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PRICE VOLATILITY OF AGRICULTURAL PRODUCTS: EVIDENCE FROM PRODUCER FRUITS PRICE IN BATU MUNICIPALITY, INDONESIA

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Abstract: This paper attempts to investigate the price volatility of fruits with higher economic values, which are avocado, apple, guava, banana, and jackfruit, and analyzes the long-term and short-term period relationship between production and prices of these fruits. The data used are the quarterly productions and prices of avocado, apple, guava, banana, and jackfruit on the producer level for 2012 to 2020 obtained from Agriculture office of Batu Municipality. The volatility evaluation was using the ARCH/GARCH. The long-term relationship was analyzed using the Johansen cointegration test, and the short-term relationship used the Error Corection Mechanism (ECM). The results of the volatility analysis confirmed that every fruit studied had a low volatility rate. In addition, the productions and prices of the commodities studied had been cointegrated in the long-run; however only avocado, guava, and apple have a short-run relationship. The government is suggested to provide price and production information systems to ensure farmers' market access.

Keywords: price volatility, fruits, ARCH/GARCH, cointegration, ECM

Abstrak: *Studi ini bertujuan menginvestigasi volatilitas harga buah-buahan bernilai ekonomi tinggi, yaitu alpukat, apel, jambu biji, pisang, dan nangka, serta menganalisis hubungan jangka panjang dan jangka pendek antara produksi dan harga buah-buahan ini. Data yang digunakan adalah produksi dan harga per kuartal alpukat, apel, jambu biji, pisang, dan nangka pada tingkat produsen dari tahun 2012 hingga 2020 yang diperoleh dari Dinas Pertanian Kota Batu. Evaluasi volatilitas menggunakan ARCH/GARCH. Hubungan jangka panjang dianalisis menggunakan uji kointegrasi Johansen, dan hubungan jangka pendek menggunakan Error Corection Mechanism (ECM). Hasil analisis volatilitas mengkonfirmasi bahwa setiap buah yang diteliti memiliki tingkat volatilitas yang rendah. Selain itu, produksi dan harga komoditas yang diteliti telah kointegrasi dalam jangka panjang; namun, hanya alpukat, jambu biji, dan apel yang memiliki hubungan jangka pendek. Pemerintah disarankan untuk menyediakan sistem informasi harga dan produksin untuk memastikan akses pasar bagi para petani.*

Kata kunci: *volatilitas harga, buah-buahan, ARCH/GARCH, kointegrasi, ECM*

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INTRODUCTION

Fruits are agricultural products that are designated as strategic commodities and have large market opportunities both for domestic and export (Fousah et al. 2008). In addition, the fruit has a varying prices, types, and quality levels, so people from various income classes can consume fruit according to their income and willingness. The demand for fruit is increasing in line with the increasing awareness of the need for good nutrition, lifestyle, and people's purchasing power (Popescu et al. 2021). Consumption of fruit also increases with the high public knowledge about health and awareness of healthy living (Rahmawati et al. 2018; Englund et al. 2021). According to WHO (2014), in general, the function of fruits is as antioxidants which help ward off free radicals and prevent serious diseases. Individuals who lack fruit intake have a higher risk of coronary heart disease, stroke, and cancer (Afshin et al. 2019).

Batu Municipality is one of the important fruit producers in East Java Province, Indonesia. Batu Municipality is a center for fruits production, especially apple (PPID, 2019). There are 27 types of fruits cultivated in Batu Municipality, such as avocado, apple, guava, banana, jackfruit, and so on, that have high economic value. These five types of fruits are also included in the top ten of the highest productions in Batu Municipality (BPS Kota Batu, 2020). On the producer side, fruits have potential business prospects when coupled with increased production of both quantity and quality, as well as people's demand for fruit (Schreinemachers et al. 2018). The problem is the production depends on the weather, pests and diseases, disasters, and damage (Skendžić et al. 2021). The production fluctuates because of the seasonal in the nature of field productions. The quantity of production is influenced by internal factors such as farmer education, farming experience, knowledge and skills (Rachmina et al. 2013), as well as external factors of harvest area and environmental factors, socio-economic and cultural factors (Adeoye, 2020).

In the Java Island, distribution or marketing of horticulture products are one of the issues that have grown to be a major concern. This issue is significant because it affects the farmers' performance in their farming practices (Tinaprilla and Pratiwi, 2017). Distribution issues are strongly tied to the inefficiencies of the marketing chain, which includes marketing actors, from producers to consumers. Long trade chains increase complexity and disruptions, such as delivery delays (Winarno et al. 2020). In addition, the distance between producers and consumers can result in high lead times and transportation costs that affect supply chain efficiency (Ganeshkumar et al. 2017). Then, the price is an indicator to show the issues of the marketing chain's efficiency. Price is also an indicator of market effectiveness because it can reflect the availability of information in the market in the past, present, and future (Dragota et al. 2019).

Mostly in developing countries, the agricultural sector cannot respond well to consumer demand with an ineffective marketing system because it is not supported by efficient price signals (OECD, 2012). Farmers will suffer more from price changes on horticultural products than others. This implies the difficulty of the farmers at the right time selling products to generate more profit (Rocchi and Randelli, 2019). Farmers face uncertainty in their farming as a result. The frequent price changes in horticultural products are also indicate that the market inequilibrium.

The issue addressed in this research is that Batu Municipality has become one of national fruit production center. However, based on production data obtained from the Batu Municipality Department of Agriculture, fruit production tends to be unstable. In 2020, avocado production in the first quarter was 27,827 quintals, which decreased to 9,047 quintals in the second quarter, and increasing to 17,790 quintals in the last quarter. Meanwhile, guava production in the first quarter was 9,523 quintals and decreased gradually to 3,807 quintals in the fourth quarter. On the other hand, jackfruit production in the first quarter showed 7,898 quintals and increase to 9,699 quintals in the last quarter. Likewise, apple in the first quarter showed 72,274 quintals and increased gradually to 160,549 quintals in the third quarter. This condition is different from banana production. Banana production in the first quarter was 2,428 quintals and continued to decline to 1,878 quintals in the last quarter. The increase and decrease in production cannot be separated from the agro-climate condition, cultivation technology, and harvest area. This is compounded by factors influencing fruit demand in society, making it difficult to predict, unlike the determinants of staple food demand such as rice. In terms of demand, fruit use is not the same as food crops (FAO, 2020). The level of public consumption of vegetables and fruit is still below the expected dietary pattern (BKP, 2021). The demand for fruit is only based on demands for diet and complementary food intake. Fruit consumption depends on individual perceptions, awareness of healthy living, and income (Slamet & Nakayasu, 2017).

Price fluctuations in horticulture commodity do not always give negative signals to producers (FAO and OECD, 2011). This is because producers will get more profits when prices increase. Meanwhile, when there is a price decrease, the producer will get a small profit, or even a loss, given that producer's purpose in doing fruit farming is commercial to make a profit (Bhat et al. 2017). Therefore, it is necessary to conduct research related to the price volatility of fruits to map the uncertainty of prices, to provide recommendations to local governments in formulating policies and strategies in maintaining price stabilization.

The aims of this study are (1) to analyze the price volatility of the fruit's producer level in Batu Municipality and (2) to analyze the long-run and short-run relationship between the price of fruits and the production of fruits in Batu Municipality.

METHODS

Determination of the location in this study was carried out using the purposive method. The sample criteria used are cities or districts with high levels of fruit production. This criterion refers to the fruit's quarterly production data published by the Central Bureau of Statistics (BPS) in 2020, in relation to the fruits of this study are classified as annual crops. Batu Municipality is one of the centers for fruits production in Indonesia, especially on Java Island. This research was conducted in November-December 2022. The data collected in this study are in the form of quarterly production and price at the producer level data for avocado, apple, guava, banana, and jackfruit in Batu Municipality from 2012–2020. The data is sourced from the Agriculture Office of Batu Municipality.

The data analysis method used is the ARCH-GARCH model to analyze price volatility with the Eviews 12 application software. In line with previous empirical research on the volatility of horticultural commodities by Sekhar et al. (2018); Sahara et al. (2019); Ezeaku et al. (2021); and Khofifah et al. (2022). Time series data is volatile, potentially heteroscedastic, resulting in "biased results" (Mokosolang et al. 2015). Therefore, this model is chosen because the ARCH-GARCH model can handle heteroscedasticity in the data. Johansen's cointegration test was used to analyze the long-term relationship between price and fruit production. Meanwhile, the analysis of the short-term relationship between price and fruit production uses the error correction model (ECM) test method. To support the relationship between production and price, a Granger causality test was carried out to see if there was a one-way or two-way causal relationship.

Price Volatility Analysis

Volatility is defined as a quantitative measure of the degree of variability or fluctuation in prices over a certain period that is not directed at the price level. The existence of price volatility is characterized by a sharp increase in prices which is then followed by a decline in prices and then back up but cannot be estimated when it will happen again (Živkov et al. 2020). The steps of analyzing price volatility are:

Stationarity Test

Gujarati (2011) explains that stationarity must be considered in using time series data to avoid "nonsense" or "spurious regression". The variable producer prices for avocado, apple, guava, banana, and jackfruit are stationary with different test levels using an intercept without a trend or with a trend. Price data for avocado, apple, guava, and jackfruit have been stationary at the first difference level, and banana price data is stationary at the level. Time series data that are not stationary at the level must be stationary through differencing (Lestari et al. 2022). The t-statistic value of each fruit price is greater than the critical value at 5% significance level in absolute terms.

ARIMA Model Selection

The ARIMA model was chosen because the data is stationary after the differencing process. Selection of the best ARIMA model is based on the F-statistics probability value, which is significant or close to zero, the smallest Akaike Info Criterion (AIC) and Schwarz Criterion (SC) values. The best ARIMA model are ARIMA (1,1,2) for avocado, ARMA (1,0) for guava, ARIMA (3,2,1) for apple and jackfruit, ARMA (0,1) for banana, which are significant at the 95% confidence level or the probability value is less than alpha 5%.

Volatility analysis can also be done using the ARIMA model if the model is indeed good to use. The value of volatility is known through the sum of the AR and MA coefficients (Lapetit, 2011). The ARIMA equation formed is:

$$Yt = \mu + \Sigma pi{=}0\ \varphi i Yt - i + \Sigma qj{=}0\ \theta j \varepsilon t - j + \varepsilon t \quad (1)$$

Where μ is the mean, q is lagged error terms, p is lagged dependent variables, φ is coefficient for AR and θ for MA, ε_j is random residual with constant variance (white noise), and t – j is lag for a certain period.

Heteroskedasticity Test and ARCH Effect

Heteroscedasticity in the data can produce a weak model with a larger variation of measurement error (Bissoondoyal-Bheenick et al. 2020). The heteroscedasticity test is used to determine whether the data has constant variance (Wooldridge, 2013). The heteroscedasticity test was carried out using the white heteroscedasticity test by looking at the probability value of F-statistics. The heteroscedasticity test results for the ARIMA model of avocado, guava, apple, jackfruit, and ARMA of banana showed a probability value of 0,0000, smaller than the significance level of 5%. It means, the ARIMA and ARMA model of all these commodity rejects H_0 and is indicated to have a variant that is not constant (heteroscedastic).

The ARCH effect test is used to determine whether the ARIMA model can be continued to the ARCH/GARCH analysis. The ARCH effect test is done by looking at the kurtosis value in the data. Guava price data has a kurtosis value of 6,359593, and banana is 9,1616444. While, the value of kurtosis avocado is 2,929866, apple is 2,197018, and jackfruit is 2,83007. It means, the price data for guava and banana have an ARCH effect and can be continued using the ARCH/GARCH model for volatility analysis. Meanwhile, the price data for avocado, apple, and jackfruit do not have an ARCH effect, so it is enough to analyze the volatility using the ARIMA model. Data with a kurtosis value of more than 3 indicates the data is heteroscedastic and has an ARCH effect, so ARCH/GARCH modeling can be done (Lestari et al. 2022).

ARCH/GARCH Modeling

ARCH-GARCH is one of the more advanced methods of measuring volatility in agricultural commodity prices with a more detailed and complex approach (O'Connor and Keane, 2011). The the ARCH/GARCH model selection is based on the Akaike Information Criterion (AIC) that is a measure of the difference between the true model and the estimated model with high probability (Matsuda et al. 2021) and Schwarz Criteria (SC) that selects simpler models than AIC with different formulations (Koehler & Murphree, 1988), and the coefficient is not more than 1. The smallest AIC and SC value is commonly used to determine the best model (Lin, 2018). The ARCH/GARCH equations are:

$$\sigma^2 PG_t = \alpha_0 + \alpha_1 \varepsilon^2 PG_{t-1} + \beta_1 \sigma^2 PG_{t-1} + \varepsilon_t \quad (2)$$

$$\sigma^2 PB_t = \alpha_0 + \alpha_1 \varepsilon^2 PB_{-1} + \beta_1 \sigma^2 PB_{t-1} + \varepsilon_t \quad (3)$$

Where σ^2 is the residual variance at time t, α_0 is a constant, ε^2_{t-1} is the volatility of the previous period or the ARCH term, α_1, β_1 are the estimated parameter, σ^2_{t-1} is the residual variance of the previous period or the GARCH term. Meanwhile, PG_{t-1} and PB_{t-1} respectively are producer prices of the t-period for guava and banana, and ε_t as a stochastic factor.

In this study, the best ARCH/GARCH model for guava is GARCH (1,0) and banana is ARCH (0,1). Lapetit (2011) explains that the value of volatility can be known through the sum of the ARCH (α) and GARCH (β) coefficients. If $\alpha+\beta < 1$, it means that the price has low volatility. If $\alpha+\beta = 1$, then it is classified as high volatility. While the result of $\alpha+\beta > 1$, the price is indicated to have extremely high volatility.

Cointegration Analysis

The Johansen cointegration test uses the Maximum Likelihood (ML) method. The ML parameter estimation method is a consistent, symmetrically distributed, and unbiased median (Cheung and Lai, 1993). The steps taken in the Johansen cointegration test are:

Stationarity Test

The data on prices for avocado, guava, apple, and jackfruit are stationary at first difference levels. The results of the stationarity test on the productions variable for avocado, guava, apple, and jackfruit are stationary at the first difference level using an intercept without a trend or with a trend. While the banana production data has been stationary at the same level as the price data. The t-statistic value of each fruit price is greater than the critical value at the 5% significance level in absolute terms. Therefore, the price and production of avocado, guava, apple, banana, and jackfruit can be tested for cointegration.

Determination of Optimal Lag Length

Determination of the optimal lag length is very important in the cointegration test. Lags that are too long can increase the degree of error in forecasting, and a lag that is too short can eliminate relevant information (Bahmani-Oskooee and Brooks, 2003). The optimal lag length is determined based on the criteria for the smallest AIC and SC values and the largest Likelihood Ratio (LR) value indicated by a sign (*) in Eviews. Based on Table 1, the optimal lag length of each fruit data is different. It means that production and price data from avocado, guava, apple, and jackfruit have different degrees of freedom and lags.

Cointegration test

One of the advantages of the Johansen cointegration test analysis is that it has a strong procedure in the case of heteroscedasticity (Kühl, 2010). Johansen's cointegration test is carried out using the assumption that there is no intercept and trend in the trend deterministic assumption based on the AIC and SC values indicated by the sign (*) in the Eviews. The cointegration analysis between production data and fruit prices is determined based on the trace statistic and maximum eigenvalue with a probability value of less than 5%. The addition of the maximum eigenvalue as a consideration in determining the cointegration analysis can be used as a correction for the estimated number of parameters (Mandala and Kim, 1999) because in many cases, the use of trace statistics tends always to indicate cointegration (Adiyoga et al. 2009).

Error Correction Model Analysis

The ECM test is carried out if two-time series variables have a long-term relationship or are cointegrated. According to Gujarati (2011) two-time series variables that have a long-term equilibrium, it is possible also to have a short-term equilibrium. The ECM equations in this study are:

$$\Delta Y_t = \alpha + b_0 X_t + b_1 EC_{t-1} + \varepsilon_t \quad (4)$$

Where Y_t is the price variable at time t. Meanwhile, X_t is the production variable at time t. Constants are indicated by α, while the estimated parameters are indicated by b_0, b_1. For EC_{t-1} is the Error Correction Term and εt is the stochastic factor.

Granger Causality Analysis

Granger causality test is intended to determine a unidirectional or bidirectional causality relationship between two variables or which variable causes changes or other events to occur first (Chvosteková et al. 2021). The Granger Causality Test in this study was intended to determine whether each fruit's price and production variables were statistically related. Where the Granger causality test must use the optimal lag length. The optimal lag length allows us to retain sufficient and relevant information (Kacou et al. 2022). If the F-statistics probability is smaller than the 5% significance level, the decision is to reject H_0, which means there is a causal relationship, and vice versa. There are two functions in this research, (1) Price is a function of production, or price does not Granger cause production. H_0 is fruit production does not affect fruit prices, while H_a is fruit production affects fruit prices. (2) Production is a function of price, or production does not Granger cause price. H_0 is fruit price does not affect fruit production, while the H_a is fruit price affects fruit production.

Table 1. Optimal lag length of fruit prices and productions data

Price and Production Data	AIC	SC	LR	Optimal Lag
Avocado	48.52349	49.17110	19.83736	3
Guava	43.00199	44.84075	3.335178	9
Apple	52.09990	52.37199	4.924010	1
Banana	40.95665	42.78042	0.478541	5
Jackfruit	47.24847	48.28573	3.055663	4

RESULTS

Price Volatility Analysis

In Table 2, based on the ARIMA equation for the avocado price variable, it is known that the avocado price at the producer level for the 2012-2020 period is low volatility category. The categorization is based on the sum of the AR and MA coefficients of -1,752183 (less than 1). The previous price influences the low volatility of avocado prices at the 95% confidence level, which can be seen from the probability of the AR coefficient. Guava price volatility is also categorized as a low level of volatility. The categorization is based on the GARCH coefficient value of 0,332903, less than 1. In terms of probability, statistically the guava price is not influenced by the previous residual variance because it has an alpha of more than 5% significance level.

The prices of apple, jackfruit, and banana at the producer level are classified as low volatility. Shown by the sum of the AR and MA coefficients of -1.269294 (less than 1) for apples. The same categorization also occurs in jackfruit prices, which is indicated by the sum of the AR and MA coefficients, which is -1.339800. Statistically, the price volatility of apples and jackfruit is not influenced by the previous price or residual because the significant level of the coefficient is more than 5%. In addition, the volatility of banana prices indicated by the ARCH coefficient of 0.733242 is also classified as low volatility. The volatility is not affected by the previous price variance in the 95% confidence level.

In essence, all fruit prices in this study are classified as low level of volatility. The results of this study are in line with Pertiwi et al. (2013) and Khabibah et al. (2019) indicates that the economic law of low risk low return applies (Zaremba, 2017). However, bananas have the highest volatility value. There are many types of bananas (Hapsari & Lestari, 2016) with varied consumption uses (Netshiheni et al. 2020). Therefore, bananas have a specific demand so prices will increase or decrease when banana production cannot meet public demand. In general, bananas are fruits with important economic and social values in society and can be consumed by everyone (Debebe and Dagne, 2018). The demand for bananas tends to increase at certain times, such as religious or curtain events and celebrations. The highest increase in banana prices occurred in the third quarter of 2020 due to increased demand. In 2020, the world was shocked by of the corona virus disease (COVID-19) outbreak which almost infected countries around the world. Indonesia is one of the countries infected by COVID-19. This pandemic caused panic buying among the public because they wanted to boost their immune system against viruses and other diseases by consuming bananas (Odiase and Saghaian, 2022). Production of bananas tends to be stable; so, it cannot respond to an increase in demand because of the specific event in the community. Then, prices will rise and vice versa. These results confirm the statement by Deng et al. (2021) that an increase in a commodity's price is a condition where the supply of a commodity cannot respond to the rise in demand for that commodity.

Table 2. The equation of price volatility of fruits in batu municipality

Variable	Equation	Volatility Value ($\alpha + \beta$)
Price of avocado	$Yt = \mu + \Sigma pi=0\ \varphi iYt–i + \Sigma qj=0\ \theta j\varepsilon t–j + \varepsilon t$ (-0.752211) (-0.999972) (0.0439) (0.9997)	-1.752183
Price of guava	$\sigma 2PGt = \alpha 0 + \beta 1\sigma 2PGt\text{-}1 + \varepsilon t$ (0.332903) (0.9838)	0.332903
Price of apple	$Yt = \mu + \Sigma pi=0\ \varphi iYt–i + \Sigma qj=0\ \theta j\varepsilon t–j + \varepsilon t$ (-0.269294) (-1.000000) (0.1751) (0.9998)	-1.269294
Price of banana	$\sigma 2PBt = \alpha 0 + \alpha 1\varepsilon 2PBt\text{-}1 + \varepsilon t$ (0.733242) (0.4877)	0.733242
Price of jackfruit	$Yt = \mu + \Sigma pi=0\ \varphi iYt–i + \Sigma qj=0\ \theta j\varepsilon t–j + \varepsilon t$ (-0.339800) (-1.000000) (0.1105) (0.9999)	-1.339800

Johansen Cointegration Analysis

Johansen's cointegration test results based on trace statistical values can be seen in Table 3. The production and price data of avocado, guava, apple, and jackfruit more than the critical values. In addition, the probability value of each of these types of plants is less than the 5% significance level. Meanwhile, the cointegration test results based on the maximum eigenvalue can be seen in Table 4. The production and price data for avocado, guava, apple, and jackfruit are more than the critical value with a probability value of less than the 5% significance level. Based on the trace statistic in Table 3 and the maximum eigenvalue in Table 4, it is known that the production and price of avocado, guava, apple, and jackfruit are cointegrated or have a long-term balance. This long-term relationship indicates that the production of these fruits will affect the price. Therefore, the supply and price of fruits will move hand in hand in the long term. In line with Ai-hua (2012) the tension of supply becomes a basic contributor to price movements.

Error Correction Model Analysis

Statistically, in Table 5 show that the probability value of t-1 avocado, guava, and apple is less than 5%. It means these fruits also have a short-term relationship or adjustment process between price and production, except banana and jackfruit. This condition indicates that other factors that may strongly influence the prices of these two commodities, aside from their production itself. The formation of fruit prices is not only influenced by production factors. In addition, it is also affected by demand conditions (Trostle, 2008), transportation costs, the absence of market regulations, inadequate post-harvest handling, and lack of storage facilities (Khan et al. 2018).

The coefficient of avocado has a value of 0,000813. The positive sign can be interpreted as the price and avocado production having a positive relationship. If avocado production increases, the price of avocados also increases. This condition cannot be separated from the relatively high price of avocado, so it is included in the luxury goods type (Rana, 2020). Therefore, even if there is an increase in production, prices will also rise. Due to avocados becoming a commodity with high demand in the community.

The guava coefficient also shows a positive sign with a value of 0.972565. The probability value of the coefficient is 0.0000. The increase between production and price in the short term occurs simultaneously at the 99% confidence level. This study's result align with the findings of Khan et al. (2018). At the beginning of the harvest season, prices tend to increase. Meanwhile, at the end of the season, prices will fall. One of the problems in guava farming is guava production which is concentrated in the season and can affect price formation (Nava et al. 2014). In Batu City, guava is the fourth most produced fruit. Guava has a good return on revenue with minimum input, thus encouraging farmers to run guava farming commercially (Kumar, 2019).

Table 3. Cointegration test based on trace test

Price and Production Data	Trace Statistics	Critical Value
Avocado	61.56078***	12.32090***
Guava	24.62939***	12.32090***
Apple	61.32915***	12.32090***
Banana	22.21099**	20.26184**
Jackfruit	53.20968***	20.26184***

Note: t statistics in parentheses; **p < 0.05; ***p < 0.01

Table 4. Cointegration test based on maximum eigenvalue

Price and Production Data	Max-Eigen Statistic	Critical Value
Avocado	46.66017***	11.22480***
Guava	24.57523***	11.22480***
Apple	38.78406***	11.22480***
Banana	13.91851*	15.89210*
Jackfruit	31.74923***	15.89210***

Note: t statistics in parentheses; **p < 0.05; ***p < 0.01

The Xt coefficient value for apples is -0.000769 with a probability value of 0.5518. This value indicates that if apple production increases, the price will decrease, and vice versa at the 50% confidence level. When viewed from the probability value, changes in the price of apples are not entirely influenced by production. This is because the fluctuations in the price of apples in Batu Municipality are not only caused by apple production, but also the increasing number of imported apples which causes competition between local apple prices and imported apples (Ruminta, 2015). Apple cultivation has become less intensive, so many apple plants are no longer maintained, and farmers are no longer eager to cultivate apple plants because the price of Batu apples has dropped due to a lack of competitiveness against the many imported apples flooding the market.

Granger Causality Analysis

The Granger causality test is intended to prove whether there is a causal relationship between prices at the producer level and fruit production in Batu Municipality. Granger causality test results are summarized in Table 6.

Table 6 shows the results of the Granger causality test on price and fruit production. Based on the table, it can be seen that all types of fruits in this research only have a one-way relationship, except bananas. In guava and apple, it can be seen that the production affects the price within the 95% confidence level. In addition, it is seen from the probability that avocado production also affects prices, but with a 90% confidence level. At the same time, the results of the causality test of jackfruit showed that the price affected the production of jackfruit. Statistically, this is evidenced by the decision of the test results that reject H0 at the 95% confidence level. In Batu Municipality, jackfruit ranks fourth as the most produced fruit. Jackfruit has abundant availability because it is adaptive and able to grow well in changing climatic conditions (Weintraub et al. 2022). Judging from price developments during 2012–2020, which fluctuated but tended to increase, it became a commercial stimulus for farmers to cultivate jackfruit. Essentially in line with Wen et al. (2015) as a traditional price-setting factor, but under certain conditions, agricultural commodity prices can determine the quantity of the next harvest (Xie & Wang, 2017).

Table 5. ECM Test for Fruits in Batu Municipality

Price and Production	Variable	Coefficient	Probability
Avocado	Xt	0.000813	0.8168
	εt-1	-0.436370	0.0063
	C	211.7528	0.6114
Equation	ΔYt = 211.7528 + 0.000813Xt – 0.436370εt-1 + εt		
Guava	Xt	0.972565	0.0000
	εt-1	-4.140000	0.0000
	C	5458.286	0.0000
Equation	ΔYt = 5458.286 + 0.972565Xt – 4.140000εt-1 + εt		
Apple	Xt	-0.000769	0.5518
	εt-1	-0.537611	0.0020
	C	99.37445	0.8582
Equation	ΔYt = 99.37445 – 0.000769Xt – 0.537611εt-1 + εt		
Banana	Xt	0.015229	0.8286
	εt-1	0.256691	0.1339
	C	8032.775	0.0000
Equation	ΔYt = 8032.775 + 0.015229Xt – 0.256691εt-1 + εt		
Jackfruit	Xt	-0.001126	0.0806
	εt-1	-0.271808	0.0591
	C	842.9730	0.1579
Equation	ΔYt = 842.9730 – -0.001126Xt – 0.271808εt-1 + εt		

Table 6. Granger causality test for fruits in batu municipality

Causality Guideline	F-statistics	Probability	Decision
Avocado			
Price does not Granger Cause Production	2.61544	0.0724	Reject H0
Production does not Granger Cause Price	0.36471	0.7790	Accept H0
Guava			
Price does not Granger Cause Production	4.03267	0.0311	Reject H0
Production does not Granger Cause Price	0.53023	0.8182	Accept H0
Apple			
Price does not Granger Cause Production	5.64584	0.0237	Reject H0
Production does not Granger Cause Price	0.31847	0.5765	Accept H0
Banana			
Price does not Granger Cause Production	0.41469	0.8329	Accept H0
Production does not Granger Cause Price	0.41469	0.8329	Accept H0
Jackfruit			
Price does not Granger Cause Production	0.94455	0.4562	Accept H0
Production does not Granger Cause Price	3.02536	0.0384	Accept H0

Managerial Implication

The low volatility of fruit prices indicates that price fluctuations are insignificant in the producer market. This is due to these fruits being among the top ten in production in Batu Municipality, making them available year-round despite production fluctuations. While fruit production can generally meet community needs, demand is influenced by dietary preferences, supplementary food choices, and seasonal consumption related to ecological, waste, quality, freshness (Massaglia et al. 2019), and lifestyle factors (Moreb et al. 2021).

The low volatility of fruit prices at the producer level is also related to the characteristics of perishable fruit, so producers must reach the market as soon as possible before the fruit becomes rotten. Maintaining earnings while minimizing fruit and vegetable losses requires an ideal and efficient marketing system (Ramjan and Talha Ansari, 2018). In most developing countries, transportation problems and the perishable nature of fruit make farmers tend to look for the fastest alternative so that their production is sold, namely through collectors at low prices (Niyaz and Demirbaş, 2015).

The above phenomenon indicates that farmers as fruit producers act as price takers in the marketing chain. Most farmers see themselves as “price takers” and think they have no control over prices and must accept what is offered (FAO, 2005; Pertiwi et al. 2013). Farmers don't know how to find new buyers or how market demand is changing, and which products are the most profitable to develop. This condition illustrates the existence of information asymmetry (Carolina et al. 2016), where there is a disconnection between farmers and the fruit market in Batu Municipality. Farmers are unable to understand market demand due to these conditions, so they only plant based on the previous year's information or blindly planting following others (Ai-hua, 2012). For this reason, information is needed regarding the marketing conditions, especially prices, so that information becomes part of farmers’ decisions in using their production resources. Considering that in Batu Municipality, there is still no information system related to the price of fruits. Information on price changes provides beneficial information for producers to decide on marketing strategies (Muflikh et al. 2021).

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Fruit price volatility at the producer level in Batu Municipality shows that all fruit in this research has low price volatility. The low-price volatility stems from the occurrence of excess supply and/or demand, as well as perishable characteristics of fruit, causing prices to become unstable. This condition is exacerbated by the asymmetry of information in the trade system and the position of farmers who are only price takers. Meanwhile, the results of the cointegration analysis show that the production and prices of all fruit in this research are cointegrated or have a long-term relationship. However, only the production and price of avocado, guava, and apple have a short-term relationship.

Recommendations

To address problems in the upstream sector, the government through the ministry of agriculture and the agriculture and food security agency can provide price and production information systems to ensure farmers' market access that easily accessible for farmers. Information related to price predictions in the future is also needed, so that farmers can use it as a consideration for preparing prices for farming strategy, especially in determining production and selling prices. The provision of this information system needs to be followed up with socialization among farmers through agricultural extension to ensure that every farmer can access the information system. In addition, it also requires to provide technological innovations post-harvest handling such as storage or processed technology. Besides being able to control the supply of product in the market and keep fruit fresh and durable, this effort can also help farmers to regulate their sales to obtain favorable prices.

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