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Forecasting Commodity Price of Cayenne Pepper (Capsicum Frutescens L.) in Jember with Holt-Winters Exponential Smoothing Method to Get Financial Benefit

Muhammad Hanif Fadloli[1], R. Abdoel Djamali[2]
[1,2]*Department of Agribusiness Management Jember State Polytechnic, Indonesia*
abdoel_djamali@polije.ac.id

Abstract

Cayenne pepper is one of the largest horticultural crop commodities produced in Jember Regency. Cayenne pepper has a high economic value and is in great demand by the people of Jember Regency, but the commodity price of cayenne pepper has a pattern of sharp fluctuations. The purpose of this research is to predict the price and identify the factors that influence the price of cayenne pepper in Jember Regency. This research is included in the type of quantitative descriptive research that uses the Holt-Winters Exponential Smoothing method as forecasting and the simple regression method as a determinant of the factors that influence prices. The results of this study are the most optimal forecasting parameter values, namely the alpha (α) value of 0.5, beta (β) of 0 and gamma (γ) of 0.22, and produce a MAPE value of 34%. Factors that affect changes in the price of cayenne pepper in Jember Regency are the price of substitute ingredients (red chilies) and rainfall.

Keywords
Forecasting; cayenne pepper; holt-winters

I. Introduction

Cayenne pepper is one of the commodities of horticultural crops that have high economic value and easy in the process of planting. East Java is the largest province that produces cayenne pepper in Indonesia with annual production of 578.88 thousand tons or 47% of the total national production [1]. Jember is one of the districts in East Java province that has abundant production of cayenne pepper, amounting to 191,215 quintals/year [2]. The amount of cayenne pepper production in Jember Regency shows that environmental conditions are supportive and the interest of farmers is also great. In addition to the amount of production, consumer or public interest in cayenne pepper is also high, it can be seen from the data of the Central Statistics Agency of East Java [3] that the consumption of cayenne pepper by the people of East Java Province in 2019 was 2.76 Kg/individual/year. The amount of consumption of cayenne pepper in the same year is greater than the commodity of red pepper by 0.01 kg/individual/year and shallots by 2.31 kg/individual year. This shows the great interest of the people of East Java, especially the people of Jember to the commodity of cayenne pepper.

The amount of abundant production and high public interest in the commodity cayenne pepper in Jember is inversely proportional to the fact that the price of cayenne pepper has a sharp fluctuating pattern, this can be seen according to data from PIHPS NASIONAL [4] that the price of cayenne pepper in Jember Regency in April 2022 was Rp 20,000 then in June of the same year the price of cayenne pepper in Jember Regency was Rp 60,000 or increased by 67% and in November of the same year the price of cayenne pepper in Jember Regency decreased by 78% to Rp 13,000. This condition is very impactful for the community on household spending and for farmers in determining the planting period of cayenne pepper.

Forecasting is an art and science in predicting future events [5]. Based on the above problems, this study was prepared with the title "forecasting commodity prices cayenne pepper (Capsicum Frutescens L.) In Jember With Holt-Winters Exponential Smoothing Method".

II. Review of Literature

2.1 Chili Price

Chili is an agricultural commodity that is needed every day as a spice or other processed mixture. Chili is a plant classified as annuals. According To Tjahjadi [6] saying that the chili plant has many branches, and each branch has flowers and fruits. Chili plants can adapt to loamy, Sandy or sandy-clay soils.

The characteristic of chili plants that are the dream of every connoisseur's tongue is a spicy taste. This spicy taste comes from the content of a substance called capsicin. Capsicin is an addictive substance that causes a spicy and hot taste, this substance has the property to reduce pain. Other chili content that has benefits is the content of bioflafonoids which are useful as a healer of inflammation due to cold air and relieve polio [7].

2.2 Factors Affecting Changes in The Price of Cayenne Pepper2

According to Untoro [8], "price is the ability that a good or service has, expressed in terms of money". According to Kotler [9], "the price represents the amount of money that the customer must pay for the product to be purchased". According to Palar, et al [10] factors that affect the price of cayenne pepper is consumer demand, the price of goods substitutes (substitutes), the price of complementary goods, and consumer tastes. Meanwhile, according to Wardhana, et al [11] the factors that affect the price of cayenne pepper is the production of cayenne pepper, the price of goods substitutes(substitutes), the price of cayenne pepper two months earlier, rainfall, and demand for cayenne pepper.

2.3 Eksponential Smoothing Holt-Winters

Exponential smoothing is one type of moving average forecasting by weighting in a decreasing (exponential) to the value of older observations, provided that the new value is given a relatively larger weight than the value of older observations [12]. Holt-Winters method or commonly called Triple exponential Smoothing is one of exponential Smoothing forecasting methods, where this method is used when the data has Trend and seasonal patterns [12]. This method is called Triple exponential Smoothing because it has 3 times the weighting, that is, α, β, γ. Where α is the overall data smoother, β is the trend data smoother, γ is the seasonal data smoother. The values are between 0 to 1 which is determined by the smallest approximate accuracy value because the smaller the approximate accuracy value, the smaller the estimate will be. Holt-Winters method is divided into two, namely the Additive model and Mutiplicative model [13]. The determination of which model is used depends on the characteristics of the time series data.

a. Models Additive

This Model is used when seasonal variation data is constant. This method has the following equation:

a. Overall smoothing (level)

$$L_t = \alpha\ (\ y_t - S_t - s) + (1-\alpha\ )\ (L_{t-1} + b_{t-1})$$

(1)

b. Trend smoothing

$$b_t = \beta\,(L_t - L_{t-1}) + (1-\beta)\,(b_{t-1}) \qquad (2)$$

c. Seasonal smoothing

$$F_{t+m} = L_t + mb_t + S_{t+m-S}$$

d. Forecasting value

$$S_t = \gamma\,(y_t - L_t) + (1-\gamma)(S_{t-s}) \qquad (3)$$

Description :
α = smoothing constant for the level (0< α <1)
β = the smoothing constant for the trend (0< β <1)
γ = smoothing constant for seasonality (0< γ <1)
L_t = new smoothing value or current estimated level
yt = new observations or actual data of Period t
bt = estimated trend
St = seasonal estimate
m = the number of times forward
s = length of season
Ft+m = predicted value of M for the next period

b. Models Multiplicative

This Model is used when the size of the seasonal component is proportional to the level of the trend . The equation for the Multiplicative model is as follows:

a. Overall smoothing (level)

$$L_s = \alpha\left(\frac{y_t}{S_{t-s}}\right) + (1-\alpha)(L_{t-1}+b_{t-1}) \qquad (5)$$

b. Trend smoothing

$$b_t = \beta(L_t - L_{t-1}) + (1-\beta)(b_{t-1}) \qquad (6)$$

c. Seasonal smoothing

$$S_t = \gamma\left(\frac{y_t}{L_t}\right) + (1-\gamma)(S_{t-s}) \qquad (7)$$

d. Forecast value

$$F_{t+m} = (L_t + mb_t)S_{t+m-S} \qquad (8)$$

Description :
α = smoothing constant for the level (0< α <1
β = the smoothing constant for the trend (0< β <1)
γ = smoothing constant for seasonality (0< γ <1)
L_t = new smoothing value or current estimated level
yt = new observations or actual data of Period t
bt = estimated trend
St = seasonal estimate
m = the number of times forward
s = length of season
Ft+m = predicted value of M for the next period

c. Mean Absolute Persentage Error (MAPE)

In doing forecasting does not always produce the same data as the actual data, the data is only close to the actual data. To minimize the limitation of length, then a forecasting accuracy test (forcast error) in order to evaluate the forecasting method in order to obtain the best formula. In measuring the accuracy of forecasting, the method that can be used is to calculate the Mean Absolute percentage Error (MAPE). MAPE is a measure of relative accuracy based on absolute values used to determine the percentage deviation of predicted results with actual data. The calculation of the MAPE equation is as follows [14]:

$$\text{MAPE} = \frac{1}{n}\sum_{i=1}^{n}\left[\frac{y'_i - y_i}{y_i} + \frac{y'_i - y_i}{y_i} + \cdots + \frac{y'_i - y_i}{y_i}\right] \times 100\%$$

Description:
N = amount of data
y'i= predicted result on the i-th index = 1, 2,..., n
yi = actual value at the i-th index = 1, 2,..., n

Table 1. Criteria Mape

Value MAPE	Criteria
<10%	Very Good
10%-20%	Good
20%-50%	Good enough
>50%	Bad

III. Research Method

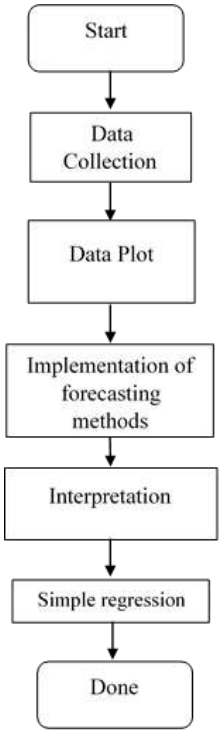

Figure 1. *Research Flow*

This study includes a type of quantitative descriptive research, the population of this study is the district of Jember and the sample in this study is the total sampling, ie the entire price of cayenne pepper in Jember. This research Data is sourced from secondary data, namely from the Central Statistics Agency (BPS), Information System availability and development of staple food prices (SISKAPERBAPO) in East Java and the National Strategic Food Price Information Center (PIHPS). The flow of this study began with the input and cleaning of data, then performed data plotting to identify the type of data patterns that occur in the actual data. The next stage is the implementation of the Holt-Winters exponential Smoothing forecasting method and determining the accuracy value using the Mean Absolute presentation Error (MAPE), and followed by determining the most optimal parameters. The last step is to determine the factors that affect the price of chili using a simple regression analysis.

IV. Result and Discussion

4.1 Data collection and cleaning

Table 2. Comparison Of Data Before And After Cleaning

Before Cleaning & Processing							After Cleaning & Processing			
Date & Market		1	2	.....	30	31	Number	Date	Price	
Jan-18	Market Kebonsari	Rp 40.000	Rp 40.000		Rp 28.000	Rp 25.000	1	01/01/2018	Rp	30.000
	Market Kreongan	Rp 25.000	Rp 34.000		Rp 25.000	Rp 25.000	2	02/01/2018	Rp	37.000
	PIHPS	-	Rp 33.650		Rp 26.150	Rp 25.850	3	03/01/2018	Rp	34.000
	Market Tanjung	Rp 25.000	Rp 40.000		Rp 26.000	Rp 26.000	4	04/01/2018	Rp	36.000
				:				:		
				:				:		
Dec-22	Market Kreongan	Rp 30.000	Rp 30.000		Rp 47.000	Rp 47.000	1821	26/12/2022	Rp	42.000
	Market Mangli	Rp 30.000	Rp 32.000		Rp 46.000	Rp 54.000	1822	27/12/2022	Rp	41.000
	Pasar Tanjung	Rp 28.000	Rp 27.000		Rp 47.000	Rp 54.000	1823	28/12/2022	Rp	43.000
	Market Tegal Besar	Rp 35.000	Rp 30.000		Rp 45.000	Rp 50.000	1824	29/12/2022	Rp	44.000
	Market Wirolegi	Rp 30.000	Rp 28.000		Rp 45.000	Rp 60.000	1825	30/12/2022	Rp	45.000
	PIHPS	Rp 22.850	Rp 24.650		Rp 37.150	-	1826	31/12/2022	Rp	53.000

Criteria data are cleaned and processed according to Table 2 are as follows :

1. The values of the data are wrong, in the data on the price of cayenne pepper in Jember Regency there are some unreasonable data, namely the price value does not match the price in general, for example, the price of chili on December 1, 2022 with the source of PIHPS is Rp 22,850. This price value is not like the value of the price of chili in general, where the value of chili in general is always rounded to thousands as in the price of chili in other markets, so it needs improvement by rounding.
2. Fix the chaos of data, data on the price of cayenne pepper in Jember separated from various sources, so it needs processing in order to produce the main price by performing an average on each date.

4.2 Data Plot

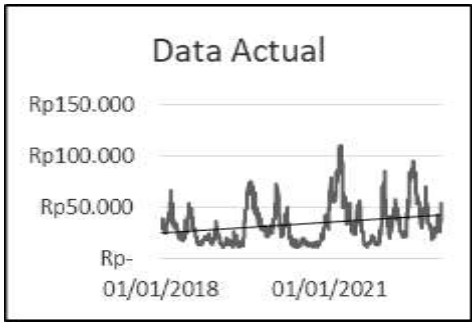

Figure 2. *Chili Price Data Plot chart in Jember Regency 2018-2022*

Figure 2 show that the plot of cayenne pepper price data in Jember Regency in 2018 to 2022 has a trend and seasonal data pattern. Trend data patterns can be seen on the horizontal line that tends to move upwards in the price range of Rp 20,000 to Rp 40,000. Seasonal data patterns can be seen from the movement of chart 4.1 which has a relatively similar repeating pattern. This pattern can be seen in Table 4.2 exactly on December 03 of each year, where the price of chili has a relatively similar range, which is Rp 16,000 to Rp 32,000.

Table 3. Seasonal Data on the Price Of Cayenne Pepper In Jember 2018-2022

DATE	PRICE
13/12/2018	Rp16.000
13/12/2019	Rp23.000
13/12/2020	Rp32.000
13/12/2021	Rp29.000
13/12/2022	Rp32.000

Table 3 shows the pattern of seasonal data multificative model, it can be seen from the increase/trend data, the distribution of data is not around the average rat value, and there are seasonal factors that have repeated fluctuations and getting bigger with increasing time.

4.3 Inisialisasi

Table 4. Initialization

DATE	LEVEL	TREN	SEASONAL
01/01/2018	-	-	1,068
02/01/2018	-	-	1,317
03/01/2018	-	-	1,210
04/01/2018	-	-	1,281
05/01/2018	-	-	1,281
:	:	:	:
:	:	:	:
31/12/2018	28100,890	5,016	0,569

Calculation of initialization that can be seen in Table 4 that the initialization generated at the level and trend components is 1 time in 1 season, while the seasonal component as much as 337 data in 1 season. The initialization of the level component is 28100,890, in the trend component it is 3,522 and in the seasonal component it is 1,068,

1,317,..., 0,569. This initialization process is used as a reference calculation on testing data to find the most optimal forecasting pattern that produces the smallest error. The calculation of the initialization of the level, trend and musisman is as follows [13] :

Initialization Level

$L_S = \frac{1}{S}(Y_1+Y_2+\ldots+Y_S)$

$L_{337} = \frac{1}{337}(\text{Rp } 30.000 + \text{Rp } 37.000 +\ldots+ \text{Rp } 16.000)$

$L_{337} = \frac{Rp9.470.000}{337}$

$L_{337} = 28100{,}890$

Initialization Trend :

$b_S = \frac{1}{S}\left[\frac{Y_{S+1}-Y_1}{S} + \frac{Y_{S+2}-Y_2}{S} + \cdots + \frac{Y_{S+S}-Y_S}{S}\right]$

$b_{337} = \frac{1}{337}\left[\frac{Rp30.000 - Rp15.000}{337} + \frac{Rp37.000 - Rp15.000}{337} + \cdots + \frac{Rp16.000 - Rp28.000}{337}\right]$

$b_{337} = \frac{-15000 + (-22000) + \cdots + 12000}{337}$

$b_{337} = \frac{1186{,}944}{337}$

$b_{337} = 3{,}522$

Initialization Seasonal :

$S_t = \frac{y_t}{L_s}$

$S1 = \frac{Rp30.000}{28100{,}890}$

$S1 = 1{,}068$

Description:

L_S = initialization Level

Y_t t = actual Data

b_S = trend initialization

S_t = seasonal initialization

s = length of season

4.4 Smoothing Method Eksponensial Holt Winters

Table 5. Testing Equipment Data

DATE	PRICE	FORCAST
01/01/2018	Rp 30.000	-
02/01/2018	Rp 37.000	-
03/01/2018	Rp 34.000	-
:	:	:
:	:	:
04/12/2018	Rp 15.000	Rp 21.124
05/12/2018	Rp 15.000	Rp 16.293
06/12/2018	Rp 16.000	Rp 14.773
:	:	:
:	:	:
29/12/2022	Rp 44.000	Rp 53.912
30/12/2022	Rp 45.000	Rp 53.955
31/12/2022	Rp 53.000	Rp 60.747

The next step after the initialization process is to test forecasting using testing data for 4 years (2019-2022) or 1489 days and then look for optimal parameters with reference to the smallest MAPE value, then the forecasting method can be applied to data for the next 1 year (2023). Testing data forecasting using parameters for the test are determined based on the parameter limits between 0 to 1, where the parameter α = 0.3, the parameter β = 0.2, and the parameter γ = 0.6. Forecasting calculations are as follows:

A. Overall smoothing (level)

$L_t = \alpha(\frac{y_t}{S_{t-s}}) + (1- \alpha)(L_{t-1}+b_{t-1})$

$L_{366} = 0{,}3(\frac{Rp30.000}{1{,}068}) + (1- 0{,}3)(27693{,}151 + 4{,}631)$

$L_{366} = 4215{,}133531 + 0{,}7 \times 28104{,}412$

$L_{366} = 23888{,}22214$

B. Trend smoothing

$b_t = \beta(L_t - L_{t-1})+(1-\beta)(b_{t-1})$

$b_{366} = 0{,}2(28100{,}890 - 21118{,}126)+(1-0{,}2)(4{,}631)$

$b_{366} = -1396{,}553 + 0{,}8 \times 4{,}631$

$b_{366} = -1393{,}735158$

C. Seasonal smoothing

$S_t = \gamma\left(\frac{y_t}{L_t}\right)+(1-\gamma)(S_{t-s})$

$S_{366} = 0{,}6\left(\frac{Rp15.000}{21118{,}126}\right)+(1-0{,}6)(1{,}068)$

$S_{366} = 0{,}603 + 0{,}427$

$S_{366} = 0{,}853206912$

D. Forecasting value

$F_{t+m} = (L_t+mb_t)S_{t+m-S}$

$F_1 = (27693{,}151 + 1 \times 4{,}631)1{,}083$

$F_1 = 27693{,}151 \times 1{,}083$

$F_1 =$ Rp27.698

Description :

α = smoothing constant for the level (0< α <1)

β = the smoothing constant for the trend (0< β <1)

γ = smoothing constant for seasonality (0< γ <1)

L_t = new smoothing value or current estimated level

yt = new observations or actual data of Period t

bt = estimated trend

St = seasonal estimate

m = the number of times forward

s = length of season

Ft+m = predicted value of M for the next period

4.5 Measurement Accuracy Value (MAPE)

Table 6. Measurement Accuracy Value (Mape)

DATE	PRICE	FORCAST	MAPE
04/12/2018	Rp 15.000	Rp21.124	41%
05/12/2018	Rp 15.000	Rp16.293	9%
06/12/2018	Rp 16.000	Rp14.773	8%
:	:	:	:
:	:	:	:
29/12/2022	Rp 44.000	Rp53.912	23%
30/12/2022	Rp 45.000	Rp53.955	20%
31/12/2022	Rp 53.000	Rp60.747	15%
Average MAPE			34%

Measurement of the accuracy of forecasting the price of cayenne pepper in Jember using the Mean Absolute Percentage Error (MAPE) with the following formula [14]:

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left[\frac{y'_i - y_i}{y_i} + \frac{y'_i - y_i}{y_i} + \cdots + \frac{y'_i - y_i}{y_i}\right] \times 100\%$$

$$MAPE = \frac{1}{1489}\sum_{i=1}^{1489}\left[\frac{Rp15.000 - Rp\ Rp21.122}{Rp15.000} + \frac{Rp15.000 - Rp\ Rp16.290}{Rp15.000} + \cdots + \frac{Rp53.000 - Rp\ Rp60.742}{Rp53.000}\right] \times 100\%$$

$$MAPE = \frac{1}{1461}\sum_{i=1}^{1461}[512{,}5736179] \times 100\%$$

MAPE = 34%

Description :
N = amount of data
y'i= predicted result on the i-th index = 1, 2,..., n
yi = actual value at the i-th index = 1, 2,..., n

4.6 Determining The Optimal Parameter

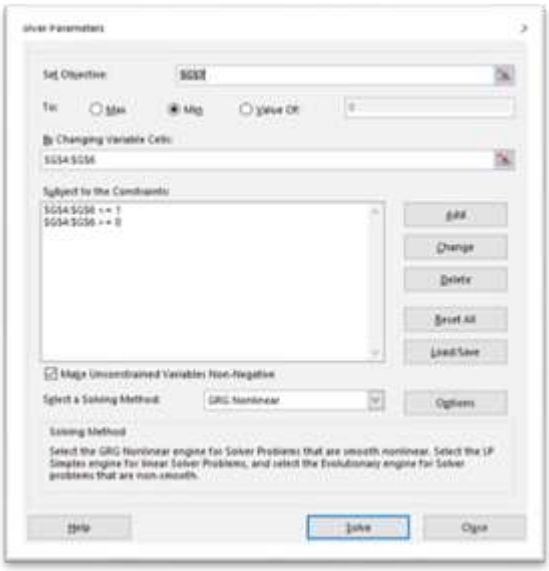

Figure 3. *Solve Icon To Determine The Optimal Parameter Value*

Determination of optimal parameter values is carried out using the help of MS software. Exel, precisely on the solver icon contained in the menu bar data. Determination of the optimal parameter value is based on the average value of the smallest MAPE. The first step that needs to be done is to choose a set of objectives or references in determining the optimal parameter value, in this case the average value of the smallest map. The next step is to select the min option so that the program responds to the lowest value, then select the alpha, beta and gamma place in the cell, then set the parameter value limit which is between 0 to 1. The last step is to click the solve menu. Cells that have been linked as alpha, beta and gamma will automatically show the value of the optimal parameters, the value of the optimal parameters in forecasting the price of cayenne pepper in Jember is 0.50 for the parameters of Alpha (α), 0 for the parameters of beta (β) and 0.22 for the parameters of gamma (γ).

4.7 Forecasting the price of cayenne pepper in Jember Regency in 2023

Table 7. Forecasting The Price Of Cayenne Pepper In Jember Regency In 2023

DATE	FORCAST	NUMBER M
01/01/2023	Rp50.791	1
02/01/2023	Rp50.582	2
03/01/2023	Rp52.043	3
:	:	:
:	:	:
29/12/2023	Rp51.915	363
30/12/2023	Rp52.159	364
31/12/2023	Rp50.271	365

Forecasting the price of cayenne pepper in Jember Regency in 2023 uses the same formula as the testing data, only the M value is adjusted to the date sequence. The First Order begins on 01/01/2023 to 31/12/2023, so it can be seen in Table 7 that the cayenne pepper forecasting data in Jember Regency in 2023 are 365 data, with seasonal or seasonal values on 01/01/2022 to 31/12/2022, level and trend values on 31/12/2022 as a reference for all forecasting in 2023. Level, trend and seasonal values use the latest or the most optimal parameters, namely 0.54 for the alpha parameter (α), 0 for the beta parameter (β) and 0.28 for the gamma parameter (γ). The calculation of forecasting the price of cayenne pepper in Jember Regency in 2023 is as follows [13]:

$F_{t+m} = (L_t + mb_t)S_{t+m-S}$
F_1 = (60739,290 + 1 × 3,522) 0,836
F_1 = 60742,81194× 0,836
F_1 = Rp50.789
Description :
α = smoothing constant for the level (0< α <1)
β = the smoothing constant for the trend (0< β <1)
γ = smoothing constant for seasonality (0< γ <1)
L_t = new smoothing value or current estimated level
yt = new observations or actual data of Period t
bt = estimated trend
St = seasonal estimate
m = the number of times forward
s = length of season
Ft+m = predicted value of M for the next period

4.7 Simple regression

a. Rainfall

Regression analysis of the effect of rainfall on the price of cayenne pepper produces a correlation value (r) of 0.61, this value has a meaning, namely the relationship of rainfall to the price of cayenne pepper is in a strong Category. The value of r is positive, so it can be interpreted that the relationship between rainfall and the price of cayenne pepper unidirectional, if rainfall rises then the price of cayenne pepper rises. R Square value of 38% which means the price of cayenne pepper is influenced by the rainfall factor of 38% and 62% influenced by other factors. Significance F value of 0.5 or greater than the value of Alpha (0.05), then the overall effect of rainfall on the price of cayenne pepper is not significant.

b. Production of Cayenne Pepper

Regression analysis of the effect of cayenne pepper production on the price of cayenne pepper resulted in a correlation value (r) of 0.378, this value has a meaning, namely the relationship of cayenne pepper production to the price of cayenne pepper is in the low category. The R value is positive, so it can be interpreted that the relationship between the production of cayenne pepper and the price of cayenne pepper unidirectional, if the production of cayenne pepper rose then the price of cayenne pepper rose. R Square value of 14% which means the price of cayenne pepper is influenced by the production of cayenne pepper by 14% and by 86% influenced by other factors. Significance F value of 0.35 or greater than the value of Alpha (0.05), then the effect of cayenne pepper production on the price of cayenne pepper is not significant.

c. Price of Substitute Goods (Red Pepper)

Regression analysis of the effect of the price of substitute goods (red pepper) to the price of cayenne pepper resulted in a correlation value (r) of 0.86, this value has a meaning, namely the relationship of the price of cayenne pepper to the price of substitute goods (red pepper) is in a very strong Category. The value of r is positive, so it can be interpreted that the relationship between the price of cayenne pepper and the price of cayenne pepper unidirectional, if the price of cayenne pepper rose then the price of cayenne pepper rose. R Square value of 74%, which means that the price of cayenne pepper is influenced by the price of substitute goods (red pepper) by 74% and by 26% influenced by other factors. The Significance value of F is 0.002 or less than the value of Alpha (0.05), then the effect of the price of substitute goods (red pepper) on the price of cayenne pepper is significant.

d. Price of Complementary Goods (Tomatoes)

Regression analysis of the effect of the price of complementary goods (tomatoes) to the price of cayenne pepper produced a correlation value (r) of 0.38, this value has a meaning, namely the relationship of the price of cayenne pepper to the price of complementary goods (Tomatoes) is in the low category. The value of r is positive, so it can be interpreted that the relationship between the price of cayenne pepper and the price of complementary goods (tomatoes), if the price of cayenne pepper rises then the price of complementary goods (tomatoes). R Square value of 15% which means that the price of cayenne pepper is influenced by the price of complementary goods (tomatoes) by 15% and as much as 85% influenced by other factors. Significance F value of 0.7 or greater than the value of Alpha (0.05), then the effect of the price of complementary goods (tomatoes) to the price of cayenne pepper is not significant.

4.8 Discussion

Figure 4. *Comparison Chart Of Forecasting Results With Real Data*

The forecasting results as seen in graph 4 show that forecasting the price of cayenne pepper in Jember Regency in 2023 is in the price range of Rp 24,000 to Rp 100,000. The beginning of 2023, to be precise in January, the price of cayenne pepper in Jember Regency averaged Rp 54,000, for 2 consecutive months in February and March the average price of cayenne pepper rose by Rp 60,000 and Rp 76,000, the next 2 months in April and May the average price of cayenne pepper fell successively by Rp 48,000 and Rp 34,000, for 2 consecutive months in June and July the average price of cayenne rawit rose by RP 52,000 and RP 72,000, respectively, for 2 consecutive months in August and September the average price of cayenne pepper fell by Rp 39,000 and Rp 25,000, 3 months later in October, November and December the average price of cayenne pepper fluctuated in price by Rp 33,000, Rp 32,000 and Rp 39,000, respectively.

The factors that affect the price of cayenne pepper in Jember are rainfall, production of cayenne pepper, the price of substitute goods (red pepper), the price of complementary goods (Tomatoes). The results of regression calculations show that the most influencing factor on the price of cayenne pepper in Jember is the price of substitute goods (Red Pepper) which is in the category of very strong with an r value of 0.86 and R Square value of 74%. The next factor that most affects the price of cayenne pepper is rainfall which is in the strong category with an r value of 0.61 and an R value of 38% Square. The next factor is classified as a low category, namely the production of cayenne pepper and the price of complementary goods (tomatoes). Cayenne pepper production has an r value of 0.37 and R Square value of 14%, while the price of complementary goods (Tomatoes) has an R value of 0.38 and R Square value of 15%.

V. Conclusion

1. The value of the optimal parameters of forecasting the price of cayenne pepper in Jember with a value of α of 0.5, 0 and 0.22.
2. The accuracy of forecasting the price of cayenne pepper in Jember using a map of 34%, this value according to Table 1 is included in the category of sufficient, so the forecasting results are still acceptable. The results of forecasting the price of cayenne pepper in Jember Regency in 2023 are in the price range of Rp 24,000 to Rp 100,000. The beginning of 2023, to be precise in January, the price of cayenne pepper in Jember Regency averaged Rp 54,000, for 2 consecutive months in February and March the average price of cayenne pepper rose by Rp 60,000 and Rp 76,000, the next 2 months in April and May the average price of cayenne pepper fell successively by Rp 48,000 and Rp 34,000, for 2 consecutive months in June and July the average price of cayenne

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3. Factors that affect changes in chili prices in Jember is the price of substitution materials (red pepper) and rainfall.

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