Passion fruit agro-industry supply chain performance assessment in North Sumatra

Kimberly Febrina Kodrat[1,*]**, Sukaria Sinulingga**[1]**, Humala Napitupulu**[1]**, Rika Ampuh Hadiguna**[2,**]

[1]Industrial Engineering Department, Universitas Sumatera Utara, Medan, Indonesia
[2]Industrial Engineering Department, Universitas Andalas, Padang, Indonesia

*kimberlyfebrina@yahoo.co.id, **hadiguna10@gmail.com

Abstract. In the agro-industry sector, supply chain management activities such as the procurement of raw materials, processing, warehousing, distribution, and transportation networks are of utmost importance. Agricultural commodities are perishable, seasonal, varying, and bulky in nature which cause difficulties in its management compared to non-agricultural products. Supply chain performance is an indicator of the success of a company. Therefore its assessment is needed to control and determine the performance feasibility of the company. This study aims at assessing the performance of the passion fruit syrup agro-industry supply chain in North Sumatra. The performance is assessed using SCOR and AHP models. The results show that the three performance assessment matrices with the highest weight are processing costs (0.165), delivery accuracy (0.146), and perfect goods condition (0.122). The supply chain performance was categorized as average (78.69%).

1. Introduction

The development of agro-industry in Indonesia is an inseparable part of the national industrial policy framework, evident from its substantial contribution (44.3% in 2017) towards non-oil and gas GDP. The feasibility of industrial development in Indonesia can be seen through the development of natural resource-based industries such as cocoa, rubber, CPO, food and beverage, steel and upstream aluminum, and seaweed (DG Industri agro, 2017). The passion fruit syrup industry is categorized in the food and beverage industry, which had a growth of 4.53% in 2017. As one of the pillars of agribusiness, agro-industry plays an important role in increasing income distribution and economic growth.

In agro-industry, many challenges and problems occur in applying supply chain management (Vorst, 2006). They emerge from the perishable, bulky, and seasonable nature of agricultural commodities. Actors in the supply chain, namely farmers as suppliers' suppliers, collectors as suppliers, transportation services as third-party logistics, processing industries as manufacturers, delivery services, distributors, and retailers will pay thorough attention to these characteristics.

Business competition, especially in agro-industry, has become increasingly tight. To survive, companies must supply the right products at the right time with the right cost. The awareness of cheap, fast, and quality products have generated the new Supply Chain Management concept in the 1990s.

Supply Chain Management (SCM) is an effective business management approach that has been a concern of academics, consultants, practitioners, and business managers in recent years (Wong and Wong, 2007). The evolution of SCM in the last decade has produced many studies concerning its performance assessment as shown by (Najmi et al, 2013).

Company performance is the realization of its goals. Many factors, including company suppliers, internal companies, distributors, and end-user consumers affect supply chain performance which is why it is an important parameter to assess.

In modern management, supply chain management is one of the concepts that can be used as a basis for performance assessment. Performance assessment plays an important role in achieving company goals on account of its functions and roles in planning, controlling, and evaluating the realization of the company goals. It will greatly contribute to performance improvement and other related programs which help to maintain the superiority of the supply chain strategy.

Given the importance of supply chain performance assessment, experts have provided various applicable performance assessment alternatives, one of which is the Supply Chain Operation Reference (SCOR) model. It was introduced by the Supply Chain Council (2008) and can be used as a basis for strategic decision making (Huan Sheoran and Wang, 2004). SCOR is a reference model of supply chain operation which is based on the process approach (process-based approach). It can objectively assess performance based on existing data and identify aspects needing improvements to create competitive advantages (Pujawan, 2015).

This method has 5 scopes, namely: 1) Plan, 2) Source, 3) Deliver, 4) Process, and 5) Return. In addition, SCOR also utilizes several dimensions, namely: 1) Reliability, 2) Responsiveness, 3) Flexibility, 4) Cost, and 5) Asset (Sillanpaa, 2011). Some of these dimensions are decomposed in several Key Performance Indicators (KPIs) that are self-determined by related industries. Therefore, in assessing supply chain performance, the determination of KPIs plays a crucial role in measuring the performance of the passion fruit syrup industry supply chain.

Therefore, it is necessary to determine the KPIs prior to assessing the passion fruit syrup agroindustry supply chain performance in order to understand the key issues so that future improvements will be on target. The next step is to provide weighting value for each KPI in order to realize performance improvements.

The passion fruit syrup industry supply chain starts from farmers as raw material suppliers, collectors, juice industries, syrup industries, and retailers. A number of problems were encountered: 1) incorrect number and time-delivery of goods, 2) delivery errors, and 3) decreasing customer demands. The performance of both the company and the suppliers has caused these problems to occur.

In order to further observe the problems occurring in the passion fruit syrup industry, research is needed on the performance assessment of its supply chain. Performance assessment is crucial in determining the efficiency of activities carried out by supply chain actors so that relevant action can be taken. It is also needed to correct problems and prevent further damage, regulate coordination to meet consumer demands (Chopra and Meindl, 2006), create an effective and efficient upstream to downstream integration (Marimin and Maghfiroh, 2010), evaluate supply chain performance in a holistic manner, determine necessary improvements to create competitive advantage (Rachman, 2014), and optimize the supply chain model.

2. Research Method

This research uses a descriptive observational method. The research steps are as follows:

1. Identifying the Passion Fruit Syrup Agro-industry Supply Chain.

This is done by observing the passion fruit syrup agro-industry supply chain and designing a framework for assessing its performance through the SCOR model.

2. Composing the SCOR process.
   SCOR includes three levels of processes to develop the Key Performance Indicator (KPI) for the passion fruit syrup industry supply chain. KPIs designed with SCOR are grouped into five dimensions, namely reliability, responsiveness, flexibility, cost, and assets (Salazar, 2012).
3. Validating the KPIs.
   Validation is carried out through in-depth interviews with experts and stakeholders in the passion fruit agro-industry chain.
4. KPI Weighting.
   Weighting is given to each KPI using the Analytical Hierarchy Process (AHP) model.
5. Assessing Supply Chain Performance.

2. 1 Level Identification in SCOR Model

The SCOR model is decomposed into three processing hierarchies equivalent to the Abolghasemi, et al (2015) model:

1. Level 1 is the highest level that provides a general definition of five important processes: plan, source, deliver, make (process), and return.
2. Level 2 is known as the configuration level, in which the passion fruit syrup agro-industry supply chain can be configured based on its core processes. It can form the current (as is) and the desired (to be) configurations.
3. Level 3 is the process element level containing process elements and references (benchmarks and best practices).

The hierarchy structure in this study was determined as follows:

1. Level 1: reliability, responsiveness, flexibility, and cost
2. Level 2: Perfect Order Fulfillment (POF), Source Cycle Time, Supply Chain Source Return Flexibility, and Adaptability, Cost to Plan
3. Level 3: Key Performance Indicator (KPI) determination

2. 2 Identifying and Determining Key Performance Indicators (KPI)

Identifying and determining the Key Performance Indicators (KPI) are the framework for the passion fruit syrup industry performance assessment. Identification is carried out through in-depth interviews and questionnaires from 3 experts representing academics, practitioners, and 5 experts representing passion fruit syrup companies based on position, education, and employment time.

The questionnaire is semi-closed questions to select KPIs that are commonly used in the supply chain performance assessments (Ulya, et al. 2017). However, open questions were also presented through in-depth interviews to provoke the emergence of new KPIs as passion fruit agro-industry supply chain performance indicators. All KPIs are transformed into hierarchical forms then weighted based on the AHP model.

2. 3 KPI Weighting through Analytical Hierarchy Process

AHP is a paired comparison matrix, where A1 in the column to the left is compared with A1, A2, A3, and so on in regard to the C property in the upper left corner. This process is repeated for column A2 and so on.

A1	A11	A21	A31....................A1n
A2	A21	A22	A23....................A2n
A3	A31	A32	A33 ....A3n
.....	.....	.....	....
An	An1	An2	An3 ....Ann

Figure 1. AHP Pairing Comparison Matrix

To fill a paired comparison matrix, a number is used to describe the importance of an element with respect to that trait. The most important thing to consider in AHP is inconsistency.

The comparison is "Perfectly Consistent" if and only if aik, akj = aij, where i, j, k = 1,2,3 ....,n. However, this consistency must not be forced even if the high level of inconsistency is undesirable. If the reciprocal matrix is consistent then ƛ max = n. Saaty (1993) defines a measure of consistency as the Consistency Index =

$$CI = \frac{\lambda maks - n}{n-1} \text{ ....(1)}$$

Description: ƛ max : the largest eigenvalue of the metric in order
n : number of criteria

For each matrix n, a random matrix was created and the following CI averages are assessed:

$$CR = \frac{CI}{RI} \text{ ....(2)}$$

Description: CR: Consistency Ratio
CI: Consistency Index
RI: Random Index

CR value of ≤ 0.1 is tolerable, anything above requires a revision. CR = 0 is "perfectly consistent".

4. Results and Discussion

4. 1 Metric Weighting for Supply Chain Performance Assessment using AHP

Weighting applies an α value of 0.5 indicating that experts have an average level of trust at the time of assessment and an ω value of 0.5 which indicates that the assessment given was neither optimistic nor pessimistic in accordance with the decision-making concept of AHP (Saaty, 2014). The results of the matrix weighting of passion fruit syrup agro-industry supply chain performance hierarchically are shown in Figure 1 and tabulated in Table 1.

Table 1. Weight of Each Supply Chain Performance Assessment Indicator

No	Performance Attributes	Performance Indicator (Matrix)	Weight
1	Business Process	Planning	0.186
		Procurement	0.202
		Cultivation	0.303
		Processing	0.169
		Delivery	0.140
2	Performance Parameters	Added Value	0.170
		Quality	0.510
		Risk	0.320
3	Performance Attributes	Reliability	0.380

		Responsiveness	0.186
		Agility	0.160
		Cost	0.275
4	Performance Matrix (Indicator)	Fully Sent Order (FSO)	0.111
		Delivery Speed (DS)	0.146*
		Perfect Item Condition (PIC)	0.122
		Raw Material Acquirement Cycle Time (RMAC)	0.109
		Processing Cycle Time (PC)	0.077
		Production Speed Flexibility (PSF)	0.111
		Production Capacity Alteration Ability (CAA)	0.049
		Processing Fee (PF)	0.165*
		Maintenance Costs (MC)	0.110

The expert assessment consistency index is 0.032, meaning that a consistent assessment was provided.

Of all the performance assessment matrices, the processing cost performance matrix (0.165) was the most weighted followed by the delivery accuracy matrix (0.146). The weighting results indicate that cost is an important factor in providing on-time deliveries.

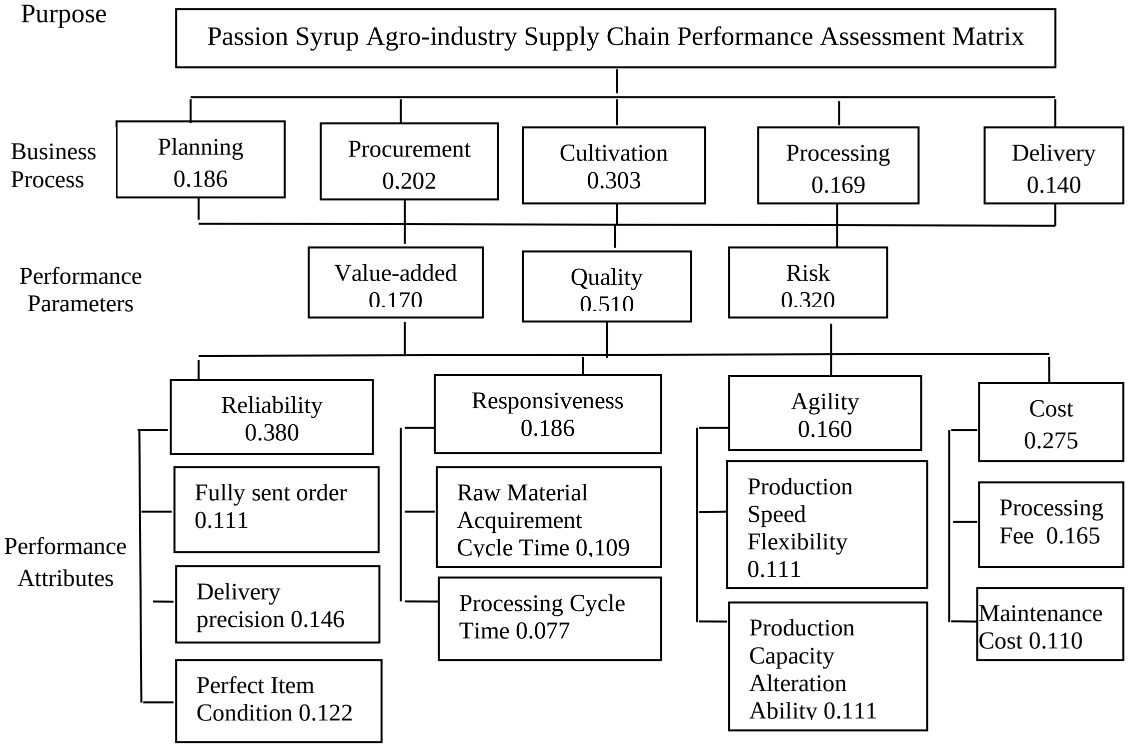

Figure 1. Hierarchy and weighting results of passion fruit syrup supply chain agro-industry performance assessment matrix

4.2. Passion Fruit Syrup Agro-Industry Supply Chain Performance Assessment

Supply chain performance was assessed using Supply Chain Operation Reference (SCOR) 11 which describes supply chain in four performance attributes, namely reliability, responsiveness, agility, and cost.

The assessment was started by creating the initial hierarchical structure based on the basic supply chain functions (plan, source, deliver, make, and return) focusing on reliability, responsiveness, flexibility, and costs. This initial hierarchy is adjusted according to the conditions of the company and integrated into several performance indicators. The performance was assessed using actual data of each supply chain actor and the weighing results of the matrices shown in Table 1. The results were categorized based on the five criteria of performance standards according to Rotaru, et al (2014). Table 2 shows the performance of each member of the supply chain.

Table 2. Performance Standards

Performance Grade	Criteria
90-100	Excellent
80-89	Good
70-79	Average
60-69	Insufficient
< 60	Poor

The actual value of each performance indicator for each of the 7 agro-industries using the percentage of the target and being integrated with the results of matrix weighting as shown in Table 3. Integration starts from the performance assessment matrix to the business process, resulting in a passion fruit syrup agro-industry supply chain performance assessment as shown in Table 4.

Table 3. Actual value of each passion fruit syrup agroindustry supply chain performance indicators

No	Indicator	Company Name						
		Dewi	Gundaling	Brastagi	GK	Sarang Tawon	Pohon Pinang	Piramid Unta
1	Fully Sent Order (FSO)	93%	95 %	97 %	98 %	97 %	96 %	97 %
2	Delivery Precision (DP)	85 %	82 %	84 %	87 %	88 %	89 %	90%
3	Perfect Item Condition (PIC)	95 %	96 %	93 %	92 %	91 %	93 %	94 %
4	Raw Material Acquirement Cycle Time (RMAC)	3 days	5 days	5 days	6 days	7 days	8 days	8 days
5	Processing Cycle Time (PC)	70 days	71 days	72 days	73 days	75 days	75 days	75 days
6	Production Speed Flexibility (PSF)	82 %	83 %	84 %	85 %	86 %	83 %	82 %
7	Production Capacity Alteration Ability (CAA)	5 days	6 days	5 days	4 days	2 days	3 days	3 days
8	Processing Fee (PF)	IDR65 / day	IDR66	IDR67	IDR68	IDR68	IDR65	IDR66/ day
9	Maintenance Costs (MC)	IDR72 / day	IDR73/ day	IDR75/ day	IDR75 / day	IDR75 / day	IDR75 / day	IDR75/ day

Table 4. Passion fruit syrup agro-industry supply chain performance

No	Supply Chain	Performance (%)	Information
1	Farmer	75.36	
2	Collector	82.99	
3	Juice Industry	81.64	
4	PT. Dewi	79.72	

5	PT. Gundaling	69.43	
6	PT. Brastagi	69.30	Lowest
7	PT. GK	82.13	
8	PT. Sarang Tawon	82.63	Highest
9	PT. Pohon Pinang	82.24	
10	PT. Piramid Unta	82.55	
11	Retailer	77.68	
	Average	78.69	

Table 4 shows that PT Brastagi has the lowest supply chain performance (69.30%). This is caused by the low value of production speed flexibility (70%). The company is unable to respond to changes in demand in a timely manner because of its small working capital. The poor quality of its distribution system has also affected its reliability attribute, in which the products are not in accordance with consumer demands. Based on field observations, there was an accumulation of passion fruit syrup in the warehouse of PT Brastagi which indicates an increase in storage (warehouse) costs. In addition to passion fruit syrup, PT Brastagi also produces other types of synthetic-based syrup to anticipate the seasonal unavailability of passion fruit. The unpredictable distribution system and market conditions are factors that affect companies in selling passion fruit syrup so that they also influence the performance of retailers.

The highest performing supply chain actor was PT Sarang Tawon with a score of 82.63%, followed by retailers with a score of 77.68%. One of the factors affecting the performance of retailers is the full sent order matrix score of 75%. In general, retailers in North Sumatra also sell synthetic-based syrup alongside passion fruit syrup. Therefore, it can be concluded that the performance of the passion fruit syrup agro-industry supply chain in North Sumatra is average (78.69).

5. Conclusions

1. Passion fruit syrup agro-industry supply chain performance in North Sumatra is in the average category, assessed using 9 performance indicators (performance matrices): full sent orders, delivery precision, perfect item conditions, raw material acquirement cycle time, processing cycle time, production speed flexibility, production capacity alteration ability, processing fee, and maintenance costs having an average score of 76.90%.
2. In carrying out passion fruit syrup agro-industry supply chain activities, information flow at the agroindustry-supplier and farmer-supplier nodes is still not well established.

Reference

[1] Abolghasemi, M., Khodakarami, V., & Tehranifard, H. 2015. A new approach for supply chain risk management: Mapping SCOR into Bayesian network. *Journal of Industrial Engineering and Management,* 8(1), 280-302.

[2] Chopra S, Meindl P. 2006. *Supply Chain Management: Strategy, Planning, and Operations*. Third Ed. Upper Saddle River, NJ (US): Pearson Prentice Hall.

[3] Hayami, Y. and Kikuchi, M.I. 1987. *Rural Economic Dilemma*. Jakarta: Yayasan Obor Indonesia.

[4] Huan, S. H., Sheoran, S. K., & Wang, G. (2004). A review and analysis of supply chain operations reference (SCOR) model. Supply Chain Management: An Int. Journal, 9(1), 23–29.

[5] Marimin, M. N. 2010. *Aplikasi Teknik Pengambilan Keputusan dalam Manajemen Rantai Pasok*. Bogor (ID): IPB Press.
[6] Najmi, A., Gholamian, M. R., Makui. A. 2013. Supply chain performance models: A literature review on approaches, techniques, and criteria. *Journal of Operations and Supply Chain Management*, 6(2), 94 – 113
[7] Pujawan, I.N. 2010. *Supply Chain Management*. Surabaya: Penerbit Guna Widya.
[8] Rotaru, K., Wilkin, C., & Ceglowski, A. 2014. Analysis of SCOR's approach to supply chain risk management. *International Journal of Operations & Production Management,* 34(10), 1246-1268.
[9] Saaty, 1991. *Pengambilan Keputusan Bagi Para Pemimpin.* (Translation). Jakarta: PT PustakaBinaman Pressindo.
[10] Salazar, F., Cavazos, J., & Nuño, P. 2012. Strengths and weaknesses of SCOR model: Supply chain biodiesel castor. In *IIE Annual Conference. Proceedings* (pp. 1-10). Institute of Industrial Engineers-Publisher
[11] Sillanpaa, I. & Kess, P. 2011. Supply chain performance measurement framework for manufacturing industries–a theoretical approach. In *MIC 2011: Managing Sustainability, Proceedings of the 12th*. Portorož: University of Primorska, Faculty of Management Koper.
[12] Supply Chain Council. 2008. SCOR Quick Reference Version 11, /SCOR Reference Guide.
[13] Sumiati, 2012. Pengukuran performansi supply chain perusahaan dengan pendekatan supply chain operation reference (SCOR) di PT Madura Guana Industri (Kamal-Madura). Yogyakarta: *Posiding Seminar Nasional Sains dan Teknologi (SNAST).*
[14] Ulya, M.A. & Jakfur, A.B. 2017. Penentuan dan pembobotan key performance indicator (KPI) sebagai alat pengukuran kinerja rantai pasok produksi keju Mozarella di CV. Brawijaya Dairy Industri.
[15] Vorst, JGAJ Van der. 2006. Performance measurement in agrifood supply chain networks: An overview. quantifying the agri-food supply chain. C. Ondersteijn, Â. J. Wijnands, R. Huirne, O. van Kooten. *Springer Science Business Media*. Chapter 2:13-24.
[16] Wigaringtyas, L.D. 2013. Pengukuran kinerja supply chain management dengan pendekatan supply chain operation reference (SCOR) (Studi kasus: UKM Batik Sekar Arum, Pajang, Surakarta). *Jurnal Teknik Industri, 5*(1), 23-28.
[17] Wong W.P. and Wong K.Y., 2007. Supply chain performance measurement system using DEA modeling. *Industrial Management & Data Systems*. Vol. 107 No. 3, pp. 361–38