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Forecasting Red Cayenne Chili Prices to Maintain Inflation Stability in West Nusa Tenggara

Sab'ul Masani[1*], Daeva Mubarika Raisa[1], Dyah Ayu Suryaningrum[1], Ade Rezkika Nasution[1], Yousf Bellin Swarli[2]
[1]Fakultas Pertanian, Universitas Mataram, Mataram, Indonesia
[2]Fakultas Ekonomi dan Bisnis Islam, Institut Studi Islam Sunan Doe, Lombok Timur, Indonesia
sab'ulmasani@staff.unram.ac.id

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Corresponding Author: Sab'ul Masani1, Universitas Mataram,
Email: sab'ulmasani@staff.unram.ac.id

ABSTRACT

Inflation is a key challenge in economic management because it directly influences purchasing power, living costs, and price stability. In West Nusa Tenggara Province, red cayenne pepper is a volatile food commodity and a major contributor to regional inflation due to sharp price fluctuations and high consumption. This study aims to develop a price forecasting model for red cayenne pepper using the Triple Exponential Smoothing (Holt–Winters) method, which accounts for level, trend, and seasonal components to reflect dynamic price movements. The study uses monthly red cayenne pepper price data from January 2022 to June 2025 sourced from the National Food Agency. Descriptive analysis is applied to identify price characteristics and movement patterns, while inferential analysis is used to estimate the forecasting model. The smoothing parameters α, β, and γ are optimized using EViews and Microsoft Excel to determine the best model specification. The results show that the optimal parameters are α = 0.1, β = 0.3, and γ = 0.3. The model successfully captures seasonal price behavior and achieves a Mean Absolute Percentage Error (MAPE) of 37.54% and a Root Mean Squared Error (RMSE) of 25,557.5, indicating acceptable forecasting performance for a volatile commodity. Forecasts for July 2025 to June 2026 indicate substantial price variability, with the lowest projected price occurring in October 2025 at IDR 58,862.32 per kilogram and the highest in March 2026 at IDR 145,004.93 per kilogram. Seasonal patterns reveal price declines during peak harvest periods and sharp increases during supply shortages.

Keywords: *Triple Exponential Smoothing, Inflation, Red Cayenne Chili*

INTRODUCTION

One of the major challenges faced by a country or region in macroeconomics is inflation, which is often described as an economic "disease" that can lead to bankruptcy or instability. Therefore, governments are required to play a critical role in maintaining inflation at a proportional level (Sundoro, 2021). Inflation refers to a condition in which the prices of goods increase continuously over a relatively long period and occur generally across various types of goods (Jain et al., 2022). Inflation can also be characterized as a condition in which the rising prices of certain goods and services lead to a widespread increase in the prices of other commodities across the economy. This phenomenon signifies a reduction in the aggregate purchasing power of money, which may ultimately undermine overall economic stability.

In the context of macroeconomic analysis, the dynamics of commodity prices are often used as a leading indicator of inflation, since their movements can provide early signals of potential changes in the general price level in the future (Wahyuni et al., 2024). Therefore, monitoring and analyzing commodity price fluctuations are essential for the formulation of monetary policy and inflation control strategies.

Inflation represents a fundamental indicator used to evaluate the degree of economic stability within a country. Extreme fluctuations in inflation can result in various adverse impacts, ranging from reduced public purchasing power to increased poverty levels (Ristiya et al., 2023). The causes of inflationary fluctuations are complex and multidimensional. From a financial perspective, inflation can be triggered by an excessive increase in the money supply that is not accompanied by proportional growth in the production of goods and services, leading to an imbalance between demand and supply (Hidayati et al., 2022). This condition is commonly referred to as demand-pull inflation. On the supply side, factors such as scarcity of goods due to crop failures, distribution disruptions, or rising raw material costs can lead to cost-push inflation. In the agricultural sector, for instance, low yields caused by extreme weather or pest attacks reduce food supply, resulting in sharp increases in food prices.

One of the strategies to control inflation is through the monitoring of food commodity prices, especially commodities categorized as volatile, such as red cayenne chili (*Capsicum frutescens*) (Hidayati et al., 2022). This commodity often becomes a driver of seasonal inflation due to sharp price fluctuations, which may be caused by production factors, distribution issues, or extreme weather disturbances (Ulya et al., 2023). The rise in red cayenne chili (*Capsicum frutescens*) prices not only contributes to inflation but also increases household consumption burdens and creates public concern due to the uncertainty of basic food prices (Erlangga & Darsyah, 2018). Such extreme price volatility often complicates local governments' efforts to maintain inflation stability and protect consumers' purchasing power. Therefore, price stabilization of red cayenne chili (*Capsicum frutescens*) is a strategic measure to maintain both regional and national economic balance.

At the national level, the Central Statistics Agency (BPS) recorded that in November 2023, red cayenne chili (*Capsicum frutescens*) contributed significantly to the inflation rate, accounting for 43.7 percent year-on-year, while in West Nusa Tenggara Province, the contribution of red cayenne chili (*Capsicum frutescens*) to inflation in December 2024 was 0.30 percent year-on-year.

A substantial body of literature has examined the forecasting of red cayenne chili (Capsicum frutescens) prices using a variety of quantitative approaches. Previous studies have applied Double Exponential Smoothing to capture trend dynamics (Khatimah et al., 2023), while others have relied on ARIMA-based models to exploit stochastic time-series properties (Sarah et al., 2024; Ulya et al., 2023; Fiqa et al., 2024). More recently, advanced machine-learning techniques, such as Long Short-Term Memory (LSTM) networks combined with attention mechanisms, have been employed to enhance predictive performance (Witanti et al., 2024). Despite the methodological diversity of these studies, the existing literature remains largely focused on improving predictive accuracy without sufficiently addressing the suitability of forecasting models to specific regional contexts and policy objectives. In particular, empirical evidence on the application and effectiveness of the Triple Exponential Smoothing (Holt–Winters) method for forecasting red cayenne chili prices in West Nusa Tenggara is still limited. This represents a notable research gap, given that West Nusa Tenggara exhibits distinct seasonal production cycles and supply–demand patterns that strongly influence price volatility. Unlike Double Exponential Smoothing, which only accounts for level and trend components, the Holt–Winters approach explicitly incorporates seasonal effects, making it theoretically more appropriate for agricultural commodities characterized by recurring price cycles. Moreover, prior studies rarely integrate forecasting outcomes into a policy-relevant framework, especially in relation to proactive inflation control strategies at the regional level.

By addressing these limitations, the present study fills both a contextual and methodological gap by evaluating the performance of the Triple Exponential Smoothing (Holt–Winters) model in capturing seasonal price dynamics of red cayenne chili in West Nusa Tenggara, while simultaneously linking the forecasting results to their potential use as an early warning instrument for regional inflation management. This dual focus not only advances the methodological literature on agricultural price forecasting but also provides empirically grounded insights to support evidence-based policymaking in inflation stabilization and food security.

Building upon the preceding discussion, this study seeks to construct a more precise and adaptive forecasting model for red cayenne chili (Capsicum frutescens) prices by employing the Triple Exponential Smoothing approach. This method simultaneously accounts for the level, trend, and seasonal components inherent in time-series data. Through this method, the research seeks to provide more precise price predictions compared to previous studies, thereby offering a stronger foundation for decision-making among agribusiness actors, policymakers, and stakeholders in anticipating price fluctuations of red cayenne chili (*Capsicum frutescens*). Ultimately, the findings are expected to support price stabilization efforts and strengthen food security, particularly in West Nusa Tenggara Province.

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RESEARCH METHODS

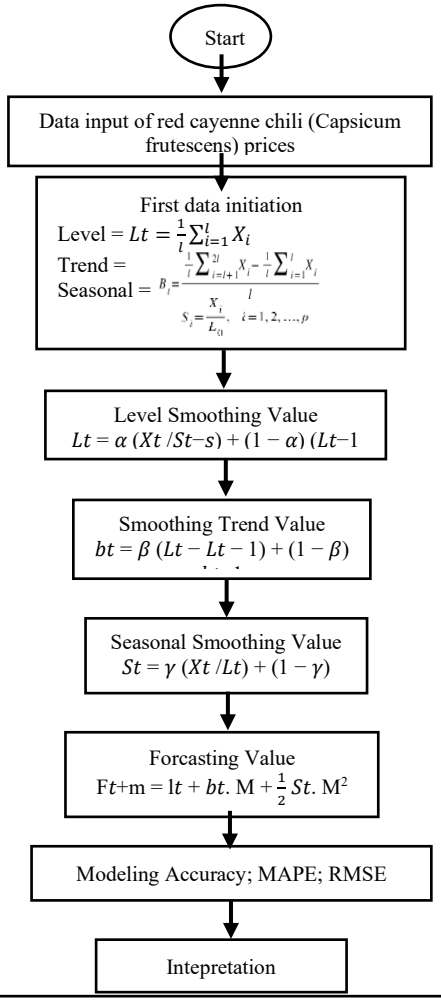
Data Source

This research employed secondary data sourced from the National Food Agency (Badan Pangan Nasional). The data analyzed consist of monthly cabai rawit merah prices (IDR/kg) based on consumer prices in West Nusa Tenggara, recorded continuously from January 2022 to June 2025. Data analysis was conducted through two main approaches: descriptive analysis and inferential analysis. The descriptive approach was employed to comprehensively explore the characteristics of the data through the computation of summary statistics and data visualization (data plotting). This process aimed to provide an information summary, identify price movement patterns, and systematically map data distribution. Furthermore, inferential analysis was employed to examine and model the data through the Triple Exponential Smoothing method, aiming to produce precise price forecasts that incorporate the level, trend, and seasonal components. This technique is highly suitable for time-series data characterized by seasonal fluctuations, such as the red cayenne chili price data in West Nusa Tenggara. By applying this approach, the study generates forecasts that are not only more accurate but also more responsive to both seasonal variations and underlying trend movements within the dataset (Nur et al., 2024).

Triple Exponential Smoothing

Triple Exponential Smoothing represents a forecasting technique for time-series data in which historical observations are weighted exponentially, giving greater importance to more recent data points. This technique utilizes the smoothed values from previous observations to generate forecasts for subsequent periods. Unlike simple smoothing methods, Triple Exponential Smoothing can accommodate both trend and seasonal components through the use of three primary smoothing parameters: alpha (α), beta (β), and gamma (γ) (Hidayati et al., 2022).

The study utilizes the Triple Exponential Smoothing approach for time-series data analysis, aiming to determine the optimal model configuration and produce reliable forecasting results. The analytical process was conducted using EViews and Microsoft Excel software for computation and data visualization, following these stages:



In the Triple Exponential Smoothing approach, the initial stage involves identifying the optimal parameter values through a trial-and-error process to achieve results that most closely match the actual observations (Syafhira Ananda Galasca & Harahap, 2025). The analytical procedures adopted in this study using the Triple Exponential Smoothing method are outlined as follows:

1. Determining Initial Values
   This step serves as the foundation for establishing the initial values of each parameter, namely the level (α), trend (β), and seasonal (γ) components.
2. Determining the Smoothing Values
   This stage involves constructing the smoothing model using the Triple Exponential Smoothing method by estimating the level, trend, and seasonal components iteratively
3. Forcasting Values
   The classical decomposition method in forecasting assumes that time-series data can be decomposed into several main components: seasonal index, trend, cycle, and random (error) factors that have been previously identified. However, forecasting cannot be performed on the error component due to its unsystematic and random nature (Ersita et al., 2024).
4. Forecast Validation
   The accuracy level of cabai rawit merah price forecasts in this study was evaluated using two forecasting error indicators: Root Mean Squared Error (RMSE) and Mean Absolute Percentage Error (MAPE).
   The Root Mean Squared Error (RMSE) is calculated using the following equation:

$$\text{RMSE} = \sqrt{\frac{1}{n}\sum_{t=1}^{n}\left(Y_t - \hat{Y}_t\right)^2} \quad \text{.....(1)}$$

   Dan untuk MAPE:

$$\text{MAPE} = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{Y_t - \hat{Y}_t}{Y_t}\right| \times 100\% \quad \text{.....(2)}$$

   Where:
   γt : the actual data value at time period *t*
   Yt : the forecasted value corresponding to γt
   n : the number of time periods used
5. Model Accuracy Measurement
   The level of smoothing accuracy is used to assess how closely the generated forecasts match the actual data. A smaller error value indicates a higher quality of smoothing and, consequently, a more reliable forecasting model. The accuracy of the smoothing process can be evaluated using the Mean Absolute Percentage Error (MAPE) (Nur et al., 2024). The following criteria are commonly used to interpret MAPE values:

Table 1. MAPE Accuracy Categories

MAPE	Category
< 10%	Excellent
10 - 20%	Good
20 - 50%	Fair
>50%	Poor

RESULTS AND DISCUSSION

Descriptive Analysis

Descriptive analysis was employed to extract and summarize information from the collected dataset, thereby providing a general overview of the characteristics and distribution of the data (Nur et al., 2024). In this study, the descriptive analysis includes the calculation of the mean, median, standard deviation, as well as the determination of maximum and minimum values.

Table 2. Descriptive Analysis of Red cayenne chili (*Capsicum frutescens*) Price Data in West Nusa Tenggara, January 2022 – June 2025

Mean	50012.5
Median	43573.5
Standard Deviation	19134.13
Kurtosis	1.9767
Skewness	1.32397
Minimum	25399
Maximum	112174

Sourcer: Secondary Data, analyzed

Based on table 1, it can be seen that the average consumer price of red cayenne pepper in West Nusa Tenggara from the period of January 2022 to June 2025 is Rp. 50,012.5/Kg, the highest price is in 2025 in March which is Rp. 112,174/Kg, this shows that there is a high price fluctuation Where the increase is up to twofold, while the lowest price is Rp. 25,399/Kg, namely in September 2023. For the standard deviation value of 19134.13, this high standard deviation value indicates that the price of red cayenne pepper in the period from January 2023 to June 2025 has a high level of variation or fluctuates significantly. A Skewness value of 1.32 indicates a right-skewed distribution of the data, signaling the dominance of below-average prices with some high fluctuation values. Meanwhile, the Kurtosis of 1.97 indicates a flatter peak distribution and a relatively even distribution of data, so the price is volatile with occasional spikes.

Initial Parameter Values

The next stage is the initialization phase. The first process in this method involves initialization, which consists of determining the initial smoothing values for the level, trend, and seasonal components using the consumer price data of red cayenne chili (*Capsicum frutescens*) in West Nusa Tenggara for the period January 2023 to June 2025.

The formula used for initializing the level component is expressed as follows:

$$Lt = \frac{1}{l}\sum_{i=1}^{l} X_i$$

= (39529 + 37726 + 63385 + 47175 + 43798 + 68050 + 66487 + 40285 + 48891 + 37159 + 25470 + 35420) / 12
= 46113,8

The initialization results indicate that the initial level parameter obtained in this study is 46,113.8.

Trend Component Initialization

The formula used for initializing the trend component is expressed as follows:

$$B_l = \frac{\frac{1}{l}\sum_{i=l+1}^{2l} X_i - \frac{1}{l}\sum_{i=1}^{l} X_i}{l}$$

= (63506 - 39519) + (64720 - 37726) + (79334 - 63385) + (43349 - 47175) + (39833 - 43798) + (41191 - 68050) + (33271 - 66487) + (38612 - 40285) + (25399 - 48891) + (38827 - 37159) + (65473 - 25470) + (70201 - 35420)
= (23987/12) + (26994/12) + (15949/12) - (3826/12) - (3965/12) - (26859/12) - (33216/12) - (1673/12) - (23492/12) + (1668/12) + (40003/12) + (34781/12)
= (1998,92 + 2249,50 + 1329,08 – 318,83 – 330,42 – 2238,25 – 2668 – 139,42 – 1957,67 + 139 + 3333,58 = 2898,42)/12
= 349,66

The initialization results indicate that the initial trend parameter obtained in this study is 349.66.

Seasonal Initialization Stage

The initialization formula for the seasonal component is as follows:

$$S_i = \frac{X_i}{L_0}, \quad i = 1, 2, \ldots, p$$

S_1 = 46113,8 / 39519 = 0,9
S_2 = 46113,8 / 37726 = 0,8
S_3 = 46113,8 / 63385 = 1,4

S_4 = 46113,8 / 47175 = 1,0
S_5 = 46113,8 / 43798 = 0,9
S_6 = 46113,8 / 68050 = 1,5
S_7 = 46113,8 / 66487 = 1,4
S_8 = 46113,8 / 40285 = 0,9
S_9 = 46113,8 / 48891 = 1,1
S_{10} = 46113,8 / 37159 = 0,8
S_{11} = 46113,8 / 25470 = 0,6
S_{12} = 46113,8 / 35420 = 0,8

The seasonal component initialization was performed over a 12-month period, which serves as the baseline reference for forecasting in the following months.

Accuracy Value

The subsequent stage in implementing the Triple Exponential Smoothing (Holt–Winters) method involves determining the smoothing parameters—α (alpha), β (beta), and γ (gamma)—whose values are constrained within the interval of 0 to 1 to minimize forecasting errors. The optimal values of these parameters were identified through a trial-and-error procedure using Microsoft Excel. The outcomes of the parameter optimization, conducted with the Solver tool, are summarized in the following table:

Table 3. Parameter Value, α, β, dan γ.

α	β	γ
0.1	0.3	0.3
MSE	RMSE	MAPE
2712.83	25557.5	37.54

Source: Secondary Data, analyzed

Based on the results shown in the table, the parameter values of α = 0.1, β = 0.3, and γ = 0.3 in the Triple Exponential Smoothing (Holt–Winters) model were selected, as they yielded the lowest values of Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and Mean Absolute Percentage Error (MAPE) compared to other parameter combinations during the optimization process. The MSE value was 2,712.83, the RMSE was 25,557.5, and the MAPE value, classified as reasonable, was 37.54%.

A relatively low α value indicates that the level component estimation is more stable, while the moderate β and γ values maintain a balance between the model's ability to adapt to trends and seasonal patterns without being overly sensitive to random fluctuations. With this configuration, the model successfully minimizes overall prediction errors, thereby providing optimal forecasting accuracy for the analyzed data.

Forcasting

Subsequently, using the parameter values α = 0.1, β = 0.3, and γ = 0.3, a forecast of the monthly prices of cabai rawit merah in West Nusa Tenggara was conducted for the period July 2025 to June 2026. The results of this forecasting are presented in Table 4 below.

Table 4. Forecasted Monthly Prices of Red cayenne chili (*Capsicum frutescens*) in West Nusa Tenggara, July 2025 to June 2026

Month/Year	Price (Rp) / Kg	Month/Year	Price (Rp) / Kg
Jule-2025	78939.34	January-2026	107730.00
August-2025	64559.10	February-2026	101630.01
September-2025	60560.10	March-2026	145004.93
Oktober-2025	58862.32	April-2026	112293.86
November-2025	60918.70	May-2026	81676.76
December-2025	75703.27	June-2026	107578.73

Source: Secondary Data, analyzed\

Based on the forecasting results presented in Table 3, the price of rawit merah cili in West Nusa Tenggara for the period July 2025–June 2026 is projected to experience significant fluctuations. In the first half of the forecasting period, prices tend to decline from IDR 78,939.34/kg in July 2025 to the lowest point of IDR 58,862.32/kg in October 2025, before gradually increasing toward the end of the year, reaching IDR 75,703.27/kg in December 2025. Entering 2026, prices are expected to rise sharply, peaking in March 2026 at IDR

145,004.93/kg, representing the highest level during the forecast period. Afterward, prices are projected to decline to around IDR 81,676.76/kg in May 2026, followed by a slight rebound to IDR 107,578.73/kg in June 2026.

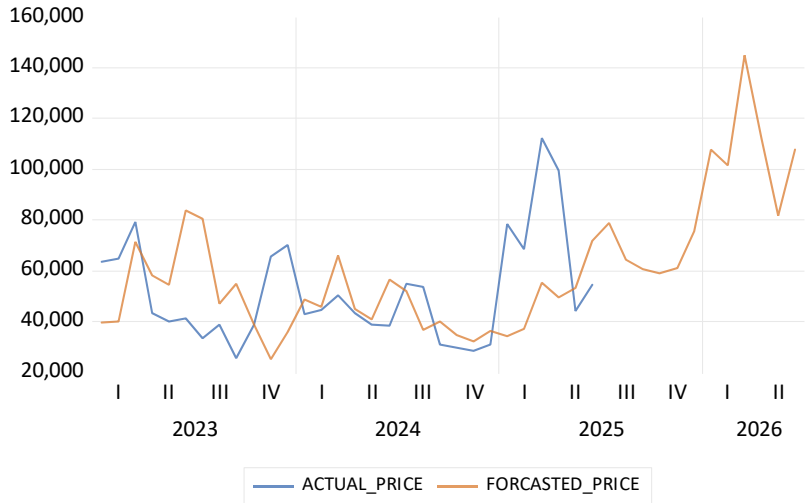
This pattern indicates a strong seasonal cycle, with lower prices occurring at the end of the harvest season and significant increases during periods of limited supply an important consideration for distribution planning and price stabilization policies. In addition to reflecting the pattern of price fluctuations, the forecasting results also reveal a seasonal characteristic consistent with the production cycle of red cayenne chili (*Capsicum frutescens*) in West Nusa Tenggara. The price decline observed between August and October 2025 is likely associated with the peak harvest season, when abundant supply causes a gradual decrease in prices. Conversely, the sharp price surge in early 2026 particularly in March may be attributed to reduced supply due to climatic factors, the onset of a new planting period, or distribution constraints, reinforcing the influence of seasonality on price behavior.

The wide variation between the lowest and highest prices demonstrates high market volatility, suggesting that the forecasting information can serve as a valuable reference for farmers, traders, and local governments in formulating strategies for production scheduling, planting, storage, and distribution. Such strategies can help minimize losses and maintain price stability for consumers.

Inflation trends in West Nusa Tenggara from 2022 to mid-2025 also exhibited fluctuations. On average, inflation declined from 2022 to 2024 but began to rise again in the first half of 2025. The highest inflation rate in 2022 occurred in July, reaching 1.24%, coinciding with the red cayenne chili (*Capsicum frutescens*) price of IDR 66,487/kg. In 2023, inflation remained relatively stable at an average of 0.25%, while in 2024, inflation decreased further, accompanied by stable red cayenne chili (*Capsicum frutescens*) prices averaging IDR 40,518/kg. However, in 2025, inflation recorded a significant increase, peaking at 2.04% in March, along with a sharp rise in cabai rawit merah prices reaching IDR 112,174/kg.

These findings indicate that fluctuations in red cayenne chili (*Capsicum frutescens*) prices contribute to inflation volatility in West Nusa Tenggara. Therefore, the price forecasts for July 2025 to June 2026 serve as an early signal of potential inflation instability during that period. Consequently, the Provincial Government of West Nusa Tenggara, together with the Regional Inflation Control Team (TPID), should prepare anticipatory measures to maintain inflation stability in the coming period, particularly during months when red cayenne chili (*Capsicum frutescens*) prices are expected to rise (Hidayati et al., 2022).

Figure 1. Actual Price and Forecasted Price of Red Cayenne Chili (*Capsicum frutescens*) in West Nusa Tenggara



Source: Secondary Data, analyzed

Figure 1 shows a comparison between the actual price of red cayenne pepper in West Nusa Tenggara Province in the in-sample period (January 2022–June 2025) and the forecasting results outside the sample (July 2025–June 2026) produced using the Triple Exponential Smoothing (Holt–Winters) method. Based on the results of these projections, in the second semester of 2025 to early 2026 the price of red cayenne pepper is expected to increase significantly, with the highest peak price projected to occur in March 2026 of IDR 145,004.93/kg. After the observation data deadline of June 2025, the forecasting curve shows a sharp pattern of fluctuations, reflecting the influence of seasonal factors and supply constraints in a given period.

Referring to the results of this forecast, one of the strategic steps that can be taken by the West Nusa Tenggara Provincial Government together with the Regional Inflation Control Team (TPID) to mitigate the

potential surge in the price of red cayenne pepper is the implementation of market operations. Market operations are policy instruments carried out by the government, either directly or through cooperation with business actors, with the aim of containing price increases and maintaining price affordability for consumers. Apart from being an effort to control prices, market operations also play a role in ensuring the availability of the supply of red cayenne pepper in the market so that the balance between demand and supply is maintained. Regular market operations, especially ahead of religious holidays or when prices start to show an upward trend, can help stabilize prices. This effort needs to be supported by cross-sector coordination, including cooperation with local farmers, distributors, and traditional markets, so that distribution runs smoothly and the potential for hoarding that can trigger inflation can be minimized. With careful planning and consistent implementation, market operations can be an effective policy instrument in maintaining the stability of red cayenne pepper prices while supporting inflation control in West Nusa Tenggara Province.

CONCLUSION

The projected increase in red cayenne chili (Capsicum frutescens) prices during July 2025–June 2026 is closely linked to regional inflation dynamics, particularly within the volatile food component. Given its considerable weight in the Consumer Price Index (CPI), price fluctuations in this commodity directly influence inflation trends. The forecasted surge from IDR 58,862.32/Kg in October 2025 to IDR 145,004.93/kg in March 2026 may significantly elevate monthly inflation rates. This reflects a seasonal pattern in which prices typically rise at the beginning of the year and decline toward year-end. To mitigate this potential impact, the West Nusa Tenggara Provincial Government and the Regional Inflation Control Team (TPID) should adopt proactive strategies, particularly during major religious holidays such as Eid al-Fitr and Eid al-Adha. These strategies may include conducting market operations, strengthen supply chains, and collaborate with local farmers to maintain price stability and safeguard household purchasing power.

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