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Mushroom price forecasting in the major producing states

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Abstract
The present study is an attempt to forecast the prices of mushroom in the markets of Punjab, Jammu and Kashmir, Himachal Pradesh, and India. The time-series data on the monthly price of mushroom required for the study was collected from the AGMARKNET website for the period January 2008 to December 2019. The seasonal ARIMA model was used for the modeling of price using the Box-Jenkins technique and best-fitted models were selected based on lowest RMSE, AIC, BIC and MAPE values. The models ARIMA $(2,1,2)(1,1,1)_{[12]}$, ARIMA $(1,0,4)(1,1,2)_{[12]}$, ARIMA $(1,1,1)(2,1,1)_{[12]}$, and ARIMA $(3,1,1)(1,1,2)_{[12]}$ were found to be the best fitted model for Punjab, Jammu and Kashmir, Himachal Pradesh and India respectively. After model models validations, the mean absolute percentage error values were close to the value of fitted models. The results revealed that forecasted wholesale prices of mushroom were higher in the markets from September to November 2020-21. The best-identified models were used for predicting the future prices of 24 months (January 2020 to December 2021). The analysis was done in "R" statistical software.

Keywords: ARIMA, SARIMA, MAPE, forecasting, price, mushroom, time series

Introduction
Agriculture is the backbone of our country. The Green revolution provided the required food sufficiency but nutritional sufficiency still needs to be achieved. The scarcity of land and water resources for agriculture along with climate change is aggravating the prevailing situations. In answer to above, all challenges mushrooms playing a vital role. The mushroom cultivation as an eco-friendly alternative for agro-waste recycling and provide better nutrition for the vast vegetarian population. In the present diet-conscious era, mushrooms are increasingly considered as a future vegetable owing to its medicinal and nutritional properties and the consumer demand for mushrooms markedly expanded in recent years. Mushrooms are considered as a potential substitute of muscle protein on account of their high digestibility (Pavel, 2009) [12]. The mushroom cultivation also strengthens the livelihood of farmers by generating constant farm income and employment opportunities. The recent production data (official data of ICAR-DMR (2017), Solan) showing that the share of button mushroom in India is maximum amounting to 73% followed by oyster mushroom which contributes about 16%. There are two main types of mushroom growers in India, those who are growing white button mushroom round the year under controlled conditions and seasonal growers who are growing button mushrooms during the winter seasons in north-western part of India. In India, the total production of mushrooms is 0.15 million tonnes (ACRIPM-2018).

The present study is aimed to forecast the wholesale prices of mushroom for the markets of Punjab, Jammu, and Kashmir, Himachal Pradesh, and India. As the price of mushrooms keeps changing from time to time, it creates risks to producers, traders and consumers involved in the production, marketing and consumption of mushroom. Thus, it is important to forecast the mushroom prices. Price forecasts are critical to market participants who make production and marketing decisions, and to policymakers who administer commodity programs and asses the market impacts of domestic or international events (Sharma, 2015) [13].

Literature Review
Gupta *et al* (2019) [8] studied on the price behaviour of pigeon pea in the Kawardha market by using of ARIMA model. Dhakre and Bhattacharya (2014) [17] worked on the price behaviour of potato and their forecasting in the Agra market using the ARIMA models. Gupta *et al* (2018) [9] forecasting of arrivals and prices of major pulse in Chhattisgarh. Darekar *et al*. (2016) validated that the ARIMA model forecasted onion prices in Kolhapur and Yeola markets respectively. Khin *et al*. (2008) [10] forecasted natural rubber prices in the world market. Burark and Sharma (2012) [3] confirmed the suitability of ARIMA models in agricultural price

forecasting. Ozer and Ilkdogan (2013) [11] examined cotton prices in the world by ARIMA model, by using 102 per month which covered the period January 2004 and June 2012 of the world price of cotton. Shukla and Jharkharia (2011) [14] forecasted the wholesale vegetable market in Ahmedabad.
Keeping this mind, the present study has been attempted to forecast the monthly average prices of mushroom by using Autoregressive Integrated Moving Average (ARIMA) model.

Materials and methods

Data Collection

The time-series data on the monthly average price of mushroom for 12 years (from January 2008 to December 2019) of Punjab, Jammu and Kashmir, Himachal Pradesh, and India was used for forecasting the prices. Last one year (2019) of data kept for modal validation. The time-series data were collected from the AGMARKNET website as per the availability.

Analytical Method

Box-Jenkins (ARIMA) Model: The Box-Jenkins models (1976), are especially suited to short term forecasting because most ARIMA models place greater emphasis on the recent past rather than the distant past. ARIMA is used to produce an accurate forecasts based on an explanation of historical data on a single variable. Since it does not assume any specific pattern in the past data of the time series that is about to be forecasted, this model is different from other models that are used for forecasting the future values of the time series. In this study, the analysis performed by ARIMA is divided into four stages viz., identification, estimation, diagnostics, and forecasting. R programming software was used for time series analysis and developing ARIMA models and forecasting mushroom prices.
The ARIMA (p, d, q) model can be represented by the following general forecasting equation:

$$Y_t = \mu + \sum_{i=1}^{p} \Phi_i Y_{t-i} + \sum_{j=1}^{q} \theta_j \varepsilon_{t-j} + \varepsilon_t$$

Where, Y_t is prices, μ is the mean of series, the $\Phi_1, \dots \Phi_p$ are the parameters of the AR model, the $\theta_1 \dots \theta_q$ are the parameters of the MA model and the $\varepsilon_t, \varepsilon_{t-1}, \dots, \varepsilon_{t-q}$ are the noise error terms. The value of p is called the order of the AR model while the value of q is called the order of the MA model (Gupta *et al*., 2018) [9].
Since seasonal time series data is taken for this study, ARIMA model can be extended easily to handle seasonal aspects denoted as ARIMA (p, d, q) (P, D, Q), where the small letter parentheses part (p, d, q) indicates the non-seasonal part of the model while the capital letter part (P, D, Q) indicates the seasonal part of models being the number of periods per season (Barathi 2011) [1]. The general seasonal autoregressive integrated moving average (SARIMA) model written as follows:

$$\Phi_P(B^s)\phi_p(B)\,\nabla_s^D \nabla^d\, Y_t = \theta_q(B)\Theta_Q(B^s)\varepsilon_t$$

Where,

- $\Phi_P(B^s) = (1 - \Phi_1 B^s - \dots - \Phi_P B^{sP})$ is the seasonal AR operator of order P ;
- $\phi_p(B) = (1 - \phi_1 B - \dots - \phi_p B^p)$ is the regular AR operator of order p;
- $\nabla_s^D = (1 - B^s)^D$ represents the seasonal differences and $\nabla_s^D = (1 - B)^d$ the regular differences;
- $\Theta_Q(B^s) = (1 - \Theta_1 B^s - \dots - \Theta_Q B^{sQ})$ is the seasonal moving average operator of order Q;
- $\theta_q(B) = (1 - \theta_1 B - \dots - \theta_q B^q)$ is the regular moving average operator of order q;
- ε_t is a white noise process;

Identification Stage

Model identification involves defining the orders (p, d, and q) of the AR and MA components of the time series model. The first stage of ARIMA model is to identify that the variable, which is about to be forecasted, is a stationary time series or not. Stationary means the values of the variable over time fluctuates around a constant mean and variance. The ARIMA model cannot be made until we make the series stationary. First, we have to take the difference of the time series 'd' times to obtain a stationary series to obtain an ARIMA (p, d, q) model, where 'd' is the order of differencing. Before moving further, we will have to test the differenced time series for stationarity (unit root problem) by Augmented Dickey-Fuller test (ADF).

The criterion of Model Selection: The best model was selected based on the following criteria.

i. **Low Akaike Information Criteria (AIC):** AIC is estimated by

$$AIC = -2\ln(L) + 2K$$

Where, *K*= Number of Parameters and *L*= Maximized log-likelihood

ii. **Low Bayesian Information Criteria (BIC):** Sometimes, Bayesian Information Criteria (BIC) is also used and estimated by

BIC = log σ2 + (m log n)/n.

iii. **Mean Absolute Percent Error (MAPE)**: It is a measure of percentage error for the model and it can be easy to understand for model accuracy.

$$\text{MAPE} = \frac{1}{n}\sum_{i=1}^{n}\frac{|(y_i - \hat{y}_i)|}{\hat{y}_i} \times 100$$

Where, y_i = i^{th} actual value and $\hat{y}_i$ = i^{th} predicted value

iv. **R.M.S.E (Root Mean Square Error):** Root Mean Square Error is defined as the differences between the value of population and sample predicted by a model and observed values.

$$\text{RMSE} = \sqrt{\frac{R_{res}SS}{n - p}}$$

Results and Discussion

Model identification

The first step in developing an ARIMA model is to determine if the monthly mushroom price series are stationary. For this, we used the Augmented Dickey-Fuller test (ADF), which was performed to determine if the series is stationary or not. The test confirmed that the data was nonstationary for without difference. In this case, differencing of lag 1 gave the significant result, so with differencing of lag 1(d =1) is stationary in respect to mean and variance. Thus, there is no need for further differencing the time series and then the adopted difference order is d = 1 for the ARIMA (p, d, q) model. The test statistic and its p-value are presented in Table 1.

Table 1: Augmented Dickey-Fuller test

S.N.	State	With differences Dickey-Fuller statistic	p-value
1.	Punjab	-6.3605	0.01
2.	Jammu and Kashmir	-4.168	0.01
3.	Himachal Pradesh	-3.7619	0.02
4.	India	-7.1743	0.01

This test allows going further in the steps for ARIMA model development which are to find out the appropriate values of (p, d, q) (P, D, Q). It was done by observing the Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) values. The Auto Correlation Function helps in choosing the appropriate values for the ordering of moving average terms (MA) and Partial Auto-Correlation Function for those autoregressive terms (AR). The ACF graph showing significant spike at lag 1 but there are no significant spikes at seasonal lags (lag 12, 24) which gives us the non-seasonal and seasonal MA orders i.e. q=1 and Q=0. Similarly, the PACF graph showing significant spike at lag 1 but no significant spikes at seasonal lags (lag 12, 24) which gives us the non-seasonal and seasonal AR orders i.e. p=1 and P=1. These are tentative orders and we tried some other models similar to these models. The autocorrelation function and partial autocorrelation function for mushrooms of Punjab, Jammu and Kashmir, Himachal Pradesh, and India were obtained and presented in fig. 1 to 4.

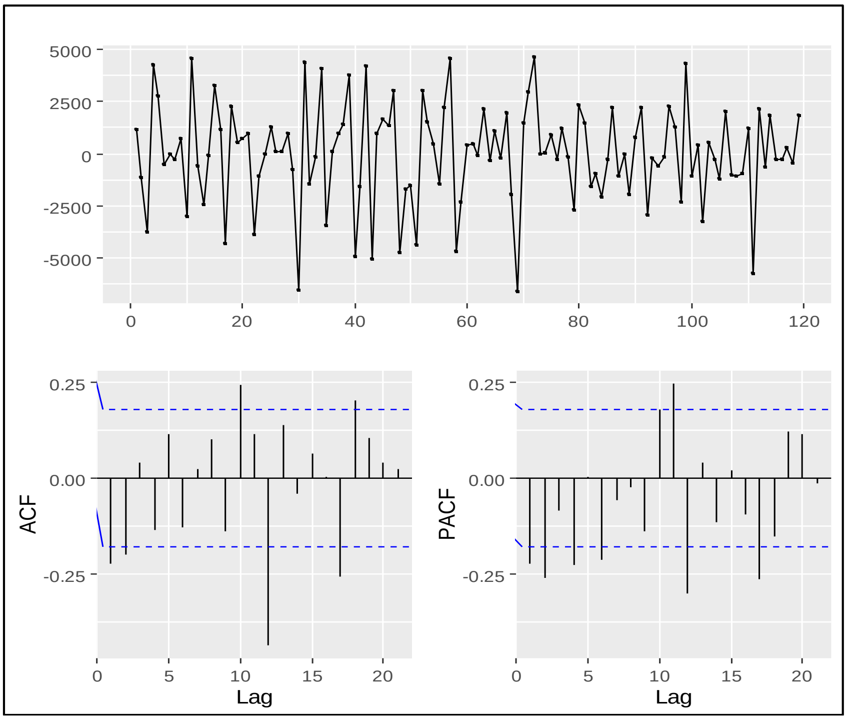

Fig 1: ACF and PACF graph of Punjab

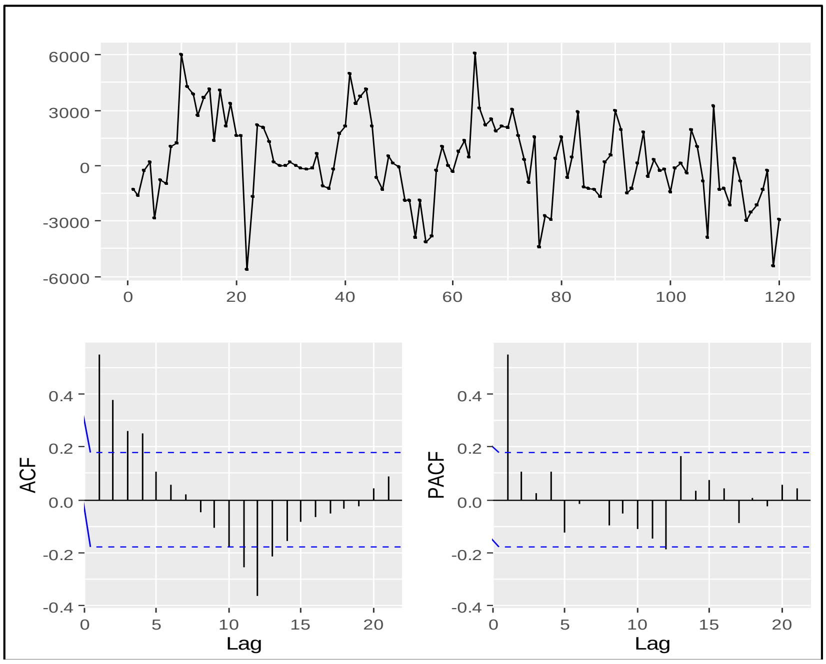

Fig 2: ACF and PACF graph of Jammu and Kashmir

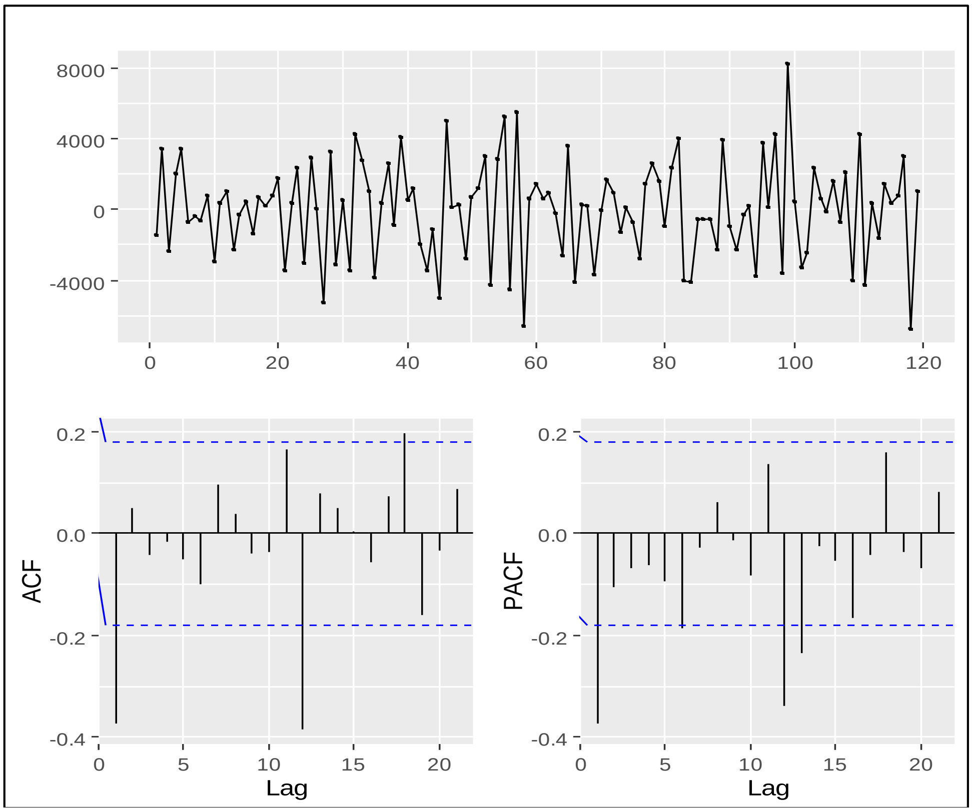

Fig 3: ACF and PACF graph of Himachal Pradesh

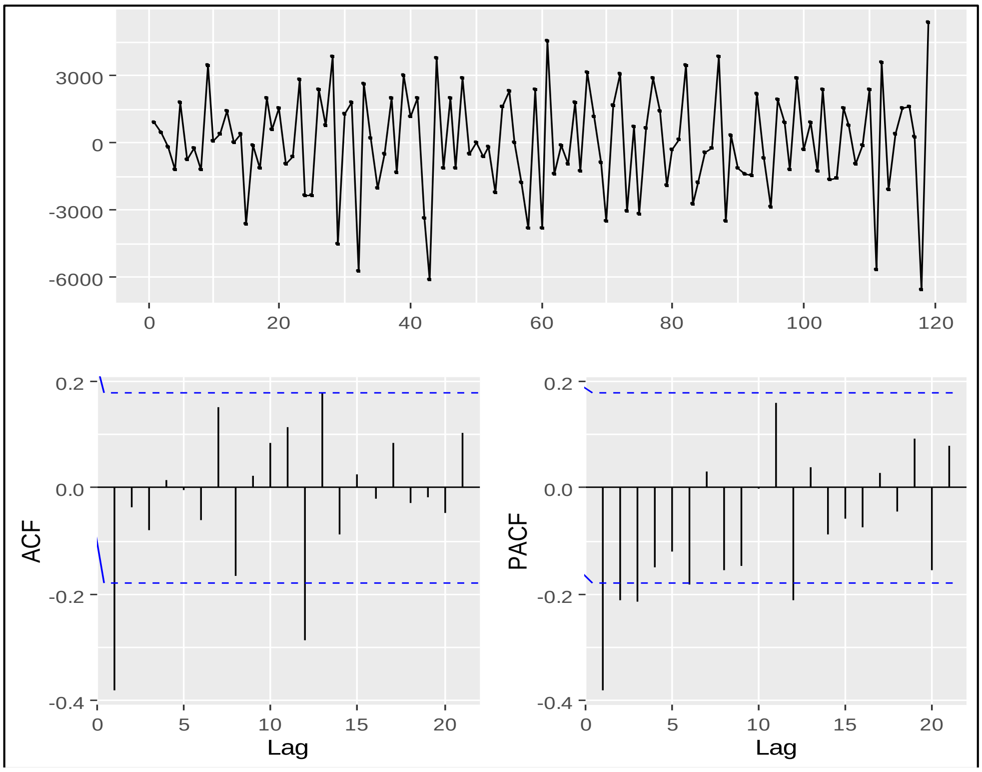

Fig 4: ACF and PACF graph of India

The lowest values of RMSE, MAPE, AIC and BIC, the model ARIMA (2,1,2) (1,1,1)$_{[12]}$, ARIMA (1,0,4) (1,1,2)$_{[12]}$, ARIMA (1,1,1) (2,1,1)$_{[12]}$, and ARIMA (3,1,1) (1,1,2)$_{[12]}$ were the best fitted model for Punjab, Jammu and Kashmir, Himachal Pradesh and India respectively. The results of these coefficients are given in Table 2. ARIMA model was estimated after transforming the variables under study into stationary series through the computation of either seasonal or non-seasonal or both, the order of differencing. A careful examination of ACF and PACF up to 24 lags revealed the presence of seasonality in the data.

Table 2: Residual analysis of monthly prices of mushroom

S.N.	State	Arima Model	Rmse	Mape	AIC	BIC
1.	Punjab	(2,1,2) (1,1,1)[12]	1610.855	17.90277	2136.582	2156.035
		(5,1,2)(1,1,1)[12]	1601.613	17.90514	2141.203	2168.995
		(4,1,1)	1643.932	20.35672	2325.45	2342.70
2.	Jammu and Kashmir	(1,0,4) (1,1,2)[12]	1432.447	8.920503	2136.202	2161.289
		(1,1,1) (1,1,1)[12]	1441.91	9.186708	2115.325	2129.221
		(1,1,1) (0,0,1)[12]	1588.804	10.20293	2313.894	2325.395
3.	Himachal Pradesh	(1,1,1) (2,1,1)[12]	1432.4447	9.45767	2136.202	2162.289
		(0,1,3) (0,0,1)[12]	1993.951	17.64784	2374.577	2388.953
4.	India	(3,1,1) (1,1,2)[12]	1580.76	12.64809	2129.368	2151.368
		(1,0,3) (2,1,0)[12]	1668.5831	13.71269	2150.579	2170.09
		(2,1,1) (0,0,1)[12]	1590.022	14.4837	2314.268	2325.769

Model diagnostics

The model verification is concerned with checking the residuals of the model to see if they contained any systematic pattern which still could be removed to improve the chosen ARIMA (Darekar and Reddy, 2017) [6]. After model validation, MAPE value found to be 20.19636, 6.718749, 13.93263 and 13.31298 for ARIMA (2,1,2) $(1,1,1)_{[12]}$, ARIMA $(1,0,4)(1,1,2)_{[12]}$, ARIMA $(1,1,1)(2,1,1)_{[12]}$, and ARIMA $(3,1,1)(1,1,2)_{[12]}$ respectively. MAPE values of these models which were present in permissible range. Hence we conclude that, the model ARIMA $(2,1,2)(1,1,1)_{[12]}$, ARIMA $(1,0,4)(1,1,2)_{[12]}$, ARIMA $(1,1,1)(2,1,1)_{[12]}$, and ARIMA $(3,1,1)(1,1,2)_{[12]}$ were the best fitted model for Punjab, Jammu and Kashmir, Himachal Pradesh and India respectively. The results show that autocorrelations of residuals were not significantly different from zero at any reasonable level. This proved that the selected ARIMA models were an appropriate model for forecasting mushrooms price in the states of Punjab, Jammu and Kashmir, Himachal Pradesh and India. The result of Box Ljung Q statistics also confirms the same. The results of diagnostics a represented in fig.5 to 8.

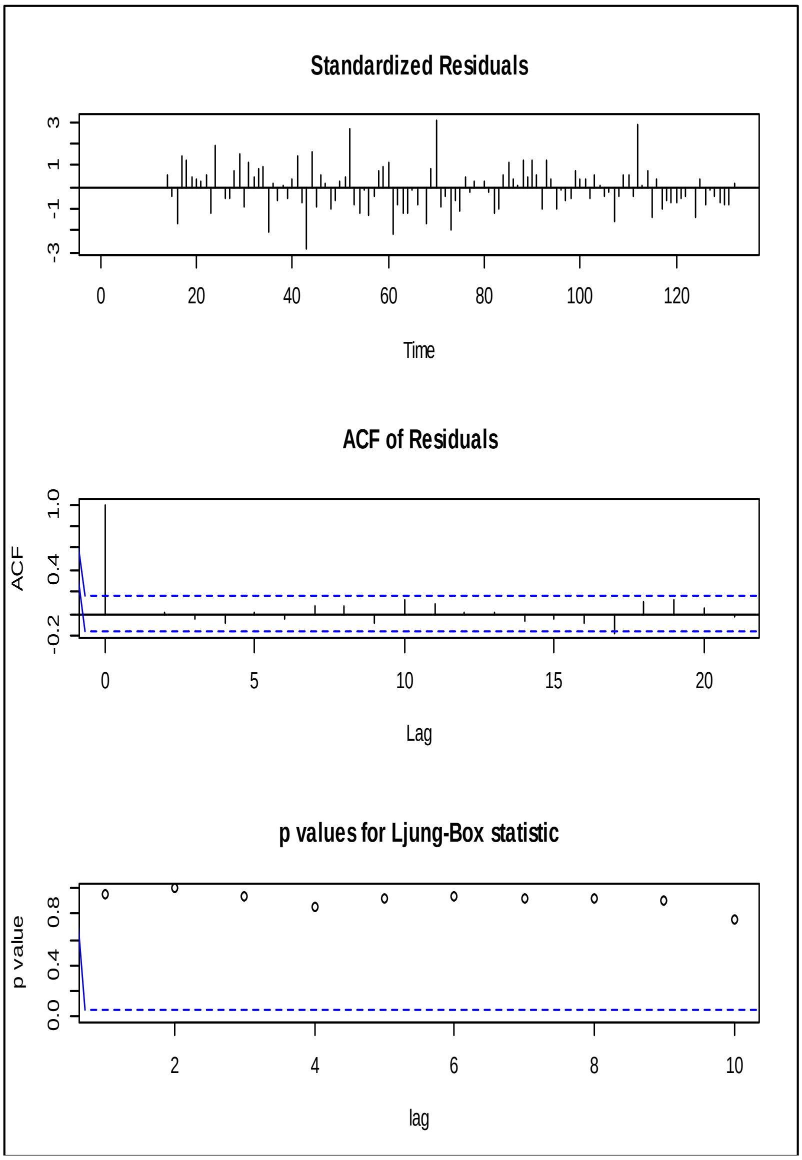

Fig 5: Residuals analysis of model ARIMA $(2,1,2)(1,1,1)_{[12]}$

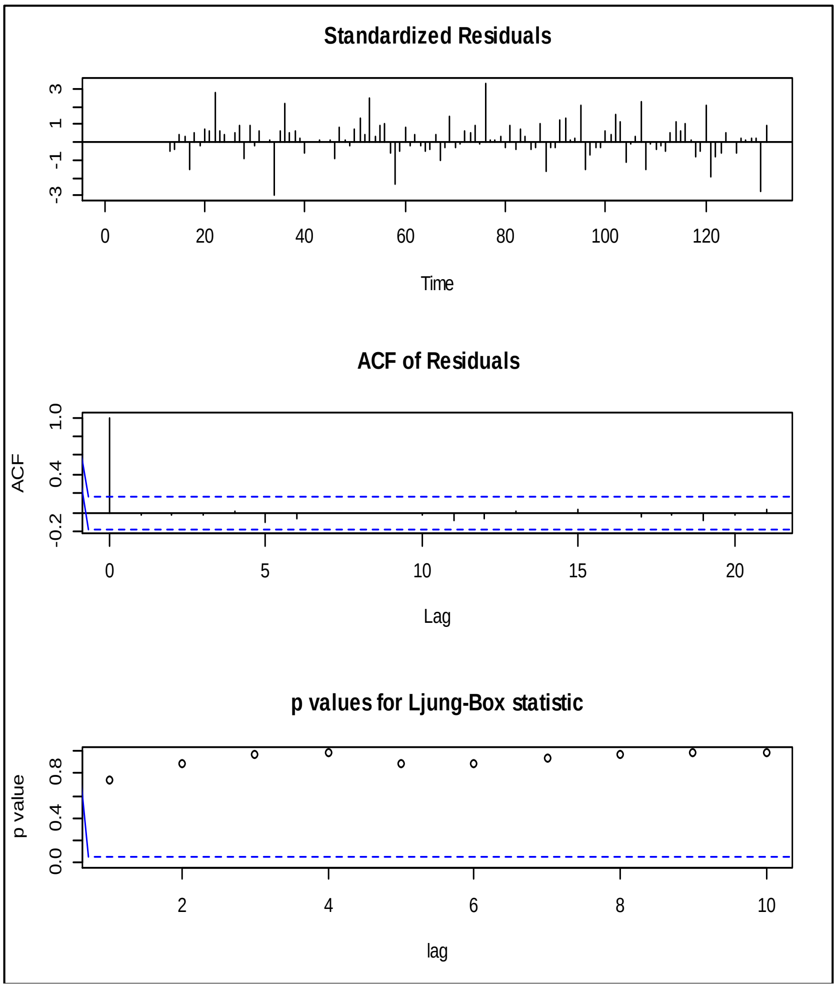

Fig 6: Residuals analysis of model ARIMA (1,0,4)(1,1,2)[12]

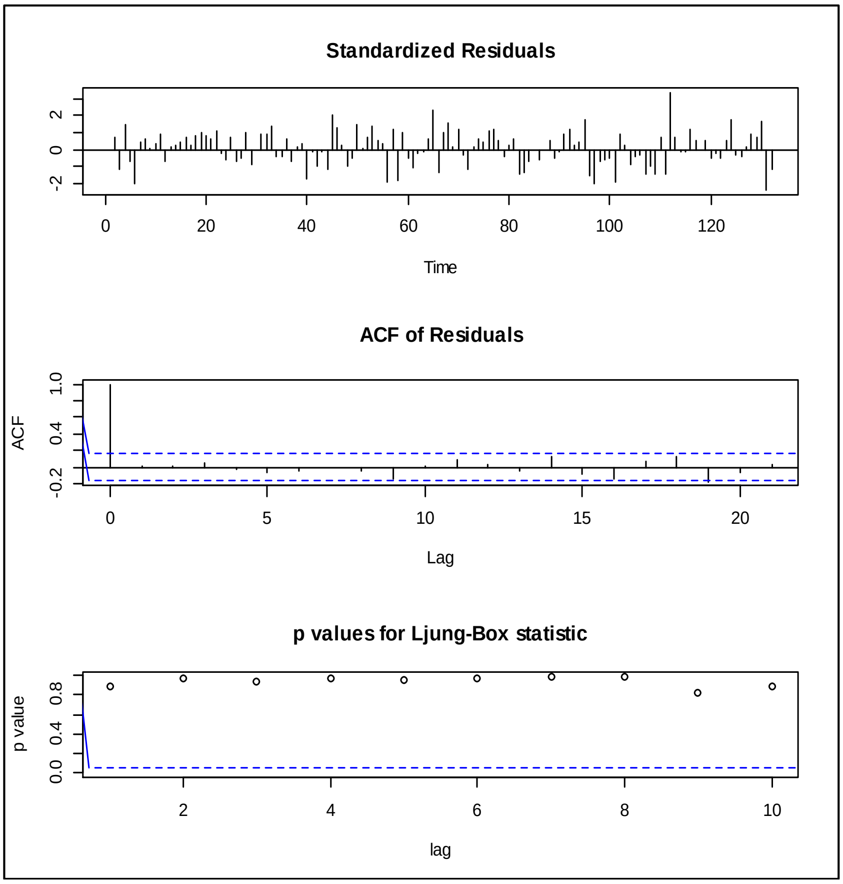

Fig 7: Residuals analysis of model ARIMA (1,1,1)(2,1,1)[12]

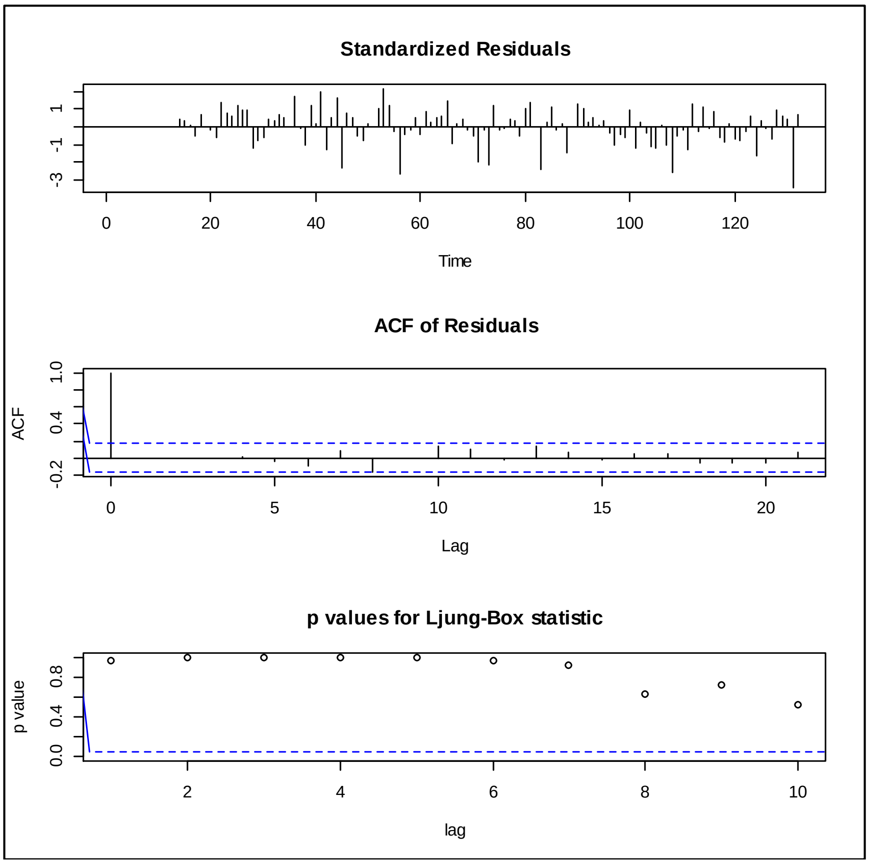

Fig 8: Residuals analysis of model ARIMA (3,1,1)(1,1,2)[12]

Forecasting

The models ARIMA (2,1,2) (1,1,1)[12], ARIMA (1,0,4) (1,1,2)[12], ARIMA (1,1,1) (2,1,1)[12], and ARIMA (3,1,1) (1,1,2)[12] which we are fitting to our time series data for the states of Punjab, Jammu and Kashmir, Himachal Pradesh and India. The forecasting was done for two years from January 2020 to December 20211 which are shown in Table 3 & 4. The forecasted values of mushroom in the selected states show that wholesale prices of mushroom in Punjab, Jammu and Kashmir, Himachal Pradesh and India would be ruling in the range of Rs. 7191.36-9545.32 per quintal, Rs. 10103.26-13270.62 per quintal, Rs. 10001.94-14550.88 per quintal and Rs. 11416.92-15479.72 per quintal respectively. The wholesale prices of mushroom in the markets from September to November 2020-2021 would be high and low from December to March in the selected states.

Table 3: Forecasts of mushroom prices in Punjab and Jammu & Kashmir with 95% CL

		Forecasted Prices for Punjab			Forecasted Prices for J&K		
Year	**Month**	**Forecasted Prices(Rs/qt)**	**Lower Limit**	**Upper Limit**	**Forecasted Prices(Rs/qt)**	**Lower Limit**	**Upper Limit**
2020	January	7191.36	3925.00	10457.72	10645.82	7647.03	13644.61
2020	February	7952.49	3880.66	12024.32	10674.73	7269.11	14080.35
2020	March	8313.33	3991.69	12634.97	10643.58	7074.92	14212.24
2020	April	9276.77	4722.67	13830.87	11890.24	8275.90	15504.50
2020	May	8664.63	3983.94	13345.32	12240.87	8587.31	15894.43
2020	June	8546.58	3718.90	13374.26	12786.69	9095.35	16478.03
2020	July	7770.99	2836.16	12705.82	12591.61	8863.91	16319.31
2020	August	7739.51	2682.00	12797.02	12876.61	9113.92	16639.31
2020	September	8317.61	3157.47	13477.76	12877.60	9081.23	16673.98
2020	October	8881.56	3609.50	14153.63	13270.62	9441.83	17099.42
2020	November	9319.71	3947.16	14692.25	12313.62	8453.91	16173.34
2020	December	8306.08	2827.92	13784.25	10884.07	6995.50	14772.64
2021	January	7580.73	1822.11	13339.35	10103.26	5954.43	14252.09
2021	February	8122.16	2146.10	14098.23	10527.23	6260.30	14794.17
2021	March	8556.05	2426.52	14685.58	10779.03	6435.51	15122.56
2021	April	9545.32	3263.95	15826.68	12235.40	7844.28	16626.53
2021	May	8884.10	2472.82	15295.39	12400.23	7964.74	16835.71
2021	June	8846.45	2301.83	15391.07	12796.16	8318.00	17274.32
2021	July	7925.77	1258.53	14593.01	12528.96	8009.75	17048.17
2021	August	7898.81	1106.61	14691.00	12717.06	8158.36	17275.76
2021	September	8511.38	1600.66	15422.10	12586.44	7989.75	17183.13
2021	October	9169.70	2139.29	16200.12	12948.73	8315.52	17581.94
2021	November	9665.89	2520.01	16811.77	12301.79	7634.00	16969.59
2021	December	8583.48	1321.38	15845.57	10448.12	5748.43	15147.82

Table 4: Forecasts of mushroom prices in Himachal Pradesh and India with 95% CL

		Forecasted Prices for Himachal Pradesh			Forecasted Prices for India		
Year	**Month**	**Forecasted Prices(Rs/qt)**	**Lower Limit**	**Upper Limit**	**Forecasted Prices(Rs/qt)**	**Lower Limit**	**Upper Limit**
2020	January	10001.94	6166.05	13837.83	12118.48	8750.61	15486.36
2020	February	10611.22	6301.51	14920.93	11416.92	7764.58	15069.26
2020	March	10299.94	5610.31	14989.57	12768.26	8862.05	16674.48
2020	April	13059.30	8020.93	18097.68	12258.21	8261.41	16255.01
2020	May	12518.08	7153.73	17882.43	13192.73	9116.15	17269.32
2020	June	12454.55	6782.94	18126.16	13466.35	9329.70	17603.00
2020	July	13039.05	7075.99	19002.11	13545.28	9349.95	17740.62
2020	August	13292.51	7051.60	19533.43	13553.60	9302.77	17804.43
2020	September	14136.00	7629.08	20642.91	13874.20	9568.23	18180.18
2020	October	13648.18	6885.72	20410.64	14742.16	10381.97	19102.35
2020	November	13164.03	6155.32	20172.74	15804.18	11389.76	20218.61
2020	December	10563.78	3317.06	17810.51	12361.98	7894.00	16829.95
2021	January	10463.19	2762.30	18164.09	12661.77	7877.98	17445.56
2021	February	11116.27	3102.31	19130.23	12512.75	7602.60	17422.91
2021	March	10824.71	2515.42	19134.00	13517.35	8485.84	18548.87
2021	April	13527.63	4933.49	22121.76	13538.77	8420.95	18656.60
2021	May	12951.18	4081.37	21820.99	14036.07	8835.70	19236.44
2021	June	12766.03	3628.85	21903.20	13808.06	8531.64	19084.49
2021	July	13343.59	3946.65	22740.53	14103.76	8752.48	19455.04
2021	August	13574.29	3924.58	23224.00	14126.78	8702.40	19551.17
2021	September	14550.88	4654.85	24446.91	14340.37	8843.53	19837.22
2021	October	14015.32	3878.95	24151.69	15479.72	9911.34	21048.11
2021	November	13496.28	3125.13	23867.43	15297.35	9657.16	20937.54
2021	December	11061.00	4600.06	21661.95	13009.01	7297.91	18720.11

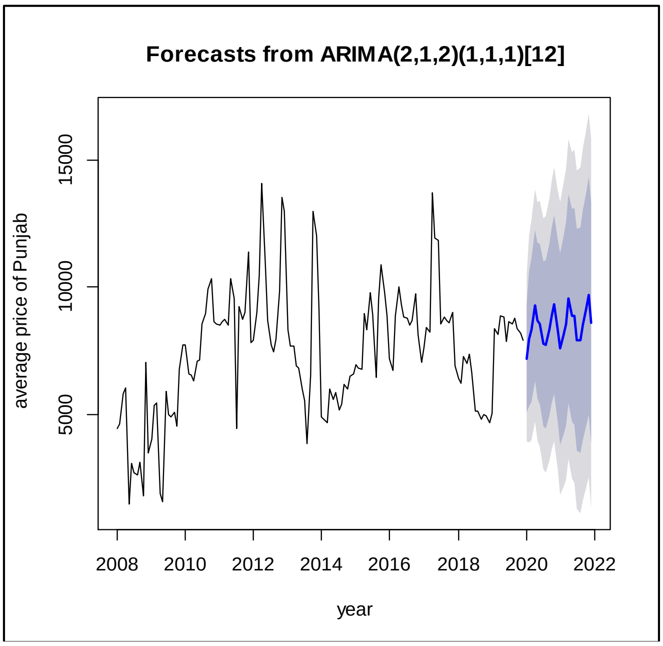

Fig 9: Forecast for the seasonally adjusted prices in Punjab.

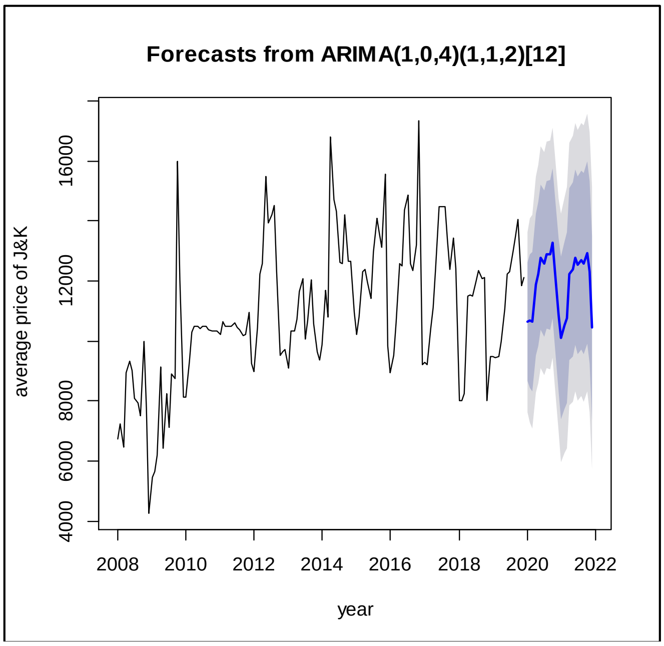

Fig 10: Forecast for the seasonally adjusted prices in J&K

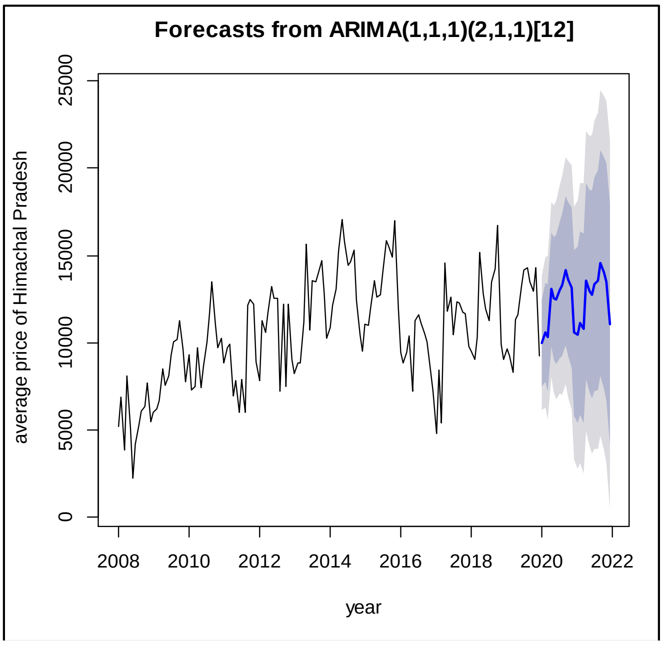

Fig 11: Forecast for the seasonally adjusted prices in India

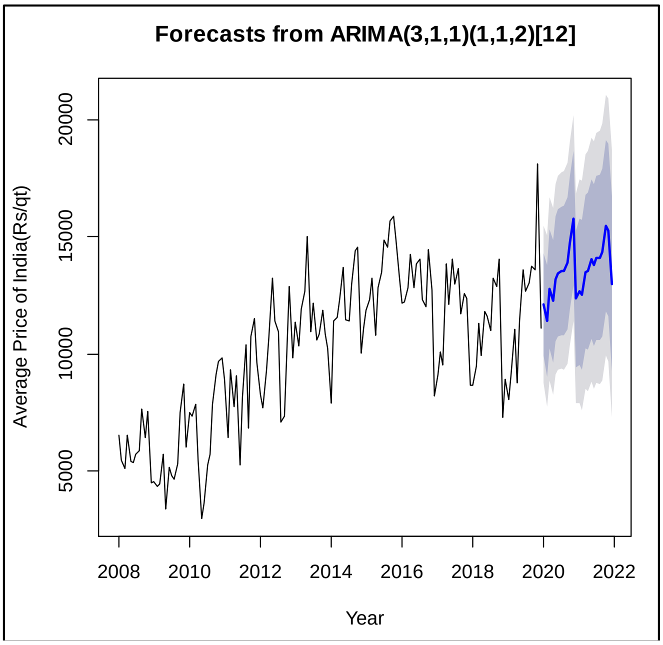

Fig 12: Forecast for the seasonally adjusted prices in India

Conclusion

The study analysed the time series data of prices of mushroom through ARIMA modelling and concluded that ARIMA $(2,1,2)(1,1,1)_{[12]}$, ARIMA $(1,0,4)(1,1,2)_{[12]}$, ARIMA $(1,1,1)(2,1,1)_{[12]}$, and ARIMA $(3,1,1)(1,1,2)_{[12]}$ were best fitted for the state of Punjab, Jammu and Kashmir, Himachal Pradesh and India. A similar model was used by Darekar *et al*. (2015) to forecast the prices and arrivals of agricultural commodities and drawn conclusions. The forecasted results suggest that there is likely a possibility of higher mushroom prices from September to November. Hence, farmers are advised to increase mushroom acreage where ever suitable agro-climatic conditions exist and their sale in suitable markets can be planned suitably. The paper used historical monthly prices of mushroom in major mushroom growing states to forecast future prices for the harvest month by using ARIMA models.

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