Improvement Analysis On Optimization Production Management at Ginger Factory Using Forecasting and Production Planning Method

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Abstract
Optimization Production Management is a crucial and important component which has a critical role for controlling and affecting the production comprehensively. Process determining on each stage of production, mainly focused on production plans which start from demand and sales forecasting. Subsequently, sales forecasts will be predicted and evaluated on the appropriate inventory supply and stock. This paper proposes to obtain and gain several ways for optimizing production management for maximizing the production process and system and also yielding less waste and defect

Keywords
Ginger, Forecasting Demand, Production Planning Method, Production Management, Optimization

1. Introduction
Ginger (*Zingiberofficinale* Roscoe) belongs to the family Zingiberaceae (Wagner 1980) and genus *Zingiber*. Other names of ginger are African ginger, Black ginger, Cochin ginger, GanJiang, Gegibre, Ingwer, Jamaican ginger, and Race ginger. Turmeric, cardamom, and galangal are other notable members of the ginger family. The English botanist William Roscoe gave the plant the name *Zingiber*, derived from a Sanskrit word *singabera* which means horn-shaped due to the protrusions on the rhizome (Katzer 1999). The genus includes about 85 species of aromatic herbs from East Asia and tropical Australia (Bhatt et al. 2013).

Ginger is grown throughout South Eastern Asia, China and in parts of Japan, Austria, Latin America, Jamaica and Africa. India is the top producer of Ginger, followed by China, Indonesia, Nepal and Thailand, but the most expensive and high quality varieties come from Jamaica, Australia, and South India (Gayur and Gilani 2005). It is mentioned in ancient Chinese, Indian, and Middle Eastern periodicals and has long been valued for its aromatic, culinary, and medicinal properties (Langner 1998). Ginger is also grown as a decorative plant. Patterned foliage, deliciously perfumed flowers in a rainbow palette of colors and surprising seed pods make the ginger plant an interesting and noteworthy ornamental plant.*Cautleya, Globba, Roscoea, Kaempferia,* and *Siphonochilus Are* grown for ornamental and medicinal purpose but not for spice (Branney 2005).

Concerning the recent condition of pandemic Covid-19, ginger has become a high demand commodity in the market. Credibility of ginger efficacy that can boost the immune system effectively and maintain good health condition of the body. From the existing high demand, there is a various problem of unsynchronized supply and stock of the ginger itself. The minimum quantity of salable products will affect the consumer behavior which results in less profit and gaining loss. Inconsistency of supply chain on the production management is the main problem that needs to be correctly solved. The solution for better improvement on production management is yielding the production scheduling model. The main purpose of the production scheduling model is to find the most effective production schedules (Nurcahyo R. 2016)

1. 1 Objectives
This research aims to help ginger companies to fulfill customer demand despite the uncertainties and the fluctuating demand level in order to avoid losses on the shortage or excess production of said item. Specifically, moving average method model functions are to analyze and determine data obtained from the ginger factory production.

In addition, this research maximizes and increases the revenue of their business from the production aspect. Moreover, this paper also takes accuracy of the forecast result to be able to determine the right amount of products needed.

2. Literature Review

2.1 Jahe Hidayah

Jahe Hidayah has been encouraging people to live the highest quality of life through traditional herbal solutions. Today, Jahe Hidayah has become a trusted name for health and wellness and is recognized for its high standards of quality. This company was built with a commitment to using ingredients that can be grown in your garden and sourced from nature, and not in the laboratory. Jahe Hidayah have a quality assurance system and very strict quality control to ensure that all the materials we use up to the production process are to produce the highest quality products that are safe for consumption.

Hidayah Red Ginger is a health drink made from the main ingredients of selected red ginger. Hidayah Red Ginger has quality natural herbal ingredients packed with modern and hygienic machines. So it is very safe to drink at any time. Hidayah Red Ginger is specially formulated to give your overall health improvement. Hidayah Red Ginger has a special blend of high quality red ginger, Black Seed, ginseng, honey, secang, and other herbs that help your body absorb the essential nutrients needed to increase body immunity. Hidayah Red Ginger is made from 100% herbs and contains no preservatives, artificial colors, and artificial flavorings. Drink AMH Red Ginger every day to maintain health and increase immunity.

2.2 Time-Series

Time series is a set of data observations ordered in time. The time series method is a forecasting method using the analysis of the relationship pattern between the variables to be estimated and the time variable. Forecasting a time series data needs to pay attention to the type or pattern of data. In general, there are four types of time series data patterns, namely horizontal, trend, seasonal, and cyclical (Hanke and Winchern 2005). Horizontal patterns are unexpected and random events, but their occurrence can affect fluctuations in time series data. The trend pattern is the tendency of the data direction in the long term, it can be in the form of an increase or decrease. Seasonal patterns are fluctuations in data that occur periodically within one year, such as quarterly, monthly, weekly, or daily. While the cyclical pattern is the fluctuation of the data for more than one year.

Time Series Forecasting takes a step further, which is to predict future events, from the insights we get, from a series of events that have occurred, we can calculate events in the future, this is certainly very useful because with this we can do many things, such as anticipate what will come in the future (Ganderkusuma 2021).

2.3 Production Plan

Production planning is a plan for all production activities regarding the type of product, volume, cost, and all matters relating to how to get the product. Production planning becomes production planning for one period, so it is included in operational planning within the company.

In production planning, companies are required to be able to estimate or estimate the demand for products that are expected to be provided by the company in the future. Thus, forecasting is an integral part of production planning which is ultimately expected to become a real picture of production results.

2.3.1 Master Requirement Planning

A system which has a focus on maintaining the inventory levels as low as possible. The specific and detail of product requirements are determined and scheduled on the time of necessary need. MRP systems became a prominent approach to managing the raw material flow and components of the factory in the late 20th century (Mabert 2007). MRP should be used effectively in the process system for creating perfect system functioning. As the component on Inventory management, MRP purpose is reducing the waste inventory left on the production system.

Material Requirement Planning's function is to maintain the date of needed and date of production for reducing wastes of stock and material. MRP consists of a part and subpart, and creates the production plan of both items. This system is useful and has several advantages for manufacturers to determine accurately the analysis order, production process, and inventory management execution. The adequate inventory management will be created comprehensively. One of the inventory management methods is Material Requirement Planning (MRP) (Heizer 2014).

2.3.2 Level Strategy Production

While planning production over a period of a year, it becomes necessary to deal with fluctuation in demand month to month. One approach to planning is to change production output to match sales (i.e., chase sales). In level strategy, output is kept constant, with buildup of inventory when demand is low and inventory depletion when demand is greater than the production output (Ramadhani 2021). Constant production output incurs inventory holding and backorder costs while a chase strategy incurs costs associated with changes in output.

Many companies experience variable demand for their products. This is probably most noticeable in products that have seasonal demand patterns, such as snow blowers or lawn mowers, but demand for other products may vary appreciably throughout the year. In such cases, companies face several different options meeting demand. Generally, these options fall into two "pure strategies" – a chase strategy and a level strategy. Under the chase strategy, production is varied as demand varies. With the level strategy, production remains at a constant level in spite of demand variations (Swamidass 2000).

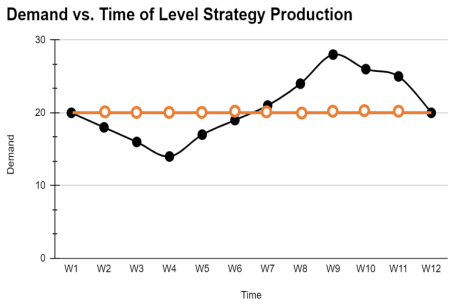


Figure 1. Demand and Time Relation of Level Strategy Production

3. Methods

3.1 Simple Moving Average

The Simple Moving Average or commonly abbreviated as SMA is the simplest Moving Average and does not use weighting in the calculation of the closing price movement (Nathania 2021). Simple moving average (SMA) is calculated by taking the average value of the price of a security at a certain time back. This calculation can be taken from the average value of the opening price, closing price, highest price, or lowest price of a security. The formula for calculating the simple moving average (SMA) indicator is as follows (Widodo and Hansun 2015).

$$SMA = \frac{v_x + v_{x-1} + \cdots + v_{x-(n-1)}}{n} \ldots (i)$$

$$\text{Where, } v_x = Value\ for\ metric\ x$$

$$n = no.of\ years\ in\ subset.$$

Figure 2. Simple Moving Average (SMA) Formula Calculation

3.2 Measurement of Forecasting Error

Different criteria such as forecast error measurements, the speed of calculation, interpretability and others have where - y is the measured value at time t, - predicted been used to assess the quality of forecasting. Forecast error measures and forecast accuracy are the most important in solving practical problems. Typically, the commonly used forecast error measurements are applied for estimating the quality of forecasting methods and for choosing the best forecasting mechanism in case of multiple objects. A set of "traditional" error measurements in every domain is applied despite their drawbacks. These error measurements are used as presets in domains despite drawbacks (Shcherbakov et al. 2013).

3.2.1 Mean Absolute Percentage Error (MAPE)

Mean Absolute Percentage Error (MAPE) is the average value of the absolute difference that exists between the predicted value and the realized value expressed as a percentage of the realized value. The use of Mean Absolute Percentage Error (MAPE) in evaluating forecasting results can see the level of accuracy of forecasting numbers and their realization. The Mean Absolute Percentage Error (MAPE) value can be calculated using the

following equation (Nabillah 2020).

$$\text{MAPE} = \frac{1}{n}\sum_{n=1}^{n} \frac{|\text{Actual} - \text{Forecast}|}{\text{Actual}} * 100\%$$

Figure 3. Mean Absolute Percentage Error (MAPE) Formula Calculation

3.2.2 Mean Absolute Deviation (MAD)

Mean Absolute Deviation is a natural scale parameter of Laplace distribution and offers a direct measure of a random variable. The Mean Absolute Deviation is the first measure of overall forecast error for a model. Heizer and Render (2014) noted that the value of mean absolute deviation is computed by taking the sum of the absolute values of the individual forecast error and dividing by the number of periods of data. Mean Absolute Deviation can be computed by the following formula.

$$\text{MAD} = \frac{\Sigma|\text{Actual} - \text{Forecast}|}{n}$$

Figure 4. Mean Absolute Deviation (MAD) Formula Calculation

3.2.3 Mean Squared Error (MSE)

Mean Squared Error (MSE) is a method to calculate the square of all errors of forecasting in each period and divided with the sum of the period of forecasting. Heizer and Render (2014) stated that MSE is a second way of measuring overall forecast error. The Mean Squared Error value can be calculated with this following formula.

$$\text{MSE} = \frac{\Sigma(\text{Forecast errors})^2}{n}$$

Figure 5. Mean Squared Error (MSE) Formula Calculation

4. Data Collection

These are collected data that were provided by the factory in 2021. Therefore the study focused on the seven main products, Which are red ginger, turmeric galangal, curcuma, nutriplus, JMP ginger cream, and SS ginger bottle. Table 1 shows the income statement that shows the Hidaya Karya Makmur factory condition 2021.

Table 1. Hidayah Karya Makmur Income Statement

Notes	Account Ammount	Total
SALES		
Red Ginger Sales	124,206,000	
Tumeric Sales	54,991,000	
Galangal Sales	21,560,000	
Curcuma Sales	21,209,000	
Nutriplus Sales	24,930,000	
JMP Ginger Creamer Sales	85,279,000	
SS Ginger Bottle Sales	14,192,500	
Good Return Sales	15,778,600	
Income		
		330,588,900
COST OF GOODS SOLD		
Red Ginger Expenses	97,800,000	
Tumeric Expenses	43,300,000	
Galangal Expenses	16,584,615	
Curcuma Expenses	16,700,000	
Nutriplus Expenses	17,807,143	
JMP Ginger Creamer Expenses	77,526,364	
SS Ginger Bottle Expenses	9,461,667	
		279,179,789
Gross Profit		51,409,111
COSTS		
Operational Costs		
Sales Wages	7,291,798	
Operational Wages	3,791,666	
Office Stationery	370,000	
Transportation Bills	2,975,000	
Electrical and Telephone Bills	877,254	
Other Business Costs	3,446,700	
Bank Administration Expenses	2,877,400	
Bank Interest Expenses	5,237,760	
Transportation Service Bills	675,000	
Promotion Expenses	-	
Total Costs		27,542,578
Net Profit		23,866,534
OTHER INCOME & EXPENSES		
Other Income	324,658	
Other Expenses	750,000	
Total Other Income & Expenses		(425,342)
Net Profit Before Income Tax		
		23,441,192

Table 2. Table of Percentage on Type Product Sales

Product Types	Sales	Sales Percentage	Cumulative Percentage
Red Ginger Sales	124,206,000	36%	36%
JMP Ginger Creamer Sales	85,279,000	25%	60%
Tumeric Sales	54,991,000	16%	76%
Nutriplus Sales	24,930,000	7%	84%
Curcuma Sales	21,560,000	6%	90%
Galangal Sales	21,209,000	6%	96%
SS Ginger Bottle Sales	14,192,500	4%	100%
Total	346,367,500	1	

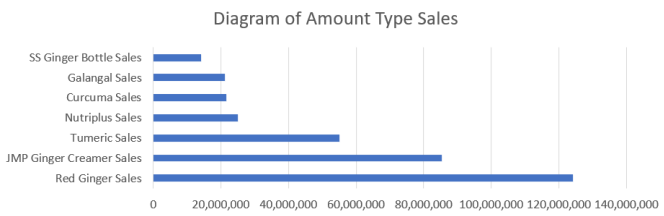


Figure 6. Diagram of Amount on Type Product Sales

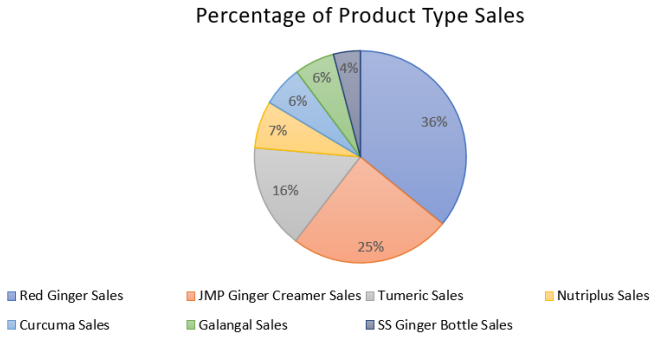


Figure 7. Diagram of Percentage on Type Product Sales

We analyzed the proportion of the product that was produced by the factory. The data were summarized and grouped by the types of products. Table 2 shows the proportion based on the type of each product. Products that were included in the cumulative percentage table are products that were repeatedly produced in the entire year. Based on the data, we can conclude that in 2021, red ginger was in highest demand at 36 % of the entire sales. Followed by tumeric in 25% sales. However the other products were not as significant as two. Figure 6 helps the visualization of significance of the products that are produced by the factory. Hence this study is to analyze a method of time forecasting using moving average models in red ginger as the highest product produced.

The powdered red ginger were made by 4 main components: watered ginger, white sugar, herb, and palm sugar. Bill of material for the powdered ginger has three levels which are level 0, level 1, level 2 as seen in the figure below. The details of components weight to make a single sachet of 20 gram powdered red ginger is shown on the Bill of Materials and quantity summary is attached on the table form below.

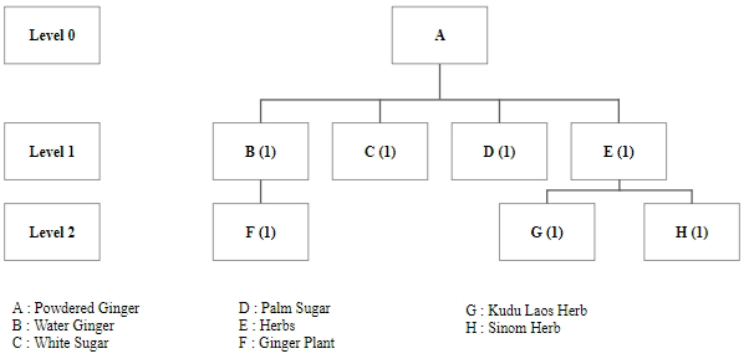


Figure 8. Bill of Materials (BOM) of Powdered Ginger Drink

As seen by Table 4 and Table 5, It can be seen from the data that the number of sales exceeds the production quantity of the factory. This proves that the factory company strategy in planning and deciding production quantities are not sufficient enough. This leads the company to have a recurring out-of-stock situation and can not create the maximum sales.

Table 3. Raw Material Requirement for one sachet of powdered ginger drink.

Material		**Quantity (kg)**
Watered Ginger		0.008
White Sugar		0.01
Palm Sugar		0.001
Herbs	Kudu Laos	0.0005
	Sinom	0.0005

Table 4. Production Quantity of Red Ginger on December 2021

Production Quantity of Red Ginger	
Desember 2021 W-1	1,864
W-2	1,862
W-3	1,290
W-4	1,269

Table 5. Demand Sales Quantity of Red Ginger on December 2021

Demand Sales Quantity of Red Ginger	
Desember 2021 W-1	1,848
W-2	1,845
W-3	1,842
W-4	1,814

5. Results and Discussion

From the data collection above, we can get the results by using a simple moving average method (SMA). Our research objective is to forecast significant products by selecting the highest demand to enable planning in the industry. We use time series model analysis for the year 2021 to show our objective.

5.1 Numerical Results

To find out whether production capacity will meet demand in January 2021, the simple moving average forecasting method is used. The simple moving average is used with 3 periods and 4 periods to find out which one is the best for the forecasting. Table 6. and Table 7. are forecasting for production volume during December 2021 and January 2022. Table 8. and Table 9. represent forecasting demand during December 2021 to January 2022.

Table 6. Forecast Production Volume 3 Periods

Desember 2021 W-1	1585.78
W-2	1675.02
W-3	1768.26
W-4	1670.56
Januari 2022 W-1	1704.61
W-2	1714.48
W-3	1696.55
W-4	1705.22

Table 7. Forecast Production Volume 4 Periods

Desember 2021 W-1	1588.78
W-2	1655.21
W-3	1721.64
W-4	1647.87
Januari 2022 W-1	1653.38
W-2	1669.52
W-3	1673.10
W-4	1660.97

Table 8. Forecast Demand 3 Periods

Desember 2021 W-1	1,859.22
W-2	1,850.65
W-3	1,847.79
W-4	1,844.93
Januari 2022 W-1	1847.79
W-2	1846.84
W-3	1846.52
W-4	1847.05

Table 9. Forecast Demand 4 Periods

Desember 2021 W-1	1,863.51
W-2	1,856.36
W-3	1,849.22
W-4	1,846.36
Januari 2022 W-1	1853.86
W-2	1851.45
W-3	1850.22
W-4	1850.48

Table 10. Value of MAPE, MAD, and MSE on Demand Forecast Error

	Ginger 3 MA	Ginger 4 MA
MAPE	1.38%	2.00%
MAD	19.62	29.77
MSE	1630.34	3118.46

From the comparison on Table 10 as supporting data, it can be seen that based on MAPE Value for forecasting demand better using the 3 periods compared to the 4 periods. The value of MAPE, MAD, and MSE on using 3 periods is lower than using 4 periods. It can be concluded that the percentage of error using 3 periods calculation on demand forecasting is getting smaller, high accuracy, and reliable.

Table 11. Value of MAPE, MAD, and MSE on Production Forecast Error

	Ginger 3 MA	Ginger 4 MA
MAPE	3.21%	3.03%
MAD	48.1	49.2
MSE	12878.9	11747.7

By establishing these two criteria on Table 11 of the period, we were able to determine the differences between the two methods. MAD and MSE have the same numbers, which means we're going to have to make a conclusion based on the MAPE, MAD, and MSE numbers, therefore we can conclude that the 4 periods moving average on the production forecast is better compared to the 3 periods because of lower value on the 3 indicators so the forecast will be low error, high accuracy, and reliable

5.2 Graphical Results

According to Figure 9, the line series of the actual number of demand, forecast using 3 periods, and forecast using 4 periods are showing an irregularity pattern line. The chart visualizes that there is a change in the slope of the line where the first it rises then becomes a fluctuating line. Characteristic and movement of the data chart based on actual numbers collected before.

Demand Forecast Error

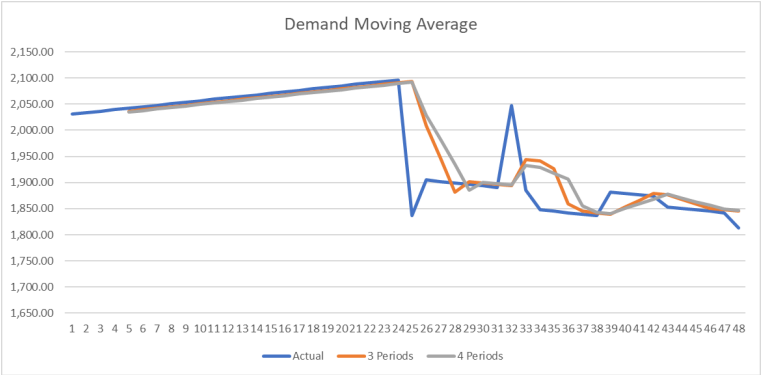
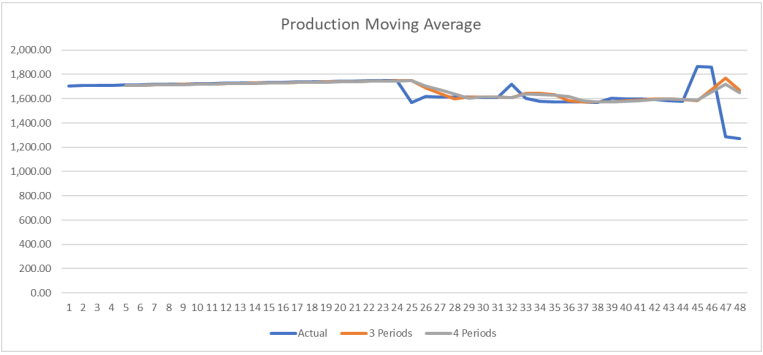


Figure 9. Demand Moving Average Graphs in actual condition, 3 periods calculation, and 4 periods calculation



Production Forecast Error

Figure 10. Production Moving Average Graphs in actual condition, 3 periods calculation, and 4 periods calculation

Figure 10 shows the result of the Single Moving Averages method of MAPE, MAD, and MSE which calculates the average of historical data in two different ways, moving averages method in 3 and 4 month. The trend of this type of product indicates a relatively stable high production and it eventually decreased in the last 4 weeks of 2021.

5.3 Proposed Improvement

Using forecasting analysis for production capacity volume and customer demand sales from Single Moving Average method, the production process of the ginger factory will be optimized. Comparison using multiple points of view of the calculation including 3 period calculation and 4 calculation will visualize the better method for the certain data, either production capacity volume, or customer demand sales. By doing several methods on forecasting, the gap on the excess production and sales will be reduced and minimized so the manufacturing and economical process will be effective and efficient.

Table 12. MRP of Watered Ginger in January 2021

Lead time: 0 Lot Size: Multiplication 0f 4

Watered Ginger		Week			
		JAN 2022 W-1	JAN 2022 W-2	JAN 2022 W-3	JAN 2022 W-4
Gross Requirement (pcs)		1848	1847	1847	1847
Project On Hand Inventory (pcs)	0	0	1	2	3
Net Requirement (pcs)		1848	1847	1846	1845
Planned Order Receipt (pcs)		1848	1848	1848	1848
Planned Order Receipt (kg)		14,784	14,816	14,784	14,752
Planned Order Release (kg) *		14,784	14,816	14,784	14,752

*1 sachet of red ginger = 0,008 kg watered ginger

Table 13. MRP of White Sugar in January 2021

Lead time: 0 Lot Size: Multiplication 0f 4

White Sugar		Week			
		JAN 2022 W-1	JAN 2022 W-2	JAN 2022 W-3	JAN 2022 W-4
Gross Requirement (pcs)		1848	1847	1847	1847
Project On Hand Inventory (pcs)	0	0	1	2	3
Net Requirement (pcs)		1848	1847	1846	1845
Planned Order Receipt (pcs)		1848	1848	1848	1848
Planned Order Receipt (kg)		18,48	18,48	18,48	18,44
Planned Order Release (kg) *		18,48	18,48	18,48	18,48

*1 sachet of red ginger = 0,01 kg white sugar

Table 14. MRP of Palm Sugar in January 2021

Lead time: 0 Lot Size: Multiplication 0f 4

Palm Sugar		Week			
		JAN 2022 W-1	JAN 2022 W-2	JAN 2022 W-3	JAN 2022 W-4
Gross Requirement (pcs)		1848	1847	1847	1847
Project On Hand Inventory (pcs)	0	0	1	2	3
Net Requirement (pcs)		1848	1847	1846	1845
Planned Order Receipt (pcs)		1848	1848	1848	1848
Planned Order Receipt (kg)		1,848	1,848	1,848	1,848
Planned Order Release (kg) *		1,848	1,848	1,848	1,848

*1 sachet of red ginger = 0,001 kg palm sugar

Table 15. MRP of Herbs in January 2021

Lead time: 0 Lot Size: Multiplication 0f 4

Herbs		Week			
		JAN 2022 W-1	JAN 2022 W-2	JAN 2022 W-3	JAN 2022 W-4
Gross Requirement (pcs)		1848	1847	1847	1847
Project On Hand Inventory (pcs)	0	0	1	2	3
Net Requirement (pcs)		1848	1847	1846	1845
Planned Order Receipt (pcs)		1848	1848	1848	1848
Planned Order Receipt (kg)		0,924	0,924	0,924	0,924
Planned Order Release (kg) *		0,924	0,924	0,924	0,924

*1 sachet of red ginger = 0,0005 kg herbs

The MRP of watered ginger, white sugar, palm sugar, and herbs is calculated to satisfy the following demand in January 2022. The usage of Material Requirements Planning (MRP) in determining the production quantity and inventory level is a form of improvement strategy that was used to prevent out-of-stock situations in January 2022. The company can better determine the production quantity because of the data that was forecasted. The forecasted categories were forecasted demand, inventory, and net requirement. Using these calculations, the company can prevent the occurrence where the quantity of materials exceeds the amount needed for production. Decrease in the number of unmet demands will increase the amount of products sold, which would result in the company's overall profit.

5.4 Validation

Table 16. Error summary of the forecasted data and the average of actual data

	Demand 3 MA	Demand 4 MA	Production 3 MA	Production 4 MA
MAPE	1.38%	2.00%	3.21%	3.03%
MAD	19.62	29.77	48.1	49.2
MSE	1630.34	3118.46	12878.9	11747.7
Actual Average Data		1,967.79		1,661.78

The error shown by the value of MAPE, MAD, and MSD are the accuracy that were measured by being the most common measurement in forecast error. Table 16 shows that among the other data being measured, the MAPE of demand and production that were forecasted has low inaccuracy. Demand forecast has under 2% error and production forecast has below 3,5 % error. We can conclude that a single moving average can be used to forecast demand and production capacity in a red ginger drink company.

6. Conclusions

In this research, after analyzing the graphic for the forecasted data and actual data, the errors were calculated to measure the difference between forecasted data and actual data. From the previous numerical results, we concluded that the graph for demand was inconsistent and had an irregular pattern and the pattern of production has decreased in the past 4 weeks. The factory is using the Make-To-Order (MTO) method and as a result, the production demand does not follow a predictable pattern. When using a moving average model, it works the best when the data has a reasonably linear trend and follows a definite pattern. However, in this particular company, our data does not reveal a significant pattern or any linear trend as moving average models simply smooths out the variation in the results.

The accuracy of various statistical techniques and MAPE predictors were studied in this paper. For the purpose of researching that, we gather the data of 1 year sales and capacity of production at this company. Based on the number of MAPE, MAD, and MSD that have been calculated, we estimated that the number of MAPE is less than 5% for the demand and production of red ginger drink. The forecast accuracy was enough to show that the forecast was fairly accurate.

According to our calculation in production planning, we can see that the company has a problem in stock management and has many occurances in out-of-stock situations. Using Material Requirement Planning (MRP), the company can decrease the chance the products stocks outs and ensure the materials are always available when needed. This strategy can increase the overall profit of the company and decrease the chance of having an ineffective production.

References

Bhatt, Neeru & Waly, Mostafa & Musthafa, Mohamed Essa & Ali, Amanat. *Ginger: A functional herb* 2013.

Branney, *TME. Hardy gingers: Including Hedychium, Roscoea, and Zinziber (Royal Horticulture Society Plant Collector Guide.* 2005.

Gandesrukma, N.C., Sanjaya, B.P., Damayanti, A., Nurcahyo, R. *Implementation of Time Series Forecasting Using Single Moving Average Model-A Case Study in Printing Industry.* https://www.scopus.com/inward/record.uri?eid=2-s2.0-85125889723&partnerID=40&md5=6e8f2a113d9f0b2b5a72dd75aa3a360f. 2021.

Gayur MN, Gilani AH. *Species differences in the prokinetic effects of ginger*. *Int. J. Food Sci. Nutr*. 57: p65-73. 2005.

Hanke, Winchern , Journal of Business Forecasting, doi.org/10.1016/0169-2070(96)88199-4. 1996.

Heizer, J. Render, B. *Operation Management: Sustainability and Supply Chain Management (11 ed.)*. 2014.

Junaidi. *Estimasi Dan Pemilihan Model Dengan Minitab (Seri 3 peramalan)*. Retrieved April 27, 2022, from https://junaidichaniago.wordpress.com/2009/03/14/estimasi-dan-penentuan-model-dengan-minitab-seri-3-peramalan/. 2009

Katzer, G.http://www-ang.kfunigraz.acat/katzer/engl/generic_framehtml?Zing_off.html. 1990.

Langner E, Greifenberg S, Grunwald J. *Ginger: History and use. Advances in Therapy*, 15; p25-44. 1988.

Mabert, Vincent A. *The early road to material requirements planning. Journal of Operations Management, Vol.25, Issue 2*, p346-356. 2007.

Nabillah, Ida & Ranggadara, Indra. *Mean Absolute Percentage Error untuk Evaluasi Hasil Prediksi Komoditas Laut. JOINS (Journal of Information System)*. 5. 250-255. 10.33633/joins.v5i2.3900. 2020.

Nathania, C.J., Iskandar, F.R., Wicaksonoputra, A.F., Nurcahyo, R. *Production Planning Forecasting using Single Moving Average and Exponential Smoothing Method in PT. Semen Indonesia*. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85125938055&partnerID=40&md5=3096aa2af05cbf1ad96d1b5d9d4b2d04. 2021.

Nurcahyo, R., Rachman, A., Agustino, T. *Production efficiency improvement through preventive maintenance and production scheduling optimization. Proceedings of the International Conference on Industrial Engineering and Operations Management*. 2016. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85018440291&partnerID=40&md5=5f575e0b287afb2493d74869d507a839. Accessed on 24 April 2022.

Ramadhani, S., Salsabila, S., Goeltom, S.O.A., Nurcahyo, R. *Improving Production Planning Strategy in Micro Enterprises*.https://www.scopus.com/inward/record.uri?eid=2-s2.0-85125893481&partnerID=40&md5=b124e696ba78fc1a89bd6117ec28d67f. 2021.

Shcherbakov, Maxim & Brebels, Adriaan & Shcherbakova, N.L. & Tyukov, Anton & Janovsky, T.A. & Kamaev, V.A. *A survey of forecast error measures. World Applied Sciences Journal*. 24. p171-176. 10.5829/idosi.wasj.2013.24.itmies.80032. 2013.

Swamidass P.M. *Encyclopedia of Production and Manufacturing Management*. Springer, Boston, MA. https://doi.org/10.1007/1-4020-0612-8_506. 2000.

Wagner H. *Pharmazeutische Biologie. drogen und ihreinhaltsstoffe*. Stuttgart: Gustav fischerVerlag. 1980.

Widodo, David & Hansun, Seng. *Implementasi Simple Moving Average dan Exponential Moving Average dalam Menentukan Tren Harga Saham Perusahaan*. ULTIMATICS. 7. 113. 10.31937/ti.v7i2.354. 2015.

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