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Analyzing the Seasonal Variations and Price Trends in Major Onion Markets of India

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Authors' contributions

This work was carried out in collaboration among all authors. Author HBP performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript. Author UDB helped in reviewing the literature, helped in data collection and also helped in technical writing of manuscript. Author MGD designed the study, guided the author HBP in research and writing the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The study was conducted about to analyse the onion price trend, seasonality and correlation in major markets of larger onion producing states of India with a study period of twenty years for onion crops (2001 to 2020). These data were collected from various portals such as APEDA, Agmarknet, and NHB. The data collected were subjected to statistical analysis using different methods. Twenty years data was used to analyze the seasonal and irregular fluctuations in onion prices, the variability of onion prices in major states in India and to measure trend and estimate rates of

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change in onion price in major states of India. The co-efficient of quadratic trend (T^2) found non-significant in all markets reveals no change in growth pattern of onion price in last two decades, which indicates that farmers were not benefited by rise in price; it is the effect of inflation factors only. On an average the onion prices in major markets of India was increased annually at the rate of 8.50 per cent during last two decades. The seasonality is prevailing throughout all markets of onion in India. The price indices were found more than 100 in the months of August to January and lower during February to July. The magnitude of price volatility was found the highest in Bhopal (88.25%) and the lowest in Mahuva (53.81%) market. Whereas, the magnitude of arrival volatility was found the highest in Mahuva (187.25%) and the lowest in Mumbai (31.97%) market. The monthly (>0.87) and yearly (>0.90) onion prices were found highly correlated among all the markets. As onion price are highly volatile, requires creation of storage capacity to meet specific requirement of humidity and temperature, and the Government should take immediate action to enhance export, when price falls drastically and allow the import, when price increase beyond certain level.

Keywords: Onion; price trend; seasonality; correlation; market; India.

1. INTRODUCTION

The demand of agricultural goods is inelastic and its prices fluctuate more than those of industrial goods. Hence, it has enormous human and political implications, especially in developing country like India, so price play a more important role in agricultural sector. Onion (*Allium cepa* L.) is one of the most important spice and commercial crop in India. Onion is consumed round the year by all sections of people throughout the world.In India, onion is cultivated in both seasons as kharif and rabi-summer crop. In last decades the area under onion in India increased to more than double and production to more than fourfold due to notable increased in productivity from 10.59 t/ha in 2000 to 18.70 t/ha in 2019 [1]. Maharashtra is the major onion growing state covering about 6.18 lakh ha area with production of 106.83 lakh tonnes, followed by Madhya Pradesh (42.70 lakh tonnes), Karnataka (22.75 lakh tonnes), Gujarat (14.22 lakh tonnes). Gujarat achieved the highest productivity of onion in the country ranging from 24 t/ha to 31 t/ha, since last three decades or more.

The production pattern of onion also changes considerably over years due to change in resource use pattern, production technology and price of input and output. The variation in the output of the onion leads to wild fluctuations in its prices, exposing the vegetable growers to more risk as compare to the growers of other crops. Considering the nature and causes of price rise and their impacts on consumers amidst the galloping price rise in onions is important [2,3]. The prices of onion fluctuate widely and farmers' response to price change causes bumper production, which tends to decrease prices of onion drastically. Such a situation is not only creating domestic disturbances in the food economy, but also causing hardship to the farmers. Hence, this study has been taken up with the following specific objectives: (i) to measure trend and estimate rates of change in onion price in major states of India, and (ii) to analyse the seasonal and irregular fluctuations in onion prices.

2. MATERIALS AND METHODS

2.1 Compound Growth Rate

The compound growth rates (CGRs) of sugar exports was calculated by using the exponential function of the following specification:

$$Y_t = ab^t u_t \quad (1)$$

Where,

Y_t = Dependent variable (export quantity/ export value, of sugar and Jaggery in the year 't', etc.)
T = Time variable in years taking the value of 1, 2, 3,...,n
A = Intercept;
B = Regression coefficient (1+r)
R = Compound growth rate
u_t = Error term

For the purpose of estimation, the equation was expressed in logarithmic form.

$$\text{Log } Y_t = \text{Log } a + t \log b + \log e \quad (2)$$

The value of log b in equation (2) was computed using the formula,

$$\text{Log b} = \frac{(\sum t \text{ Log } Y - (\sum t . \sum \text{Log } Y / N))}{\sum t^2 - \left(\frac{\sum t^2}{N}\right)} \quad (3)$$

Where,

N = Number of years.

Subsequently, the compound growth rate (%) was computed using the formulation,

Compound growth rate (r) = [(Antilog of log b) -1] *100 (4)

2.2 Trend in Yearly Prices

Initially, a trend diagram of yearly index numbers of major market wise wholesale prices of onion were drawn for the period from 2001 to 2020. The trend in annual prices has been analyzed with the help of following models.

2.2.1 Linear and quadratic models

Following two models were employed.

$P_t = \beta_0 + \beta_1 T + U$
$P_t = \beta_0 + \beta_1 T + \beta_2 T^2 + U$ …(5)

Where,

P_t= Yearly index numbers of wholesale prices,
T = Time (1,2,3,…., t),
U = Disturbance term with usual assumptions, and, β_0, β_1, β_2 are parameters estimated

2.3 Computation of Seasonal Variation

The seasonal variations are short term fluctuations that occur within a year, which could be isolated from the original composite series and to study them separately, the decomposition of the time series data was done by assuming a multiplicative model of the following form.

P = T x C x S x I …(6)

Where,

P = Monthly Price,
T = Trend values,
C= Cyclical variations,
S = Seasonal variation,
I = Irregular variations.

This multiplicative model assumes the interaction among the different components.

Taking the whole period together seasonal indices were worked out. To remove the effect of trend and cyclical variations, twelve months moving averages were calculated and centered. A further ratio of original price indices to centered moving average was calculated to obtain the combined effect of S x I. In order to remove the effect of I, these ratios were averaged and adjusted seasonal indices has been obtained.

2.3.1 Coefficient of average seasonal variations

Highest and lowest values were compared by plotting the seasonal indices on a graph. Then the coefficients of the average seasonal price index variation were worked out using following formula.

$$\text{Coefficient of av. seasonal price index variation} = \frac{\text{Highest index} - \text{Lowest index}}{(\text{Highest Index} + \text{Lowest index})/2} \times 100 \quad \ldots(7)$$

2.3.2 Irregular fluctuations in prices

The irregular component in an annual series of process does not have a definite pattern. It was estimated by following formula.

$$\text{Index of irregular variation} = \frac{\text{Ratio to moving average in a month}}{Adjusted\ seasonal\ index\ in\ that\ month} * 100 \quad \ldots(8)$$

2.4 Inter-Relationship between Prices of Different Markets

Correlations co-efficient between yearly prices of crop under study would be worked out to determine inter-relationship between them.

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[\, n\sum x^2 - (\sum x)^2]\, [\, n\sum y^2 - (\sum y)^2]}} \quad \ldots(9)$$

Where,

R = Co-efficient of correlation,
x and y = Two variables under study,
N = Total number of observations.

3. RESULTS AND DISCUSSION

3.1 Trends in Yearly Prices

3.1.1 Estimation of linear trend

A linear model was applied to analyze twenty years of wholesale onion prices data (2001-2020) in selected markets. The regression

coefficients in Table 1 were highly significant, suggesting a substantial portion of price variation could be explained by the linear trend. Lasalgaon market exhibited the highest annual rate of increase at 24.95 per cent, while Bhopal market had the lowest at 14.18 per cent. The coefficient of multiple determination (R2) surpassed 52 per cent for all markets, indicating that over 50 per cent of the onion price variation could be explained by the linear trend.

3.1.2 Estimation of quadratic trend

It is also important to check the assumption of constant rate of increase in the prices over twenty years. Hence, a quadratic model was also tried, which indicates the change in growth pattern of prices over time. Table 2 reveals that the regression co-efficient associated with time variable (*i.e.* T) was maximum in Bengaluru market and minimum in Mahuva market. These co-efficient were non-significant in case of Mumbai and Ahmedabad markets. Whereas, the coefficients of quadratic term (*i.e.* T^2) found to be non-significant in all markets. The R^2 showed > 52 per cent variations in all the markets could be explained by quadratic trend. Adjusted co-efficient of multiple determination was also worked out to know the better fit, besides it indicated that linear model is a better fit than quadratic model.

The co-efficient of multiple determinations (R^2) was similar (as linear) in Bengaluru, Bhopal, Mumbai and Lasalgaon market suggesting absence of quadratic trend. Thus, quadratic trend results revealed that onion price in all the markets under study have not shown increasing growth pattern, but indicated almost constant growth pattern during 2001 to 2020. Hence, the rise in onion price was only due to inflation and farmers were not benefited at all.

3.1.3 Estimation of compound rate of increase in annual prices

Compound annual growth rates (CAGR) for onion prices were determined for each market using the exponential function, as detailed in the methodology. Table 3 presents decade-wise and overall period results. Notably, from 2001 to 2010, onion prices increased significantly across all markets. Bengaluru market recorded the highest CAGR at 14.24 per cent per annum, while Patna market had the lowest at 9.43 per cent per annum.

Table 1. Estimation of linear trend in yearly prices of onion in major markets of India

Markets	Intercept β_0	Co-efficient for Time β_1	R^2	Adjusted R^2
Ahmedabad	35.35	21.07* (5.44)	0.62	0.60
Bengaluru	65.45	18.14*** (5.77)	0.65	0.63
Bhopal	45.63	14.18*** (4.43)	0.52	0.49
Hyderabad	41.2	15.38* (7.12)	0.74	0.72
Jaipur	55.86	23.56* (3.81)	0.68	0.64
Mumbai	46.85	19.18* (3.47)	0.63	0.60
Patna	47.42	16.01* (5.71)	0.64	0.62
Lasalgaon	38.71	24.95* (5.60)	0.64	0.62
Mahuva	39.23	16.77*** (3.24)	0.57	0.55

Note: Figures in the parentheses are standard errors.
****, * Significant at 1 and 10 per cent probability level*

Table 2. Estimation of quadratic trend in yearly prices of onion in major markets of India

Markets	Intercept β_0	Co-efficient for time β_1	Co-efficient for T^2 β_2	R^2	Adjusted R^2
Ahmedabad	69.32	11.81	0.44	0.63	0.59
Bengaluru	47.56	23.02*	-0.23	0.65	0.61
Bhopal	57.22	11.02*	0.15	0.52	0.47
Hyderabad	64.63	8.99*	0.3	0.75	0.72
Jaipur	55.85	18.77*	0.23	0.68	0.64
Mumbai	65.97	13.96	0.25	0.63	0.58
Patna	64.22	11.43*	0.22	0.65	0.6
Lasalgaon	56.32	20.14*	0.23	0.64	0.59
Mahuva	73.32	6.70*	0.44	0.58	0.54

*Note: * Significant at 10 per cent probability level*

Table 3. Estimation of compound rate of increase in onion prices in major markets

Markets	2001 to 2020		2011 to 2020		2001 to 2020	
	CGR%	R^2	CGR%	R^2	CGR%	R^2
Ahmedabad	12.24	0.70	8.97	0.29	9.19	0.71
Bengaluru	14.24	0.78	4.35	0.14	8.33	0.72
Bhopal	9.84	0.56	5.92	0.12	7.84	0.60
Hyderabad	11.06	0.58	8.08	0.42	8.57	0.76
Jaipur	12.52	0.11	6.59	0.24	9.56	0.78
Mumbai	12.12	0.71	7.25	0.23	8.66	0.71
Patna	9.43	0.67	6.59	0.23	8.17	0.74
Lasalgaon	13.32	0.76	6.78	0.20	9.61	0.74
Mahuva	11.60	0.69	7.90	0.24	8.33	0.69

Note: All the CGR values are significant at 1 per cent probability level

In the subsequent period (2011-2020), Ahmedabad market exhibited the highest CAGR at 8.97% per annum, with Bengaluru market showing the lowest at 4.35 per cent per annum. This indicates a larger increase in onion prices during the 2000s compared to the 2010s.

From 2001 to 2020, Lasalgaon market demonstrated the highest CAGR at 9.61 per cent per annum, followed by Jaipur (9.56%) and Ahmedabad (9.19%), while Bhopal market had the lowest increase at 7.84 per cent per annum. On average, onion prices in major Indian markets significantly increased annually at a rate of 8.50 per cent per annum over the last two decades. These findings align with Mulla et al. [4], who reported a similar trend of a 6.22 per cent per annum increase in onion prices in the Kurnool market of Karnataka from 2003 to 2017.

3.2 Seasonal Variations in Onion Prices

3.2.1 Seasonal indices

Seasonality in the supply of agricultural commodities is primarily linked to the seasonality in production, dictated by specific weather conditions conducive to crop growth. Understanding the magnitude of changes and seasonal variations in prices is crucial for a comprehensive analysis. Figs. 1 and 2 illustrate the adjusted monthly seasonal indices for onion prices in selected markets during the study period, revealing the presence of seasonality in these regulated markets.

The highest seasonal index levels were observed in October in Jaipur market (143.08 points), closely followed by Lasalgaon and Bhopal. In contrast, Ahmedabad, Bengaluru, Mumbai, Patna, and Mahuva markets reached their maximum seasonal index levels in November, ranging from 123.07 to 138.64 points. Additionally, the Hyderabad market reached its peak in December. Although there were slight variations in the pattern of market prices among the selected markets, indices consistently exceeded 100 from August to January. Lower indices were evident in April and May, ranging from 54.30 (Bhopal) to 74.10 (Mahuva) points. This dip aligns with the trend of increased sales immediately post-harvest, potentially driven by cash needs or limited storage facilities. This observation resonates with similar findings by Basavaraj [5] for onion prices in Karnataka, Shiyani and Kakalia [6] in Gujarat during the 1980s and 1990s, Sharma and Sharma [7] for selected vegetables in India, and Mulla et al. [4] for onion prices in the Kurnool market of Andhra Pradesh. Also Sharma et al. [8] noted the similar results in their study of Capturing the price volatility of onion and potato in selected markets of Gujarat.

3.2.2 Coefficient of average seasonal variations

To assess differences in the magnitude of seasonal variation for peak and trough periods, the coefficient of average seasonal price indices was calculated for onions in respective markets during the study period (2001-2020). The highest coefficient of average seasonal variation was observed in Bhopal market (88.25%), while the lowest was in Mahuva market (53.81%). This indicates that, except for Mahuva market, onion prices exhibited a high degree of average seasonal variation in the selected markets. In contrast, the coefficient of arrivals variation had its maximum value in Mahuva market (187.25%) and the minimum in Mumbai market (31.97%). Despite being the largest onion-producing market in Gujarat, Mahuva experiences wide fluctuations in arrivals during the off-season due to limited storage facilities. This aligns with findings by

Reddy et al. (2012), who noted high variability in onion arrivals in selected Indian markets, particularly in March and April.

Among the markets, both arrivals and prices showed higher coefficients of variation in Ahmedabad and Kolkata. This may be attributed to the nature of onions, being a vegetable crop with constant demand throughout the year. After the harvest season, prices tend to decline, leading to wide seasonal variability. Additionally, unseasonal rains and hoarding by large traders in lean seasons contribute to price fluctuations.

The correlation coefficients between prices and arrivals ranged from -0.35 to 0.22. Bhopal, Lasalgaon, and Mahuva markets exhibited a negative correlation, while Ahmedabad, Bengaluru, Hyderabad, Jaipur, Mumbai, and Patna markets showed positive but poor correlation between prices and arrivals. This reflects the price fluctuation during both pre and post-harvest periods, aligning with observations by Amand and Gummagolmath [9], who noted exogenous factors interfering in market functioning and keeping onion prices higher despite increased arrivals.

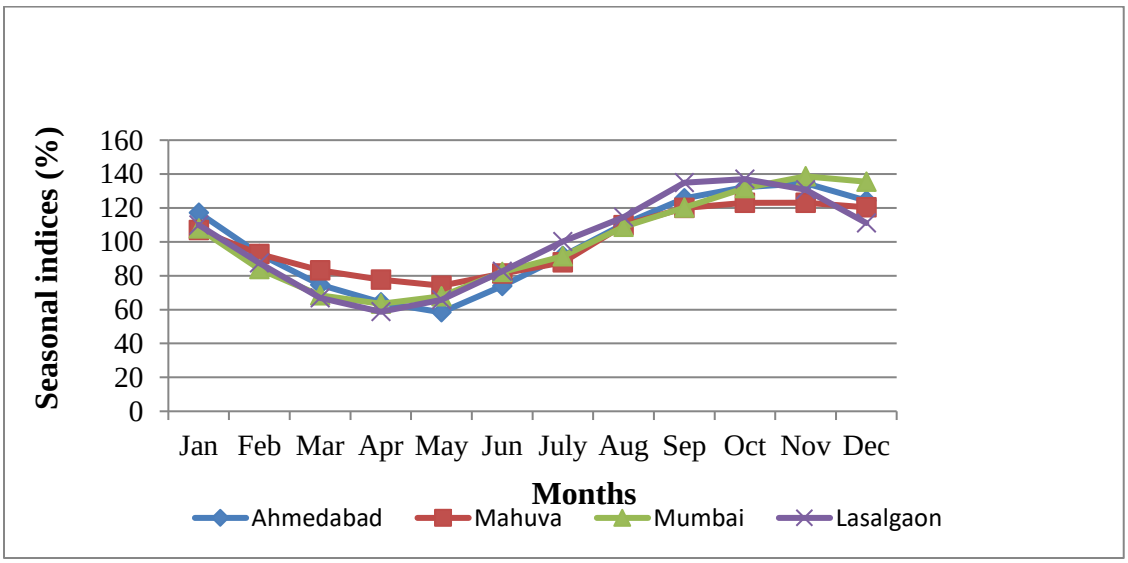

Fig. 1. Seasonal indices of onion wholesale prices in selcted (producers) markets (2001 to 2020)

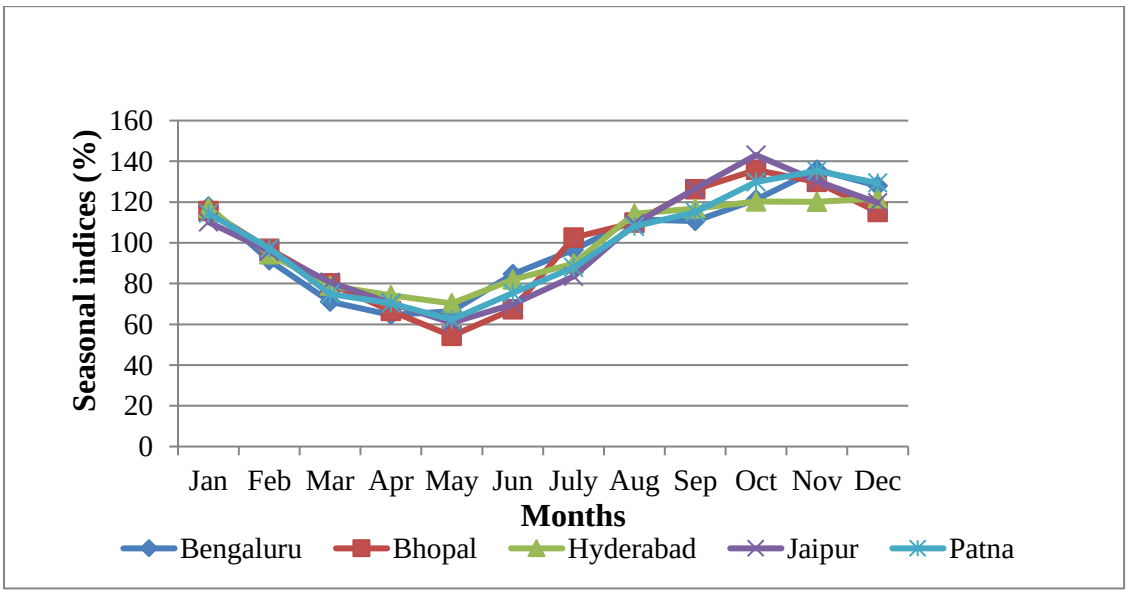

Fig. 2. Seasonal indices of onion wholesale prices in selected (consumers) markets (2001 to 2020)

Table 4. Coefficients of average seasonal prices and arrivals index variation (2001 to 2020)

Markets	Price variation (%)	Arrivals variation (%)	correlation coefficient of monthly arrivals and prices
Ahmedabad	82.45	45.65	0.15
Bengaluru	74.46	95.89	0.19
Bhopal	88.25	102.78	-0.07
Hyderabad	57.06	34.31	0.19
Jaipur	83.87	45.78	0.03
Mumbai	79.63	31.97	0.16
Patna	76.57	70.89	0.22
Lasalgaon	82.75	92.87	-0.35
Mahuva	53.81	187.25	-0.10

3.3 Irregular Fluctuations in Onion Prices

Irregular price variations, characterized by unpredictable and non-systematic behavior, were assessed through the calculation of the index of irregular fluctuation for the middle year 2010 during the entire study period, as outlined in the methodology section.

Fig. 3 illustrated the irregular indices of onion prices in selected markets. The maximum index of irregular fluctuation for onion prices was observed in May, reaching 513.48 points in Ahmedabad market, followed by Patna with 495.31 points, and Bengaluru in April with 446.48 points. Conversely, the minimum irregular fluctuation indices were noted in December, with Mumbai having 49.24 points, followed by Bengaluru with 49.61 points, and Ahmedabad with 57.42 points. These fluctuations highlight the random and unpredictable nature of onion prices in the selected markets.

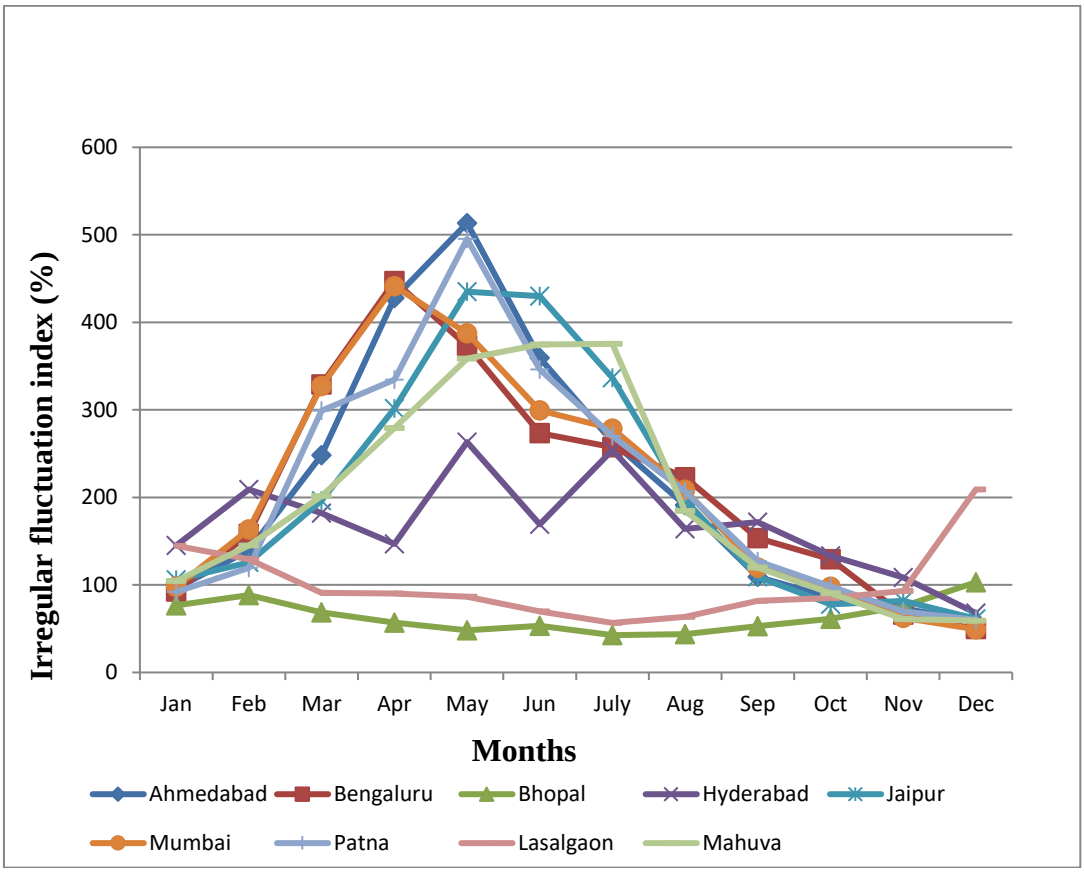

Fig. 3. Indices of irregular fluctuation in wholesale prices of onion in selected markets (2001 to 2020)

Table 5. Simple correlation coefficients of monthly prices of onion

Markets	Ahmedabad	Bengaluru	Bhopal	Hyderabad	Jaipur	Mumbai	Patna	Lasalgaon	Mahuva
Ahmedabad	1	0.934	0.960	0.931	0.937	0.982	0.977	0.951	0.940
Bengaluru		1	0.899	0.916	0.875	0.954	0.932	0.897	0.908
Bhopal			1	0.893	0.916	0.955	0.958	0.911	0.898
Hyderabad				1	0.897	0.926	0.933	0.876	0.889
Jaipur					1	0.929	0.937	0.904	0.908
Mumbai						1	0.979	0.949	0.933
Patna							1	0.941	0.913
Lasalgaon								1	0.909
Mahuva									1

*Note: *** Significant at 1 per cent probability level*

Table 6. Simple correlation coefficients of yearly prices of onion

Markets	Ahmedabad	Bengaluru	Bhopal	Hyderabad	Jaipur	Mumbai	Patna	Lasalgaon	Mahuva
Ahmedabad	1	0.975	0.980	0.973	0.980	0.993	0.991	0.991	0.972
Bengaluru		1	0.966	0.961	0.967	0.981	0.972	0.978	0.967
Bhopal			1	0.943	0.974	0.984	0.981	0.981	0.962
Hyderabad				1	0.980	0.980	0.980	0.979	0.935
Jaipur					1	0.990	0.993	0.993	0.952
Mumbai						1	0.995	0.997	0.968
Patna							1	0.997	0.956
Lasalgaon								1	0.959
Mahuva									1

*Note: *** Significant at 1 per cent probability level*

3.4 Inter-Relationship of Onion Monthly and Yearly Prices in Different Markets

To establish the interrelation between onion prices across various markets, simple correlation coefficients were calculated for both monthly and yearly price movements during the study period. The results are presented in Tables 5 and 6, respectively.

Table 5 reveals that the correlation coefficients for the monthly price movements of onions in the selected markets were consistently above 0.87 and highly significant. This indicates strong correlations among all the consumption and production markets, emphasizing a robust connection in the price movements of onions across different regions. Similarly, Table 6 illustrates that the correlation coefficients for the yearly prices of onions in the selected markets exceeded 0.90 and were highly significant. This further confirms a substantial and statistically significant correlation in the yearly price trends of onions across the studied markets.

These findings align with a study conducted by Dave and Tarpara (2016) on the price behavior of major pulses in Gujarat state during 2003 to 2013. They reported correlation coefficients of monthly and yearly prices for pulses exceeding 0.90 and being highly significant, indicating a strong interrelation in price movements.

4. CONCLUSION

Over the past two decades, onion prices have witnessed a substantial annual increase of 8.50 per cent in major markets across India. The non-significant coefficient of the quadratic trend (T2) across all markets indicates a consistent growth pattern in onion prices, attributing the rise primarily to inflationary factors rather than benefits accruing to farmers. Seasonal indices underscored the lowest onion prices in April-May and the highest in October-November for most markets, revealing significant seasonal and irregular fluctuations. In some markets, a positive correlation between arrivals and prices was observed, possibly influenced by exogenous factors. The strong correlation coefficients of monthly (>0.87) and yearly (>0.90) onion prices across all markets indicate a robust interconnectedness in price movements.To address the high volatility in onion prices, it is imperative for the government to implement measures such as enhancing storage and irrigation facilities. Additionally, curbing cartel-like behavior among traders in Agricultural Produce Market Committees (APMCs) is crucial for stabilizing onion prices and ensuring fair returns to farmers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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