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Arrival and prices of garlic and ginger in agricultural produce market committee, Nagpur

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Abstract
The present study was conducted to assess the arrival and prices of Garlic and Ginger in the Agricultural Produce Market Committee (APMC), Nagpur. Garlic (*Allium sativum*) and Ginger (*Zingiber officinale*) are important spice-vegetable crops widely used in Indian households for their culinary and medicinal values. Due to their perishable nature and seasonal harvesting, their prices often fluctuate in the market.
In this study, secondary data on the arrival and prices of Garlic and Ginger for the last twenty years (2004 to 2024) were obtained from Agmark.net and APMC, Nagpur. The data were processed to analyze the growth rate, variability, trends, and seasonal and cyclical fluctuations of these crops in APMC, Nagpur. The growth rate was analyzed using the exponential model. The arrival and prices of Garlic showed a positive and significant growth rate during the first period (0.94% and 0.47%). Similarly, the arrival and prices of Ginger showed positive and significant growth rates during the first period (1.05% and 0.80%).
The highest variability in Garlic arrival was observed during the first period (125.04), and in prices during the overall period (121.32). In the case of Ginger, the highest variability in arrival was recorded during the overall period (89.09), and in prices during the first period (70.43).
Trend analysis revealed that Garlic arrival followed a cubic trend, while prices followed a logarithmic trend. For Ginger, both arrival and prices followed a cubic trend. Seasonal analysis showed that Garlic arrival increased from February to May, while prices declined from February to June. For Ginger, arrival increased from October to March (except January), while prices declined from September to March. Cyclical variation observed in both arrival & prices of Garlic and Ginger. The higher arrival of Garlic recorded during the year 2018, 2008, 2010 & 2012. Similarly for Ginger during the year 2011, 2005 and 2023.

Keywords: Garlic (*Allium sativum*), ginger (*Zingiber officinale*), arrival, prices, variability, growth rate, trend analysis, seasonal fluctuations, cyclical variation, APMC Nagpur

Introduction
Garlic *(Allium sativum)*, the origin of Garlic is in Central Asia, but cultivated all over the world, in Spain, France, Egypt, and USA. Garlic has been cultivated in Central Asia from thousands of years and historically used for medicinal purposes. It is used as a vegetable, medicinal herb that has accumulated over the centuries.
Garlic plant, the green top as well as the bulbs are principally used as spice for flavouring and seasoning vegetable dishes, it gives the food a delightful fragrance. It is usually dehydrated for industrial and home use. Its folk medicinal use includes treatment of whooping cough, lung diseases, stomach complaints and disorders and as a specific for colds, sore eyes and ear-ache, its ability to protect crop against a variety of fungal and bacterial diseases has been scientifically proven.
In 2021, global Garlic cultivation exceeded 1.6 million hectares. Approximately 10 million metric tons of Garlic are produced annually from about 1 million hectares. In 2023, China dominated global Garlic production with a 76.28% share, followed by India at 9.28%. In 2020-21, Garlic was grown on 385,324 hectares with an average yield of 8,104 kgs/hectare.
In India, Madhya Pradesh and Gujarat are prominent Garlic producers. In the 2021- 2022 period, Madhya Pradesh accounted for 62.85% of India's total Garlic production. In Maharashtra, Garlic is cultivated across approximately 3,756 hectares, yielding around 5,925 kg per hectare. The state contributes about 0.71% to India’s total Garlic production. Prominent Garlic growing districts in Maharashtra known for Garlic cultivation include Nashik, Pune, and Thane. Ginger *(Zingiber officinale)*, Ginger is one of the important

commercial spice crop belonging to the family Zingiberaceae. The origin of Ginger is in Southeast Asia, but cultivated all over the word. India is one of the leading Ginger producing country. In 2022, global Ginger production reached 4.8 million metric tons, cultivated across 456,747 hectares. China and India are the leading producers, with India accounting for the largest area under cultivation. Other significant producers include Nepal, Thailand, and Nigeria. In India, the area under Ginger cultivation averages around 141 thousand hectares, with an average production of 956.81 thousand metric tons. Karnataka, Orissa, Assam, Meghalaya, Arunachal Pradesh, and Gujarat collectively contribute about 65% of India's total Ginger production. In Maharashtra, Ginger is cultivated across a significant area, with a total production of approximately 1.32 lakh tonnes annually. Satara district is known for having a large area dedicated to Ginger farming. Sangli, Kolhapur, and Nashik climate are well-suited for Ginger cultivation.

The present study was carried out with the following Objectives

1. To estimate the growth rate of arrival and prices of Garlic and Ginger.
2. To measure the variability in arrival and prices of Garlic and Ginger.
3. To analyse the market trends in arrival and prices of Garlic and Ginger.
4. To examine the seasonal and cyclical fluctuations in market arrival and prices of Garlic and Ginger.

Methodology

This section focused on selection of market, commodity, period of study, source of data and analytical tools to achieve the objectives.

Selection of market

The agricultural produce market committee, Kalamna, Nagpur was selected for the study.

Selection of commodity

Garlic and Ginger was selected for study.

Period of study

The study was based on month wise data of arrival and prices of Garlic and Ginger from Agricultural Produce Market Committee, Nagpur for the period of last 20 years i.e. (2004-2024).

Data collection

The study based on secondary data. Secondary data consisting of monthly prices and arrival of Garlic and Gingercollected from Agriculture Produce Market Committee, Kalamna, Nagpur. The website www.agmarknet.nic.in is also used for the purpose.

Analytical tools

The tools were used to estimate growth, variability, trend, seasonal and cyclical indices are as below.

1. Growth rate in arrival and prices

The compound growth rate of arrival and prices of Garlic and Ginger was worked out by using exponential method

$$Y = ab^t \qquad (1)$$

Where,
Y = arrival or Prices
a = Constant
b = Regression coefficient t = time period

This equation estimated after transforming (1) as follows, log.

Y=log a+t logb

Annual compound growth rate in percentage is calculated as,

CAGR = [Antilog (log b) - 1] x 100

2. Variability in arrival and prices

To study the degree of instability in arrival and prices of Garlic and Ginger was measured by using coefficient of variation.

$$CV\% = \frac{\sigma}{\overline{X}} \times 100$$

$$\sigma = \frac{\sqrt{\sum (X-\overline{X})^2}}{n}$$

Where,
σ = Standard Deviation $\overline{X}$ =Arithmetic mean X = Variable
n = Number of observations

3. Trends in arrival and a prices

The trends in arrival and prices of Garlic and Ginger were computed for the series data of 2004-24. To trace the path of process different parametric trend models were used. Among the competitive trend models, the best models were selected based in their goodness of fit (measured in term of R^2) value and significance of the coefficients.

Sr. No.	Function	Equation
1	Linear	Y = a + bX
2	Logarithmic	Log Y = Log a + Log bX
3	Exponential	$Y = ab^X$
4	Power	Y = a (bx)
5	Quadratic	$Y = a+bx+cx^2$
6	Cubic	$Y = a+bx+cx^2+dx^3$
7	Inverse	1/X and Y
8	Square root	$Y = a+b\sqrt{x}$

Seasonal and cyclical indices in arrival and prices

The seasonal indices in arrival and prices were worked out by using simple average method.

$$SI = \frac{\text{Monthly Average}}{\text{Average of Monthly Averages}} \times 100$$

Cyclical Indices were calculated for the arrival and prices of Garlic by using residual method.

$$\text{Cyclical Indices} = \frac{\text{Original yearly value}}{\text{Estimated trend value}} \times 100 = \frac{T \times C \times I \times 100}{T} = (C \times I) \times 100$$

Where,
T = Trend
C = Cyclical component
I = Irregular component

Table 1: Growth rates of arrival and prices of Garlic during the study period 2004-24

Sr no.	Period	CGR (%)	
		Arrival	Prices
1	First period (2004-2014)	0.94***	0.47***
2	Second period (2015-2024)	0.78***	0.12^{NS}
3	Overall period (2004-2024)	0.72***	0.45***

Note: *** = significant at 1%, NS is non-significant

The growth rate in arrival of Garlic increased by 0.94%, 0.78% and 0.72% per annum significantly during first, second and overall period respectively. While prices were increased by 0.47%, and 0.45% per annum significantly during first and overall period respectively

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Table 2: Growth rates of arrival and prices of Ginger during the study period 2004-24

Sr no.	Period	CGR (%)	
		Arrival	Prices
1	First period (2004-2014)	1.05***	0.80***
2	Second period (2015-2024)	0.89***	0.45***
3	Overall period (2004-2024)	0.73***	0.44***

Note: *** = significant at 1%

In Ginger growth rate of arrival increased by 1.05%, 0.89% and 0.73% per annum significantly during first, second and overall period respectively. Similarly prices increased by 0.80%, 0.45% and 0.44% per annum significantly during first, second and overall period respectively.

Variability in arrival and prices of Garlic and Ginger

Table 3: Variability in arrival and prices of Garlic during the study period 2004-24

Sr. no.	Period	CV (%)	
		Arrival	Prices
1	First period (2004-2014)	125.04	24.29
2	Second period (2015-2024)	78.70	8.38
3	Overall period (2004-2024)	102.36	121.32

Results and Discussion

1. Growth rate of arrival and prices of Garlic and Ginger

The coefficient of variation for arrival of Garlic were 125.04, 78.70 and 102.36 percent for the first, second and overall period respectively. Highest variability of arrival observed during the first period (2004-14) i.e. 125.04%. For prices coefficient of variation were 24.29, 8.38 and 21.32 percent for the first, second and overall period respectively. Highest variability of prices observed during the overall period (2004- 24) i.e. 121.32%.

Table 4: Variability in arrival and prices of Ginger during the study period 2004-24

Sr no.	Period	CV (%)	
		Arrival	Prices
1	First period (2004-2014)	77.72	70.43
2	Second period (2015-2024)	79.55	50.24
3	Overall period (2004-2024)	89.09	61.94

The coefficient of variation for the arrival of Ginger were 77.72, 79.55 and 89.09 percent for the first, second and overall period respectively. Highest variability in arrival of Ginger observed during the overall period (2004-24) i.e. 89.09%. For the prices coefficient of variation were 70.43, 50.24 and 61.94 percent for the first, second and overall period respectively. Highest variability in prices observed during the first period (2004- 14) i.e. 70.43%.

2. Trends in arrival and prices of Garlic and Ginger

Table 5: Trends in arrival of Garlic during study period 2004-24

Equation	Parameter Estimated				
	R2	**constant**	**b1**	**b2**	**b3**
Linear	0.14	7483.8	120.24	-	-
Logarithmic	0.13	15745.0	8389.4	-	-
Exponential	0.11	5979.2		-	-
Power	0.14	-	1410.7	-	-
Quadratic	0.15	2634.4	240.47	0.50	-
Cubic	0.16	8167.3	32.192	2.32	-0.008
Inverse	0.03	23157.1	-46909.7	-	-
Square Root	0.14	-2292.5	2342.33	-	-

Knowing the overall performance, path of movement of the series was traced through parametric trend model Table 5 wide range of models has been explored, among the competitive models best fitted models are selected based on the R^2 along with significance of coefficients. Among the competitive parametric model, cubic models are found best fitted for arrival of Garlic which is R2 value is 0.16.

Table 6: Trends in prices of Garlic during study period 2004-24

Equation	Parameter Estimated				
	R2	**Constant**	**b1**	**b2**	**b3**
Linear	0.06	2336.2	21.41	-	-
Logarithmic	0.58	1815.2	1497.4	-	-
Exponential	0.06	2142.5		-	-
Power	0.06	-	802.75	-	-
Quadratic	0.06	2059.1	28.28	-0.02	-
Cubic	0.06	829.4	88.88	-0.65	0.001
Inverse	0.06	2336.2	21.41	-	-
Square Root	0.06	629.5	413.86	-	-

Among the competitive models best fitted models are selected based on the R^2 along with significance of coefficients. Among the competitive parametric model, logarithmic models are found best fitted for prices of Garlic which is R^2 value is 0.58.

Table 7: Trends in arrival of Ginger during study period 2004-24

Equation	Parameter estimated				
	R2	**constant**	**b1**	**b2**	**b3**
Linear	0.218	4125.4	88.51	-	-
Logarithmic	0.164	-10163	5550.2	-	-
Exponential	0.222	4698.1	-	-	-
Power	0.206	-	1052.4	-	-
Quadratic	0.222	5986.2	42.37	0.19	-
Cubic	0.228	3396	170.31	-1.13	0.009
Inverse	0.033	15555.1	-30292.8	-	-
Square Root	0.204	-2135.9	1633.89	-	-

Among the competitive models best fitted models are selected based on the R^2 along with significance of coefficients. Among the competitive parametric model, cubic models are found best fitted for both arrival and price of Ginger which R2 value for arrival of Ginger is 0.228 and for price 0.24.

Table 8: Trends in prices of Ginger during study period 2004-24

Equation	Parameter estimated				
	R2	**constant**	**b1**	**b2**	**b3**
Linear	0.23	1578.6	14.5	-	-
Logarithmic	0.14	-391.2	825.9	-	-
Exponential	0.23	1637.7	-	-	-
Power	0.19	-	873.4	-	-
Quadratic	0.23	1769.4	9.7	0.02	-
Cubic	0.24	1218.4	36.9	-0.26	0.0008
Inverse	0.00	3364.8	-1701.2	-	-
Square Root	0.21	595.7	263.2	-	-

3. Seasonal and cyclical indices in arrival and prices of Garlic and Ginger

Table 9: Seasonal indices of arrival and prices of Garlic during study period 2004-24

Month	Arrival	Price
January	64.35	114.22
February	123.47	90.81
March	201.40	61.75
April	180.65	61.71
May	116.17	72.91
June	91.74	79.55
July	80.71	161.41
August	70.32	97.51
September	74.61	103.93
October	66.81	109.54
November	65.10	120.93
December	64.69	125.74

The results of the seasonal indices revealed that the highest arrival of Garlic in the APMC Nagpur market occurred in the month of March (201.40), followed by April (180.65) and February (123.47). In terms of prices, the highest seasonal index was observed in month of December (125.74), followed by November (120.93) and January (114.22).

Conversely, the lowest arrival of Garlic were recorded in month of January (64.35), followed by December (64.69) and November (65.10). For Garlic prices, the lowest indices were found in month of April (61.71), followed by March (61.75) and June (79.55).

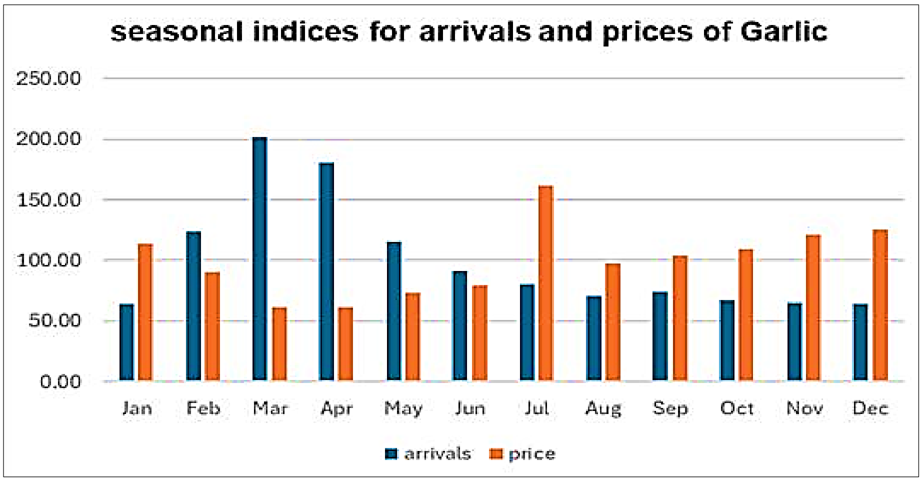

Fig 1: Seasonal Indices of arrival and prices of Garlic during the study period 2004-2024

Table 10: Seasonal indices of arrival and prices of Ginger during study period in 2004-24

Month	arrival	Price
January	97.51	90.96
February	107.89	89.68
March	152.75	93.36
April	92.89	100.29
May	88.23	114.88
June	75.70	123.87
July	80.86	120.77
August	86.34	115.84
September	96.08	96.02
October	104.95	86.80
November	108.30	83.54
December	108.50	83.99

The results of the seasonal indices indicated that the highest arrival of Ginger in the APMC Nagpur market was recorded in the month of March (152.75), followed by December (108.50) and November (108.30). In terms of Ginger prices, the highest seasonal index was observed in month of June (123.87), followed by July (120.77) and August (115.84).

On the other hand, the lowest arrival were noted in month of June (75.70), followed by July (80.86) and August (86.34). For Ginger prices, the lowest indices were recorded in month of November (83.54), followed by December (83.99) and February (89.68).

Fig 2: Seasonal Indices of arrival and prices of Ginger during the study period 2004-2024

Table 11: Cyclical indices of arrival and prices of Garlic during study period 2004-24

Year	Arrival	Prices
2004	62.84	76.99
2005	76.61	71.52
2006	43.03	149.30
2007	44.40	146.77
2008	187.69	50.19
2009	126.43	89.48
2010	100.60	184.46
2011	133.38	141.94
2012	183.01	34.60
2013	64.00	61.34
2014	46.03	71.63
2015	45.40	106.30
2016	32.53	221.25
2017	170.66	62.30
2018	193.58	35.87
2019	116.56	100.03
2020	109.61	111.36
2021	131.44	66.99
2022	84.93	32.02
2023	57.80	109.39
2024	89.50	176.27

The cyclical variations observed in the arrival and prices of Garlic during the study period of 2004-2024. From the result of cyclical indices its observed that the heavy arrival of Garlic found in 2018 (193.58) followed 2008 (187.69) followed by 2012 (183.01) and lowest price in 2022 (32.02) followed by 2012 (34.60) followed by 2018 (35.87).

Table 12: Cyclical indices of arrival and prices of Ginger during study period 2004-24

Year	arrival	Prices
2004	96.15	187.66
2005	152.95	113.82
2006	66.49	53.11
2007	59.47	72.15
2008	109.36	110.76
2009	128.18	101.21
2010	97.65	94.41
2011	199.72	59.54
2012	110.70	57.56
2013	65.71	188.58
2014	56.60	155.39
2015	73.36	87.81
2016	41.74	80.30
2017	124.54	63.75

2018	94.27	79.75
2019	87.71	117.17
2020	93.01	87.13
2021	140.27	46.61
2022	78.35	54.53
2023	145.52	137.12
2024	78.24	151.64

From the result of cyclical indices it observed that the heavy arrival of Ginger found in 2011 (199.72) followed 2005 (152.95) followed by 2023 (145.52) and lowest price in the 2021(46.61) followed by 2006 (53.11) followed by 2022 (54.53) followed by 2012 (57.56).

Conclusion

- Growth rate analysis using the exponential model showed a positive and significant increase in both arrival and prices during the first period for Garlic (0.94% and 0.47%) and Ginger (1.05% and 0.80%).
- Variability analysis indicated that the highest fluctuations in Garlic arrival occurred in the first period (125.04), while price variability was greatest in the overall period (121.32). For Ginger, maximum variability in arrival was found in the overall period (89.09) and in prices during the first period (70.43).
- Trend analysis showed that Garlic arrival followed a cubic trend and prices a logarithmic trend, whereas both arrival and prices for Ginger followed a cubic trend.
- Seasonal indices indicated peak arrival of Garlic from February to May and a price declined from February to June. Ginger arrival were highest from October to March (except January), with prices declining from September to March.
- Cyclical variations were observed in both crops, with peak arrival years for Garlic being 2008, 2010 and 2012 and for Ginger in 2005, 2011, and 2023.

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