Forecasting the Prices of Poultry Egg and Meat in Major Markets of Karnataka Using ARIMA Models

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Abstract

Poultry production, a key contributor to India's agricultural sector, faces challenges such as price volatility, seasonal fluctuations, and external market influences. Accurate price forecasting for poultry products like eggs and meat is crucial for stabilizing markets and ensuring the livelihood of stakeholders. This study employs the ARIMA (Auto-Regressive Integrated Moving Average) model to forecast egg and meat prices in Karnataka's major markets, including Bengaluru, Hubli, and Mysuru, using monthly price data from January 2017 to March 2025. The Box-Jenkins methodology was applied for model identification, estimation, and diagnostic checking. The optimal models were selected based on the Mean Absolute Percentage Error (MAPE), showing high forecast accuracy for meat prices in Hubli (MAPE = 3.27%) and Bengaluru (MAPE = 4.54%), while egg prices in Bengaluru (MAPE = 7.12%) and Mysuru (MAPE = 7.51%) displayed higher variability, suggesting the influence of external factors not captured by the basic model. The forecast indicates a steady price increase, reflecting ongoing market dynamics. These findings demonstrate the effectiveness of ARIMA models for market forecasting, while highlighting the need for refinement to consider factors impacting egg prices. The study underscores the value of such models in informed decision-making, market interventions, and policy development to improve the stability and sustainability of Karnataka's poultry industry.

1. INTRODUCTION:

Agriculture and allied sectors form the backbone of India's economy, significantly contributing to employment and GDP. Poultry production, including eggs and meat, has witnessed robust growth due to increasing demand for protein-rich diets (Alders, 2012; Niranjan et al., 2008). The poultry industry has expanded rapidly, driven by low capital investment, quick returns, short generation intervals, and minimal land requirements (Raghunandhan and Pallavi, 2023). Quality healthcare, along with the production and supply of livestock and poultry feed, ensures nutritious food for the growing population (Singh, 2016). Poultry farming has also created substantial employment opportunities in urban and peri-urban areas (Surest *et al.,* 2015).

India's poultry population increased from 3,476.1 lakh in 1997 to 8,078.9 lakh in 2019 (Deshmanya *et al.,* 2023). Karnataka, ranking 6th in poultry production, recorded a total poultry population of 5.95 crore in 2019, an 11.32% increase over the previous census and 81.44% of the population comprises commercial poultry, while 18.56% accounts for backyard poultry (Annual Report, 2024). The highest distribution is in Kolar (14.47%), followed by Bengaluru Rural (12.01%). Approximately 9.23 lakh households in the state engage in poultry farming (Government of Karnataka, 2019).

In 2022-23, India produced 138.38 billion eggs, making it the second-largest producer globally (BAHS, 2023). Karnataka ranks fifth in egg production, contributing 6.51% to the national total (PIB, 2023). This growth is driven by increased urban demand, advancements in technology, improved feed quality, and enhanced housing systems. However, challenges like high feed costs, disease outbreaks, limited rural market development, seasonal price fluctuations, and shifting government policies affect the livelihoods of over 1.6 million farmers (Naphade and Badhe, 2021). The Centrally Sponsored Scheme "National Livestock Mission" promotes entrepreneurship, private investment, and rural youth participation to foster self-reliance in the sector.

Despite its importance, price forecasting for poultry products in Karnataka remains underexplored. As a leading poultry-producing state, Karnataka requires robust price prediction mechanisms to stabilize markets, protect stakeholders, and ensure food security. ARIMA models, known for their effectiveness in time-series forecasting, are particularly suited for agricultural commodities with seasonal and cyclical trends. This study aims to forecast egg and meat prices in Karnataka's key markets using ARIMA models, providing critical insights for producers, consumers, and policymakers.

2. METHODOLOGY

2.1. Box-Jenkins (ARIMA): In time series analysis, an ARIMA model is a generalization of an ARMA model. These models are fitted to time series data either to better identify with the data or to predict future points in the series. They are applied in many cases where data illustrate evidence of non-stationarity, whereas differencing step can be applied to reduce the non-stationarity. Non-seasonal ARIMA models are generally denoted ARIMA (p, d, q) where parameters are non- negative integers then p, d, q refer to the autoregressive, differencing, and moving average terms for the non-seasonal component of the ARIMA model. Seasonal ARIMA models are usually denoted ARIMA (p, d, q) (P, D, Q) m, where m refers to the number of periods in each season, and P, D, Q refer to the autoregressive, differencing, and moving average terms for the seasonal component of the ARIMA model. ARIMA models form an important area of the Box {Jenkins approach to time-series modelling. It is also known as Box-Jenkins method. A non-seasonal stationary can be modeled as a combination of the past values and the errors which can be denoted as ARIMA (p, d, q) are can be expressed as

$$y_t = c + {}_{\varphi 1}y_{t-1} + {}_{\varphi 2}y_{t-2} + \cdots + {}_{\varphi p}y_{t-p} + e_t - \Theta_1 e_{t-1} - \Theta_2 e_{t-2} - \cdots - \Theta_q e_{t-q}$$

The Box-Jenkins (ARIMA) methodology for analyzing and modelling time series

is characterized by four steps:

- Identification
- Estimation
- Diagnostic checking
- Forecast

2.1.1. Identification: The identification stage, finding the time series data is stationary or not and compare the estimated Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) to find a match. We choose, as a tentative model, the ARMA process whose theoretical ACF and PACF best match the estimated ACF and PACF.

2.1.2. Estimation: Estimating the parameters for Box {Jenkins models is a rather complicated non {linear estimation problem. The main approaches for fitting Box - Jenkins models are nonlinear least squares and maximum likelihood estimation. Parameter estimates are usually obtained by maximum likelihood, which is asymptotically correct for time series. Estimators are always sufficient, efficient, and consistent for Gaussian distribution and which are asymptotically normal with efficient for several non-Gaussian distribution.

2.1.3. Diagnostic Checking: The diagnostic checking is necessary to test the appropriateness of the selected model. Model selection can be made based on the values of certain criteria like log likelihood, Akaike Information Criteria (AIC)/ Bayesian Information Criteria (BIC)/ Schwarz-Bayesian Information Criteria (SBC).

AIC = {n (1 + log 2π) + n log σ^2+ 2m}

BIC = -2 log(L) + k log (n)

SBC = log σ^2 + (m log n) /n

If the model selection is done, it is necessary to verify the satisfactoriness of the estimated model. This is done by studying the pattern among the residuals, if there is any. The estimated residuals can be computed as

$\hat{e}$=Y_t- $\widehat{Y}_t$; Where $\widehat{Y}_t$ is the estimated observation at time t.

The values of ^et, which are either less than -3 or greater than 3, indicate that the corresponding residuals are outliers. The values of ACF may be studied to verify whether the series of residuals is white-noise. After tentative model has been fitted to the data, it is important to perform diagnostic checks to test the satisfactoriness of the model. It has been found that it is effective to measure the overall adequacy of the chosen model by examining a quantity Q known as Ljung-Box statistic whose approximate distribution is chi-square and computed as

follows:

Q = n (n + 2) $Q = n(n+2)\sum_{p=1}^{h}(n-k)^{-1}r_p^2$

The Ljung-Box (Q) statistic is compared to critical values from chi-square distribution. While the diagnostic checking is fulfilled effectively and the model is found adequate, the fitted model can be used for forecasting purpose.

2.1.4 Forecasting: Forecasting is the prediction of values of a variable based on identified past values of that variable or other associated variables. Forecasting also may be based on expert judgments, which in turn are based on chronological data and experience. In analysis part, the appropriate model is found satisfactory, and the fitted model can be used for forecasting purpose Zhang, G. P. (2003).

3. RESULTS AND DISCUSSION

3.1 Best fit forecast models for monthly prices of poultry egg and meat in major markets of Karnataka

Table 1 shows the best-fit forecast models for poultry product prices in Karnataka major markets from January 2017 to March 2025 highlight remarkable accuracy. Meat prices show lower Mean Absolute Percentage Errors (MAPE) in Hubli (3.27%) and Bengaluru (4.54%), while egg price forecasts have slightly higher MAPEs in Bengaluru (7.12%) and Mysore (7.51%). This variability suggests that egg price forecasts might be more complex and potentially influenced by factors outside the scope of basic ARIMA modelling.

Table 1: Best fit forecast models for monthly prices of egg and meat of poultry major markets in Karnataka (2017 January-2025 March)

Products	Markets	Model	MAPE
Meat	Bengaluru	(0,1,4) (0,0,0)	4.54
	Hubballi	(2,1,3) (0,0,0)	3.27
Egg	Bengaluru	(1,0,0) (0,1,1)	7.12
	Mysore	(0,0,1) (0,1,0)	7.51

3.2 Monthly price forecast of poultry meat in Bengaluru

Table 2 presents the ex-post forecast of monthly meat prices in the Bengaluru market for 2023–2025. The data shows a high degree of consistency between actual and forecasted prices, with validity percentages ranging from 97.04% to 109.60%. The forecast is notably accurate for most months, especially in 2023, where validity is close to 100%. However, some deviations were observed, such as in January 2023 (108.18%) and January 2024 (109.60%), indicating potential underestimation of market trends. In addition, slight under-predictions occurred in June, July, and August 2024, with validity falling below 98%. These variations may be attributed to unforeseen market fluctuations caused by external economic or seasonal factors not fully captured by the model, suggesting that occasional adjustments may be necessary for certain months. For 2024–2025, the forecast shows a steady rise in prices, ranging from ₹266/kg in October 2024 to ₹277/kg in March 2025, reflecting ongoing price growth likely driven by rising demand or cost factors. Overall, the ARIMA model proves to be a reliable tool for price forecasting, helping stakeholders make informed decisions. This provides a strong foundation for functional food, offering poultry producers the opportunity to expand their product range with new offerings (Perić *et al.,* 2011).

Table 2: Ex-post forecast of monthly prices of meat in Bengaluru market of Karnataka during 2023 January to 2025 March

Year and month	Bengaluru Market		
	Actual meat price (₹ /kg)	Forecast meat price (₹ /kg)	Validity (%)
2023 January	220	238	108.18
2023 February	225	225	100.00
2023 March	230	234	101.74
2023 April	235	238	101.28
2023 May	240	243	101.25
2023 June	245	242	98.78
2023 July	250	248	99.20
2023 August	255	253	99.22
2023 September	260	257	98.85
2023 October	265	260	98.11
2023 November	270	265	98.15
2023 December	275	270	98.18
2024 January	250	274	109.60
2024 February	255	248	97.25
2024 March	260	253	97.31
2024 April	265	265	100.00
2024 May	270	274	101.48
2024 June	275	267	97.09
2024 July	260	274	105.38
2024 August	270	262	97.04
2024 September	265	271	102.26
2024 October		266	
2024 November		271	
2024 December		271	
2025 January		274	
2025 February		276	
2025 March		277	

3.3 Monthly price forecast of poultry meat in Hubballi

The ex-post forecast of monthly meat prices for the Hubballi market from January 2023 to March 2025, demonstrated in Table 3, demonstrates the accuracy of the ARIMA model. The forecasted prices closely align with the actual prices, as shown by the validity percentages, which remain near 100%. In 2023, the validity ranged from 96.52% to 111.90%, with the highest deviation in January (111.90%). For 2024, validity percentages varied between 96.80% and 106.94%, indicating consistent forecasting performance, such as the forecast price of ₹262/kg for January compared to the actual ₹245/kg. Even for the period from October 2024 to March 2025, where actual data is unavailable, the forecasted prices maintain continuity, offering valuable insights into future market trends. This forecast model provides a solid foundation for managing market uncertainties and ensuring economic stability in Hubballi's meat sector.

Table 3 Ex-post forecast of monthly prices of meat in Hubballi market of Karnataka during 2023 January to 2025 March

Year and month	Hubballi Market		
	Actual meat price (₹ /kg)	Forecast meat price (₹ /kg)	Validity (%)
2023 January	210	235	111.90
2023 February	215	210	97.67
2023 March	220	222	100.91
2023 April	225	224	99.56

2023 May	230	222	96.52
2023 June	235	229	97.45
2023 July	240	233	97.08
2023 August	245	237	96.73
2023 September	250	242	96.80
2023 October	255	247	96.86
2023 November	260	252	96.92
2023 December	265	257	96.98
2024 January	245	262	106.94
2024 February	250	242	96.80
2024 March	255	254	99.61
2024 April	260	258	99.23
2024 May	265	257	96.98
2024 June	255	263	103.14
2024 **July**	260	253	97.31
2024 August	265	261	98.49
2024 September	265	266	100.38
2024 October		262	
2024 November		261	
2024 December		262	
2025 January		263	
2025 February		262	
2025 March		260	

3.4 Monthly egg price forecasts for the Bengaluru and markets

The ex-post forecast of monthly egg prices in Bengaluru market from January 2023 to March 2025 illustrated in Table 4 shows the predictive accuracy and variability of the applied ARIMA model. Validity percentages during the period ranged from 81.57% to 123.41%, indicating instances of both high alignment and deviation between forecasted and actual prices. In 2023, the forecasted prices closely matched actual prices, with notable accuracy in months like June (₹577.95/100 eggs, 99.79% validity) and December (₹586.92/100 eggs, 100.11% validity). Conversely, February 2023 (115.75%) and April 2024 (105.58%) saw overestimations, while February 2024 (81.57%) marked the lowest alignment. Forecast prices for the post-2024 period provide continuity, projecting an upward trend with prices stabilizing around ₹600/100 eggs by early 2025. The fluctuations indicate that egg prices are influenced by factors beyond the ARIMA model's scope, such as seasonal demand, climate effects on production, and feed price volatility. Improving forecast accuracy may require refining the model by incorporating additional variables to capture these influences more effectively.

Table 4 Ex-post forecast of monthly prices of egg in Bengaluru market of Karnataka during 2023 January to 2025 March

Year and month	Bengaluru Market		
	Actual egg price (₹ /100 eggs)	Forecast egg price (₹ /100 eggs)	Validity (%)
2023 January	552.42	515.72	93.36
2023 February	451.25	522.32	115.75
2023 March	458.55	409.9	89.39
2023 April	430.67	475.2	110.34
2023 May	491.88	451.77	91.85
2023 June	579.17	577.95	99.79
2023 July	495.16	539.87	109.03
2023 August	481.45	1440.73	91.54
2023 September	504.83	498.78	98.80
2023 October	552.74	518.31	93.77
2023 November	574.83	632.1	109.96

2023 December	586.29	586.92	100.11
2024 January	573.39	588.79	102.69
2024 February	578.79	472.14	81.57
2024 March	474.84	586.01	123.41
2024 April	423.28	446.88	105.58
2024 May	564.19	484.41	85.86
2024 June	560.14	651.4	116.29
2024 July	560.89	476.05	84.87
2024 August	575.63	547.1	95.04
2024 September	585.12	598.93	102.36
2024 October		632.95	
2024 November		609.46	
2024 December		620.84	
2025 January		607.86	
2025 February		613.18	
2025 March		509.16	

3.5 Monthly egg price forecast of poultry egg in Mysuru market

The ex-post forecast analysis of monthly egg prices in the Mysuru market from January 2023 to March 2025 revealed in Table 5, highlights moderate forecasting accuracy, with validity percentages ranging from 82.45% to 112.05%. Notably, forecasted prices aligned well with actual prices during some months, such as June 2023 (97.39%) and December 2023 (102.73%), while deviations were observed in months like February 2024 (82.45%) and March 2024 (112.05%). The forecasted prices for future months indicate a steady rise, with projections for December 2024 reaching ₹618.67 and March 2025 at ₹497.22 per 100 eggs. These fluctuations suggest that egg prices are affected by factors beyond the model's scope, such as seasonal demand, production conditions, or feed cost volatility. The forecast accuracy indicates the potential for improving reliability by refining the model to include additional influencing variables. The projected prices emphasize the importance of continuous monitoring and adjustments for precise price predictions to aid market stakeholders. Establishing long-term connections within vertical production chains is recommended as a survival strategy which allows them to manage price and production risks while enhancing the quality and consistency of poultry products (Rodić *et al.,* 2010).

Table 5 Ex-post forecast of monthly prices of egg in Mysuru market of Karnataka during 2023 January to 2025 March

Year and month	Mysuru Market		
	Actual egg price (₹ /100 eggs)	Forecast egg price (₹ /100 eggs)	Validity (%)
2023 January	553.71	509.98	92.10
2023 February	453.11	480.57	106.06
2023 March	461.48	408.68	88.56
2023 April	434	463.23	106.74
2023 May	496.88	446.02	89.76
2023 June	584.4	569.12	97.39
2023 July	496.16	511.11	103.01
2023 August	484.52	443.49	91.53
2023 September	505.57	487.74	96.47
2023 October	557.81	491.91	88.19
2023 November	576.83	591.39	102.52
2023 December	596.61	612.9	102.73
2024 January	574.03	567.94	98.94
2024 February	579.83	478.09	82.45
2024 March	475.16	532.42	112.05
2024 April	424.22	428.55	101.02
2024 May	506.32	516.86	102.08

2024 June	550.86	601.39	109.17
2024 July	520.88	493.94	94.83
2024 August	500.65	519.52	103.77
2024 September	510.8	518.56	101.52
2024 October		576.14	
2024 November		598.89	
2024 December		618.67	
2025 January		596.09	
2025 February		601.89	
2025 March		497.22	

4. CONCLUSIONS

ARIMA models have proven effective in forecasting poultry product prices in Karnataka, particularly for meat prices in Hubballi and Bengaluru markets, with low Mean Absolute Percentage Errors (MAPE). However, the variability in egg prices highlights the need to include factors like feed costs, seasonal production changes, demand fluctuations and policy changes in the models (Lu, 2023). Accurate price forecasting is essential for market stability, stakeholder protection, and informed decision-making. Hybrid models, integrating ARIMA with techniques like neural networks or support vector machines, offer potential for improved predictive performance (Bulut & Hudaverdi, 2022; Júnior *et al.,* 2019; Zhang, 2003). Measures like price stabilization funds and buffer stock mechanisms can address seasonal fluctuations and uncertainties (Srinivasan & Jha, 1999). Training programs on interpreting and utilizing market data could empower stakeholders, including farmers and policymakers (Velmurugan, 2024). Additionally, expanding digital platforms for real-time market information dissemination can further reduce information asymmetry and enhance transparency (Meena *et al.,* 2019). These strategies can improve the precision and applicability of price forecasting in Karnataka's poultry sector, fostering resilience and sustainable growth.

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