# Price Volatility Analysis of Red Cayenne Pepper and Curly Red Chili in Kebumen District

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**Abstract.** Kebumen Regency is an area with a surplus of chilies. The purpose of this study was to analyze the price volatility of red cayenne pepper and curly red chili at the consumer level. The research used was the ARCH-GARCH approach (Autoregressive Conditional Heteroscedasticity (ARCH) and Generalized Autogressive Conditional Heteroscedasticity (GARCH)) with the assistance of the Eviews 12.0 software. The data was weekly time series data for the period January 2019 to December 2021. The type of red chili used for research were curly red chilies and red cayenne peppers. The results showed that the best model for the volatility of curly red chili is ARCH (1), which means that the price of curly red chili at the consumer level is influenced by the volatility of the previous week. It has low volatility with an ARCH coefficient value of 0.171429 and a probability of 0.0365. The volatility of red cayenne pepper showed similar results, namely with an ARCH coefficient value of 0.173510 and a probability of 0.0319. Furthermore, the volatility model on chili prices at the producer level is still needed.

**Keywords:** Price volatility · ARCH GARCH · Chili price · Red chili

## 1 Introduction

Agriculture is an important role in the national economy. More than 40 percent of Indonesian people depend on this sector for their lives, either directly or indirectly. Therefore, agriculture is one of the sectors that has a large contribution to the total national GDP. The agricultural sector ranks second after the manufacturing sector with a contribution of 13.70% of the total GDP in 2021. Horticulture is an agricultural subsector that has an important contribution to the Indonesian economy. So far within the sector agriculture, horticultural GDP ranks second after the crop subsector food. The contribution of horticulture is 21.17% to the total agricultural GDP from livestock and plantation sectors, while the food crops sector provides contribution of 40.75% [1].

The red cayenne pepper commodity has the highest price difference compared to other commodities (red chili binoculars, green cayenne pepper, shallot, cutting garlic,


S. B. Sulistyo et al. (Eds.): ICSARD 2022, ABSR 30, pp. 56–69, 2023.
https://doi.org/10.2991/978-94-6463-128-9_8

chicken meat, and beef) at a price Rp74,000 [2]. The highest price is Rp87,500 and the lowest price is Rp13,500. The second order is the curly red chili commodity with the highest price of Rp67,500 and the lowest price of Rp12,000, so there is a price difference of Rp55,500.

Based on the Central Statistics Agency (BPS), red cayenne pepper production in Indonesia will reach 1.39 million tons in 2021. However, this number has decreased by 8.09% from 2020 of 1.5 million tons. The decline in cayenne pepper production in 2021 is the first time in the last five years. In 2017, the production of cayenne pepper was recorded at 1.15 million tons, then its production continued to increase until 2020. In 2021, the highest production of cayenne pepper occurred in July, reaching 134.4 thousand tons. Meanwhile, the lowest occurred in February, which was 94.54 thousand tons. East Java is the province with the largest cayenne pepper production in Indonesia, reaching 578.88 thousand tons in 2021. This amount contributes 41.75 percent to the national cayenne pepper production [1].

Kebumen Regency is the highest poor population compared to the surrounding areas such as Wonosobo, Banjarnegara and Banyumas. Throughout 2019, in Kebumen Regency, there were several commodities that dominantly contributed to inflation, namely rice, sugar, meat, chili, shallots, garlic, eggs, etc. Based on Table 1, red chili are staple goods that have the highest price gap and fluctuating in Kebumen [3]. This causes chili to have a high price risk. The chili price risk level is greater than the production risk level. Price risk is higher than production risk because prices are more variable and difficult for farmers to [4]. So that the analysis of the volatility of red cayenne pepper and curly red chili prices is very important for price stability policies in Kebumen.

The problem of prices on chili commodities is still happening. There are indications that in Indonesia there are fluctuations in chili prices within a certain period and also disparities in chili prices between regions. Volatility is a measure of the statistical change in a security's price in a certain period so that volatility literally means unstable, a condition where data moves up and down, sometimes even in an extreme way. One of the main applications of volatility modeling is that it is used to measure risk. Volatility is usually proxied by the standard deviation of the return which has important implications in calculating risk. Volatility can also be used in forecasting prices within a certain period. This price forecasting uses time series data. This sometimes causes the emergence of the phenomenon of heteroscedasticity. It can be caused by market movements that suddenly plummeted, meaning that the data experienced extreme ups and downs fluctuations. In the financial literature this is referred to as volatility clustering [5].

In connection with volatility and heteroscedasticity phenomena, developed a concept called ARCH (Autoregressive Conditional Heterocedasticity) [6]. The ARCH method is used to estimate the presence of heteroscedasticity in a time series data so that the forecasting results can be more accurate. This model was further developed by [6] with a concept called GARCH (Generalized Autoregressive Conditional Heterocedastic).

## 2 Materials and Methods

The steps of ARCH-GARCH analysis were: (1) data stationarity test using unit root test, which used to identify whether the data is stationary or not, this is important to prevent spurious regression which can cause regression results that are not necessarily good or biased, both in sign and magnitude [7]. (2) ARMA-ARIMA test, at this stage, the best ARMA/ARIMA smallest Akaike Information Criteria (AIC) and Schwarz Criterion (SC) values. (3) ARCH-LM test, at this stage, simulations of several models of variance are carried out using the best ARIMA model, estimation of model parameters, and selection of the best ARCH-GARCH model from several alternative models based on the size of the model goodness and the real coefficients. (4) Selection of the best model.

The best model and forecasting volatility using the ARCH-GARCH model. Descriptive statistical analysis was carried out as a first step to determine whether the price of the commodity contained heterogeneity-scedasticity effects. Using statistical descriptive variables: Mean, Standard Deviation, Skewness, Kurtosis, Max and Min. If the data shows a kurtosis value of more than 3, the data indicates that it has heteroscedasticity, it is necessary to do an analysis using the ARCH/GARCH Model. The ARMA/ARIMA model obtained accurate prediction results when the variance of the error is constant, it is called homoscedasticity [2].

This research was conducted in June 2022. The data used in this study is secondary data in the form of time series data. The weekly average price of red cayenne peppers and curly red chilies at the consumer level in the period January 2019 to December 2021. Weekly price data the source is from the Central Java PIHPS Commodity Production and Price Information system.

This research on price volatility analysis of red chili and curly red chili was completed using the ARCH GARCH model with the help of Eviews 10 software. This approach was chosen because not all data met the assumption of homoscedasticity. Data that has an unequal error term variance, where the error term is larger at some point in the data series, is called data that has heteroscedasticity. With heteroscedasticity, the ordinary least squares approach can still be used (unbiased). However, the level of confidence with this conventional method will be low, so it is not accurate. In contrast to the conventional approach, the ARCH GARCH model views heteroscedasticity as a variant to be modeled. This approach not only corrects the shortcomings of conventional methods, but also calculate the variance of each error term [8]. The stages of volatility analysis using the ARCH GARCH model are as follows:

## 2.1 Model Parameter Estimation

Parameter estimation of the model is done by determining by following the Box-Jenkins method [7], namely:

1) Data stationarity test

   Stationarity test was performed to avoid spurious regression using the ADF test (detecting the presence of unit roots test). The data can be said to be stationary if it does not contain a unit root and conversely the data is said to be non-stationary if the result of the t-statistic value is less than the critical value, so it is necessary to transform the data using Box-Cox transformation (logarithm).
2) Identification and determination of the ARIMA model

   The ARIMA model can be obtained based on collerogram results (ACF and PACF patterns) from stationary data to determine AR order (p) and MA order (q) from ARIMA model (p,d,q). Meanwhile, the order of d is determined based on the number of logarithmic transformations performed.

3) Selection of the best ARIMA models

The ARIMA model can be said to be the best if it can meet the following criteria: residual random, parsimonious, estimated parameters are significantly different from zero, invertibility and stationarity conditions are met (the AR and MA coefficients are less than one each), the suitability of the iteration process, and The MSE is small. At this stage, the best ARIMA model is selected based on the smallest Akaike Information Criteria (AIC) and Schwatrz Criterion (SC) values.

## 2.2 Determination of the ARCH-GARCH Model

Determining the ARCH-GARCH model can be done if the resulting average model contains the ARCH effect in it with the following steps [9]:

1) ARCH effect testing

This stage is carried out to identify the presence of heteroscedasticity. The data is said to have an ARCH effect if the results of testing the autocorrelation value on the square of chili price data are significant at 15 different times examined from the behavior of ACF and PCAF data.

2) Determination of the ARCH-GARCH model

This stage is carried out by simulating several models of variance using the best ARIMA model, estimating model parameters, and selecting the best ARCHGARCH model from several alternative models. The criteria used as a measure of the goodness of the model, namely by looking at the values of AIC and SC. A good model is a model that has the smallest AIC and SC values, has a significant coefficient, the coefficient value is not greater than one, and the coefficient is not negative.

The criteria used as a measure of the goodness of the model are:

Akaike Information Criterion (AIC)

$$AIC = \ln(MSE) + 2\,(K/N) \tag{1}$$

Schwartz Criterion (SC)

$$SC = \ln(MSE) + [K(\log N]/N \tag{2}$$

where:

MSE = mean squared error

K = number of estimated parameters

N = number of observations

A good model is a model that has the smallest AIC and SC values. Another requirement in the ARCH GARCH model that must be met is to have a significant coefficient, the coefficient value is not greater than one ($\delta + \; < 1$), and the coefficient is not negative ($k > 0, > 0, > 0$).

### 2.3 Model Evaluation

The model evaluation stage is carried out by checking the adequacy of the model. If the model is not adequate, it is necessary to go back to the identification stage to get a better model. The steps taken are to analyze the residuals as follows [8].

1) *Residual normality*

   The test used to measure whether the residuals are normally distributed is the JarqueBera test, which measures the difference between the skewness and kurtosis of the data from a normal distribution, and includes a measure of diversity. The hypotheses in this test are:

   H0: Residual spread normally

   H1: Residual does not spread normally

   The statistical value of the Jarque-Bera (JB) test is obtained by the formula:

$$JB = N-K/6\,(S2 + 1/4(k - 3)2) \tag{3}$$

   where:

   S = stickiness

   K = Sharpness

   k = number of estimating coefficients

   N = number of observation data

2) *Residual freedom*

   The test used to measure the presence of autocorrelation in the analyzed data is the L Jung-Box statistical test, namely by checking the residual squared autocorrelation coefficient. The model is not feasible if the value of Q* is greater than the value (α) with degrees of freedom kpq or if P ((k – p – q) > Q*) is less than the 0.05 level of significance $x^2$.

3) *Presence of ARCH-GARCH effect or presence of heteroscedasticity*

   At this stage a test is carried out to see the presence of the ARCH effect on the selected ARCH GARCH model through the Lagrange Multiplier (ARCH-LM) test.

### 2.4 Model Parameter Estimation

The best model will be used to estimate the price volatility of cayenne pepper and curly red chili [10]. The measure of volatility can be indicated by the standard deviation value which is the square root of the estimated variance of the ARCH GARCH model. The greater the volatility of the price of cayenne pepper and curly red chili, the more likely the price will rise or fall drastically.

## 3 Results and Discussion

Analysis of chilli price volatility in Kebumen District using the ARCH-GARCH approach has been carried out, with the results described below.

**Table 1.** Stationarity test of red cayenne pepper and curly red chili price data at the level of the 2019–2021 period

| | | red cayenne pepper | | curly red chili | |
|---|---|---|---|---|---|
| | | t-Statistic | Prob.* | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | −10.98967 | 0.0000 | −2.604898 | 0.2789 |
| Test critical values: | 1% level | −4.020396 | | −4.019151 | |
| | 5% level | −3.440059 | | −3.439461 | |
| | 10% level | −3.144465 | | −3.144113 | |

## 3.1 Model Parameter Estimation

### 3.1.1 Stationary Test

The initial stage of this research is to test the stationarity of the data. The stationarity test was carried out to see the influence of the trend on the price data of red chili and curly red chili. The results of the stationarity test show that all price data for cayenne pepper and curly red chili are not stationary, mean or variance at the level. This is indicated by the results of the ADF test value of less than the critical value of 1%. In more detail, the stationarity test values for red cayenne pepper and red chili data are presented in Table 1.

The red cayenne pepper and curly red chili price data plot showed the absence of a specific seasonal element and tends to have a random pattern. However, there would an increase in prices at the end of the year until the beginning of the following year. With the pattern of the growing season, the potential for chili price increases to occur at the end of the year and the beginning of the year. Tests performed on non-stationary data will cause spurious regression. Therefore, data transformation was carried out to analyze seasonal differencing and regular differencing. After transforming the first difference, the data is then tested for stationarity again.

Table 2 shows that the price data for red cayenne pepper and curly red chili are stationary, this can be seen from the ADF test value which is greater than the critical value at various levels of confidence. Stationary chili price data in the first logarithm transformation (first difference) shows the order of $d = 1$. The results of this study are in line with previous studies which show that the data is stationary at the first difference level. The stationary data after the transformation showed that the average model in this study is the ARIMA model [11].

### 3.1.2 Arima Model Identification

The next step is to create a tentative ARIMA model based on the collerogram (ACF and PACF patterns) on stationary data. The results showed that the ACF and PACF patterns were in the form of dying down. Therefore, it can be assumed that the right model is a mixed (autoregressive – moving average) model. In detail, the behavior of the ACF and PACF data on the prices of red cayenne pepper and curly red chili for the period January

**Table 2.** Stationarity test of red cayenne pepper and curly red chili price data at the first difference level for the 2019–2021 period

| | | Red cayenne pepper | | Curly red chili | |
|---|---|---|---|---|---|
| | | t-Statistics | Prob.* | t-Statistics | Prob.* |
| Augmented Dickey-Fuller test statistics | | −11.06362 | 0.0000 | −17,91542 | 0,0000 |
| Test critical values: | 1% level | −2.580470 | | −2,580164 | |
| | 5% level | −1.942967 | | −1,942924 | |
| | 10% level | −1.615298 | | −1,615325 | |

2019 to December 2021 is shown in Table 3 and Table 4. It is compatible with [11] that ACF and PACF patterns were dying down, so it can be expected that the right model was an autoregressive (moving average) model. Several ARIMA models were used in this study based on ACF and PACF patterns. The model was chosen according to the largest coefficient of determination (R-squared) and the smallest Akaike Information Criterion (AIC) and Schwartz Criterion (SC).

The selection of the best ARIMA model (Table 5) is based on several criteria, namely the parsimonious model, the forecasting residuals are random, the invertibility condition, the estimated parameters are significantly different from zero, and the stationarity is met as indicated by the AR and MA coefficients, each of which is less than one. The smallest value of Akaike Information Criteria (AIC) and Schwatrz Criterion (SC). From several ARIMA models, the best models are ARIMA (5,1,1), (1,1,1) and (0,1,1) for red cayenne pepper and ARIMA (1,1,1), (1,1,0) and (0,1,1) for curly red chili.

## 3.2 Determination of the ARCH-GARCH Model

### 3.2.1 ARCH Effect Testing

Testing the ARCH effect on the best ARIMA model that has been obtained is the first step in identifying the ARCH-GARCH model. The test was carried out to detect ARCH errors in the price data of cayenne pepper and curly red chili. The data does not need to be modeled into ARCH-GARCH if there is no ARCH error in it [12]. After obtaining the best ARIMA model, the results of the best ARIMA model were carried out by the Lagrange Multiplier test to ensure that the GARCH model no longer contained elements of heteroscedasticity. The model used to detect heteroscedasticity can be determined by assessing the significance of the probability value of the F-statistic and chi-squared at 5% significance level [9]. The result of the F-statistic for red cayenne pepper is 8.916460 with a probability value of 0.0033 and curly red chili is 41.33713 with a probability value of 0.00000 which indicates that there is an ARCH effect. So that it can proceed to the next stage, namely by completing the ARCH/GARCH modeling (Table 6).

**Table 3.** Correlogram of red cayenne pepper price data for the 2019–2021 period

| Log | Partical Correlation | Auto Correlation | Q-Stat | Prob | Log | Partical Correlation | Auto Correlation | Q-Stat | Prob |
|---|---|---|---|---|---|---|---|---|---|
| 1 | −0.447 | −0.447 | 31.343 | 0.000 | 19 | 0.024 | −0.002 | 44.541 | 0.001 |
| 2 | −0.309 | −0.047 | 31.699 | 0.000 | 20 | −0.032 | −0.033 | 44.738 | 0.001 |
| 3 | −0.286 | −0.041 | 31.969 | 0.000 | 21 | −0.060 | 0.000 | 44.738 | 0.002 |
| 4 | −0.230 | 0.025 | 32.069 | 0.000 | 22 | −0.065 | 0.019 | 44.802 | 0.003 |
| 5 | −0.171 | 0.022 | 32.145 | 0.000 | 23 | 0.036 | 0.037 | 45.054 | 0.004 |
| 6 | −0.083 | 0.031 | 32.302 | 0.000 | 24 | −0.007 | −0.050 | 45.507 | 0.005 |
| 7 | −0.078 | −0.036 | 32.518 | 0.000 | 25 | −0.042 | −0.008 | 45.521 | 0.007 |
| 8 | −0.136 | −0.046 | 32.873 | 0.000 | 26 | −0.080 | −0.008 | 45.532 | 0.010 |
| 9 | −0.172 | 0.000 | 32.873 | 0.000 | 27 | 0.023 | 0.065 | 46.338 | 0.012 |
| 10 | −0.056 | 0.094 | 34.353 | 0.000 | 28 | 0.071 | 0.018 | 46.401 | 0.016 |
| 11 | −0.099 | −0.065 | 35.068 | 0.000 | 29 | −0.013 | −0.104 | 48.499 | 0.013 |
| 12 | 0.038 | 0.081 | 36.167 | 0.000 | 30 | −0.050 | 0.018 | 48.564 | 0.017 |
| 13 | −0.024 | −0.096 | 37.747 | 0.000 | 31 | 0.006 | 0.049 | 49.039 | 0.021 |
| 14 | −0.066 | −0.005 | 37.751 | 0.001 | 32 | −0.078 | −0.059 | 49.733 | 0.024 |
| 15 | −0.035 | 0.043 | 38.078 | 0.001 | 33 | −0.090 | 0.031 | 49.919 | 0.030 |
| 16 | 0.078 | 0.068 | 38.882 | 0.001 | 34 | −0.137 | −0.014 | 49.956 | 0.038 |
| 17 | −0.095 | −0.153 | 42.998 | 0.000 | 35 | −0.048 | 0.041 | 50.294 | 0.045 |
| 18 | −0.013 | 0.093 | 44.540 | 0.000 | 36 | 0.083 | 0.031 | 50.484 | 0.055 |

### 3.2.2 ARCH-GARCH Model

After completing the search stage for the best ARIMA, the model that can be applied to the weekly price data for red cayenne pepper and curly red chili at the consumer level is ARCH (1). The results of previous studies also showed the same thing as this study, namely ARCH (1) [13], while other studies showed the best model with GARCH (1,1) [14]. The best model will then be continued to the volatility value. In detail, the results of the analysis are in Table 7. Obtained from the smallest of Akaike Information Criteria (AIC) and Schwatrz Criterion (SC) and the highest R-squared value and significant coefficient values, the coefficient of variance is not more than one, and the residual coefficient is not negative, and is free from the ARCH effect (Table 7).

## 3.3 Volatility Value

After the ARCH-GARCH model of red cayenne pepper and curly red chili has been achieve the best model, the next step that What is done is a volatility calculation to find out which month fluctuates the most. In calculating price volatility consumer grade red cayenne pepper and curly red chili weekly, there are factors that can affect the model ARCH-GARCH. These factors include production factors and planting factors as well as pests which can affect the monthly price of this cayenne pepper. Besides that. There

**Table 4.** Correlogram of curly red chili price data for the period 2019–2021

| Log | Partical Correlation | Auto Correlation | Q-Stat | Prob | Log | Partical Correlation | Auto Correlation | Q-Stat | Prob |
|---|---|---|---|---|---|---|---|---|---|
| 1 | −0.357 | −0.357 | 19.985 | 0.000 | 19 | −0.110 | −0.048 | 36.222 | 0.010 |
| 2 | −0.130 | 0.014 | 20.017 | 0.000 | 20 | −0.038 | 0.087 | 37.568 | 0.010 |
| 3 | −0.027 | 0.017 | 20.063 | 0.000 | 21 | 0.018 | −0.018 | 37.629 | 0.014 |
| 4 | −0.091 | −0.077 | 21.020 | 0.000 | 22 | 0.112 | 0.080 | 38.783 | 0.015 |
| 5 | 0.027 | 0.083 | 22.135 | 0.000 | 23 | −0.171 | −0.243 | 49.584 | 0.001 |
| 6 | 0.056 | 0.014 | 22.168 | 0.001 | 24 | −0.082 | 0.045 | 49.961 | 0.001 |
| 7 | 0.163 | 0.104 | 23.929 | 0.001 | 25 | 0.036 | 0.026 | 50.087 | 0.002 |
| 8 | 0.037 | −0.069 | 24.711 | 0.002 | 26 | −0.049 | −0.073 | 51.075 | 0.002 |
| 9 | 0.149 | 0.115 | 26.920 | 0.001 | 27 | −0.073 | 0.038 | 51.355 | 0.003 |
| 10 | −0.066 | −0.150 | 30.658 | 0.001 | 28 | 0.074 | 0.073 | 52.382 | 0.003 |
| 11 | −0.021 | 0.046 | 31.019 | 0.001 | 29 | −0.099 | −0.133 | 55.774 | 0.002 |
| 12 | −0.133 | −0.072 | 31.895 | 0.001 | 30 | −0.049 | −0.011 | 55.800 | 0.003 |
| 13 | −0.027 | 0.054 | 32.387 | 0.002 | 31 | −0.044 | 0.013 | 55.833 | 0.004 |
| 14 | 0.045 | 0.080 | 33.484 | 0.002 | 32 | −0.067 | −0.109 | 58.181 | 0.003 |
| 15 | 0.056 | −0.024 | 33.484 | 0.004 | 33 | −0.086 | 0.059 | 58.877 | 0.004 |
| 16 | −0.118 | −0.100 | 33.584 | 0.004 | 34 | 0.076 | 0.098 | 60.789 | 0.003 |
| 17 | −0.056 | −0.014 | 35.352 | 0.006 | 35 | −0.204 | −0.168 | 66.502 | 0.001 |
| 18 | −0.118 | −0.051 | 35.819 | 0.007 | 36 | −0.179 | −0.020 | 66.584 | 0.001 |

**Table 5.** The obtained ARIMA model

| Commodity | ARIMA Model | Smallest | | Biggest |
|---|---|---|---|---|
| | | AIC | SIC | R-square Adjusted |
| Red Cayenne Pepper | ARIMA (5,1,1) | 22.97622 | 23.09454 | 0.381689 |
| | ARIMA (1,1,1) | 22.88229 | 22.94145 | 0.433121 |
| | ARIMA (0,1,1) | 22.87623 | 22.91567 | 0.429391 |
| Curly Red Chili | ARIMA (1,1,1) | 20.27680 | 20.35568 | 0.127816 |
| | ARIMA (1,1,0) | 20.28325 | 20.34242 | 0.116342 |
| | ARIMA (0,1,1) | 20.26422 | 20.32338 | 0.133227 |

is influence of prices in the previous period can also affect price fluctuations vegetable month. Therefore, these factors were then estimated in the model ARCH-GARCH has been selected to produce the best model.

**Table 6.** Red Cayenne Pepper and Curly Red Chili Heteroscedasticity Test

| F-statistic | Red cayenne pepper | Curly red chili |
|---|---|---|
| | 8.916460 | 41.33713 |
| Obs*R-squared | 8.530819 | 32.88278 |
| Prob. F | 0.003 | 0.000 |
| Prob. Chi-Square | 0.003 | 0.000 |

**Table 7.** The results of determining the ARCH-GARCH model of Cayenne pepper and red curly chili

| Model ARCH-GARCH | ARCH | GARCH | Log-Likelihood | AIC | SC |
|---|---|---|---|---|---|
| ARCH-GARCH Cayenne Pepper (1,0) | 0.171429 | – | −1796.500 | 23.37013 | 23.42929 |
| ARCH-GARCH Cayenne Pepper (0,1) | – | 0.171429 | −1807.088 | 23.50763 | 23.56679 |
| ARCH-GARCH Cayenne Pepper (1,1) | 0.15000 | 0.600000 | −1810.055 | 23.55915 | 23.63803 |
| ARCH-GARCH Curly Chili Pepper (1,0) | 0.171429 | – | −1547.200 | 20.14545 | 20.22433 |
| ARCH-GARCH Curly Chili Pepper (0,1) | – | 0.171429 | −1569.863 | 20.43943 | 20.51831 |
| ARCH-GARCH Curly Chili Pepper (1,1) | 0.15000 | 0.600000 | −1576.522 | 20.53925 | 20.63785 |

The best model of red cayenne pepper price volatility used in forecasting volatility at the consumer level is the ARCH (1) model. The results of research conducted by [13] showed that the price volatility of broiler commodities showed the best model ARCH (1.0) this is in line with the results of this study while beef cattle showed the best model ARCH (1.1). This best model is like what happened to the price of shallots which also has the same best model [10]. Based on the data processing of red cayenne pepper, the equation of the ARCH (1) model is obtained as follows:

$$\mathrm{ht} = 562170630 + 0.171429$$

Based on data processing curly red chili, the equation of the ARCH (1) model is obtained as follows:

$$\mathrm{ht} = 27303465 + 0.171429$$

The results of this study are in line with research conducted by [13] which shows that the best model analysis result is ARCH (1,0) but shows a high volatility value in curly red chili. This model also shows that the price movement of red cayenne pepper

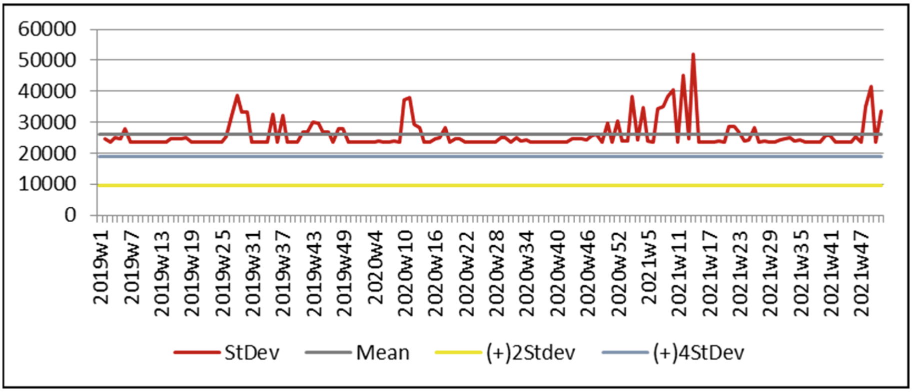


**Fig. 1.** The Volatility Pattern of Red Cayenne Pepper Prices at the Consumer Level for the 2019–2021 period

and curly red chili is only influenced by the amount of volatility on the previous day, but is not affected by the price variance. This means that if the price of chili the day before has a relatively large residual value, then tomorrow's price level will tend to be large. The chili price variance model only consists of the ARCH tribe with a coefficient value of 0.171429. This value indicates the high and low volatility of chili prices. This value is less than one and relatively small (not close to 1), indicating that chili price volatility is low. Thus, based on the ARCH (1) model, it can be estimated that the price volatility of red cayenne pepper and curly red chili in the future will be smaller. This study is in line with [9], that the volatility estimation results through this model indicate that the price volatility of red cayenne pepper and red chili is low and price movements are only influenced by the amount of volatility on the previous day (not influenced by price variances). Thus, it can be assumed that the price volatility of red chili and curly red cayenne pepper in the future will be smaller. This study shows that chili price volatility at the consumer level is low, this is inversely proportional to the research conducted by [15] which shows that the highest volatility of vegetable commodity prices is the volatility value of chili with a value of 0.00031%. The high volatility value 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. According to [16], even though chilli price volatility tends to be low because it is below number 1, it is necessary to watch out for the possibility of higher volatility in the future, especially if there is a surge in demand and supply.

Based on the volatility chart for the price of cayenne pepper in Fig. 1, it shows that in July 2019 there was an increase in the graph where it rose and fell until December 2019. After that it experienced a stable period until February 2020. In March 2020 there was an increase in the graph which was influenced by the Covid-19 pandemic which began entered in Indonesia. However, after the 5th week of the month, it decreased and began to run steadily until December 2020. In January 2021 it began to increase and soared high in March to April which was influenced because that month coincided with the day of Ramadan and entered Eid al-Fitr. Fitri where the number of requests for red chili soared. The graph shows that it was stable until December, which experienced an

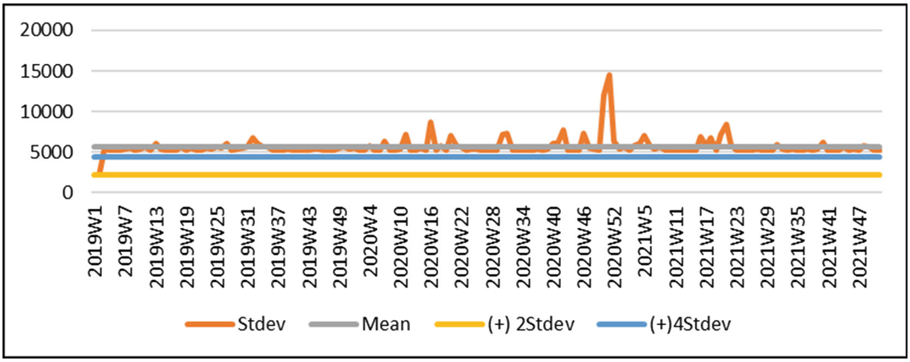


**Fig. 2.** The pattern of volatility in the price of curly red chili at the consumer level for the 2019–2021 period

increase which was influenced by Christmas Day and coincided with the end of the year where demand also increased.

According to Fig. 2, the graph at the beginning of 2019 until the end of February 2020 did not show a significant increase in the graph, while at the end of February 2020 to April 2020 there was a significant increase, although not too high. This is due to the early onset of the COVID-19 pandemic that began to enter Indonesian territory. Meanwhile, in July 2020 prices have started to stabilize. Then the price of curly red chili began to creep up in October 2020 and at this point is the beginning of the graph rising drastically. Then the graph shows stability again until the end of 2021.

Based on the Conditional Standard Deviation (CSD) chart of red chili and curly red chili above, which has been obtained shows that since the beginning of 2021, red cayenne pepper and curly red chili have fluctuated with a tendency to increase or are high and stable, high fluctuations occur at the beginning, middle and end of the year. The factors that cause fluctuations in these months in including the new year at the beginning of the month, the holy month of Ramadan and Eid al-Fitr in the middle of the month and Christmas at the end of the year. These are the things that can causing the price of cayenne pepper to increase due to increased demand as well. From the supply side, the high price volatility at the beginning of the year was caused by high rainfall so that farmers have a high risk when planting chilies [11]. This low volatility reflects the predictable characteristics of supply and demand, and the tendency for changes in the price of curly red chilies to occur not suddenly and cause shock, but rather gradually. Based on the results obtained above, it shows that it agrees with previous research conducted by [2] with the results of ARCH (1) on rice, chicken and sugar food.

## 4 Conclusion

Based on the research that has been carried out, it can be concluded that the best model to calculate the price volatility of red chili and curly red chili at the consumer level is ARCH (1). The results of the estimation of volatility through this model indicate that the price volatility of red chili and curly red chili at the consumer level is low and price movements are only influenced by the amount of volatility on the previous day (not affected by price variance). Thus, it can be assumed that the price volatility of red chili and curly red chili at the consumer level can be predicted to be smaller in the future. The lowprice fluctuations of red chili and curly red chili indicate that the time characteristics of demand and supply can be predicted. The trend of price changes occurs gradually and can be predicted because it is seasonal.

**Acknowledgments.** Acknowledgments to the Research and Community Service Institute of Jenderal Soedirman University for funding this research activity.

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