



Antioxidant Potential of Kombucha: Application of Penalized Regression Models

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INTRODUCTION & AIM

Kombucha, probiotic drink → hypoglycemic due to 6% honey.

Fermentation → generates multicollinear data ($r > |0.7|$).

Non-normal data → overfitting.

Dynamic interactions → traditional models fail.

Biostatistical study → comparison of traditional models vs. penalized models.

Figure 1. Bioactive prediction in Elastic Net predicts accurately → kombucha antioxidant activity, hybrid L1/L2 regularization.



RESULTS & DISCUSSION

Table 1. Model performance comparison (mg/ 100 mL)

Model	RMSE	MAE	R ²
Elastic Net	0.27 ± 0.06	0.22 ± 0.06	0.988 ± 0.01
Lasso	0.27 ± 0.06	0.22 ± 0.06	0.988 ± 0.01
lm + stepAIC	0.28 ± 0.06	0.23 ± 0.06	0.987 ± 0.01
Ridge	0.75 ± 0.10	0.61 ± 0.09	0.928 ± 0.03

Source: Prepared by Conde MIC., copyright 2025.

Figure 2. Standardized; residuals vs. predicted for Elastic Net

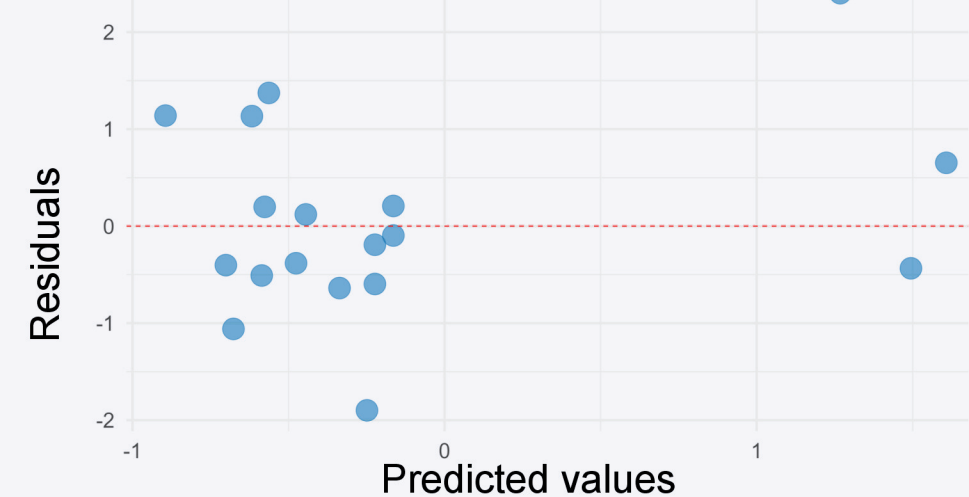


Figure 3. Histogram of standardized residuals

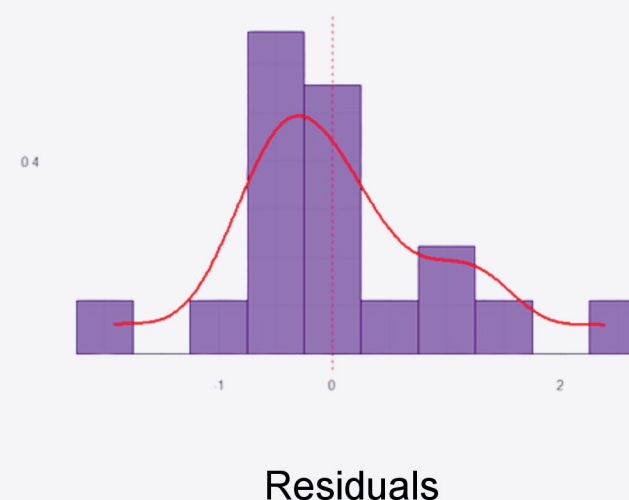
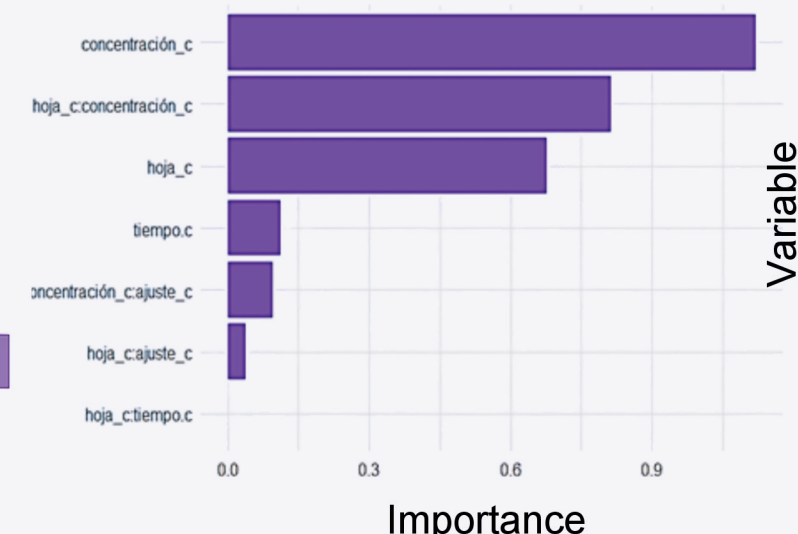


Figure 4. Variable Importance: Elastic Net



$$\text{Trolox (mg/ 100 mL)} = -1.88 \text{ (mg/100 mL)} * \text{leaf}_c + 3.13 \text{ (mg/ 100 mL)} * \text{concentration}_c + 2.27 \text{ (mg/100 mL)} * \text{leaf}_c * \text{concentration}_c$$

Optimal: *I. guayusa* 2%, without pH adjustment, days 3–6.

CONCLUSION

Elastic Net as a biostatistical standard for predicting bioactivity in fermentations. It is generalizable, selects interactions, and has effective multicollinearity management.

FUTURE WORK / REFERENCES

Future predictive biostatistical studies including process variables in biotechnology, nutraceuticals, omics, other processes, and complex dynamic systems.

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- Xu, S.; Wang, Y.; Wang, J.; Geng, W. Kombucha Reduces Hyperglycemia in Type 2 Diabetes of Mice by Regulating Gut Microbiota and Its Metabolites. *Foods* 2022, 11 (5), 754. <https://doi.org/10.3390/foods11050754>.