CHAPTER V
CONCLUSIONS AND SUGGESTIONS

This chapter brings together the key findings of the study and offers recommendations drawn from them. The conclusions presented here were arrived at through several stages of work training the model across multiple experimental scenarios, evaluating its performance on the testing data, and deploying the resulting model into a web-based application. In addition, this chapter outlines suggestions intended to guide future research efforts, with the aim of achieving better results and expanding the applicability of this approach within agricultural quality classification more broadly.

5.1 Conclusions

Drawing from the research carried out on soybean seed quality classification using EfficientNet-B0, MixUp augmentation, and Bayesian Optimization, the following conclusions can be drawn:

1. The baseline EfficientNet-B0 model proved effective at classifying soybean seed quality, reaching a testing accuracy of 91.67% and a macro F1-score of 91.70%. These figures show that transfer learning through the EfficientNet-B0 architecture works well for capturing the visual features of soybean seeds, giving a solid baseline against which the added effects of MixUp and Bayesian Optimization could later be measured.
2. Applying the MixUp technique on its own, without hyperparameter optimization, did not produce better results than the baseline scenario. In this second scenario, the model reached an accuracy of 89.31%, a macro precision of 89.66%, a macro recall of 89.21%, and a macro F1-score of 89.34%. This outcome indicates that how well MixUp performs depends heavily on the hyperparameter configuration used, and that simply adding the technique does not automatically translate into better performance.
3. Combining MixUp with Bayesian Optimization in the third scenario led to a clear improvement over using MixUp alone. Under this scenario, the model achieved an accuracy of 90.94%, a macro precision of 90.98%, a macro recall of 90.97%, and a macro F1-score of 90.92%. The Bayesian Optimization process also identified an optimal hyperparameter combination consisting of a learning rate of 0.000409, a batch size of 16, a dropout rate of 0.3046, and a

MixUp alpha of 0.3574. These results confirm that hyperparameter optimization plays a meaningful role in improving model performance.

4. The final trained model was successfully deployed into a web application built on the FastAPI framework, and is able to carry out automated soybean seed image classification. When tested on 15 primary data images, the model produced an accuracy of 46.67% and an error rate of 53.33% a result that shows the model can still function on real-world data, even though its performance dropped noticeably compared to its results on the secondary dataset.

5.2 Suggestions

Building on the results and processes examined throughout this study, the following suggestions are offered for future work:

1. Future research should consider expanding both the size and variety of the soybean seed image dataset particularly by including a broader range of lighting conditions, camera angles, and background settings. Doing so would help strengthen the model's ability to generalize when faced with real-world scenarios.
2. Subsequent studies could explore additional hyperparameter optimization techniques and compare them against alternatives such as Genetic Algorithms or Hyperband, with the goal of arriving at an even more optimal model configuration.
3. Future development could also extend to testing other, more advanced deep learning architectures such as more recent variants within the EfficientNet family or Transformer-based models to see whether classification performance can be pushed further.
4. From a deployment standpoint, the system could be expanded into mobile or cloud-based platforms, with added features such as prediction history logging or fuller database integration. It would also be worthwhile to carry out direct user acceptance testing (UAT) with real end-users, in order to evaluate how the system performs under actual operating conditions.