CHAPTER V
CONCLUSION

This chapter summarizes the findings generated throughout the research and presents several recommendations for future development. The conclusions are derived from all research activities, including image acquisition, preprocessing, feature extraction, model development, hyperparameter optimization, performance evaluation, and implementation of the web-based classification system. The outcomes discussed in this chapter reflect the overall contribution of the study and provide a foundation for further improvements in chicken meat freshness classification systems.

5.1 Conclusion

Based on all research stages conducted, including dataset collection, image preprocessing, feature extraction, model development, hyperparameter optimization, performance evaluation, and web-based system implementation, the following conclusions can be drawn :

1. The combination of HSV, GLCM, and LBP methods was capable of extracting meaningful color and texture characteristics from digital images of chicken meat. HSV features capture variations in meat surface color, whereas GLCM and LBP features characterize texture patterns within the image. The experimental results demonstrate that these combined features can be utilized to classify chicken meat freshness into three categories, Fresh, Less Fresh, and Rotten, indicating that digital image based approaches provide a feasible solution for automated freshness assessment.
2. The implementation of LightGBM successfully addressed the chicken meat freshness classification task. Performance improvements were achieved through the application of Bayesian Optimization combined with 5-Fold Cross-Validation. Among all evaluated scenarios, the highest performance was obtained using the HSV + GLCM + LBP feature combination with an 80:20 data split, resulting in an accuracy of 90.15%, precision of 90.18%, recall of 90.15%, F1-score of 90.09%, and an AUC value of 0.9707. These results confirm that hyperparameter optimization contributes positively to both classification effectiveness and model stability.

3. The classification results demonstrate that combining color information with texture descriptors improves the capability of LightGBM to distinguish freshness categories. Compared with individual feature combinations, HSV + GLCM + LBP consistently produced superior performance. This finding suggests that integrating complementary visual information provides a richer representation of chicken meat characteristics. Evaluation using the confusion matrix further revealed that samples belonging to the Fresh category were classified more accurately, whereas most classification errors occurred between the Less Fresh and Rotten categories because of similarities in their visual appearance.
4. Following the model evaluation stage, the top performing classification model was integrated into a web application developed with the Flask framework. The application enables users to assess chicken meat freshness by uploading images directly through the web interface, after which the system performs the prediction process automatically. Input verification mechanisms were also incorporated to filter unsuitable images and maintain the quality of the classification results. The implementation of this web-based platform highlights the practical potential of the proposed method and provides a convenient tool for freshness assessment with improved accessibility, efficiency, and ease of use.

5.2 Suggestions

Considering the findings and observations obtained throughout this research, several recommendations are offered to guide subsequent studies and further improve the proposed methodology:

1. Future studies should consider expanding the size and diversity of the dataset by incorporating variations in lighting conditions, camera angles, object distances, and environmental settings. The inclusion of more representative image samples is expected to improve model generalization and maintain stable performance under real-world conditions. Furthermore, collecting data directly from operational environments would provide a more comprehensive evaluation of model robustness against image variations encountered in practical applications.

2. Further development of the method may focus on comparisons with more advanced approaches, such as deep learning models based on CNN, ResNet, EfficientNet, or MobileNet architectures, as well as transfer learning techniques, to identify potential improvements in classification performance. During the hyperparameter optimization stage, future studies may also explore methods such as Genetic Algorithms, Particle Swarm Optimization, or other optimization techniques to obtain a more optimal model configuration. The website system developed in this study can also be extended into a mobile application or a multi-device platform with additional features, such as a monitoring dashboard, centralized data management, and online database integration, to broaden its functionality and practical benefits.