| **RESEARCH ARTICLE**

Price Volatility Analysis of Red and Cayenne Pepper of Java Islands during Covid-19 Pandemic

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| **ABSTRACT**

One of the food crops that is considered an essential commodity in Indonesia and has economic value is chilli. Chilli consumption continues to increase, especially red chilli and cayenne pepper, but since the Covid-19 Pandemic, consumption has decreased. Red chilli and cayenne pepper are commodities whose production is seasonal, easily damaged, and uneven throughout Indonesia. The Covid-19 pandemic in Indonesia was first on the island of Java, which shook the supply of agricultural products and caused colossal price fluctuations in the market. Since the implementation of large-scale restrictions in Indonesia, it has caused a hampering of product distribution between regions. Fluctuations in the price of red chili and cayenne pepper often impact the high contribution of chilli to inflation. Therefore, this study aims to analyze the price volatility of red chili on Java Island and the price volatility of cayenne pepper on Java Island. The analysis method used is ARCH GARCH modelling to measure volatility. The results showed that the volatility of red chilli on Java Island is high. In contrast, the volatility of cayenne pepper on Java Island is low.

1. Introduction

Chilli (capsicum sp) is a horticultural product that plays an important role in the economy of farmers in Java. However, this commodity is one of the commodities contributing to inflation due to seasonal price fluctuations where the potential for price increases can occur during the rainy season, Ramadan, and approaching the new year. Java Island is one of the largest production centers of red chili and cayenne pepper in Indonesia. The price of red chili in Java tends to fluctuate from time to time. Based on data from the 2021 PIHPS, the price of red chili in Java from 2017 to 2021 is IDR 26,000, IDR 35,000, IDR 41,000, IDR 37,000 and IDR 38,000, respectively. Price shocks can cause price volatility in the market because the market cannot automatically stabilize the price shocks that occur, so the right policy is needed to stabilize prices (Nugrahapsari et al., 2018).

Fluctuating red chili prices can be caused by various factors, both natural phenomena (temperature), the risk of market failure, and also problems with smooth distribution. The higher the volatility of food prices, the more risky economic actors, producers, farmers, and traders will be. If price volatility is low, it can indicate that the demand and supply characteristics of red chilli can be predicted (Nugrahapsari et al., 2019).

The research results (Frasipa 2021) stated that the volatility of red chilli prices was high; this indicated price fluctuations caused by seasonal factors, so stock availability was uncertain. Nainggolan et al. (2018) analyzed the volatility of consumer prices for red chilli peppers and apple tomatoes using the ARCH/GARCH model. The study resulted in high volatility of red chilli and apple tomatoes

and red chilli peppers with a higher volatility value. In his research, Laila et al. (2017) analyzed the price movements of chilli, tomatoes, and shallots in Java. The results show that of the three commodities, chilli has a higher volatility value. Market access can also affect chilli prices because this commodity is fragile and cannot stay fresh for a long time. In their research, Yu et al. (2020) found that the price volatility of cabbage in Beijing was influenced by limited market access due to the Covid-19 pandemic.

The risk of price fluctuations can harm producers and consumers. The uncertainty of chilli prices makes it difficult for producers to predict production costs and set selling prices. Therefore, a risk analysis of chilli commodity prices is needed so that price fluctuations can be overcome immediately. Analysis of the volatility of red chilli prices in Java can illustrate policy-making in dealing with the problem of red chilli price instability.

The fluctuating characteristics of red chili and cayenne pepper prices can contribute to inflation and deflation. In December 2020, red chilies contributed to inflation in the food category by 0.12 percent and cayenne pepper by 0.05 percent. Next, in July 2021, there will be inflation of 0.08 percent, and 0.03 percent is influenced by cayenne pepper, contributing to the inflation. Apart from inflation, chili prices also contributed to deflation. The increase in national supply due to harvests at production centres was the cause of deflation in December 2019 of -0.03 percent (Bank Indonesia 2021).

Most Indonesians consume chili in fresh form (Farid and Subenti 2012; Sativa 2017), but fresh chili cannot be stored for a long time. Chilli can only survive at room temperature for four to five days. Therefore, proper handling of the distribution of red chilies and cayenne peppers must continue to be pursued (Ministry of Agriculture 2020).

The first case of the Covid-19 pandemic in Indonesia came from the island of Java. Then gradually spread to every region in Indonesia. The Covid-19 pandemic that has attacked all regions in Indonesia has caused obstacles to economic activity not only at the national level but also at the regional level. Therefore, researchers are interested in analyzing the price volatility of red chili and cayenne pepper in Java.

2. Methodology
2.1 Framework
For agricultural commodities, it is assumed that price formation is determined more by the supply side (supply shock) because the demand side tends to be stable. The demand and supply characteristics of agricultural products are inelastic and can cause agricultural commodity prices to tend to fluctuate. Prices of agricultural products fluctuate because agricultural commodities have several characteristics, including (1) being influenced by the environment such as climate, weather, pests, and diseases; (2) there are time lags between using inputs and selling outputs; (3) market structure; (4) the impact of institutions (Anindita 2008).

Volatility is the amount of price change that shows fluctuations in a period of time. Volatility does not measure the price level but measures the degree of variation that exists from one period to the next. In the case of agricultural product prices, volatility is mainly due to supply side problems. Large price movements both down and up in a short period of time indicate high volatility.

According to the Directorate-General for Agriculture and Rural Development (2009), agricultural products are goods that have inelastic properties, so their prices are more volatile.
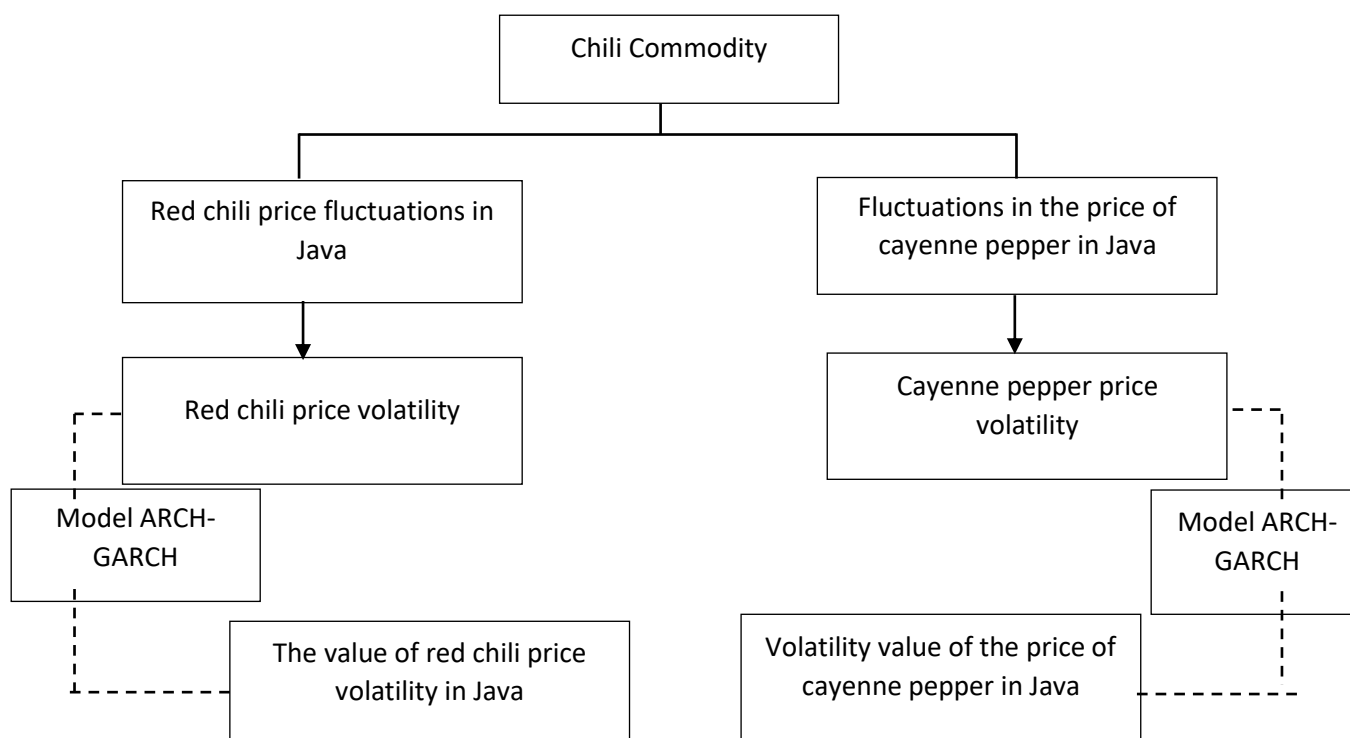
Figure 1 Thinking Framework

2.2 Data collection
The data used is secondary data in the form of daily time series data with a time period from August 1, 2018, to August 31, 2021. The data is in the form of aggregate prices of red chili and cayenne pepper from five provinces on the island of Java, including DKI Jakarta, Banten, West Java, Central Java, DI Yogyakarta, and Java Island; secondary data is needed from the National Strategic Food Price Information Center (PIHPS). The data was obtained in the form of daily data on the price of red chili at the consumer level. This type of research is quantitative research, which in its implementation, performs an interpretation based on the results of data analysis. Processing data using Eviews 10 software.

2.3 Data analysis
The analysis used to calculate the volatility of red chili prices throughout Indonesia is the analysis of the ARCH (Autoregressive Conditional Heteroscedastic) and GARCH (Generalized Autoregressive Conditional Heteroscedasticity) models. As for analyzing the ARCH-GARCH model, there are several stages of testing, including the following:

2.4 Data Stationarity Test
Stationarity test using Augmented Dicky Fuller test (ADF) With the hypothesis is as follows:

H.0: = 0, the data has a unit root or is not stationary
H.1 : ≠ 0, the data has no unit root or is stationary.

2.5 ARIMA (Autoregressive Integrated Moving Average) test
This test is divided into 2 stages, namely determining the tentative ARIMA model and selecting the best ARIMA model. The ARIMA model is expressed in ARIMA (p,d,q), where p is the order of AR (Autoregressive), q is the order of MA (Moving Average), and the number of differencing performed on the data. In estimating the ARIMA model, it can be seen that the smallest AIC and SC values are the best models and will be selected for further testing. This method was also used by Mitfahuljanah et al. (2020) and Novanda et al. (2018).

2.6 ARCH Efek Effect Test
This test aims to identify the presence of heteroscedasticity in the data. With the following hypothesis:

H_0: Residual does not have ARCH or is homoscedasticity. Shown based on a p-value greater than 5% on the correlogram of squared residual.
H_1: Residual has ARCH or is heteroscedasticity Shown based on a p-value less than 5%.

2.7 ARCH-GARCH model selection and Volatility Test.
The best ARCH GARCH model is a significant model and has the lowest AIC and SIC.

3. Results and Discussion
The island of Java, as a center for red chili and cayenne pepper production, is very influential on the national chili supply. In 2021, Java Island will contribute almost 50 percent of the national red chili and cayenne pepper production. Volatility measurements were carried out on daily consumer price data for red chili and cayenne pepper in Java. The study discusses the analysis of time series data from the price of red chili at the consumer level. The analysis is in the form of aggregate data from all provinces in Java. The following is the development of red chili prices on 5 islands from August 1, 2018, to December 1, 2021. The timing is carried out before the entry of the Covid-19 Pandemic and after the entry of the Covid-19 Pandemic into Indonesia.
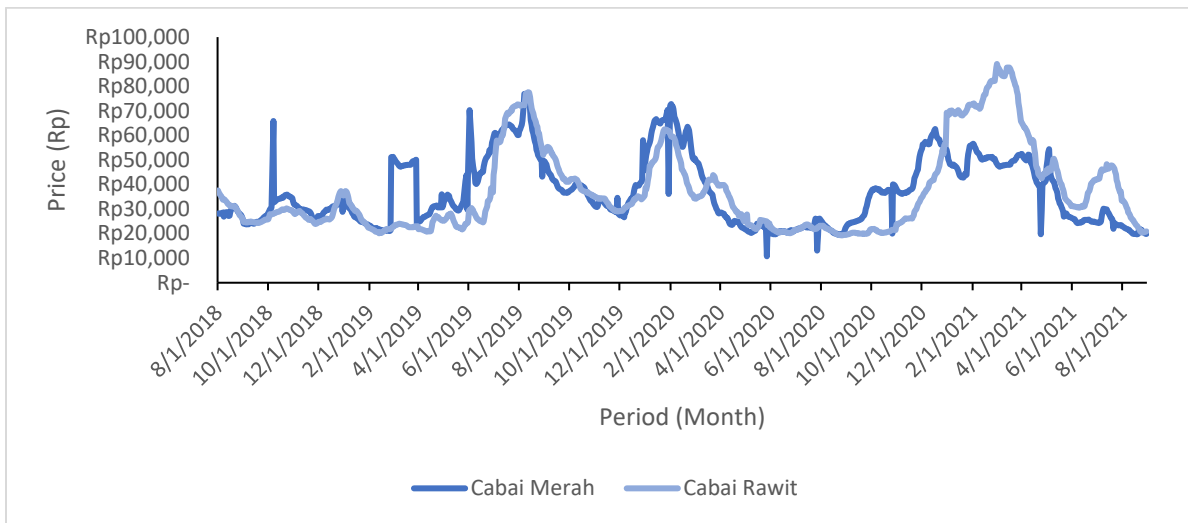

Figure 2 Price development of red chili and cayenne in Java Island 2018-2021
(processed from PIHPS)

3.1 Stage of Identification and Determination of the Mean Model
The modeling of red chili price volatility was carried out using the ARCH-GARCH method. This method consists of two stages, namely, the determination of the mean model and the determination of the variance model. Determination of the average model includes stationarity testing, identification, and determination of the ARIMA model of consumer price data for red chili and cayenne pepper in Java. Based on these variables, if the ARIMA model contains heterogeneous data, it will be continued with the determination of the GARCH model.

Table 1 The results of the stationary test of red chili prices in Java

Level	ADF Statistical Value	Critical Value 5%
Level	-2,681 (0,077)	-2,863
First difference	-28,816 (0,000)	-2,863

Table 2 Stationary test results of cayenne pepper prices in Java

level	ADF Statistical Value	Critical Value 5%
Level	-2,098 (0,245)	-2,863
First difference	-10,705 (0,000)	-2,863

In general, the stationary data is then plotted on the ACF/PACF sample comparison before determining an accurate ARIMA (Autoregressive Moving Average) model. The process of determining an accurate model, of course, is carried out by identifying the AR and MA orders on the ACF plot and also the PACF plot. In determining the order of the ARIMA model (p, d, q), the order of p and q can be seen from the ACF/PACF plot, and the order of d is obtained from the number of differencing processes carried out to obtain data that has been stationary on average. The ACF plot is useful for identifying the MA order and the PACF plot is

useful for identifying the AR order. ARIMA model (p,d,q) is a combination of autoregressive (AR) and moving average (MA) models. The order of ma given the notation (q) is determined by the number of periods of the independent variable included in the model.

Table 3 The best model for the average price of red chili and cayenne pepper

Parameters	Variable	
	Red Chili	Cayenne Pepper
Model	AR (2,1,1)	AR (1,1,1)
Sig	0,000	0,000
AIC	18,744	16,242
SC	18,757	16,256
Heterokedastisitas	0,000	0,000
AR	0,150	0,897
MA	0,111	0,646

Modeling with ARIMA often found violations of the homogeneity of residual variance (heteroscedasticity) which resulted in the use of the ARIMA model alone is inaccurate. An important assumption in regression analysis is that the residual variance is constant. The variance of the residuals does not change with changes in one or more independent variables. If this assumption is fulfilled, then the residual is homoscedasticity. If the variable variance is not constant, then the residual is heteroscedasticity. In Table 3, it can be seen that the probability results of <0.05 indicate that all daily data on red chili prices have heteroscedasticity in the distribution of data, and the data has a certain pattern. So it is necessary to test the ARCH-GARCH model on each variable.

3.2 GARCH ARCH Model Identification and Determination Phase
The first step in the identification and determination of the ARCH GARCH model is to test the ARCH effect on the best Arima model. This is done to test the presence of ARCH errors in the data. If the data does not contain an ARCH error, then there is no need to proceed to the ARCH GARCH model. Based on the heteroscedasticity test, it shows a probability value of 0.000 which indicates an ARCH effect in the model, so it can be continued with ARCH GARCH modeling.

The next step is to determine the right ARCH GARCH model by simulating several variance models on the best ARIMA model that has been obtained. The criteria for the best ARCH GARCH model are to have the smallest SC and AIC values, have significant coefficients, the coefficients of variance and residuals are not more than one and are not negative, and there is no ARCH effect. Based on these criteria, the best model that can be used in forecasting the price volatility of red chili and cayenne pepper in Java is the GARCH model (1,1) for red chili and GARCH (1,1) for cayenne pepper. In detail, the results of the analysis are in Table 4.

3.3 Model Evaluation
Model evaluation was conducted to check the adequacy of the model. On the results of the heteroscedasticity test on the GARCH model, it was found that the model was normally distributed; this was indicated by the results of the ARCH LM test, which had a probability value of 0.941 for red chili and 0.929 for cayenne pepper. This means that it is not significant to heteroscedasticity or normally distributed.

Table 4 The best model for the average price of red chili and cayenne pepper variable

Parameters	Variable	
	Red Chili	Cayenne Pepper
Model	GARCH (1,1)	GARCH (1,1)
Sig	0,000	0,000
AIC	18,336	15,574
SC	18,358	15,596

Changes in the price volatility of red chili and cayenne pepper can be influenced by the value of the square in the previous period. Large or small price volatility describes how much price risk will be faced in the future. Information about this volatility is very important for market participants, namely red chili traders. The more volatile the price of a commodity, the higher the business risk that will be faced (Pipit 2019).

3.4 Calculation of Volatility Value
The best model used in forecasting the volatility of red chili and cayenne pepper prices is GARCH(1,1). The following equation is obtained: $\sigma^2 = 3298 + 0.522 \llbracket \sigma^2 \rrbracket_{(t-1)} + 0.017 \llbracket Y^2 \rrbracket_{(t-1)}$

In this equation, it is known that the estimated parameter is significant at the 1% level of significance. This can be seen from the probability value of the ARCH term (〖ε^2〗_(t-1)) of 0.000 and the GARCH term (〖〖Y〗^2〗_(t-1)) of 0.000, which is a smaller number. of 0.001 (P < 0.001). The model has met the ARCH GARCH requirements, which have a coefficient value of not more than 1 and is not negative. This model also shows that chili price movements are only influenced by the amount of volatility on the previous day and also influenced by the price variance on the previous day. This indicates that if the price of chili the previous day has a relatively large residual value, then tomorrow's price level will tend to be large.

The value of red chili price volatility in Java is 0.522, which is higher than 0.5. This means that the price volatility of red chili is high.

$$^2= 2552+ 0.328 ^2〗_{(t-1)} + 0.704 Y〗^2〗_{(t-1)}$$

In the cayenne pepper equation model, it is known that the estimated parameter is significant at the 1% level of significance. This can be seen from the probability value of the ARCH term (〖ε^2〗_(t-1)) of 0.000 and the GARCH term (〖〖Y〗^2〗_(t-1)) of 0.000, which is a smaller number. of 0.001 (P < 0.001). The model has met the ARCH GARCH requirements, which have a coefficient value of not more than 1 and is not negative. This model also shows that chili price movements are only influenced by the amount of volatility on the previous day and also influenced by the price variance on the previous day. This indicates that if the price of chili the previous day has a relatively large residual value, then tomorrow's price level will tend to be large.

The price volatility of cayenne pepper in Java is 0.328, which is lower than 0.5. This means that the price volatility of cayenne pepper is low.
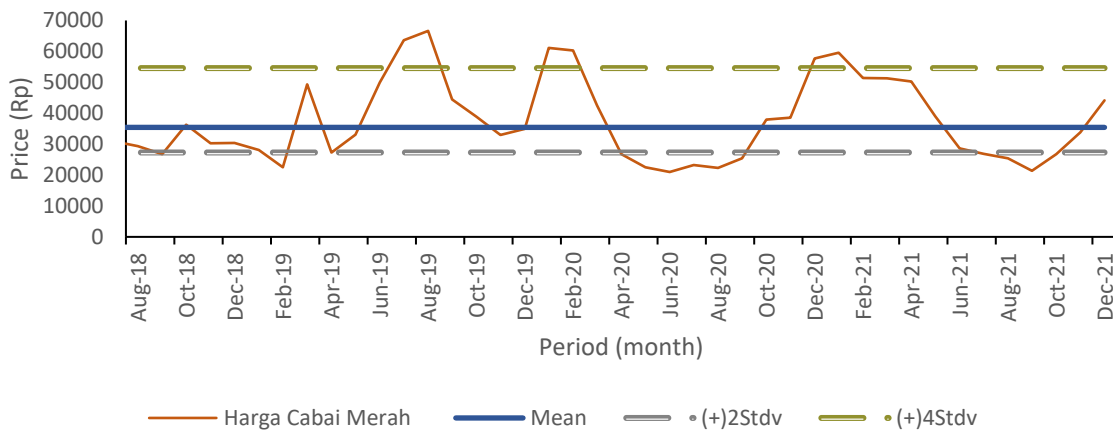

Figure 3 Red chili price volatility in Java Island from August 2018 to December 2021 (processed from PIHPS)

Based on Figure 3, it can be seen that the price movement of red chili on Java Island has fluctuated. Price movements occur to below 2 times the standard deviation and above 4 times the standard deviation. Only a few points are in the average price. From the picture, it is known that there are several price peaks on the island of Java. Among them, first in April 2018, the price of red chili was Rp. 45,000, the second, in October 2018, the price of red chili in Java was close to the average, which was Rp. 35,000. In March 2019, the price of red chili was at its peak, which reached a price of Rp. 50,000, the price increased that month. The highest price of red chili in Java throughout the period occurred in August 2019, which was Rp. 67,000. The increase in the price of red chili in that period occurred in each region and contributed 0.15 percent to inflation. This figure is half of the total inflation in Indonesia, which was 3.32 percent in August 2019. This was due to the prolonged dry season, which resulted in reduced red chili production (Bank Indonesia 2019).

In March 2020, during the Covid-19 Pandemic, the price of red chili in Java declined until June 2020. The price of red chili in Java from March 2020 to June 2020 was Rp. 55,000, Rp. 35,000, Rp. 23,000 and Rp. 21,000, respectively. The decline in chili prices at the beginning of the pandemic occurred due to social restrictions in each area, which caused economic activity to decrease. In addition, people's purchasing power prioritizes the purchase of medicines and green vegetables at the beginning of the pandemic to strengthen the body's immunity to avoid the spread of the Covid-19 virus. However, in October 2021, adjustments have begun because the government has implemented various policies so that food prices do not harm consumers and producers and so that prices return to normal on average. However, at the beginning of 2021, the price was back at its peak, which was Rp. 60,000.
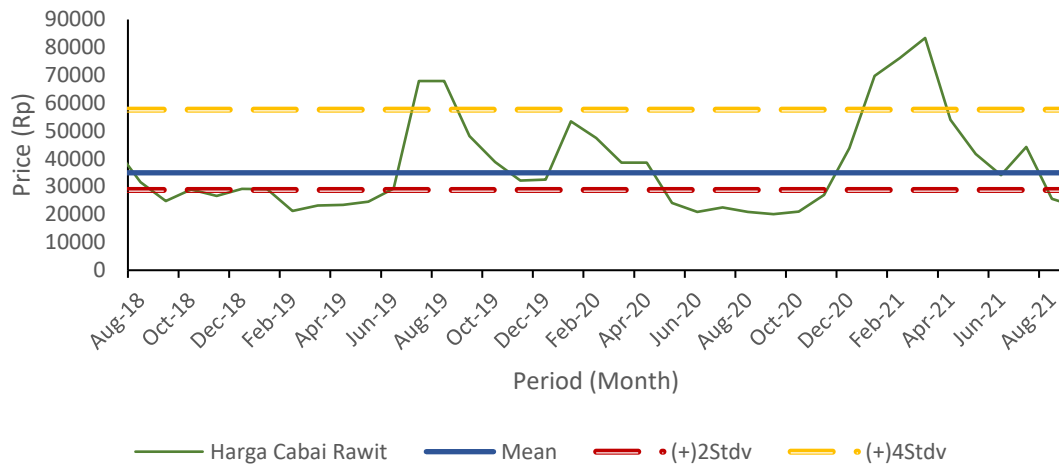
Figure 4 Price volatility of cayenne pepper in Java from August 2018 to August 2021 (processed from PIHPS)

In Figure 4 above, it can be seen that the price of cayenne pepper in Java is quite fluctuating. The first high point occurred at the beginning of the new year 2018; the price of cayenne pepper on the island of Java increased to IDR 43,000. The same high point occurred in March and July 2018 with the price of cayenne pepper Rp. 43,000. The next high point was from July to August 2019, when the price of cayenne pepper rose to Rp. 68,000. The next peak point also occurred at the beginning of the new year, 2020, when the price of cayenne pepper increased from the previous month to IDR 57,000. Then at the beginning of the Covid-19 pandemic in March 2020, the price of cayenne pepper on the island of Java decreased by Rp. 35,000. The price of cayenne pepper began to increase again in early January 2021. The highest price of cayenne pepper throughout the period was in March 2021, which was Rp. 83,000. This figure is far above the average price of cayenne pepper in Java. The phenomenon of the Covid-19 pandemic uctuations in chili prices in Java; this needs to be a serious treatment for both the local government and the central government to stabilize chili prices. The community's need for chili will continue to increase along with population growth.

In addition, chili production that continues to fall will indirectly affect the volatility of chili because more and more imported chilies will enter Java, so chili price fluctuations will increase and become more unstable. Farmers who plant chili because they switch to planting other commodities that have greater profits are also caused by weather/climate factors, uneven distribution of chilies, and uncertainty in world chili prices that affect local chili prices. Several causes of chili price fluctuations indicate that price fluctuations greatly affect the volatility value of chili, so the most basic thing that must be considered from chili commodities so that the value of chili volatility is not too large is the price of chili, which must be maintained. The high volatility value of chili indicates that the risk faced by chili farmers is high, where the risk in question is the loss that will be borne by the farmer. The losses borne by farmers are more due to the uncertainty of world chili prices which indirectly affects local chili prices. This uncertainty makes farmers reluctant to plant chilies, so many farmers switch to planting other, more profitable commodities. The fewer farmers who grow chili peppers, the local chili production decreases, so the only way to meet the increasing demand for chili is by importing chilies. Where with the import of chilies, the price fluctuations will be even greater due to the increasingly fierce competition between imported chilies and local chilies, which ultimately results in the price of local chilies being increasingly affected by imported chilies.

5. Conclusion
This study aimed to analyze the price volatility of red chili on Java Island and the price volatility of cayenne pepper on Java Island. The results of the study revealed that the value of red chili price volatility in Java was 0.52, meaning that the volatility was high. Also, the volatility value of cayenne pepper in Java was 0.32, meaning that the volatility was low.

In an effort to stabilize chili prices in the main production centers, namely Java, it is necessary to provide information on price references so that the prices of red chilies and cayenne peppers are the same between provinces on the island of Java. Next, the government's handling dealing with the Covid-19 pandemic has been good, so prices have started to stabilize, but the distribution of aid to the underprivileged needs to be increased again so as not to reduce strategic food consumption.

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