Demand forecasting of button mushrooms using qualitative and quantitative methods at PT. S

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Abstract. Indonesia is one of the countries with an extraordinary natural wealth of plants, one of which is mushroom plants. Button mushroom is one type of mushroom that most people favour. PT. S is a company that produces button mushroom products. The company performs demand forecasting using qualitative methods to fulfil consumer demand, benefiting production, raw material, and planting planning. This research aimed to compare the result of demand forecasting for 2021 by the company and demand forecasting using the ARIMA method as quantitative forecasting. The best ARIMA model was ARIMA (1,1,1) with a p-value of 0.000 and an MSE of 1.32. The results of demand forecasting using the ARIMA method were closer to the actual data than that of by the company. The total actual sales data from January – April 2021 is 150,958 kg. The difference between the total actual sales data and demand forecasting using the qualitative method is 2,277 kg, meanwhile, the difference between the total actual sales data and demand forecasting using the ARIMA method is 596 kg.

1. Introduction

Indonesia is a country that has abundant resources. Abundant natural resources consist of various types, one of which is plant natural resources. Its very fertile soil becomes an advantage in processing plant natural resources. One of the natural plant resources found in Indonesia is mushroom plants. A large variety of mushrooms have been utilized traditionally in many different cultures to maintain health and the prevention and treatment of diseases through their immunomodulatory and antineoplastic properties. In the last decade, the interest in the pharmaceutical potential of mushrooms has been increased rapidly, and it has been suggested that many mushrooms are like mini-pharmaceutical factories producing compounds with miraculous biological properties [1]. In addition, the expanded knowledge of the molecular basis of tumorigenesis and metastasis has allowed the discovery of new drugs against abnormal molecular and biochemical signals leading to cancer [2]. Mushrooms and fungi produce more than 100 medicinal functions and the key medicinal uses are antioxidant, anticancer, antidiabetic, antiallergic, immunomodulating, cardiovascular protector, antcholesterolemic, antiviral, antibacterial, antiparasitic, antifungal, detoxification, and hepatoprotective effects; they also protect against tumour development and inflammatory processes [3].

PT. S is a company that was founded on March 2, 1992, in Probolinggo, East Java. This company is engaged in food processing in cans or sterile plastic packaging. One of the products processed by this company is button mushrooms. Button mushrooms are processed by salting and packaged using cans. PT S already has a process that follows GMP (Good Manufacturing Practices), HACCP (Hazard
Analysis of Critical Control Point), BRCGS (British Retail Consortium Global System) quality system, and halal quality assurance.

Button mushroom products by PT. S is produced in specific quantities to meet a large number of consumer demands. The amount of production carried out by the company is certainly not done without consideration. The considerations made are adjusted to the amount of demand for consumer products in the future. The activity to estimate the amount of demand for goods or services in a certain period is to use demand forecasting [4]. Demand forecasting is a way to know the estimated demand at a specific time to run the production process effectively. Demand forecasting is also the beginning of several other plans such as raw material planning, HR planning, production planning, marketing planning, and other planning [5]. Demand forecasting has 2 methods, namely qualitative methods and quantitative methods. According to [6], quantitative methods use more informative models than qualitative methods based on subjective assessments. Demand forecasting is applied to every industry that has many functions, such as production planning, raw material planning, and seeing the company’s potential in the future.

This paper aimed to discuss and compare two forecasting methods: a qualitative method based on the company’s decision and a quantitative method using the ARIMA method. This time series technique makes very few assumptions and is very flexible. It is theoretically and statistically sounds in its foundation, and no a priori postulation of models is required when analyzing failure data. ARIMA models are, in theory, the most general class of models for forecasting a time series which can be made to be “stationarity” by differencing (if necessary), perhaps in conjunction with nonlinear transformations such as logging or deflating (if necessary) [7].

2. Material and methods
The ARIMA method is used as a quantitative method to forecast the demand for button mushrooms, while the qualitative method uses opinions from the PPIC and the marketing department. The PPIC and the marketing department will discuss forecasting demand in the following year.

The ARIMA method is a forecasting method that uses time-series data based on the statistical theory that develops by finding data series patterns and then implementing them in the future. The ARIMA model has several stages. First, by doing a stationarity test of the data on the variance, if it is not stationary it will be transformed. Second, the data is stationarity in the mean, if it is not stationary, differencing will be performed. Third, identify the ACF and PACF models to estimate the ARIMA model parameters. Fourth, perform a diagnostic test of the model to ensure that the model is correct, if it is not correct, other models will be searched. Fifth, by using the model to forecast [8].

The ARIMA model is often used for non-stationarity data observations [9]. The use of the ARIMA is appropriate because the sales data of button mushrooms were not stationary as seen in the discussion. The data used is sales data from January 2017–December 2020. The demand forecast to be carried out is from January 2021 to December 2021. In this demand forecasting, the product used is processed button mushrooms in units of kg.

3. Results and discussion
Time-series plots make it easier to visually see the data to determine what pattern is formed [10]. The data will be implemented on a plot and will be depicted using lines—the sales data of button mushroom products processed by PT. S has a random data pattern. The pattern of random data is due to fluctuating data [11]. The average PT. S sales of processed button mushrooms in 2017 – 2020 is 34,421 kg. The time-series plot obtained shows that the sales data is not stationary. It is because the data movement is not around the average. Furthermore, the data will be tested for stationary both means and variance. The time-series plot of the sale of processed button mushrooms can be seen in Figure 1.
3.1. Testing for stationarity invariance

The data stationarity test is an essential step in analyzing time-series data [12]. The stationarity test of the data serves to eliminate autocorrelation, which causes the data to be non-stationary. Data that has been stationary has the same mean, variance, and autocovariance at all times [13].

The data’s stationarity test on variance was carried out with a box-cox plot. The inspection is done by looking at the rounded value box-cox. The results of the stationarity test of the data on the variance in the processed button mushroom sales data can be seen in Figure 2.

In Figure 2, the box-cox plot has a rounded value of 2.00, showing that the data is not in a stationarity state based on variance because the rounded value is more than 1. If the round value equals 1, then the time series data is already stationary concerning variance [15]. If it is not fulfilled, then the data need to be transformed. Therefore, data transformation was done by changing the data by doing a power of 2 on each sales data. The data was transformed until it obtained the rounded value equal to 1. Based on the rounded value in Figure 3, it can be seen that the data is already stationary invariance because the rounded value is equal to 1.
3.2. Testing for the means’ stationarity

The stationarity test in means is carried out using the autocorrelation function (ACF) plot. ACF has a function to identify whether the data has a trend and whether the data is stationarity or not [16]. Autocorrelation itself is the correlation between the value of the variable and the value of the lag. Based on [17], the lag in ACF can describe elements of certain patterns in the data described by forming a pattern. In addition, if only the first three lags touch the red line (confidence limit), it indicates that the data is stationary (as presented in Figure 1), which shows that the data movement has not been around the average. The data must be different. If the plot slowly goes to zero exponentially, the mean data is not stationarity because it has a trend [18]. Data that is not stationary in the means and variance must be done for differencing first to obtain stationarity [19]. The ACF plot of the transformation data from the sale of processed button mushrooms can be seen in Figure 4.

After the differencing data stage, the new data will be replotted using ACF and time series plots to ensure that the data is stationary concerning the average. In Figure 5, it can be seen that the data is stationary because there is no drastic decrease after the 3rd lag and does not show an element of trend. Furthermore, from the time series plot, it can be seen that the differencing data that has been carried out is stationarity concerning the average. Meanwhile, the PACF (partial autocorrelation function) plot has a function to determine the order of autoregressive and seasonal autoregressive. The ACF after differencing, time series plot after differencing, and PACF plot can be seen in Figure 5.
3.3. Demand forecasting of button mushroom sales using ARIMA method

The ARIMA method is described by the notation (p,d,q) where p indicates the autoregressive model, d indicates the differencing, and q stands for the moving average model [8]. Determination of the ARIMA model notation used for forecasting is by looking at the autocorrelation plot of the differencing results and looking at the partial autocorrelation plot of the differencing results in Figure 5. The p notation is obtained from the lag that comes out on the differencing PACF plot, but no lag comes out so that the p notation is 1. The d notation is obtained from the number of differencing performed, namely 1. The q notation is obtained from the lag that comes out on the ACF plot of the differencing results, but no lag crosses the confidence limit lines, so the q notation is 1. There are several combinations of ARIMA models to determine the best combination, the combination models include {(1,1,1), (1,1,0), (0,1,1)}. The stages in determining the best notation are first seen from the p-value, whether it is significant or not, and after that, it is seen from the mean square error (MSE) value. Arima models are tested for significance test, if the p-value is close to 0 or below 0.05 then the model can be used for forecasting. The smaller the MSE value, the better so that the model can be used [20]. The results of the comparison of notations can be seen in Table 1.

Table 1. Combination of ARIMA.

| Model   | Type | P-Value | MSE  |
|---------|------|---------|------|
| (1,1,1) | AR 1 | 0.000   | 1.32 |
|         | MA 1 | 0.000   |      |
| (1,1,0) | AR 1 | 0.285   | 1.47 |
|         | MA 1 | 0.083   | 1.45 |
In Table 1, it can be seen that the ARIMA model that has a p-value of less than 0.05 is ARIMA(1,1,1). The model also has the smallest MSE value of 1.32. Hence, the ARIMA(1,1,1) was the best model to forecast the demand of button mushroom products. Forecasting was done to find out the number of sales from January 2021 to December 2021. The results of the forecasting can be seen in Table 2.

**Table 2.** Forecasting result of button mushroom sales from January to December 2021.

| Months       | Forecasting result of button mushroom sales (kg) |
|--------------|--------------------------------------------------|
| January      | 39,350                                           |
| February     | 37,826                                           |
| March        | 36,884                                           |
| April        | 36,302                                           |
| May          | 35,942                                           |
| June         | 35,720                                           |
| July         | 35,583                                           |
| Agustus      | 35,498                                           |
| September    | 35,445                                           |
| October      | 35,413                                           |
| November     | 35,393                                           |
| December     | 35,380                                           |
| **Total**    | **434,736**                                      |
| **Average**  | **36,228**                                       |

Forecasting with a qualitative method by the company uses the opinion of the PPIC department and the marketing department. The PPIC and the marketing department will discuss forecasting demand in the following year every October. The output of the discussion will determine the percentage for calculating the forecast from last year's sales. This forecasting will later function for mushroom planting planning, raw material planning, and production planning.

The company forecasts demand in 2021 by adding 15% of sales in 2020 while forecasting for 2020 is 10% of sales in 2019. The difference in 2020 and 2021 is adjusted to the opinion of the PPIC department and the marketing department, taking into account distributors and monthly orders from loyal customers. Hence, it can be said that in 2020, more customers will be ordering button mushroom products in PT. S and this affects the additional percentages of demand forecasting in 2021.

**Table 3.** Comparison of forecasting results between qualitative and quantitative methods with the actual data sales from January to April 2021.

| Months   | Forecasting result of qualitative method (kg) | Forecasting result of ARIMA (kg) | Actual sales data of button mushroom (kg) |
|----------|-----------------------------------------------|---------------------------------|-------------------------------------------|
| January  | 40,824                                        | 39,350                          | 26,294                                    |
| February | 34,831                                        | 37,826                          | 42,198                                    |
| March    | 32,827                                        | 36,884                          | 41,767                                    |
| April    | 39,603                                        | 36,302                          | 40,699                                    |
| **Total**| **148,085**                                   | **150,362**                     | **150,958**                               |
| **Average**| **37,021**                                    | **37,591**                      | **37,740**                                |
The results of the demand forecasting carried out by the company, and the ARIMA method are compared with the company’s actual sales data from January - April 2021 as seen in Table 3. The results of product’s demand in total using the ARIMA model is closer to the company’s actual sales than using the qualitative method. The total actual sales data from January – April 2021 is 150,958 kg and the difference between the total actual sales data and the demand forecasting using qualitative method is 2,873 kg, meanwhile, the difference between the total actual sales data and the demand forecasting result using ARIMA demand is 596 kg. Hence, the demand forecasting result using the ARIMA model has a much smaller difference than the demand forecasting done by the company using the qualitative method. The company can choose the best demand forecasting method to be used by the company by considering the factors of accuracy, cost, and convenience [21].

Forecasting results can be used as a benchmark to calculate the amount of inventory in the coming period. So far, the company has only relied on the number of requests from the central company. This can lead to an error in the form of a delay in the arrival of raw materials caused by inaccurate time for the next period so that the production process can be hampered [22].

4. Conclusions
The results of forecasting demand of button mushrooms from January to December 2021 using the ARIMA model get a total sales result of 434,736 kg with an average sales per month of 36,228 kg. Demand forecasting using the ARIMA method has different results from demand forecasting by companies using qualitative methods. In the results of forecasting demand by the company from January to April 2021, the total sales results are 148.085 kg, while using the ARIMA method, total sales are 150,362 kg, so there is a difference in sales from the two demand forecasting methods, which is 2,277 kg. Good forecasting has several criteria including accuracy, cost and convenience. Companies can choose the best demand forecast to be used by the company by considering the factors of accuracy, cost and convenience.

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