take part in training in making palm sugar. The W-T Strategy looks for sources of venture capital to improve products and establish a good management system and operational standards.

3.6 QSPM (Quantitative Strategic Planning Matrix) Analysis

QSPM analysis is a tool to evaluate the strategy to be implemented so that the results obtained can be more optimal. QSPM analysis is used for the selection of alternative strategies that are the main priority to run. The following is the result of the QSPM analysis as presented in Table 4.

Table 4. QSPM Analysis Results

No	Alternative Strategies	Total TAS	Ranking
1	Increase the amount of raw material	4,905	VI
2	Sharpen and improve the ability of producers by participating in training in making palm sugar	5,510	V
3	Establish and enhance cooperation with the government in the use of roomie processing machines for efficient use of labor	6,160	I
4	Improve human resources by encouraging people to take part in training in making palm sugar	5,620	IV
5	Expanding the area of sap extraction	4,875	VIII
6	Creating an MOU between producers and suppliers of raw materials	4,895	VII
7	Looking for sources of venture capital to improve products	6,06	II
8	Establish a good management system and operational standards	5,755	III

QSPM calculation results show the TAS value from the highest to the lowest, then it can, therefore, set priority strategies in increasing the production of brown sugar from palm sap that is recommended for implementation in the home industry in Kejuruan Muda District of Aceh Tamiang Regency sequentially are as follows:

1. Establish and enhance cooperation with the government in the use of roomie processing machines for efficient use of labor
2. Looking for sources of venture capital to improve products
3. Establish a good management system and operational standards
4. Increase human resources by encouraging people to take part in training in making palm sugar
5. Sharpen and improve the ability of producers by participating in training in making palm sugar
6. Increase the amount of raw material
7. Creating an MOU between producers and suppliers of raw materials
8. Expanding the area of sap collection

4. Conclusion

Based on the results of the study, it can be concluded that internal factors in increasing the production of palm sugar from palm oil palm juice in the palm sugar home industry are a strong factor that has a strategic business location, the availability of raw materials, the area of production can be adjusted, the relationship with good raw material suppliers, and producers have sufficient expertise and experience in processing palm sugar. Weaknesses factors are capital is still limited, production technology is still simple, limited human resources, management is less effective and the resulting product is not stable. While external factors include opportunities, namely high market share opportunities, the presence of government support, low levels of competition, the potential of supporting regions, and training in palm

sugar making. Threat factors are changing climate conditions, products are not well known by the community, quality standards, raw materials can not be obtained from their own land and damage to oil palm trunks. Based on the SWOT analysis diagram of the palm sugar home industry of palm oil palm juice is in quadrant I which means an aggressive strategy (SO) using the power that is owned to get the opportunity that exists is the right strategy to be applied. Based on the results of the QSPM analysis, the priority strategy that must be carried out by the palm sugar palm juice household industry is to establish and enhance cooperation with the government in the use of roomie processing machines for efficient use of labor with the highest total TAS of 6.160.

References

- [1] M. Pardamean, *Mengelola Kebun dan Pabrik Kelapa Sawit Secara Profesional*, Jakarta: Penebar Swadaya, 2014.
- [2] D. Imanua Aceh dalam angka. 2019. Serambi, Banda Aceh
- [3] M. Hakim, *Replanting Kelapa Sawit*, Jakarta: Penebar Swadaya, 2018.
- [4] D. P. Aceh, *Surat Keputusan Dinas Pertanian dan Perkebunan Aceh dengan Direktorat Jenderal Perkebunan Republik Indonesia Nomor: 61/Hk.210/VIII/2018*, Aceh: Dinas Pertanian dan Perkebunan Aceh dengan Dirjen Perkebunan Republik Indonesia, 2018.
- [5] J. Litana, "Karakteristik Kimia Parsial Nira Pada Beberapa Interval Waktu Pengambilan Dengan Variasi Lama Pelayuan Dari Batang Pohon Kelapa Sawit (*Elaeis Guineensis* Jacq) yang Ditumbangkan," *Program Studi Ilmu dan Teknologi Pangan Fakultas Pertanian USU*, vol. 2, no. 2, pp. 77-87, 2018.
- [6] T. d. I. Jufri, "STRATEGI PENINGKATAN PRODUKSI JAGUNG (Studi Kasus di Desa Kinepen Kecamatan Munthe Kabupaten Karo)," *Social Economic of Agriculture and Agribusiness*, vol. 4, no. 10, 2015.
- [7] H. Setyorini, "Analisis Strategi Pemasaran Menggunakan Matriks SWOT dan QSPM (Studi Kasus: Restoran WS Soekarno Hatta Malang)," *Teknologi dan Manajemen Agroindustri*, vol. 1, no. 5, pp. 46-53, 2016.
- [8] *D. Manajemen Strategis Konsep Ed Ke-12*, Jakarta: Salemba Empat, 2011.
- [9] R. A Isnaini, "Strategi Pengembangan Usaha Gula Aren di Kabupaten Aceh Tenggara," *Agribisnis Sumatera Utara*, vol. 2, no. 4, 2011.
- [10] *D. F. Manajemen Strategis Konsep*, Jakarta: Salemba Empat, 2010.
- [11] N. Putu Gede Sukaatmadja, "Strategi Pengembangan Pasar Tradisional Berbasis Kearifan Lokal Untuk Mengentaskan Kemiskinan di Bali," *Manajemen Strategi Bisnis dan Kewirausahaan*, vol. 2, no. 8, 2014.
- [12] R. P. Nanda, "Strategi Pengembangan Produk dengan Analisis SWOT dan Matriks BCG di PT. China Internasional Raya Legok," *Manajemen dan Bisnis*, vol. 1, no. 12, 2016.
- [13] C. Baroto T. dan Purbohadiningrat, "Analisis Strategi Pengembangan Bisnis PPOB KIPO Menggunakan Analisis SWOT dan QSPM," *Teknik Industri*, vol. 1, no. 15, pp. 88-102, 2014.