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Prediction of Fatty Acid Changes in Corn under Different Storage Conditions Based on SAMformer

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INTRODUCTION

- As one of the major staple crops in the world, the demand for corn has been climbing year by year due to global population growth and rising living standards. In 2023, global demand for corn reached 140 million tons, a 5% increase compared to the previous year.In different environments, the change in the fatty acid value of corn is very noticeable, and corn stored at high temperatures is more prone to acidification, resulting in an increase in fatty acid value. This phenomenon leads to a deterioration in corn quality and can cause severe losses for grain storage and food processing enterprises.

- Based on this, the current study utilizes the SAMformer method, taking into account various environmental conditions to establish a model predicting fatty acid changes during corn storage, including three key factors: time, initial moisture, and temperature. The experimental results indicate that this model has the best predictive performance compared to other models.

METHODS

Dataset

This project uses corn harvested from Zhengzhou, Henan in Central China as the experimental material. Corn with moisture contents of 11%, 12%, 13%, 14%, 15%, and 16% were stored in an experimental environment with a humidity of 60% at temperatures of 15° C, 20° C, 25° C, 30° C, and 35° C, respectively, for a period of 270 days. Samples were taken and tested every 5 days.

SAMformer

SAMformer is a shallow Transformerarchitecture that incorporates Sharpness-Aware Minimization (SAM) with channel-wise attention, as shown in Figure 1.

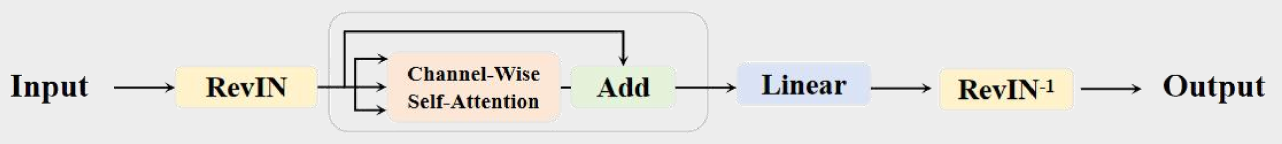

Figure 1. SAMformer model architecture.

- In this study, we use the Python programming language to train the SA Mformer model to predict fatty acid values in corn. During the training process, SAMformer learns the trends in fatty acid data in order to pre dict fatty acid values at future time points. To determine the optimal pa rameter configuration, we conducted multiple experiments by adjustin g parameters and observed the changes in losses throughout the proces s until the best parameters were determined, as shown in Table 4.

Table 4. Parameter setting for the SAMformer model.

Parameters	Parameter Setting
Dropout	0.1
loss	MSE
Optimizer	Adam
Epochs	1000
Batch_size	256
Learning rate	0.001

ANALYSIS OF RESULTS

◆Evaluation metrics for predictive models

- When evaluating the performance and fit of prediction models, commonly used metrics include: MAE (Mean Absolute Error), MSE (Mean Squared Error), RMSE (Root Mean Squared Error), MAPE (Mean Absolute Percentage Error), and SMAPE (Symmetric Mean Absolute Percentage Error). Both MAE and MSE measure the error between predicted values and actual values, but MSE applies a heavier penalty for larger errors because it is the square of the errors. RMSE is the square root of MSE, providing a standard deviation of the errors. Compared to MSE, RMSE is more intuitive in scale and easier to interpret. MAPE is based on percentage errors, thus they help in assessing the size of prediction errors relative to actual values. Similar to MAPE, SMAPE symmetrically handles the differences between predicted and actual values, and its calculation method can reduce error magnification caused by very small or large values in the dataset. The formula is as follows:

$$MAPE = \frac{100\%}{n}\left|\sum\nolimits_{i=1}^{n}\right|\left|\frac{p_i-y_i}{y_i}\right|$$

$$MSE = \frac{1}{n}\sum\nolimits_{i=1}^{n}(p_i-y_i)^2$$

$$RMSE = \sqrt{\frac{1}{n}\sum\nolimits_{i=1}^{n}(p_i-y_i)^2}$$

$$MAE = \frac{1}{n}\sum\nolimits_{i=1}^{n}|p_i-y_i|$$

$$SMAPE = \frac{100\%}{n}\sum\nolimits_{i=1}^{n}\frac{|p_i-y_i|}{(|p_i|-|y_i|)/2}$$

◆Result

- To effectively evaluate the performance of the SAMformer in predicting changes in fatty acids during the storage of corn, this paper selected LSTM and Transformer for comparative experiments, with each model having the same proportion of training, testing, and validation sets. To objectively assess and describe the performance of these models, we used five evaluation metrics to calculate the error values for each model: MSE, RMSE, MAP, MSPE, and MAE. Compared to other models, the SAMformer model exhibited the smallest prediction error, as shown in Table 5.

Table 5. Experimental results on the comparative performance of SAMformer-based corn quality prediction models.

Model	MAE	MSE	RMSE	MAPE	MSPE
LSTM	0.26	0.08	0.28	0.55	2.29
Transformer	0.16	0.04	0.20	0.35	0.21
SAMformer	0.05	0.004	0.06	0.18	0.07

CONCLUSIONS

- This experiment established a corn fatty acid prediction model based on SAMformer, using time, moisture content, and temperature as independent variables, and fatty acids as the dependent variable. It predicts the fatty acid values of corn with low moisture, safe storage moisture, and high moisture under different storage conditions. This model achieves the smallest error in predicting the quality changes during corn storage. The results show that our model can reasonably predict the changes in corn quality based on the trends of quality indicators under different environmental conditions. The methods used in this paper can help regulatory authorities take timely measures to delay the deterioration of stored corn, as well as reduce environmental pollution and save resources.

References

[1]Lehmane H , Ba R , Dah-Nouvlessounon D ,et al.Status of Techniques Used to Control Moulds in Maize Storage in Africa[J].Agricultural Sciences, 2022, 13(1):49-64.
[2]Timm N D S , Coradi P C , Correa Canizares L D C ,et al.Effects of the storage temperature and time of corn from the center and extremities of corncob on quality parameters[J].Journal of Cereal Science, 2023.
[3]Arik Kibar, E. A., Gönenç, I., & Us, F. Effects of Fatty Acid Addition on the Physicochemical Properties of Corn Starch. International Journal of Food Properties, 2014,17(1), 204–218.
[4]Newiton D S T , Coradi P C , Nairiane D S B ,et al.Effects of corn drying and storage conditions on flour, starch, feed, and ethanol production: a review[J].Journal of Food Science and Technology, 2022:1-13.
[5]Briones M A M, Fung A S F, Arboleda E R. A Literature Review of Machine Learning Models for Corn Quality Classification and Regression[J]. International Journal of Scientific Research and Engineering Development, 2024, 7(1):249-268.
[6]KhanSalman,NaseerMuzammal,HayatMunawar,et al.Transformers in Vision: A Survey[J].ACM Computing Surveys (CSUR), 2021.
[7]Ilbert R, Odonnat A, Feofanov V, et al.Unlocking the Potential of Transformers in Time Series Forecasting with Sharpness-Aware Minimization and Channel-Wise Attention[J].arXiv, 2024.
[8]Hodson T .Root-mean-square error (RMSE) or mean absolute error (MAE): when to use them or not[J].Geoscientific Model Development, 2022.

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