Production capacity and raw material storage capacity in agriculture-based industries

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Abstract. The purpose of this study is to find production capacity and storage capacity of raw material warehouses in agriculture-based industries. It is a concern; the supply of raw materials can only be done during the harvest period while production must continue throughout the year. This case occurs in the coffee processing industry, where the supply of raw materials for the harvest period is from April to August while production must be carried out every day throughout the year. To model, the problem is used by simulation using deterministic variables. Various capacity scenarios are tested to see system performance. The results that industries with raw materials from agriculture must prepare a very large raw material storage capacity.

1. Introduction

Management the industry that has the raw material from the agricultural sector has a high difficulty. Several things influence it, such as season, harvest period, weather, and land used. The quality and quantity of raw materials produced during the harvest period depend on it [1]. Various efforts were made by researchers to improve quality [2], and quantity [3].

Research on that industrial management has been carried out by several researchers. Most researchers discuss supply chain [4-9] and handling waste produced [10-12]. The discussion on the management of the production system, which includes inventory problems and production capacity has not been widely studied. The problem of production and raw material storage capacity is important to do, considering that the characteristics of the industry are made from seasonal raw materials while production must continue throughout the year.

In this study, we will discuss the determination of production capacity and storage capacity of raw materials for seasonal products. The case studied is in small industries that produce coffee. The industry gets coffee raw materials from coffee farmers only during the harvest period, which is April to August. While producing ground coffee every day, so we have to store several raw material stocks.

The raw material must be processed before it can be stored [13,14]. Processing of coffee requires a fairly long process and requires a long time. In that industries, the production process starts from the peeling process of ripe fruit called cherry, then fermentation, washing, drying until coffee grains are produced. From coffee grains peeled with huller machines to green beans. In the form of green bean this storage is done. The time needed to get green bean is seven to eleven days depending on the weather. The processing from raw material to green bean there is a shrinkage of about 80 %, example for processing 50 kg of coffee raw material, 9.6 kg of the green bean was obtained. The final process is casting into the roasted bean and grinding into a coffee powder then packaging.
To get production capacity and raw material stock capacity in the coffee industry case, it will be done by modeling problems. In the case of handling raw materials from agro, some researchers used mathematical models [15,16] and empirical approaches to problem-solving. In the case of coffee processing, the simulation model will be used to describe the characteristics of shrinking raw materials for coffee. The production process is simulated, which is tested in several situations to obtain the production capacity and storage capacity of raw materials. The research aims to obtain maximum production capacity with minimum raw material storage capacity that can be obtained.

2. Methodology
The simulation model built will describe the coffee processing process. The description of inventory conditions in this study can be described, as shown in figure 1.

![Inventory conditions](image)

Figure 1. Inventory conditions.

In figure 1, it shows that in April until August, the raw material is procured while producing, marked by a curve that rises and falls slightly. Meanwhile, from September to March, production is marked with a downward curve, which means that inventory continues to fall. The amount of each purchase of raw materials is considered constant and is the ability of farmers to provide raw materials. The quantity of each production is considered constant, but the amount is smaller than the procurement of raw materials so that at the end of this period the supply of raw materials reaches its peak.

In September and March, the curve is depicted to continue to decline with a decrease in gradient as big as production. The decline was until March ended. The question is how much quantity each time the production must be made so that production activities can be carried out throughout the year, and how much each purchase of raw materials to achieve the conditions as in figure 1.

3. Result and discussion
The simulation results show that the condition of the green bean inventory looks like in figure 1, as shown in figure 2.
Figure 2. Green bean stock.

Figure 2 shows the condition of green bean supplies for the production capacity of 40 kg ground coffee per day and receipt of raw materials of 4500 kg cheery per week during the harvest period. The highest green bean stock in the warehouse is 8875.2 kg. This case follows the pattern of inventory in the agro-industry [17]. To obtain warehouse capacity and production capacity, simulations are carried out with several scenarios as follows:

3.1. Fixed production scenario

In this scenario tested for a production capacity of 5 kg, 10 kg, 15 kg, 20 kg, 25 kg, 30 kg, 35 kg, and 40 kg per day. This value is based on the capacity of the roasting machine that processes every 5 kg. The simulation results can be seen in table 1.

| Production Capacity Kg/day | Input Cheery Kg/week | Max Stock Kg | Inv in Last period Kg | Production Capacity Kg/day | Input Cheery Kg/week | Max Stock Kg | Inv in Last period Kg |
|---------------------------|---------------------|--------------|------------------------|---------------------------|---------------------|--------------|------------------------|
| 5                         | 1000                | 2520.6       | 1425.6                 | 25                        | 3250                | 6958.2       | 1483.2                 |
| 750                       | 1714.2              | 619.2        | 3000                   | 3000                      | 5329.8              | 244.8        |                        |
| 500                       | 907.8               | -187.2       | 2750                   | 2750                      | 5345.4              | -129.6       |                        |
| 1000                      | 3428.4              | 1238.4       | 3000                   | 3000                      | 5345.4              | -129.6       |                        |
| 1250                      | 2622.0              | 432.0        | 3500                   | 3500                      | 7059.6              | 489.6        |                        |
| 1000                      | 1815.6              | -374.4       | 3250                   | 3250                      | 6253.2              | -316.8       |                        |
| 15                        | 2000                | 4336.2       | 3500                   | 3500                      | 7059.6              | 489.6        |                        |
| 2000                      | 3529.8              | 244.8        | 4000                   | 4000                      | 7967.4              | 302.4        |                        |
| 1750                      | 2723.4              | -561.6       | 3750                   | 3750                      | 7161.0              | -504.0       |                        |
| 20                        | 2500                | 5244.0       | 4000                   | 4000                      | 8875.2              | 115.2        |                        |
| 2000                      | 4437.6              | 57.6         | 4500                   | 4500                      | 8875.2              | 115.2        |                        |

3.2. Fixed input raw material scenario

This scenario is used to see the effect of raw material inputs on stock and production capacity. The number of raw materials tested is 1000 kg, 2000 kg, 3000 kg, 4000 kg and 5000 kg. The simulation results can be seen in table 2.
Table 2. Fixed input raw material scenario.

| Input Cheery Kg/week | Production Capacity Kg/day | Max Stock Kg | Inv in Last period Kg | Input Cheery Kg/week | Production Capacity Kg/day | Max Stock Kg | Inv in Last period Kg |
|----------------------|----------------------------|--------------|------------------------|----------------------|----------------------------|--------------|------------------------|
| 1000                 | 5                          | 2520.6       | 1425.6                 | 4000                 | 20                         | 10082.4     | 5702.4                 |
| 10                   | 1815.6                     | 374.4        | 25                     | 25                   | 9377.4                     | 3902.4       |                        |
| 15                   | 1110.6                     | -2174.4      | 30                     | 10082.4              | 5702.4                     | 2102.4       |                        |
| 2000                 | 10                         | 5041.2       | 2651.2                 | 35                   | 7967.4                     | 302.4        |                        |
| 15                   | 4336.2                     | 1051.2       | 40                     | 7262.4               | -1497.6                    |              |                        |
| 20                   | 3631.2                     | -748.8       | 5000                   | 7262.4               | -1497.6                    |              |                        |
| 3000                 | 15                         | 7561.8       | 4276.8                 | 30                   | 11898.0                    | 5328.0       |                        |
| 20                   | 6856.8                     | 2476.8       | 35                     | 11193.0              | 3528.0                     |              |                        |
| 25                   | 6151.8                     | 676.8        | 40                     | 10488.0              | 1728.0                     |              |                        |
| 30                   | 5446.8                     | -1123.2      | 45                     | 9783.0               | -72.0                      |              |                        |

Feasible production capacity and storage capacity are a positive ending inventory. The results taken from the tests derived from tables 1 and 2 are those that have a minimum max stock value. Based on the first scenario, it can be seen that each increase in production capacity of 5 kg will require additional cheery raw materials of 500 kg, and a green bean warehouse of approximately 900 kg. Based on the second scenario, each increase in cheery input provides decent production capacity individually. Warehouse capacity is always about twice that of raw material inputs. If every 5 kg of ground coffee through a roasting process requires 1 hour, then the maximum production capacity is 40 kg per day, if using regular time. At that capacity, the raw material is 4500 kg per week, and a maximum stock of 8875.2 kg or warehouse capacity must be twice from the input of raw materials.

Production capacity and storage capacity are interconnected, as in research Suryaningrat [2], Damiou [4], and Parajuli [8]. In the small scale coffee industry, production capacity determines the capacity for storing and receiving raw materials. The pattern that occurs, at the lowest production capacity of 5 kg/day, the minimum capacity of the raw material warehouse is 1714.2 kg, with a minimum input of 750, and each additional production capacity will increase to around 900 kg storage capacity.

4. Conclusion

The conclusion of this research is that industries with raw materials from agriculture must prepare a very large raw material storage capacity. If seen from the case of the coffee industry, each 1 kg increase in production capacity will increase around 300 kg of warehouse capacity for raw materials.

This research has not produced an optimal value, so a mathematical model will be developed involving the cost of storage and purchase.

Acknowledgment

Thanks to Sekolah Tinggi Teknologi Garut which inspiringly support the research and publication of this article.

References

[1] Jonkman J, Bloemhof J M, Vorst J G A J Van Der and Der A Van 2016 Selecting food process designs from a supply chain perspective J. Food Eng.
[2] Suryaningrat I B 2016 Implementation of QFD in Food Supply Chain Management : A Case of Processed Cassava Product in Indonesia Int. J. Advanced Sci. Eng. Inf. Technol. 6 302–5
[3] Jonkman J, Barbosa-p A P and Bloemhof J M 2018 Integrating harvesting decisions in the design
of agro-food supply chains *Eur. J. Oper. Res.*

[4] Damião C and Morabito R 2016 Production and logistics planning in the tomato processing industry: A conceptual scheme and mathematical model *Comput. Electron. Agric.* **127** 763–74

[5] Garofalo P, Andrea L D, Tomaiuolo M, Venezia A and Castrignan A 2017 Environmental sustainability of agri-food supply chains in Italy: The case of the whole-peeled tomato production under life cycle assessment methodology *J. Food Eng.* **200** 1–12

[6] Allaoui H, Guo Y, Choudhary A and Bloemhof J 2018 Computers and Operations Research Sustainable agro-food supply chain design using two-stage hybrid multi-objective decision-making approach *Comput. Oper. Res.* **89** 369–84

[7] Sazvar Z, Rahmani M and Govindan K 2018 A Sustainable Supply Chain for Organic, Conventional Agro-food products: the role of Demand Substitution, Climate Change and Public Health *J. Clean. Prod.*

[8] Parajuli R, Thoma G and Matlock M D 2019 Science of the Total Environment Environmental sustainability of fruit and vegetable production supply chains in the face of climate change: A review *Sci. Total Environ.* **650** 2863–79

[9] Orjuela-castro J A, Sanabria-coronado L A and Peralta-lozano A M 2017 Research in Transportation Business & Management Coupling facility location models in the supply chain of perishable fruits *Res. Transp. Bus. Manag.* 0–1

[10] Sharma V, Chanda P and Bhardwaj A 2016 Green supply chain management related performance indicators in Agro industry: A Review *J. Clean. Prod.*

[11] Miranda-ackerman M A, Azzaro-pantel C and Aguilar- A A 2017 A green supply chain network design framework for the processed food industry: application to the orange juice agrofood cluster *Comput. Ind. Eng.*

[12] Jayakumar S, Yuso M M, Hashi M, Rahim A and Maniam G P 2017 The prospect of microalgal biodiesel using agro-industrial and industrial wastes in Malaysia *Renew. Sustain. Energy Rev.* **72** 33–47

[13] Wijaya A, Glasbergen P and Mawardi S 2017 The mediated partnership model for sustainable coffee production: experiences from Indonesia *Int. Food Agribus. Manag. Rev.* **20** 689–708

[14] Andri I 2018 Supply chain management of coffee commodities *MATEC Web of Conferences* vol 14003 pp 1–4

[15] Pérez-pérez A, Villamonte-cornejo J C, López-rosas C, Pérez-franco R, Gustavo M and Chong C 2019 Demand Management to Optimize the Supply Chain of an Agribusiness Company *Best Practices in Manufacturing Processes* (Springer International Publishing) pp 137–57

[16] Micale R and Scalia G La 2018 Shelf life-based inventory management policy for RF monitored warehouse *Int. J. RF Technol.* **9** 101–11

[17] Dora M, Kumar M and Gellynck X 2015 The Management of Operations Determinants and barriers to lean implementation in food-processing SMEs – a multiple case analysis *Prod. Plan. Control.* **7287**