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# Forecasting coconut oil price using auto regressive integrated moving average (ARIMA) model

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**Abstract**
The study deals with the analysis of times series data on monthly wholesale prices of coconut oil in Cochin market at Kerala during January 2008 to December 2018. Augmented Dicky Fuller test was used for testing the stationarity of the series. Box- Jenkins Auto Regressive Integrated Moving Average method was used for modelling and forecasting the price of coconut oil in Cochin market. Various model selection criteria such as Akaike Information Criteria (AIC) and Schwarz Information Criteria (SIC) were used for the identification of representative model for forecasting. Analysis was done using Gretl software. The results indicated that ARIMA (1, 2, 1) model was the most adequate and efficient model for forecasting the prices of coconut oil. The results showed that there is an expectation of price of coconut oil to be in the range between ₹ 2200 to 2300 per 15 kg in Cochin market at Kerala for the period January to December 2019.

**Keywords:** ARIMA, forecast, price of coconut oil, stationary

## Introduction

Coconut (*Cocos nucifera L.*), the versatile palm popularly known as the Tree of Life, '*Kalpavriksha*', as well as 'God's Gift to Humanity'. India is the largest producer of coconut in the world with a production of 16.8 million tonnes during 2016-17, which is more than 30 per cent of the world's production. In India, coconut is cultivated in a large number of states and Union Territories but it is mainly concentrated in the coastal areas of Kerala, with an acreage share of 35.7 per cent followed by Karnataka (25.3 per cent), Tamil Nadu (22.4 per cent) and Andhra Pradesh (5.1 per cent). These four states together account for over 88.5 percent of total area, with Kerala having the highest share of production at 29.5 per cent followed closely by Tamil Nadu (28.6 per cent), Karnataka (25.4 per cent) and Andhra Pradesh (7.4 per cent). (CACP, 2018) [2]. Coconut oil is an important cooking medium in the southern parts of the country, especially in Kerala. The prices of coconut and coconut products are mainly influenced by the market prices of copra and coconut oil, which are characterized by wide fluctuations, both seasonal and cyclical. In general, coconut oil prices are influenced by demand and supply, availability of cheaper substitutes, cooking oils, availability of other vegetable oils and the policy of the Government of India related to import of edible oils. (CACP, 2018) [2]. The liberal import of cheaper edible oil and availability of palm oil at less than 60 per cent of the price of coconut oil resulted in many consumers gradually shifting to palm oil. Since the price of coconut oil in the international market is very much lower than the domestic price, the quality and the attractiveness of consumer packs are important factors to compete in the world market (Chandran and Francis, 2015) [3]. The present paper is an attempt to forecasting the price of coconut oil in Cochin (Kerala) based on monthly wholesale price of coconut oil from January 2008 to December 2018.

Bhardwaj *et al.* (2014) [1] compared the Box Jenkins Autoregressive integrated moving average (ARIMA) with generalized autoregressive conditional heteroscedastic (GARCH) models and applied them for forecasting the spot prices of Gram at Delhi market from 01 January 2007 to 19 April 2012. The Akaike Information Criteria (AIC) and Schwarz's Bayesian Information criterion (SBC) values from GARCH model were smaller than those from ARIMA model. Therefore, the GARCH was found to be better model for estimating daily price of Gram. Sharma (2015) [9] analysed the wholesale prices of wheat in Sriganganagar market of Rajasthan during 2002 to 2012. With the different model selection criteria such as root mean square error (RMSE), mean absolute deviation (MAD), mean absolute percentage error (MAPE), Schwarz's Bayesian Information criterion (SBC) and Akaike Information Criteria (AIC), the study has proved the ARIMA (1, 1, 1) model correctly predicted the future trend of the price series within the sample period of the study. A similar study by Panasa *et al.* (2017) [8] using monthly prices of maize (April 2002 to May 2017) in Telangana and found that ARIMA (2, 1, 1) model was the most adequate and efficient model. The forecasted results also showed that there were expectations of increasing maize prices in Badepalli market for the next five months (October to February). The another study by Harini *et al.* (2018) [6] analyzed the monthly cardamom (Large) Price data in Indian Market from January 2016 to December 2017 and had proved that ARIMA (2, 1, 0) model was the best fit model for forecasting the price of cardamom(large) during the period under study.

The main objective of this study was to fit an ARIMA model to the coconut oil price data in Cochin market and evaluate the efficiency of the ARIMA model on forecasting the coconut oil price from January 2019 to December 2019.

**Description of data**

The data used in this article were monthly wholesale price of coconut oil (Rs. per 15 kg) in Cochin market at Kerala. The data were collected from the publications of the Directorate of Economics and Statistics, Government of India from January 2008 to December 2018. This article mainly focused on the application of ARIMA model for modeling and forecasting of monthly wholesale price of coconut oil in Cochin with a total of 132 observations. The analysis was done using Gretl software.

## Materials and Methods

**Stationarity test**

Time series data usually contain unit root/ it is non-stationary in nature that could be spurious. If time series data is said to be stationary, its mean and variance remain the same over time. If it changes over time with some trend or pattern, then the time series is non- stationary in both mean and variance. If the time series has a unit root, the solution to transform them into stationary series by taking the difference of such time series variable.

There are various methods to test the existence of unit root. Here, Augmented Dicky- Fuller (ADF) test was used to identify the presence of unit root. The hypothesis of the model is represented as

Null hypothesis: $H_0$: $\delta = 1$ (i.e., there is unit root or the time series is non-stationary)

Alternate hypothesis: $H_a$ : $\delta < 1$ (i, e., the time series is stationary)

The model can be expressed as

$$\Delta Y_t = \beta_1 + \delta Y_{t-1} + u_t$$

Where, $Y_t$ = Actual time series value of monthly price of coconut oil, t is the time or trend variable. It is important to see the critical value of tau statistic from ADF test. If the computed absolute value of tau statistic (|τ|) exceeds the absolute critical value or Mac Kinnon Critical tau value, we reject the hypothesis of$\delta = 1$, which means that the variable is stationary. On the other hand, if the computed tau statistic (|τ|) value does not exceed the absolute critical value, we do not reject the null hypothesis, in which case the time series is non stationary. (Gujarati *et al.*, 2012) [5].

**ARIMA (Auto Regressive Integrated Moving Average) model**

In ARIMA model, AR (an Autoregressive process) represents the variables regressed on own lagged or prior values, MA (a Moving average process) is the linear combination of error terms of repeated values and I indicates the differencing process to make the variables stationary. The process of ARIMA model can be denoted as ARIMA (p, d, q) which can be expressed in the following form:

$$Y_t = \theta + \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \cdots \alpha_p Y_{t-p} + \beta_0 u_1 + \beta_1 u_{t-1} + \beta_2 u_{t-2} + \cdots + \beta_q u_{t-q} + e_t$$

where, $Y_t$ = Actual value, $u_t$= Error terms, $\alpha_i$ (i = 1, 2,…,p) and $\beta_j$ (j =1, 2,…,q) are model parameters, p and q are the number of autoregressive terms and number of moving average terms and d the number of times the series has to be differenced before it becomes stationary. The estimation of the relevant model can be carried out in a planned approach outlined by Box and Jenkins methodology (Gujarati *et al.*, 2012) [5].

**Box and Jenkins methodology**

Box and Jenkins methodology consists of four steps:

**1. Identification**

Identification means finding out the appropriate values of p, d and q.

**2. Estimation**

After identifying the appropriate ARIMA (p, d, q) model, the next stage is to estimate the parameters of autoregressive and moving average terms included in the equation.

**3. Diagnostic checking**

In order to examine whether the chosen model fits the data reasonably well, one simple diagnostic is to obtain the residuals and obtain Autocorrelation (ACF) function and Partial Autocorrelation (PACF) function of these residuals. If the residuals estimated from this model are white noise, we can accept the model.

**4. Forecasting**

The forecasts obtained from this method are more reliable than those obtained from the traditional econometric modelling.

**Auto correlation and Partial autocorrelation function**

The ACF at lags k, denoted by $\rho_k = \frac{covariance\ at\ lag\ k}{variance}$. If we plot $\rho_k$ against k, the graph we obtain is known as the population correlogram. It lies between -1 to +1, as any correlation coefficient does. Similarly, the partial autocorrelation $\rho_{kk}$ measures the correlation between the observation that are k time periods after controlling for correlations at intermediate lags (i.e., lags less than k) (Gujarati *et al.*, 2012) [5]. The theoretical pattern of ACF and PACF were shown in table 1.

**Table 1:** Theoretical pattern of ACF and PACF

| Model | Pattern of ACF | Pattern of PACF |
|---|---|---|
| AR(p) | Spikes decay exponentially | Significant spikes through lags p |
| MA (q) | Significant spikes through lags p | Spikes decay exponentially |
| ARMA (p, q) | Spikes decay exponentially | Spikes decay exponentially |

**Model Selection Criteria**

The value of Akaike Information Criteria (AIC)/ Schwarz Information Criterion (SIC) are used to compare the performance of the model and also helps to find appropriate model for forecasting. For ARIMA model it can be calculated as follow,

$$AIC = T\log(\sigma^2) + 2\,M$$

$$SIC = \mathrm{T}\log(\sigma^2) + m\,log\,(T)$$

where, T denotes the number of observation used for the estimation of parameters and $\sigma^2$ denotes the mean square error. The ARIMA model with lowest AIC/ SIC value will be more appropriate for forecasting (Lama *et al.*, 2015) [7].

**Results and Discussion**

**Stationarity test**

Stationarity test can be performed to identify whether differencing is necessary. To check the stationarity of wholesale price of the coconut oil, the ADF unit root tests was used. The result of the unit root test from real data, first difference form and second difference form of coconut oil price is shown in the Table 2. In case of real data, the p- value was greater than 5% level of significance, hence the null hypothesis of non- stationary was not rejected. So, it is necessary to look for the possible transformation to make the time series stationary. By doing the first and second differencing of the time series variable, it was found to be highly significant at 1 per cent level of significance confirming their stationarity.

**Table 2:** Augmented Dicky Fuller test for unit root

| Coconut oil price | Test statistic | 1% critical value | 5% critical value | 10% critical value | Mackinnon p-value |
|---|---|---|---|---|---|
| Real data | -1.947 | -4.030 | -3.446 | -3.146 | 0.6302 |
| First difference | -11.184 | -4.030 | -3.446 | -3.146 | 0.0000 |
| Second difference | -22.914 | -4.030 | -3.446 | -3.146 | 0.0000 |

The standard way to check for non- stationarity is to plot the time series and also its autocorrelation and partial autocorrelation function. From the Figure 1, we can visually examine the graph of the coconut oil price series over time, it has a visible trend before differencing, and after first and second differencing its variability changes over time. The correlogram and partial correlogram of the coconut oil price is shown in the Figure 2. The ACF of the price of coconut oil decayed slowly and most of the values are outside the 95 per cent confidence interval. And PACF drops dramatically, which indicates the non- stationarity of the variables. Since, differening was carried out once / twice to arrive at stationary series, the value of d in the ARIMA model may either be one or two

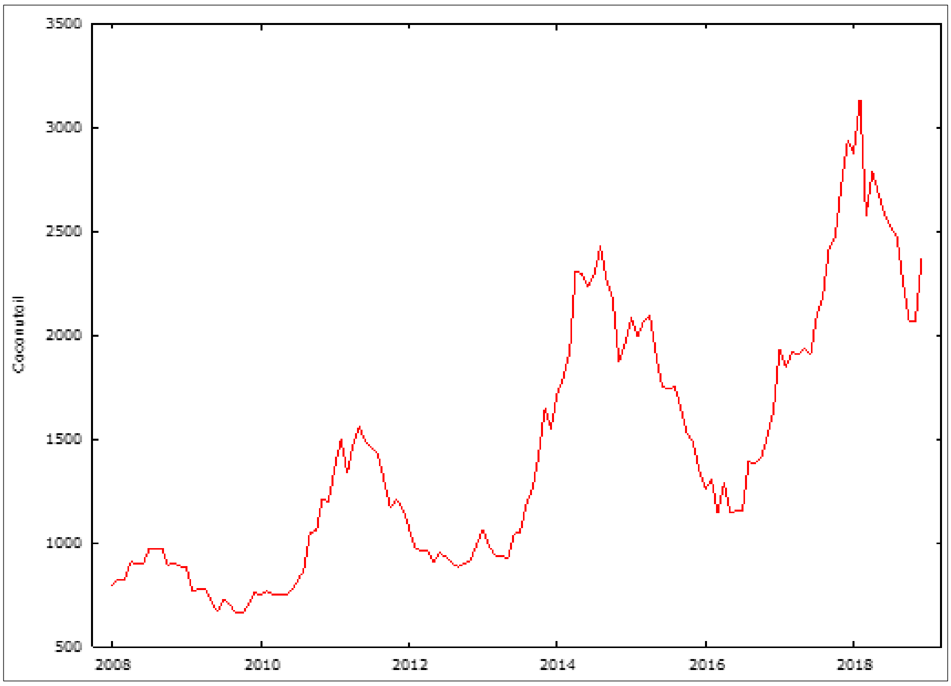


**Fig 1a:** Trend of price of coconut oil before differencing

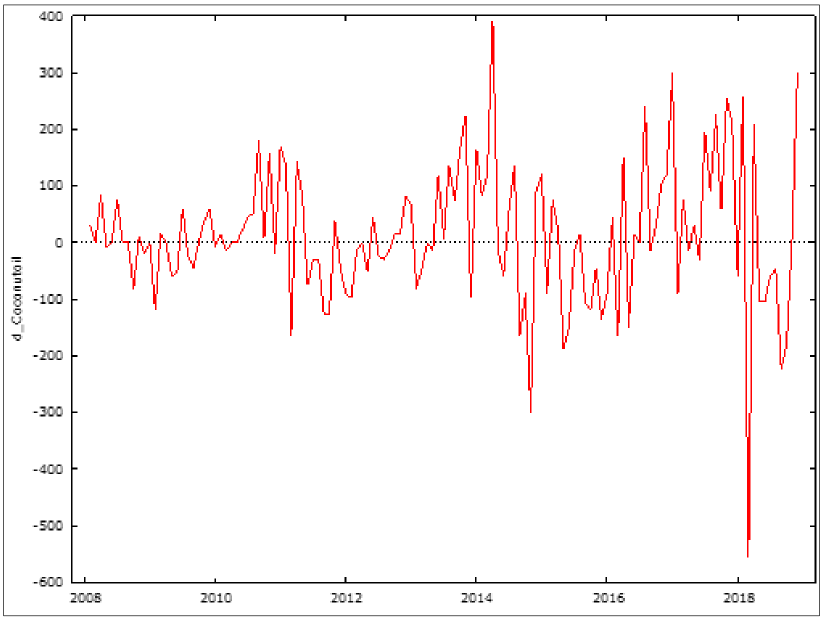


**Fig 1b:** Trend of price of coconut oil after first differencing

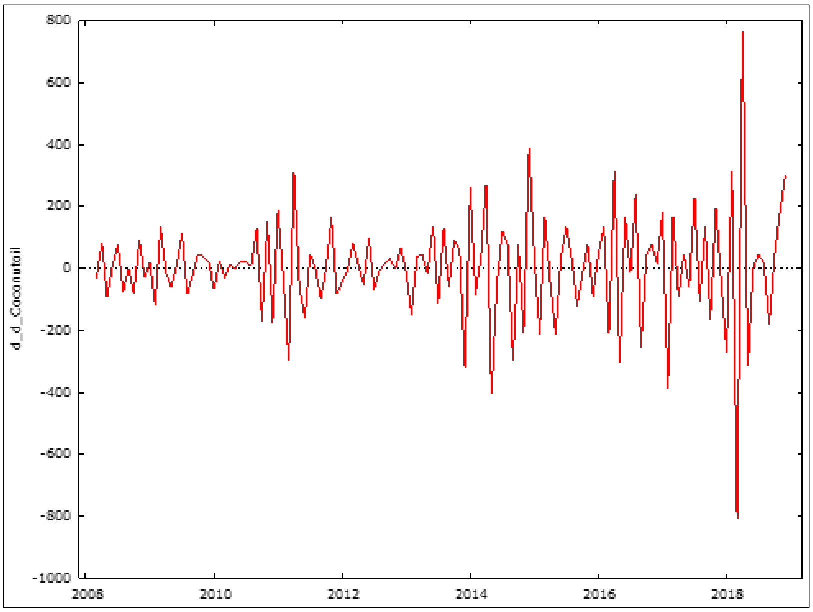


**Fig 1c:** Trend of price of coconut oil after second differencing

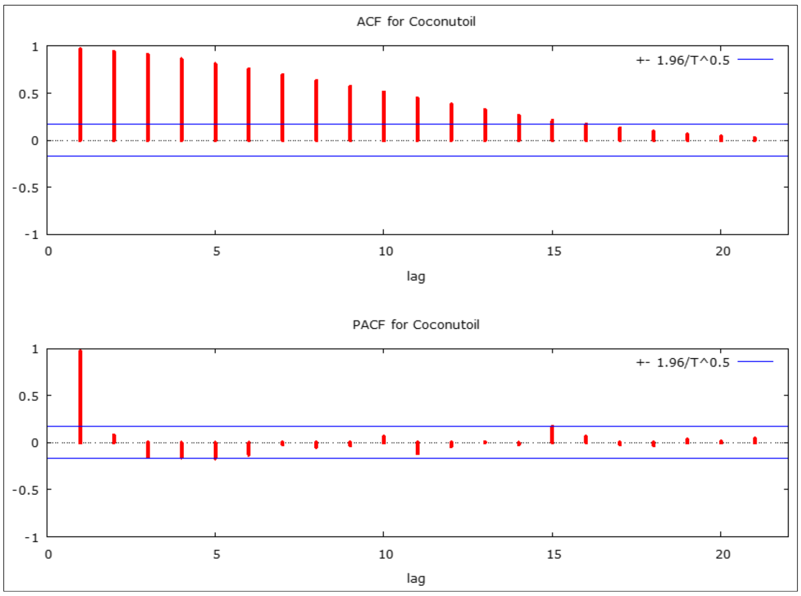


**Fig 2a:** ACF and PACF of price of coconut oil before differencing

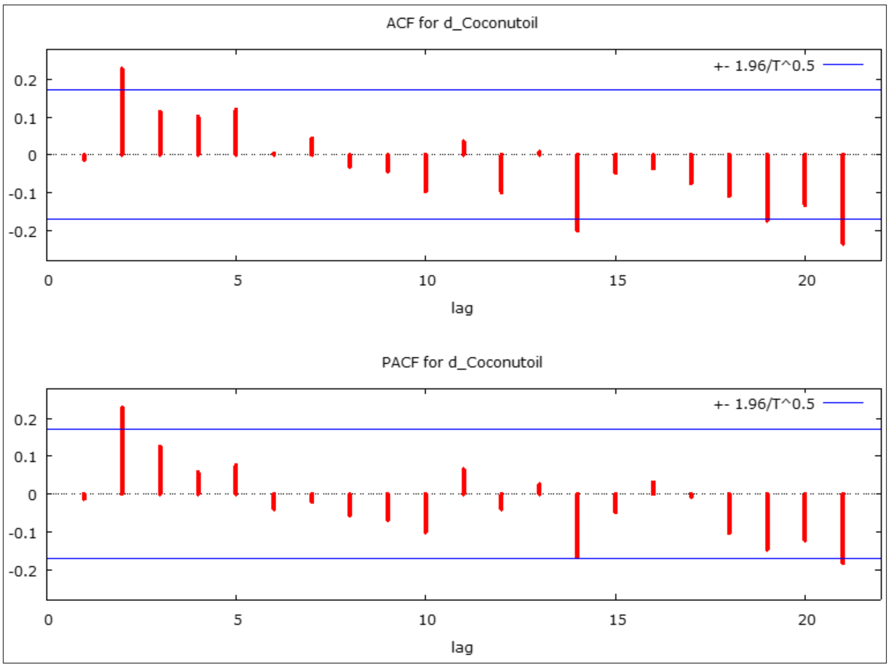


**Fig 2b:** ACF and PACF of price of coconut oil after first differencing

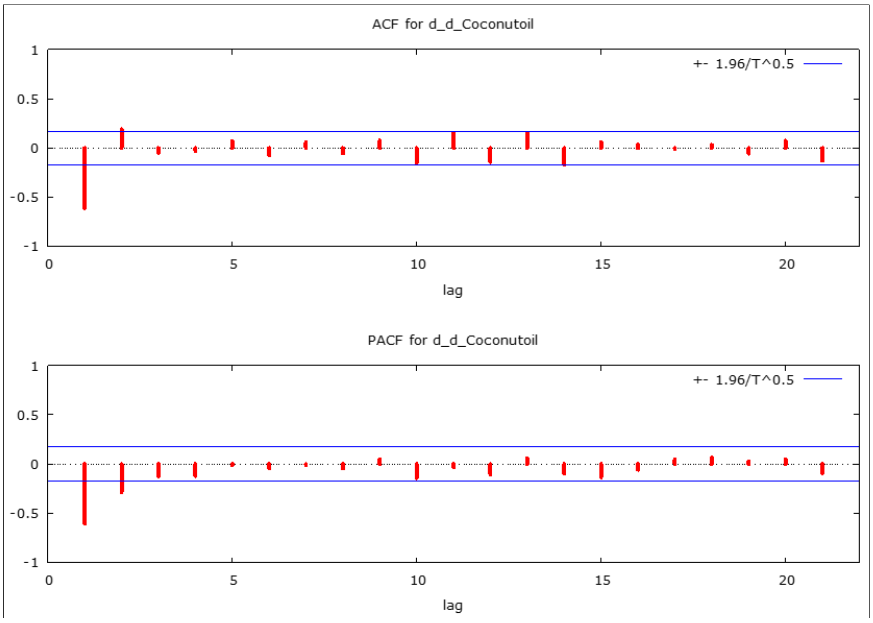


**Fig 2c:** ACF and PACF of price of coconut oil after second differencing

**ARIMA model for the price of coconut oil**

From the Table 3, we can see that the different ARIMA model with first and second order differences series viz., ARIMA(1,1,0),ARIMA(1,1,1), ARIMA(1,1,2), ARIMA(1,1,3), ARIMA(2,1,1), ARIMA(3,1,1), ARIMA(1,2,1), ARIMA(1,2,2) and ARIMA(2,2,2). The details of AIC and SIC values for different ARIMA model are also given in the Table 3.

Among the different ARIMA model, ARIMA (1, 2, 1) was found to have low Akaike Information (AIC) and Schwarz Information Criterion (SIC) as 1632.247 and 1643.718 respectively. The coefficient of AR process in ARIMA (1, 2, 1) model is significant at 5 per cent level and the coefficient of MA process is significant at 1 per cent level. The autocorrelation and partial autocorrelation of various order of the residuals of ARIMA (1, 2, 1) upto 21 lags were computed as shown in the figure 3. The auto correlation and partial autocorrelation at lag 14 and 21 were significantly different from zero and fell slightly outside the 95 % confidence interval. Hence, except lag 14 and 21, autocorrelation was absent in the residuals. Overall, ARIMA (1, 2, 1) model was the most appropriate and efficient model for forecasting the monthly price of coconut oil during January 2019 to December 2019.

Figure 4, shows the comparison of actual and the forecasted value of price of coconut oil during the post sample forecast period i.e., from January 2008 to December 2018. The result showed that the predicted value of price of coconut oil does not differ much from the actual value of price of coconut oil. The result of ARIMA (1, 2, 1) model revealed the price forecasting of coconut oil from January 2019 to December 2019 as shown in the Table 4. The forecasted results showed that there is an expectation of price of coconut oil in the range between ₹ 2200 to 2300 per 15 kg in Cochin market at Kerala.

**Table 3:** Different ARIMA model for the price of coconut oil

| Models | Coefficients of AR process | Coefficients of MA process | Log likelihood | AIC | SIC |
|---|---|---|---|---|---|
| ARIMA(1,1,0) | -0.0130 | - | -817.1334 | 1640.267 | 1648.892 |
| ARIMA(1,1,1) | -0.6073* | 0.5379 | -816.6587 | 1641.317 | 1652.818 |
| ARIMA(1,1,2) | 0.7038*** | -0.7697***<br>-0.2467*** | -812.0534 | 1634.107 | 1648.483 |
| ARIMA(1,1,3) | 0.7002*** | -0.7662***<br>0.2441***<br>0.0046 | -812.0525 | 1636.105 | 1653.356 |
| ARIMA(2,1,1) | 0.4288***<br>0.2496*** | -0.4811** | -812.2169 | 1634.434 | 1648.810 |
| ARIMA(3,1,1) | 0.3263<br>0.2396***<br>0.5300 | -0.3853 | -812.1431 | 1636.286 | 1653.537 |
| ARIMA(1,2,1) | -0.2608** | -0.7233*** | -812.1237 | 1632.247 | 1643.718 |
| ARIMA(1,2,2) | -0.3748 | -0.6051* | -812.0714 | 1634.143 | 1648.481 |
| ARIMA(2,2,2) | -1.1659***<br>-0.2656** | 0.1823<br>-0.6337*** | -811.9567 | 1635.913 | 1953.119 |

Note: * Significant at 10 per cent level, ** Significant at 5 per cent level, *** Significant at 1 per cent level

**Table 4:** Forecasts of price of coconut oil in Cochin

| Observation | Forecast | Std. Error | 95% confidence interval | |
|---|---|---|---|---|
| January 2019 | 2289.84 | 124.427 | 2045.97 | 2533.71 |
| February 2019 | 2308.63 | 177.363 | 1961.04 | 2656.26 |
| March 2019 | 2301.40 | 239.072 | 1832.82 | 2769.97 |
| April 2019 | 2300.73 | 302.834 | 1707.19 | 2894.28 |
| May 2019 | 2298.14 | 370.606 | 1571.76 | 3021.51 |
| June 2019 | 2295.83 | 441.978 | 1429.57 | 3162.09 |
| July 2019 | 2293.24 | 516.964 | 1280.01 | 3306.47 |
| August 2019 | 2290.50 | 595.434 | 1123.47 | 3457.53 |
| September 2019 | 2287.59 | 677.283 | 960.14 | 3615.04 |
| October 2019 | 2284.51 | 762.399 | 790.23 | 3778.78 |
| November 2019 | 2281.25 | 850.0677 | 613.95 | 3948.55 |
| December 2019 | 2277.83 | 942.020 | 431.50 | 4124.15 |

## Conclusions

The study proved that ARIMA (1, 2, 1) model was the best fit for forecasting of price of coconut oil in Cochin market at Kerala with low AIC (1632.247) and SIC values (1643.718). The forecasted price of coconut oil during the period from January 2019 to December 2019 is in the range between ₹ 2200 to ₹ 2300 per 15 kg. Due to high fluctuation in the price of coconut oil in Cochin market, this forecasting helps the farmers to take the suitable decision for marketing their product. The forecasting can also be applicable to the government or other economic institution to take appropriate measures to ensure the benefits of end users of the coconut oil.


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