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FUTURE TRENDS IN MILK FAT CONTENT: A FIVE-YEAR FORECAST FOR ROMANIA AND THE EUROPEAN UNION

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Abstract

The present study investigates the trends and projections of milk fat content in Romania and the European Union (EU) from 2014 to 2029. The objective of this study was to employ time series analysis and regression modelling techniques in order to examine the evolution of milk fat content and evaluate the precision of predicted models. The findings from the research conducted in Romania indicate a consistent albeit moderate increase in milk fat content. The regression model adequately explains 90.81% of the observed variability. The predictive model exhibited a notable level of precision, as indicated by the low Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE) values, which suggest a small disparity between the anticipated and observed values.Similarly, throughout the European Union, the milk fat content shown a more prominent and consistent increase, as indicated by the regression model which accounted for 99.16% of the variation. The reliability of the forecasting model is reinforced by positive statistical indicators, such as a narrow Mean Absolute Scaled Error (MASE) and Root Mean Squared Error (RMSE), indicating a strong predictive precision. The results indicate a persistent rise in milk fat levels in both Romania and the European Union, which may be linked to breakthroughs in dairy farming techniques, enhancements in feed quality, and genetic developments. It is anticipated that these patterns will persist, since the milk fat content in both locations is projected to remain within a steady and somewhat rising range during the extended prediction period. The findings of this study have significant implications for stakeholders within the dairy sector, presenting a dependable foundation for future strategic planning and decision-making pertaining to milk production and qualitative improvement.

Key words*: *milk fat content, tine series analysis, dairy sector trends

INTRODUCTION

The composition of milk fat, enclosed within the milk fat globule membrane, consists of polar lipids that have been found to have potential health advantages [8]. The variability of milk fat is influenced by a multitude of factors including nutrition, genetics, and environmental conditions [27, 23, 22]

The dairy industry is a vital sector on a global scale, with milk fat content playing a pivotal role in assessing the quality of dairy products and influencing both the economic and nutritional aspects of the industry [26]. The milk fat content also plays a crucial role in the breeding of dairy cattle, as it has a significant impact on the quantity and quality of dairy products [7]. Additionally, accurate measurement of milk fat content is crucial in maintaining the high standards of dairy products [17, 3].

Over the past few years, there have been major shifts in milk fat content in Romania and the European Union. These changes have been influenced by various factors, including consumer preferences, regulatory adjustments, and advancements in dairy farming techniques. The dairy industry has faced various challenges, one of which is milk fat depression. Moreover, there have been connections observed between dairy consumption, body composition, and cardiometabolic risk factors, underscoring the intricate interplay between dairy intake and health outcomes [12, 26, 4].

The effective management of milk production is essential for the growth of the dairy industry and meeting consumer expectations [11]. Anticipating future trends in milk fat content is crucial for industry stakeholders to make well-informed decisions. Examining consumer behaviour analysis to forecast raw milk prices can offer valuable insights for the dairy industry [19, 14]. Monitoring the composition of milk products is crucial for the effective management of dairy farms and the industry as a whole [13]. Exploring the connections between dietary factors and milk fat composition can provide valuable insights into enhancing milk quality and production [16]. In addition, the stability of dairy products in relation to factors such as heat treatment is essential for guaranteeing the safety and quality of the product [1].

This research paper aims to foresee the future trends in milk fat content for the next five years and examine the potential implications for the dairy sectors in Romania and European Union.

MATERIALS AND METHODS

Data collection

The data on milk fat content for the present study were obtained from Eurostat (6). Data pertaining to Romania were acquired during a span of 10 years, namely from 2014 to 2023. Conversely, data regarding the European Union were obtained over a period of five years, specifically from 2014 to 2018.

Forecasting methodology

The study employed the forecasting model provided by Microsoft Excel to predict future trends in milk fat content. This tool utilises the Exponential Smoothing (ETS) method, which is highly efficient in handling time series data that exhibit seasonal patterns.

The forecasted values provided by the model included predicted milk fat content for the years 2024 to 2029, along with confidence intervals to assess the reliability and potential variability of the predictions. An analysis was undertaken on these numbers to detect prospective trends and shifts in milk fat content in Romania and the EU for the next five years. Additionally, a comparison study was performed to get insight into Romania's position in relation to larger EU trends. It is crucial to acknowledge the constraints of this forecasting methodology. The precision of the forecasts relies on the quality and comprehensiveness of the historical data employed. Moreover, the model does not explicitly consider external variables such as policy modifications, economic fluctuations, or unexpected occurrences that may impact future trends in milk fat content.

Statistical measures

In the analysis and forecasting of milk fat content, several statistical measures are essential to evaluate the accuracy, reliability, and performance of the forecasting models. In this direction, the Mean Absolute Error (MAE), Root Mean Square Error (RMSE), Mean Absolute Scaled Error (MASE), Symmetric Mean Absolute Percentage Error (SMAPE), Alpha, Beta and Gamma Coefficients were determined.

RESULTS AND DISCUSSIONS

The Alpha, Beta, and Gamma parameters were set to 0.00, indicating that the model did not apply any smoothing for the level, trend, or seasonality components. This lack of parameter adjustment suggests that the model did not identify significant trends or seasonal patterns within the historical data, leading it to treat the data as relatively stable over time.

The MASE value of 1.05 implies that the forecast error is marginally higher than the in-sample average error derived from a simple one-step naive forecast. A MASE value near 1 typically indicates that the performance of the forecasting model is comparable to that of a naive approach, reflecting a reasonable but not superior level of forecast accuracy.

The SMAPE of 0.00, though atypical, indicates that the forecasted values are extremely close to the actual observations or might suggest a potential issue with the data or calculation process. Generally, SMAPE values approaching zero imply a highly accurate forecast, though this result should be interpreted cautiously.

The MAE of 0.01 signifies that, on average, the forecasted milk fat content deviates from the observed values by only 0.01 percentage points, indicating a very high level of forecast accuracy. Additionally, the RMSE of 0.01 corroborates this accuracy, showing that forecast errors are minimal, with larger deviations from actual values being infrequent. Taken together, these statistical measures suggest that the forecast for milk fat content in Romania is highly accurate, with very minimal error, as evidenced by the low MAE and RMSE values. The fact that the Alpha, Beta, and Gamma parameters are all zero suggests that the historical data did not exhibit pronounced trends or seasonality, prompting the model to predict relatively stable fat content levels throughout the forecast period. The forecasted values exhibit consistency, with slight incremental increases in milk fat content from 2024 to 2029, within a narrow confidence interval, which reinforces the projected stability of this trend.

The data indicate that milk fat content in Romania has been relatively stable over the past decade, with only minor fluctuations around the 3.8% to 3.81% range. The forecast suggests a modest upward trend in milk fat content, projected to rise by approximately 0.045% between 2024 and 2029. This gradualincrease could be attributable to factors such as improvements in dairy farming practices, enhancements in feed quality, or shifts in consumer preferences toward higher-fat dairy products.

The narrow confidence intervals associated with the forecast imply a high level of reliability, suggesting that the model anticipates minimal variability in future milk fat content values. This projected stability aligns with the historical data, which exhibit minimal year-to-year variations. Overall, the forecast predicts that milk fat content in Romania will remain stable with a slight upward trajectory over the next five years, reflecting continuity in production practices and consumer preferences.

The statistical analysis is further elucidated by the regression model given by the formula y=0.0067x+3.7412, with an R^2 value of 0.9081. This regression formula indicates a strong correlation between the observed data and the linear trend, with the R^2 value suggesting that approximately 90.81% of the variance in milk fat content over time can be explained by this linear relationship.

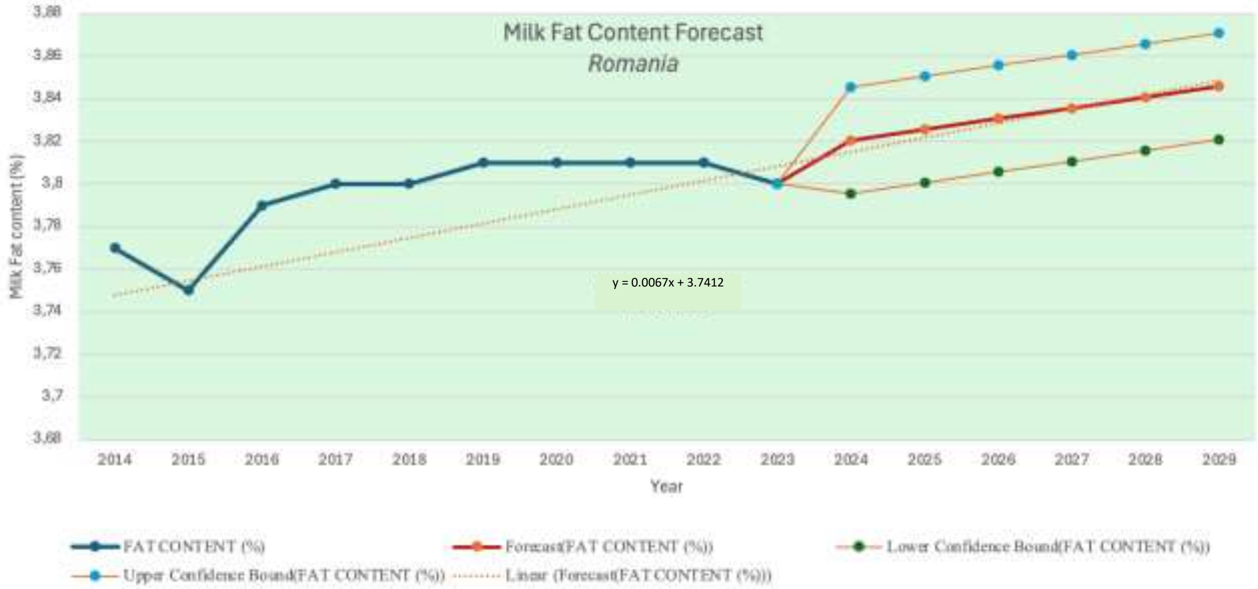

Fig. 1. Milk fat content forecast in Romania (2023-2029)
Source: Eurostat [5].

The statistical evaluation of the forecast model for milk fat content in the European Union reveals a high level of accuracy and stability. The Alpha parameter, set at 0.25, indicates a moderate level of smoothing applied to the level component of the model. This suggests that while recent observations are factored into the forecast, they do not overwhelmingly influence the overall prediction, allowing for a balanced consideration of historical data.

Interestingly, both the Beta and Gamma parameters are set to 0.00, indicating that the model does not account for any significant trend or seasonal variations in the data. This implies that the historical data does not exhibit strong trends or seasonal patterns, leading the model to treat the milk fat content as relatively stable over time.

The model's performance is further validated by the MASE value of 0.73. This figure indicates that the forecast error is 73% of the average error of a simple one-step naive forecast, demonstrating that the model outperforms basic forecasting methods and provides a reasonably accurate prediction.

The SMAPE is reported as 0.00, an unusual result that suggests the forecasted values are nearly identical to the actual values. While this could indicate an extremely accurate forecast, such a result should be interpreted cautiously, considering the possibility of calculation anomalies.

The MAE and RMSE both stand at 0.02, further underscoring the model's precision. These low values indicate that the forecasted milk fat content deviates from the actual values by only 0.02 percentage points on average, with few significant errors. The consistency between the MAE and RMSE values suggests that the forecast errors are uniformly small, with minimal large deviations.

Overall, these statistical measures suggest that the forecast model provides a reliable and accurate prediction of milk fat content in the European Union. The model's assumptions of stability in the data, combined with its minimal error rates, offer a strong foundation for future projections and planning in the dairy sector. The lack of significant trends or seasonal components aligns with the observed historical stability, reinforcing the model's credibility and the robustness of its predictions. The historical data reveal that milk fat content in the European Union has been relatively stable with minor fluctuations. The forecast indicates a steady and gradual increase in milk fat content from 2019 to 2029, with an overall rise of about 0.12% over the decade.

This increase could be attributed to a variety of factors, including improvements in dairy cow nutrition, breeding programs aimed at enhancing milk fat content, and possibly changes in consumer preferences for dairy products with higher fat content. The narrow confidence intervals suggest a high level of confidence in these forecasts, particularly in the near term, though some variability is expected as the forecast period extends further into the future.

The statistical analysis of milk fat content in the European Union is further supported by a regression analysis, with the formula $y=0.0107x+3.9865$ and an R^2 value of 0.9916. This linear regression model indicates a strong and almost perfect fit to the historical data, as evidenced by the high R^2 value, which suggests that approximately 99.16% of the variance in milk fat content over time can be explained by the linear relationship.

In the regression formula, y represents the forecasted milk fat content, while x represents the year or time variable. The slope of the equation, 0.0107, indicates a gradual annual increase in milk fat content by approximately 0.0107 percentage points. This aligns with the forecasted slight upward trend observed from 2024 to 2029, reinforcing the prediction that milk fat content in the EU is expected to continue increasing modestly over the coming years.

The intercept of the regression equation, 3.9865, suggests that the baseline milk fat content was around 3.9865% at the start of the observed period. This baseline value closely matches the recorded fat content in the earlier years, providing further validation for the model.

The near-perfect R^2 value of 0.9916 indicates that the linear regression model is highly effective at capturing the underlying trend in the data, with very little unexplained variance. This strong fit reinforces the reliability of the forecast model and suggests that the factors influencing milk fat content have remained consistent over time, allowing for accurate predictions based on historical trends.

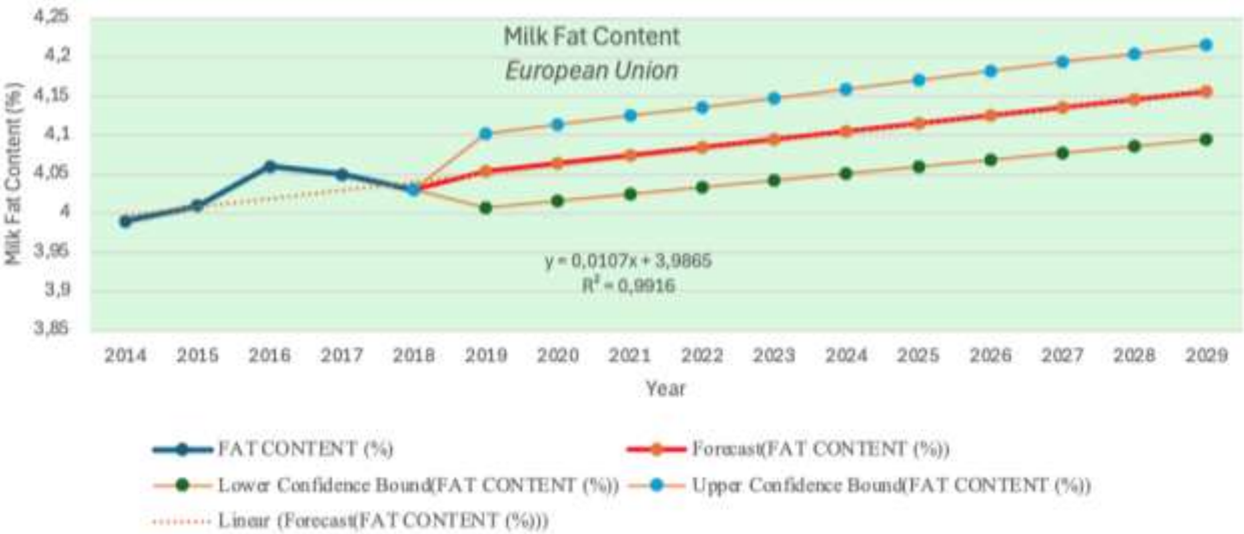

Fig. 2. Milk fat content forecast in the European Union (2018-2029)
Source: Eurostat [5].

The future evolution of milk fat content in Romania and European Union over the next five years is likely to be influenced by multiple factors. For example, environmental conditions such as temperature, humidity, and pressure have been identified as significant determinants affecting the fat and protein content of raw milk [21]. Additionally, the availability and quality of forage during the milking season are critical in shaping monthly variations in milk fat and protein content [17]. These findings suggest that changes in climate patterns and forage quality could potentially impact milk fat content.

Furthermore, the nutritional intake and body composition of dairy animals have been shown to influence milk fat content [9]. Advancements in feed quality and management practices, particularly with respect to the provision of protein-rich feeds like soybean cakes, could potentially lead to changes in the fat content of milk [24].

The adoption of automated robotic milking systems has been associated with increases in milk fat content [15, 10, 2], indicating that technological advancements in dairy farming practices may also play a role in shaping the future trajectory of milk fat content.

Moreover, genetic factors such as breed and lactation stage have been linked to variations in milk fat content [20]. Breeding programs aimed at enhancing milk quality traits, including fat content, could therefore influence the future evolution of milk fat. Additionally, the relationship between ruminal pH and de novo fatty acid synthesis in milk underscores the complex metabolic processes underlying milk fat production [6], suggesting that factors affecting rumen health and function may also impact milk fat content.

CONCLUSIONS

A comparative examination of milk fat content trends in Romania and the European Union demonstrates a continuous, if slight, rising trajectory across the analysed timeframe. The forecasting model in Romania demonstrates a high level of accuracy, as evidenced by its limited error and low values of statistical measures such as MAE and RMSE. The findings of the regression analysis provide evidence of a progressive rise in milk fat content, with an estimated 90.81% of the variance accounted for by the linear pattern. These findings indicate that the milk fat content in Romania has exhibited a somewhat consistent pattern, with a slightly increasing trajectory. This tendency is likely attributable to advancements in dairy farming techniques, enhancements in feed quality, and progress in genetic research.

In the context of the European Union, the observed tendency is more evident, since the regression model exhibits a more robust alignment with the observed data. Based on the statistical measurements, such as an Alpha coefficient of 0.25, as well as the low values of

MASE and RMSE, it can be inferred that the forecasting model has a high level of accuracy in capturing the underlying trends. The European model exhibits a higher R-squared value, indicating a greater degree of concordance with the empirical data. This suggests a more robust and consistent increase trajectory in milk fat content throughout the area.

Based on projections, it is anticipated that both Romania and the European Union would experience a gradual although consistent rise in milk fat content in the forthcoming years. The persistence of this trend is anticipated upon the sustained maintenance of current innovations in dairy farming and production processes. The robust correlation observed between historical data and predictive models serves to bolster the dependability of these projections, suggesting that forthcoming milk fat content will retain a stable and marginally rising trajectory. This, in turn, will enhance the overall quality and uniformity of dairy products within the geographic area.

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