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Quantifying seasonal market trends for tomato, pumpkin and cabbage in Guwahati (Assam, India)

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Abstract

The objective of the present study was to examine the seasonal and trend patterns in wholesale prices of tomato, pumpkin and cabbage over different seasons in Guwahati city, Assam. From time series and box plots, the study found that pumpkin prices are higher in November rather than lower prices during April to June. We find that cabbage is priced lowest from January to May and induces peaks in prices, rising the most in October. During January-April, tomato prices fall and reach a low point in April. From May onwards, the prices increase and peak in November. We performed the Mann-Kendall trend test, which showed no significant trend in the prices of all three perishable crops. It was proven that it is monthly loading and uniform across all years. Seasonal indices show a rise in the prices of pumpkins from April to October, cabbage from March to October and tomatoes from April to October reflecting their shorter shelf life and seasonal nature of these crops.

Key words: Price variations, Mann-Kendall trend test, seasonal index, time series, trend, perishable crops

Introduction

Assam, an Indian state with a rice dominated cropping pattern, has seen a notable rise in agricultural output, especially horticulture crops (GoA, 2022), aligning with the national trend of transitioning from traditional crops (Maldal, 2010; Goswami, 2016). High-value products like fruits, vegetables, eggs, dairy, meat, and fish fetch more remunerative prices than cereals due to rising demand (Jha et al., 2009). Diversification is profitable for farmers, offering higher market prices than traditional crops (Birthal et al., 2007) and boosting income, mitigating reliance on a limited number of agricultural commodities (Wainright, 1994). Despite ongoing agricultural growth and potential diversification in Assam's economy, there remains a significant issue of high postharvest crop losses (Nuthalapati et al., 2022; NABCONS, 2022). At the national level, various studies are attempted to estimate the postharvest losses at various stages of operations for food grains and horticulture crops (Sharma, 2020; Kumar et al., 2021; Nuthalapati et al., 2022; NABCONS, 2022). However, in Assam, limited research exists on estimating these losses for both food grains and horticulture crops. According to NABCONS (2022), postharvest losses in paddy are very high in Assam. Among vegetables, cabbage suffers the most losses, with tomatoes also experiencing significant losses (NABCONS, 2022; Nuthalapati et al., 2022). NEDFI (2001) estimated that the losses were highest (up to 45%) in vegetables and fruits. About ₹1,200 crores worth of food grains, spices, fruits and vegetables are lost annually in Assam.

The heavy postharvest losses of crops lead to some serious economic issues. One of the important issues arising from heavy postharvest losses is that farmers generally get non-remunerative prices for their yield (GoA, 2022), as farmers are often forced to sell at lower prices soon after harvesting rather than store for selling at a time when market prices go up. Although the Government of India has consistently been implementing various agricultural price policies, such policies hardly provide price incentives for farmers (FAO, 2022). One negative consequence of these policies is that farmers/producers may face price risks (inelastic demand for their produce) while carrying out farming activities that can negatively impact agricultural production. These risks are more acute in regard to the horticulture crops. Generally, most horticulture crops are seasonal and highly localized based on favorable agro-climatic conditions. The perishable nature of horticulture crops makes it challenging for producers to manage supply, leading to significant seasonal price variations and exposed to significant price volatility. Thus, seasonality and price spikes of perishable crops are major concerns in the agriculture sector, which have intensified further and long-lasting, causing economic instability (GoA, 2015).

This study investigates the seasonal price patterns of vegetable crops, focusing on tomato, pumpkin and cabbage in Guwahati city, Assam. It aims to understand how prices of these key crops fluctuate across different seasons. Specifically, the study aims to identify seasonal price variations associated with these crops in Assam and explore the extent of these fluctuations in the region.

Materials and methods

In this study, we purposefully selected the wholesale prices of three vegetable crops: pumpkin, cabbage, and tomato. Tomato, pumpkin and cabbage were chosen to assess their relative seasonal variation of prices. We obtained 233 weekly wholesale price data points spanning a 60-month time series from Guwahati city, Assam, covering the years 2012-13 to 2016-17 obtained from Guwahati's Deputy Director of Agriculture (Marketing) Office. To facilitate analysis, we converted the weekly data into monthly averages, aggregating the monthly wholesale price data for each month and calculating their respective means.

Our interest in analyzing seasonal variations stems from the practical utility of constructing seasonal indices, which help understand price fluctuations in vegetable crops. These indices offer insights into the presence and extent of seasonal patterns in the data. However, it's crucial to emphasize that apart from seasonality, time series data may exhibit other forms of variability, such as a steady trend or abrupt (a step change) or some other recognized variation over time, which can affect various statistical characteristics of the data like the mean, median, variance, and autocorrelation. Therefore, before checking for seasonality, we checked if there was a trend associated with the variability.

A time series, say Y_t, can be represented as the product of four components.

$$Y_t = T \times S \times C \times I$$

Where,

T= value of the trend of the data, S= value of the seasonal component of the series, C= cyclical component of the series, I= irregular component of the series

To isolate the trend component and cyclical component that is T×C from the original series, first, we checked for any significant trend by using the Mann-Kendall (MK) test for trend. MK statistic (S) was computed through pairwise comparisons of each data point with all previous data points to count the occurrences of increases, decreases, and ties. A positive S value indicates an increasing trend over time, while a negative S value signifies a decreasing trend. An S value close to zero suggests that there is no significant upward or downward trend. The magnitude of S indicates the strength of the trend, and a trend is considered statistically significant if the absolute value of S exceeds the critical value of S. We used a nonparametric test in the present study and not a simple regression model for checking trends because linear regression presumes that the residuals defined as the differences between observed and predicted values are independent, normally distributed, and exhibit constant variance. It does not consider the uncertainty of the regression fit that arises from the variability of the data around the calculated regression line. However, the MK test is the nonparametric test that assumes independent concentration measurements for assessing the significance of a trend (Hirsch et al., 1982).

Our hypothesis is:

H_0: No monotonic trend, *i.e.*, the data (Y_t, t = 0, 1, 2 …) are independent and identically distributed.

H_A: The monotonic trend is present in the data (Y_t)

The MK test statistic was calculated according to:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \mathrm{sgn}\left(X_j - X_k\right)$$

Where,

$$\mathrm{sgn}(x) = \begin{cases} 1 \text{ if } x > 0 \\ 0 \text{ if } x = 0 \\ -1 \text{ if } x < 0 \end{cases}$$

The S is approximately normally distributed as the mean and the variance σ^2 are

E(S)=0

$$\sigma^2 = \left[n(n-1)(2n+5) - \sum_{j=1}^{p} t_j(t_j-1)(2t_j+5) \right] \Big/ 18$$

Where,

'p'=number of the tied groups in the data set, t_j = number of data points in the j^{th} tied group. The statistic S is approximately normally distributed given that the following Z-transformation is employed:

$$Z = \begin{cases} \frac{S-1}{\sigma} & \text{if } S > 0 \\ 0 & \text{if } S = 0 \\ \frac{S+1}{\sigma} & \text{if } S < 0 \end{cases}$$

If a significant trend is present in the data sets, we have to eliminate the trend component from the data sets. However, if a trend is not significant, *i.e.*, the data sets are independent and identically distributed, we can perform a simple regression to estimate the constant term in the data. We calculated the constant term for each price of pumpkin, cabbage, and tomato by simply constructing the following model

$$Y = \beta_0 + \beta_1 t + e$$

Where,

t= represents the time in chronological order, Y= represents the monthly wholesale price of the three selected crops respectively.

The study is based on 60-month time series data. Therefore, assuming that no cyclical component present in the series data.

Now, the original data were divided by the estimates of constant y_t to obtain an estimate of combined seasonal and irregular components S×I (Pindyck & Rubinfeld, 1998).

$$\frac{Y_t}{y_t} = \frac{T \times S \times I}{T} = D_t = S \times I$$

Where,

Y_t = actual value, y_t = estimated constant value

After getting the seasonal and irregular components of wholesale prices of each of the three vegetable crops, we eliminated the irregular components to construct a seasonal index. For that, we averaged the values of S×I corresponding to the same month. On the basis of 60-month data, we computed the seasonal index in the following:

$$D_1 = \frac{1}{5}(d_1 + d_{13} + d_{25} + d_{37} + d_{49})$$
$$D_2 = \frac{1}{5}(d_2 + d_{14} + d_{26} + d_{38} + d_{50}) \quad \ldots. (1)$$
$$\ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots$$
$$D_{12} = \frac{1}{5}(d_{12} + d_{24} + d_{36} + d_{48} + d_{60})$$

The rationale behind this was when the S×I components D_t is averaged for each month, the irregular fluctuation is smoothed out and only seasonality remains. The 12-month averages D_1, D_2, …, D_{12} are the estimates of seasonal indices. If the aggregate of all the ratios was not equal to 12, we need to normalize them by adjusting them proportionately so that their sum is equal to 12.

Results and discussion

Time series plot and box-plot of the wholesale prices: The time plot of the monthly wholesale price of tomato, pumpkin and cabbage and its corresponding box-plot are presented in Fig. 1. The study used box-plot to allow variability of the median monthly wholesale prices of these vegetables.

It appears that for tomatoes, in the first six months, the wholesale

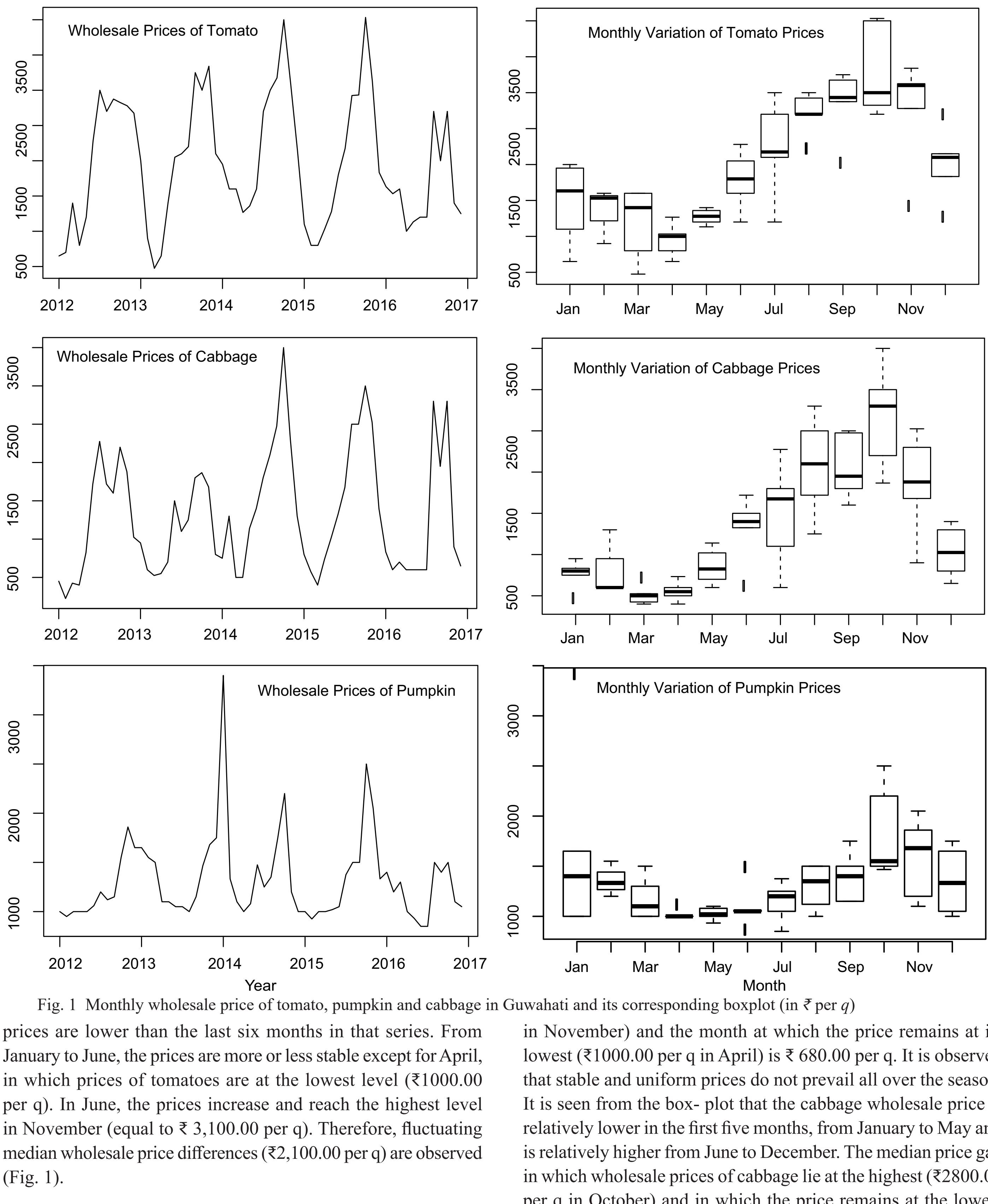

Fig. 1 Monthly wholesale price of tomato, pumpkin and cabbage in Guwahati and its corresponding boxplot (in ₹ per *q*)

prices are lower than the last six months in that series. From January to June, the prices are more or less stable except for April, in which prices of tomatoes are at the lowest level (₹1000.00 per q). In June, the prices increase and reach the highest level in November (equal to ₹ 3,100.00 per q). Therefore, fluctuating median wholesale price differences (₹2,100.00 per q) are observed (Fig. 1).

Again that the wholesale price of pumpkin in Guwahati fluctuates considerably. Box-plot indicated that the wholesale prices of pumpkin are relatively lower in April, May, and June than in the other months. Again, in July, wholesale prices are slightly up and reach the maximum in November. The median price gap between the month in which the price lies at its highest (₹1680.00 per q in November) and the month at which the price remains at its lowest (₹1000.00 per q in April) is ₹ 680.00 per q. It is observed that stable and uniform prices do not prevail all over the season. It is seen from the box- plot that the cabbage wholesale price is relatively lower in the first five months, from January to May and is relatively higher from June to December. The median price gap in which wholesale prices of cabbage lie at the highest (₹2800.00 per q in October) and in which the price remains at the lowest (₹500.00 per q in March), is ₹ 2300.00 per q.

However, other than seasonality, there may be some other factors (trend and irregular components) that also cause the price differences in the wholesale prices of tomato, pumpkin and cabbage. To eliminate the trend component, T, we have first to check whether a specific trend is associated with the data sets. Secondly, to be clear and confirm whether seasonality is associated with these variables, we constructed a seasonal index. To check for any significant trend associated with the wholesale price for tomato, pumpkin and cabbage, respectively, we will make our hypothesis in the following way.

Our null hypothesis is $|Z_{0.05}| = 1.96$

H_0: S=0 (No monotonic trend), *i.e.*, the data (Y_t, t = 0, 1, 2,…) is independent and identically distributed.

H_A: S ≠0 (Monotonic trend is present)

The results are presented in Table 1, from which we can see the values of 'S' for each vegetable crop's wholesale prices. The computed standard normal variate Z value is 0.06, 0.14 and 1.28 for wholesale prices for tomato, pumpkin, and cabbage, respectively.

Table 1. Results for Mann-Kendall test for checking the trend

Variables	S	Variance(s)	Z value	tau	'P' value
Tomato	11.00	24548.330	0.064	0.006	0.949
Pumpkin	23.00	24373.670	0.141	0.013	0.888
Cabbage	201.00	24545.000	1.277	0.114	0.202

We know that $Z\alpha$=1.96 at a 5% significance level, and we have $|Z|<|Z\alpha|$. Again, the calculated 'p' value is greater than 0.05. Thus, we accept our null hypothesis and conclude that the data contains no significant trend. There is no trend, so the data set is independent and identically distributed. Therefore, in the next step, we can use the simple regression model to find the constant term's value and its significance level. We find the value of constant term β_0 is highly significant at the one percent level. Thus, we include only the β_0 value in calculating the overall trend value y_t, excluding the β_1 value for getting seasonal and irregular value S×I in all the three-time series data sets of the wholesale prices of tomato, pumpkin and cabbage. Again, the sum of 12-month averages D_1+ D_2 + D_3+----- + D_{12} must be equal to 12, such that the average ratio per season is equal to one. We find the sum of the 12-month average for the tomato index value is 12.21. So, the seasonal index for tomato is computed by multiplying the value of 12/12.21 with the equation (1), which brings their sum equal to 12 and so on for cabbage and pumpkin. The results are presented for tomato, pumpkin and cabbage in Fig. 2, 3 and 4, respectively.

The tomato price rises sharply from April to October (Fig. 2). From October to December, prices fall rapidly due to the large quantities of tomatoes arriving in the market from different parts of the region. Tomatoes are primarily grown during the winter season, with planting typically occurring between August and September. The crop generally matures and is ready for harvest in about 2- 3 months after planting.

Fig. 3 shows seasonal pumpkin price indices for Guwahati city's major wholesale pumpkin markets. The pumpkin price rises sharply from May to October. The prices touch the ceiling point in October. However, there is a fall in the price of pumpkins in November and December, and then prices rises and reach the second highest in January. From January to May, prices fall rapidly due to the large quantities of pumpkins that arrive in the market from different parts of the region.

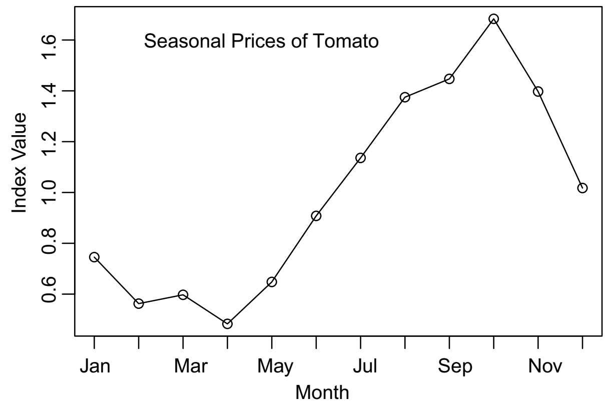

Fig. 2. Seasonal wholesale prices of tomato in Guwahati, Assam

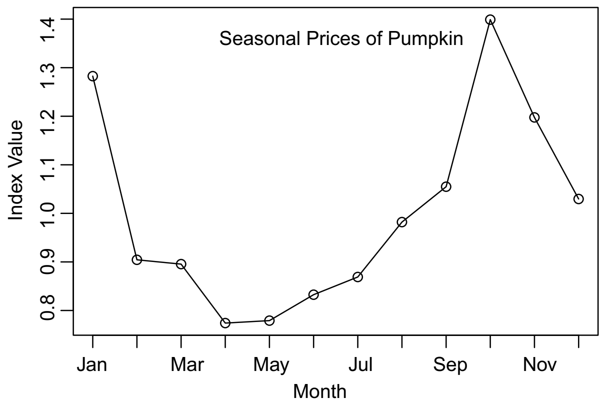

Fig. 3. Seasonal wholesale prices of pumpkin in Guwahati, Assam

On the other hand, the cabbage seasonal price index (Fig. 4) continues to rise from April until it reaches October. Afterward, there is a continuous fall in price from October to the end of March. Thus, we observed that the prices of these three vegetable crops depict a seasonal variation.

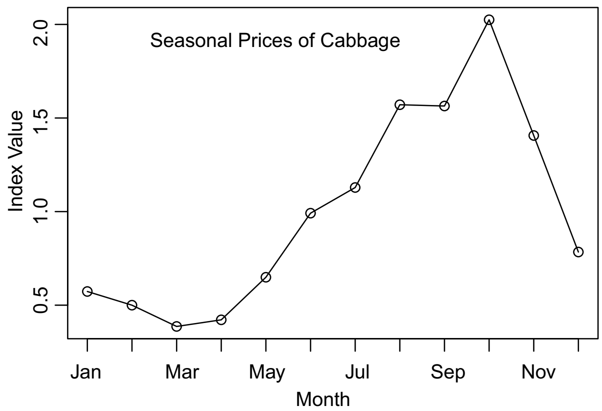

Fig. 4. Seasonal wholesale prices of cabbage in Guwahati, Assam

Previous studies have similarly observed that price volatility in horticulture is driven by seasonal production patterns (Kumar et al., 2021), leading to price spikes during off-seasons and drops during peak harvests (Yeasin et al., 2023; Kumar et al., 2023). Our findings also reveal a similar seasonal price variability in Assam. The limited use of cold storage, owing to unavailability of storage space for framers (Patowary & Sarma, 2024), and transportation challenges (Patowary, 2023) further intensify price volatility.

Again, due to poor logistics, cold chain, storage, and transport significant postharvest losses have occur particularly in India's midstream value chain (Nuthalapati et al., 2022). These losses were particularly more pronounced for vegetables as they have short shelf lives (Kumar et al., 2021). In Assam, these losses are notably high (Nuthalapati et al., 2022). Addressing gaps in storage and long-distance transportation (Mohan et al., 2023) could reduce these losses and stabilize prices by ensuring a steady supply.

The current study was conducted to determined seasonal price indices for three vegetable crops: tomato, pumpkin and cabbage, revealing significant seasonal variations. The price indices for these crops exhibit clear patterns of rise and fall. Prices peak during scarcity and drop during surplus periods. This cyclical behavior recurs annually, reflecting the short shelf life and seasonal nature of these crops in Guwahati's markets. The significant fluctuations in wholesale prices indicate seasonality tied to Assam's vegetable production, with variability levels differing among crops. Therefore, with the aim of enhancing production and potentially diversifying towards horticulture in the state, policymakers can use these insights to implement measures like developing cold storage infrastructure near significant production areas (Patowary, 2023; Guleria et al., 2023), proper dissemination of market information, constant watch on market arrival and prices can help in reducing price volatility and protect farmers and consumers (Thakur et al., 2022). Thus, future research should address existing gaps by exploring the role of storage infrastructure, the impact transportaion on seasonal price dynamics, and conducting comparative studies across different regions. This could provide valuable insights into how these factors influence pricing strategies.

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