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Market co-integration and price transmission in major pomegranate markets of India

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ABSTRACT

Pomegranate is an important fruit crop of arid and semi-arid regions of the world. It is produced in certain pockets and the prices in some markets are dependent on the prices in other markets and also on arrivals in particular markets. In some markets, only demand determines the prices of fruits. Such type of information is needed by the pomegranate growers in order to take decision for selection of markets for selling their produce at better prices with price stability. In this context, present investigations were carried out in major wholesale markets of India. The study revealed that maximum mean arrival of pomegranate was noticed in Delhi, Bangalore, Nagpur and Jaipur during the month of August. The overall maximum variability in prices was noticed in Bangalore market among different months as compared to other markets. The volatility shocks in the prices of pomegranate were quite persistence for long time in Nagpur, Bangalore and Jaipur markets during the study period. The co-integration of prices of pomegranate was observed for the selected markets. It indicated that selected markets were competitive with one another. The pair-wise Granger causality test of pomegranate prices results indicated that the market pairs Delhi-Bangalore, Bangalore-Chennai and Bangalore-Calcutta had bidirectional causality and the market pairs Bangalore-Mumbai, Mumbai-Chennai, Calcutta-Mumbai, Bangalore-Nagpur, Jaipur-Bangalore and Jaipur-Chennai had unidirectional causality. It was concluded that very high price volatility of pomegranate was present in Nagpur, Bangalore and Jaipur markets which needs to be minimized and there was need to provide price security to farming community.

Keywords: Pomegranate; arrivals; prices; markets; volatility

INTRODUCTION

Pomegranate is an important fruit crop of arid and semi-arid regions of the world. It is believed to have originated from Iran. As per the final estimates, area and production of pomegranate in India was 270 thousand ha with production of 3,086 thousand MT (Anon 2023). India ranks first in pomegranate cultivation in the world. In India, major pomegranate producing states are Maharashtra, Karnataka, Gujarat, Andhra Pradesh, Madhya Pradesh, Tamil Nadu Rajasthan (Sawant 2023). In Maharashtra, pomegranate is commercially cultivated in Solapur, Sangli, Nasik, Ahmednagar, Pune, Dhule, Aurangabad, Satara, Osmanabad and Latur. Pomegranate is produced in certain pockets and the prices in some markets are dependent on the prices in other markets and also on arrivals in particular markets. In some markets, only demand determines the prices of fruits. Such type of information is needed by the pomegranate growers in order to take decision for selection of markets for selling their produce at better prices with price stability. In this context, present investigations were carried out in major wholesale markets of India.

Sadiq et al (2018) investigated the causes of price volatility and the process of price discovery of okra in India and reported that Hyderabad market was more efficient in price discovery as six out of the seven periods earmarked were efficient in the discovery of price and the wholesale market dominated in the process of price discovery. Ghosh (2000) investigated intra-state and inter-state spatial integration of rice markets in India and utilized the ML method of co-integration. Intra-state regional integration of rice markets was evaluated by testing the long-run linear relationship between the prices of the state-specific variety of rice quoted in spatially separated locations in four selected

states. It revealed that the regional rice markets within and across the states were spatially linked in the long run. Even though the regional markets were geographically dispersed, spatial pricing relationships were consistent with market integration, suggesting that the prices provided relevant signals to the regional markets within and across the states. Reddy et al (2012) revealed that arrivals in Ahmedabad and Mumbai markets were showing constant trend, whereas, in Bangalore, Delhi and Kolkata markets, some fluctuations were noticed. In Bangalore and Delhi markets, maximum arrivals were noticed in November-December, however, in Kolkata market, it was in the month of March. Among the markets, the coefficient of variation in both arrivals and prices were found to be higher in Ahmedabad and Kolkata. It clearly indicated that although there was a steady increase in arrivals and prices over a period of time, their fluctuations from year to year were very high. Bhagat et al (2023a) studied the instability in banana export from India and suggested that there was a need to give more attention towards export of banana. ARIMA (3, 1, 6) and Brown's exponential smoothing model were found best fit for banana export and its total value respectively.

Market integration shows the extent to which prices in different markets move together. The high degree of market integration indicates the competitiveness of the markets. Market integration also plays a vital role in determining pattern and pace of diversification towards the high value crops. The formulation of valid study on the market integration in banana has potential application for the development of agricultural markets. The present investigations were undertaken to study the relationship between arrivals and prices of pomegranate, to assess the price volatility and co-integration of pomegranate among the selected markets of India.

METHODOLOGY

The monthly data on arrivals and prices of pomegranate were collected for seven markets viz Mumbai, Nagpur, Delhi, Bangalore, Chennai, Jaipur and Calcutta for the period of last ten (2012 to 2021) years from NHB database and AGMARKNET. The selection of major markets for pomegranate was based on maximum arrivals in a particular market.

The statistical analysis was carried out by using the following models and tests:

Unit root test – augmented Dickey-Fuller test:

$$\Delta \ln P_t = \alpha_0 + \delta_1 t + \gamma lnP_{t-1} + \sum_{j=i}^{q} \vartheta_j \Delta lnP_{t-j} + \varepsilon_t$$

where P = The price in each market, α_0 = Constant, t = Time or trend variable, q = Number of lag length. ε_t = Error term

Autoregressive conditionally heteroscedastic (ARCH) model [Engle (1982)]: An ARCH(m) process is one for which the variance at time *t* is conditional on observations at the previous *m* times and the relationship is:

$$Var(y_t|y_{t-1},\ldots,y_{t-m}) = \sigma_t^2 = \alpha_0 + \alpha_1 y_{t-1}^2 + \cdots + \alpha_m y_{t-m}^2$$

Generalized autoregressive conditionally heteroscedastic (GARCH) model [Bollerslev (1986)]: It uses the values of the past squared observations and past variances to model the variance at time *t* GARCH (1, 1) and is as follows:

$$\sigma_t^2 = \alpha_0 + \alpha_1 y_{t-1}^2 + \beta_1 \sigma_{t-1}^2$$

Johansen co-integration (Johansen 1988): It is used to check long run prices relation between selected markets:

$$P_t = \sum_{i=1}^{k} A_i P_{t-1} + \mu + \beta_t + \varepsilon_t ; (t = 1,2,3 \ldots T)$$

The procedure for estimating the co-integration vectors was based on error correction model (ECM) given by:

$$\Delta P_t = \mu + \pi P_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \beta \mu_t + \varepsilon_t$$

where $\Gamma_i = -(I - \Pi_i - \ldots\ldots, T)$, I = 1,2 ….K – 1; $\Pi = -(I - \Pi_i - \ldots\ldots, \Pi_k)$, μ = Constant, t = Time or trend variable, ε_t = Error term

Likelihood ratio (LR) test statistics (trace and max eigen test statistics):

$$J_{trace} = -T \sum_{i=r+1}^{N} \ln(1 - \hat{\lambda}_1)$$

where r = Number of co-integrated vectors, $\hat{\lambda}_1$ = Eigen value, $\hat{\lambda}_{r+1}$ = Largest squared eigen value

$$\lambda_{max} = -T \ln(1 - \hat{\lambda}_{r+1})$$

Granger causality test (Granger 1969):

It was used to study direction of causality for the selected time. It involves estimation of the simple form of vector autoregressive model (VAR) as below:

$$lnP_t^A = \sum_{i=1}^{n} \delta_i \, lnP_{t-1}^B + \sum_{j=i}^{n} \vartheta_j \, lnP_{t-j}^A + \mu_{At}$$

$$lnP_t^B = \sum_{i=1}^{n} \emptyset_i \, lnP_{t-i}^B + \sum_{j=i}^{n} \partial_j \, lnP_{t-j}^A + \mu_{Bt}$$

where Pt = Price, Subscripts A and B = Two markets, T = Time trend, μ_A, μ_B = Error terms of both the models

RESULTS and DISCUSSION

Variability in arrivals and prices of pomegranate in selected markets

The estimates of mean and coefficient of variation (CV) of arrivals and prices of pomegranate in selected markets of India from the period of 2012 to 2021 are presented in Tables 1 and 2.

The data given in Table 1 show that the overall mean arrivals of pomegranate in Mumbai, Nagpur, Delhi, Bangalore, Chennai, Jaipur and Calcutta markets were 2,771, 2,587, 6,747, 3,446, 1,269, 1,139 and 3,049 MT and magnitudes of coefficient of variation in arrivals were 55.61, 78.35, 33.29, 33.67, 19.80, 41.77 and 37.50 per cent respectively during the study period. The overall maximum variability in arrivals was noticed in Nagpur market among the months as compared to all other selected markets. The maximum mean arrival of pomegranate was noticed in Delhi, Bangalore, Nagpur and Jaipur during the month of August, while in case of Mumbai, Chennai and Calcutta, it was observed during April, September and December respectively.

The maximum variability in Mumbai market was recorded in the month of April, while in case of Nagpur and Bangalore markets, maximum variability was recorded in the month of August. However, in case of Delhi, Jaipur and Chennai, it was observed during the month of January.

The maximum mean variability in Calcutta market was noticed in the month of June. The lowest variability in arrivals of Delhi, Bangalore and Chennai markets was observed during the month of October, while, in case of Mumbai, Nagpur, Jaipur and Calcutta, it was noticed in the months of July, February, June and July respectively.

Bhagat et al (2023b) studied the relationship between arrivals and prices of pomegranate, to evaluate the price volatility and co-integration of pomegranate in the selected markets of Maharashtra. The co-integration of prices of pomegranate was observed for the selected markets. It indicated that selected markets were competitive to one another.

Bhagat et al (2023c) collected the data on arrivals and prices of tomato for five markets viz Mumbai, Nagpur, Nashik, Pimpalgaon and Pune and reported that the maximum variability of tomato in arrivals was noticed in Pimpalgaon market among the months as compared to Mumbai, Nagpur, Nashik and Pune. The maximum variability of tomato in prices was noticed in Pimpalgaon market among the months as compared to Mumbai, Nagpur, Nashik and Pune.

The overall mean prices of pomegranate in Mumbai, Nagpur, Delhi, Bangalore, Chennai, Jaipur and Calcutta markets were Rs 6,487, 5,290, 8,349 and 8,823, 10,319, 6,669 and 8,728 per quintal and magnitudes of coefficient of variation in prices were 17.60, 22.36, 18.34, 28.72, 11.41, 15.61 and 10.59 per cent respectively (Table 2). The overall maximum variability in prices was noticed in Bangalore market among the months as compared to other markets. The maximum mean price of pomegranate was received in Chennai market (Rs 11,692/q) during the month of April and in case of Mumbai (Rs 7,350/q), Nagpur (Rs 5,743/q), Delhi (Rs 9,276/q), Bangalore (Rs 9,634/q), Jaipur (Rs 7,975/q) and Calcutta (Rs 9,372/q.) during the months of November, March, October, March, October and October respectively.

The maximum variability in Mumbai market was recorded in January month while in case of Nagpur, Delhi, Bangalore, Chennai, Jaipur and Calcutta markets, maximum variability was recorded in June, January, December, February, October and June months respectively. The minimum variability in prices of selected markets was observed during the months of October, July, November, July, August, December and August respectively.

The results of normality and stationarity in selected markets of pomegranate are presented in Tables 3 and 4.

Table 1. Variability in arrivals of pomegranate in major markets of India (2012-2021)

Month	Quantity of pomegranate (MT)													
	Mumbai		Nagpur		Delhi		Bangalore		Chennai		Jaipur		Calcutta	
	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)
Jan	2,386	38.92	1,757	88.47	5,933	68.79	3,098	52.72	1,136	51.11	902	84.20	3,742	60.70
Feb	1,848	36.18	1,574	51.66	6,001	52.18	2,612	54.06	1,213	21.65	809	61.33	3,250	60.78
Mar	1,728	36.90	1,288	75.07	5,800	52.80	2,557	45.58	1,114	41.03	749	58.71	3,148	71.12
Apr	8,152	245.42	1,512	87.80	6,197	49.88	2,480	51.10	1,059	20.52	804	51.98	3,016	56.77
May	1,423	63.46	1,756	85.42	6,429	52.16	2,680	63.60	1,188	38.04	837	48.59	2,052	54.18
Jun	1,628	50.50	2,496	98.66	5,505	32.45	3,544	54.41	1,283	42.61	788	32.70	2,654	86.96
Jul	2,995	33.96	3,323	111.43	8,139	35.97	4,156	53.43	1,296	42.64	1,273	50.50	2,468	29.22
Aug	3,250	38.48	4,641	121.99	1,0134	38.05	6,071	80.03	1,466	13.00	2,297	57.57	3,187	40.72
Sep	3,159	81.31	3,614	106.83	8,368	52.68	4,137	55.68	1,499	12.94	2,103	46.63	2,775	55.88
Oct	2,087	35.33	2,891	55.72	6,154	22.66	3,661	27.65	1,376	9.49	1,007	52.21	2,700	38.07
Nov	2,163	50.20	3,397	103.54	5,365	43.45	2,873	45.33	1,194	22.83	900	61.89	3,319	46.79
Dec	2,433	37.21	2,793	78.45	6,940	48.89	3,483	46.80	1,405	21.24	1,195	75.32	4,277	44.65
Mean	2,771	55.61	2,587	78.35	6,747	33.29	3,446	33.67	1,269	19.80	1,139	41.77	3,049	37.50

Table 2. Variability in prices of pomegranate in major markets of India (2012-2021)

Month	Price (Rs/q)													
	Mumbai		Nagpur		Delhi		Bangalore		Chennai		Jaipur		Calcutta	
	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)
Jan	6,695	34.94	5,477	29.98	8,224	29.59	8,441	34.32	9,885	23.15	5,979	20.65	8,989	26.04
Feb	7,172	34.36	5,602	27.53	8,828	28.10	9,343	35.73	10,803	27.07	6,116	27.99	9,294	16.28
Mar	6,825	26.99	5,743	25.50	8,739	19.44	9,634	31.48	11,464	19.72	6,535	28.42	9,343	15.63
Apr	6,416	23.21	5,676	26.13	8,674	22.58	9,622	31.14	11,692	17.03	6,812	17.66	9,072	14.67
May	6,226	31.15	5,400	34.58	8,606	27.98	9,089	33.83	10,733	17.52	6,585	28.10	8,669	13.59
Jun	6,059	23.15	4,859	41.37	7,927	28.08	8,368	28.28	10,616	22.24	6,656	27.73	7,514	36.74
Jul	5,452	17.40	4,891	16.25	7,523	23.47	8,316	26.47	9,648	16.72	6,597	24.93	8,526	9.60
Aug	5,568	28.34	4,763	23.25	7,860	18.28	7,690	26.91	9,550	10.68	6,576	21.77	8,215	7.85
Sep	5,747	23.20	4,934	23.13	8,860	25.86	8,275	31.41	9,661	15.32	6,819	29.97	8,334	17.76
Oct	7,009	15.76	5,281	24.42	9,276	23.32	9,013	29.35	10,167	14.03	7,975	30.06	9,372	12.55
Nov	7,350	17.18	5,668	24.00	8,526	17.84	9,502	28.79	10,106	15.04	7,362	23.93	9,110	16.78
Dec	7,323	31.34	5,192	24.64	7,141	23.16	8,582	35.90	9,506	14.90	6,020	13.90	8,299	25.42
Mean	6,487	17.60	5,290	22.36	8,349	18.34	8,823	28.72	10,319	11.41	6,669	15.61	8,728	10.59

Table 3. Outcome of Shapiro-Wilk normality test for the prices of pomegranate in selected markets

Market	W	P-value
Mumbai	0.93	0.00
Nagpur	0.96	0.00
Delhi	0.96	0.00
Bangalore	0.93	0.00
Chennai	0.93	0.00
Jaipur	0.95	0.00
Calcutta	0.99	0.25

Table 4. Outcome of ADF and Phillips-Perron test for unit root in the prices of pomegranate

Market	Augmented Dickey-Fuller test outcome at level			Phillips-Perron test outcome at level		
	t-statistic	Prob	Remarks	Z(alpha)	Prob	Remarks
Ln (Mumbai)	–3.47	0.04	Stationary	–28.42	0.01	Stationary
Ln (Nagpur)	–2.64	0.31	Non-stationary	–28.70	0.01	Stationary
Ln (Delhi)	–2.35	0.43	Non-stationary	–34.54	0.01	Stationary
Ln (Bangalore)	–1.19	0.90	Non-stationary	–10.58	0.50	Non-stationary
Ln (Chennai)	–3.87	0.02	Stationary	–39.55	0.01	Stationary
Ln (Jaipur)	–3.43	0.04	Stationary	–25.80	0.02	Stationary
Calcutta	–3.54	0.04	Stationary	–57.68	0.01	Stationary
	Augmented Dickey-Fuller test outcome after 1st diff			Phillips-Perron test outcome after 1st diff		
D (Ln Bangalore)	–6.65	0.01	Stationary	–93.89	0.01	stationary

It was found that the prices of pomegranate in selected markets were not normal except in Calcutta market during the study period and also the prices of pomegranate in Nagpur, Delhi and Bangalore markets were non-stationary at level for augmented Dickey-Fuller test and for Bangalore market it was also non-stationary at level for Phillips-Perron test and it became stationary after first difference for both the augmented Dickey-Fuller test and Phillips-Perron test.

Price volatility

The results of price volatility are depicted in Table 5. The sum of alpha and Beta (α+β) indicated ARCH and GARCH effect for the selected pomegranate markets. It was observed that the sum of alpha and beta was nearer to 1 that is 1.07, 0.91 and 0.88 for Nagpur, Bangalore and Jaipur markets respectively that indicated that the volatility shocks in the prices of pomegranate were quite persistence for long time in these markets.

In case of Mumbai, Delhi, Chennai and Calcutta markets, the volatility shocks in the prices of pomegranate were not quite persistence for a long time.

In their study, Bhagat et al (2023c) reported a very high price volatility of tomato present in Mumbai, Nagpur, Nashik and Pimpalgaon markets. Bhagat et al (2023b) also reported a very high price volatility present in the selected markets of pomegranate in Maharashtra.

Ahmed and Singla (2017) explored market integration and price transmission in selected onion markets using Johansen cointegration, Granger causality and impulse response function. The outcomes of the study strongly buttressed to the co-integration and inter-dependence of onion markets in India. The impulse response function supported that except Mumbai and Kozhikode, all other selected markets responded well to standard deviation shock given to any of the markets. The overall regional markets of onion were strongly co-integrated that allowed the private traders and restricted the role of government intervention.

Co-integration analysis

Johansen multiple co-integration trace test was applied for indicating the long run relationship between the price series of pomegranate in selected markets

Table 5. Outcome of ARCH-GARCH analysis of pomegranate prices for the selected markets

Parameter	Mumbai	Nagpur	Delhi	Bangalore	Chennai	Jaipur	Calcutta
Alpha (α)	0.84	0.82	–0.03	0.19	0.59	0.72	–0.02
Beta (β)	–0.15	0.25	0.50	0.72	–0.10	0.15	0.59
Sum (α + β)	0.69	1.07	0.47	0.91	0.49	0.88	0.57

Table 6. Outcome of multiple co-integration analysis of logged pomegranate prices for the selected markets

Hypothesized number of CE(s)	Trace statistics			Max-Eigen statistics		
	Trace statistics	0.05 critical value	P-value	Max-Eigen statistics	0.05 critical value	P-value
None*	165.57**	134.68	0.00	66.78*	47.08	0.00
At most 1	98.79	103.85	0.10	34.58	40.96	0.22
At most 2	64.21	76.97	0.31	23.01	34.81	0.60
At most 3	41.21	54.08	0.41	16.99	28.59	0.66
At most 4	24.21	35.19	0.45	12.46	22.30	0.61
At most 5	11.75	20.26	0.47	7.21	15.89	0.64
At most 6	4.54	9.16	0.34	4.54	9.16	0.34

(Table 6). The results of multiple co-integration test showed that one co-integration equation was significant at 1 per cent level of significance which implied that there existed co-integration among the markets during the study period.

The results of pair-wise Johansen co-integration test for the prices of pomegranate are depicted in Table 7. The results clearly indicate that there existed co-integration equation between all the pairs of markets. It means that the prices of pomegranate were co-integrated in the long run. The prices of pomegranate in these pairs of markets moved together functioning efficiently. It indicated that the prices were competitive and closely associated.

The results of pair-wise Granger causality test of pomegranate prices are presented in Table 8 and it explicated that the market pairs Delhi-Bangalore, Bangalore-Chennai and Bangalore-Calcutta had bidirectional causality. It means that a price change in the former market in each pair granger caused the price formation in the latter market, whereas, the price change in the latter market was feed-backed by the price change in the former market.

The market pairs Bangalore-Mumbai, Mumbai-Chennai, Calcutta-Mumbai, Bangalore-Nagpur, Jaipur-Bangalore and Jaipur-Chennai had unidirectional causality. It means that a price change in the former market in each pair Granger caused the price formation in the latter market, whereas, the price change in the latter market was not feed-backed by the price change in the former market.

The pair-wise Granger causality test of pomegranate price results indicated that the market pairs Mumbai-Nashik, Pune-Mumbai, Nashik-Nagpur, Nagpur-Pune and Nashik-Pune had unidirectional causality (Bhagat et al 2023b).

A price change in the first market in each pair Granger caused the price formation in the second market, whereas, the price change in the second market was not feed-backed by the price change in the first market.

The overall significant negative correlation between arrivals and prices of tomato in Nagpur market was noticed by Bhagat et al (2023c). The market pair, Nagpur-Pimpalgaon had bidirectional causality and the pairs Mumbai-Nagpur, Mumbai-Nashik, Mumbai-Pimpalgaon, Mumbai-Pune, Nagpur-Nashik, Pune-Nagpur, Pimpalgaon-Nashik and Pune-Pimpalgaon had a unidirectional causality.

CONCLUSION

The maximum mean arrival of pomegranate was noticed in Delhi, Bangalore, Nagpur and Jaipur

Table 7. Pair-wise Johansen co-integration test outcome for the prices of pomegranate

Markets pair	Hypothesized number of CE(s)	Trace statistics			Max-Eigen statistics		
		Trace statistics	0.05 critical value	P-value	Max-Eigen statistics	0.05 critical value	P-value
Mumbai-Nagpur	None*	37.50**	20.26	0.00	25.98**	15.89	0.00
	At most 1*	11.52*	9.16	0.02	11.52*	9.16	0.02
Mumbai-Delhi	None*	38.01**	20.26	0.00	23.43**	15.89	0.00
	At most 1*	14.58**	9.16	0.00	14.58**	9.16	0.00
Mumbai-Bangalore	None*	89.67**	20.26	0.00	73.27**	15.89	0.00
	At most 1*	16.41**	9.16	0.00	16.41**	9.16	0.00
Mumbai-Chennai	None*	37.19**	15.49	0.00	23.08**	14.26	0.00
	At most 1*	14.11**	3.84	0.00	14.11**	3.84	0.00
Mumbai-Jaipur	None*	46.83**	20.26	0.00	32.81**	15.89	0.00
	At most 1*	14.03*	9.16	0.01	14.03*	9.16	0.01
Mumbai-Calcutta	None*	42.36**	20.26	0.00	26.83**	15.89	0.00
	At most 1*	15.53**	9.16	0.00	15.53**	9.16	0.00
Nagpur-Delhi	None*	20.54	20.26	0.05	12.24	15.89	0.17
	At most 1	8.29	9.16	0.07	8.29	9.16	0.07
Nagpur-Bangalore	None*	75.25**	12.32	0.00	75.25**	11.22	0.00
	At most 1	0.00	4.13	0.98	0.00	4.13	0.98
Nagpur-Chennai	None*	32.49**	20.26	0.00	21.37*	15.89	0.01
	At most 1*	11.12*	9.16	0.02	11.12*	9.16	0.02
Nagpur-Jaipur	None*	38.30**	25.87	0.00	23.63*	19.39	0.01
	At most 1*	14.66*	12.52	0.02	14.66*	12.52	0.02
Nagpur-Calcutta	None*	48.44**	20.26	0.00	37.11**	15.89	0.00
	At most 1*	11.33*	9.16	0.02	11.33*	9.16	0.02
Delhi-Bangalore	None*	80.19**	12.32	0.00	80.13**	11.22	0.00
	At most 1	0.06	4.13	0.85	0.06	4.13	0.85
Delhi-Chennai	None*	44.06**	25.87	0.00	25.98**	19.39	0.00
	At most 1*	18.08*	12.52	0.01	18.08*	12.52	0.01
Delhi-Jaipur	None*	40.56**	20.26	0.00	23.56**	15.89	0.00
	At most 1*	17.01**	9.16	0.00	17.01**	9.16	0.00
Delhi-Calcutta	None*	66.37**	25.87	0.00	48.64**	19.39	0.00
	At most*	17.73*	12.52	0.01	17.73*	12.52	0.01
Bangalore-Chennai	None*	92.37**	20.26	0.00	74.51**	15.89	0.00
	At most 1*	17.86**	9.16	0.00	17.86**	9.16	0.00
Bangalore-Jaipur	None*	80.09**	15.49	0.00	66.04**	14.26	0.00
	At most 1*	14.05**	3.84	0.00	14.05**	3.84	0.00
Bangalore-Calcutta	None*	100.07**	25.87	0.00	74.64**	19.39	0.00
	At most 1*	25.43**	12.52	0.00	25.43**	12.52	0.00
Chennai-Jaipur	None*	45.58**	20.26	0.00	28.70**	15.89	0.00
	At most 1*	16.88**	9.16	0.00	16.88**	9.16	0.00
Chennai-Calcutta	None*	53.74**	18.40	0.00	34.92**	17.15	0.00
	At most 1*	18.82**	3.84	0.00	18.82**	3.84	0.00
Jaipur-Calcutta	None*	41.48**	25.87	0.00	26.80**	19.39	0.00
	At most 1*	14.68*	12.52	0.02	14.68*	12.52	0.02

*Significant at 5% LoS, **Significant at 1% LoS

during the month of August. In case of Mumbai, Chennai and Calcutta, it was observed during the months of April, September and December respectively.

The overall maximum variability in prices was noticed in Bangalore market among the months as compared to other markets. The volatility shocks in the prices of pomegranate were quite persistence for long time in Nagpur, Bangalore and Jaipur markets during the study period. The co-integration of prices of pomegranate was observed for the selected market which indicated that selected markets were competitive to one another. The pair-wise Granger causality test of pomegranate price results indicated that the market pairs Delhi-Bangalore, Bangalore-Chennai and

Table 8. Market pair-wise outcome of Granger Casualty test of pomegranate prices

Market pair	Number of observations	F-statistics	P-value	Remarks
Mumbai-Nagpur	118	1.33	0.27	No causality
Nagpur-Mumbai	118	1.19	0.31	No causality
Mumbai-Delhi	118	0.49	0.62	No causality
Delhi-Mumbai	118	1.60	0.21	No causality
Mumbai-Bangalore	117	0.98	0.38	No causality
Bangalore-Mumbai	117	7.71**	0.00	Unidirectional
Mumbai-Chennai	118	5.61**	0.00	Unidirectional
Chennai-Mumbai	118	0.16	0.85	No causality
Mumbai-Jaipur	118	1.80	0.17	No causality
Jaipur- Mumbai	118	1.67	0.19	No causality
Mumbai-Calcutta	118	0.59	0.55	No causality
Calcutta-Mumbai	118	3.37*	0.04	Unidirectional
Nagpur-Delhi	118	0.45	0.64	No causality
Delhi-Nagpur	118	0.37	0.69	No causality
Nagpur-Bangalore	117	0.10	0.90	No causality
Bangalore-Nagpur	117	3.13*	0.04	Unidirectional
Nagpur-Chennai	118	0.48	0.62	No causality
Chennai-Nagpur	118	0.05	0.96	No causality
Nagpur-Jaipur	118	0.18	0.84	No causality
Jaipur-Nagpur	118	0.39	0.68	No causality
Nagpur-Calcutta	118	0.89	0.42	No causality
Calcutta-Nagpur	118	0.57	0.57	No causality
Delhi-Bangalore	117	4.55*	0.01	Bidirectional
Bangalore-Delhi	117	4.60*	0.01	Bidirectional
Delhi-Chennai	118	3.18	0.05	No causality
Chennai-Delhi	118	0.21	0.81	No causality
Delhi-Jaipur	118	1.33	0.27	No causality
Jaipur-Delhi	118	0.76	0.47	No causality
Delhi-Calcutta	118	1.48	0.23	No causality
Calcutta-Delhi	118	0.93	0.40	No causality
Bangalore-Chennai	117	14.80**	0.00	Bidirectional
Chennai-Bangalore	117	3.65*	0.03	Bidirectional
Bangalore-Jaipur	117	2.50	0.09	No causality
Jaipur- Bangalore	117	4.74*	0.01	Unidirectional
Bangalore-Calcutta	117	3.94*	0.02	Bidirectional
Calcutta-Bangalore	117	3.26*	0.04	Bidirectional
Chennai-Jaipur	118	0.31	0.73	No causality
Jaipur-Chennai	118	4.11*	0.02	Unidirectional
Chennai-Calcutta	118	0.89	0.41	No causality
Calcutta-Chennai	118	2.04	0.13	No causality
Jaipur-Calcutta	118	0.87	0.42	No causality
Calcutta-Jaipur	118	0.31	0.73	No causality

*Significant at 5% LoS, **Significant at 1% LoS

Bangalore-Calcutta had bidirectional causality. Thus a price change in the former market in each pair Granger caused the price formation in the latter market, whereas, the price change in the latter market was feed-backed by the price change in the former market. The pair-wise Granger causality test of pomegranate price results indicated that the market pairs Bangalore-Mumbai, Mumbai-Chennai, Calcutta-Mumbai, Bangalore-Nagpur, Jaipur-Bangalore and Jaipur-Chennai had unidirectional causality. Thus price change in the former market in each pair Granger caused the price formation in the latter market, whereas, the price change in the latter market was not feed-backed by the price change in the former market. It means that very high price volatility was present in Nagpur, Bangalore and Jaipur markets of pomegranate which needs to be minimized and there was need to protect the price security for the benefit of the farming community.

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