MangoNose

Electronic Nose Innovation for Measuring the Ripeness of Barracuda Mangoes Using Machine Learning for Sales Planning and Consumption

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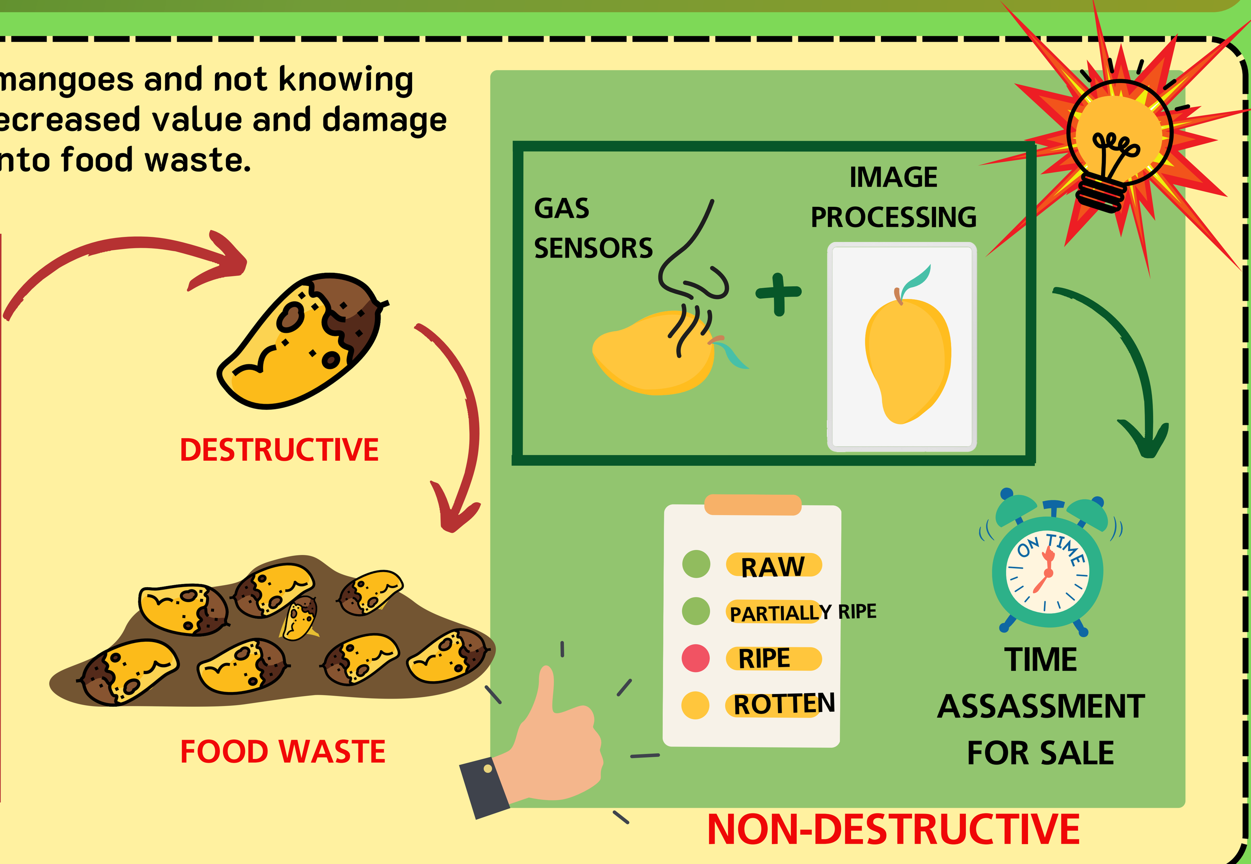
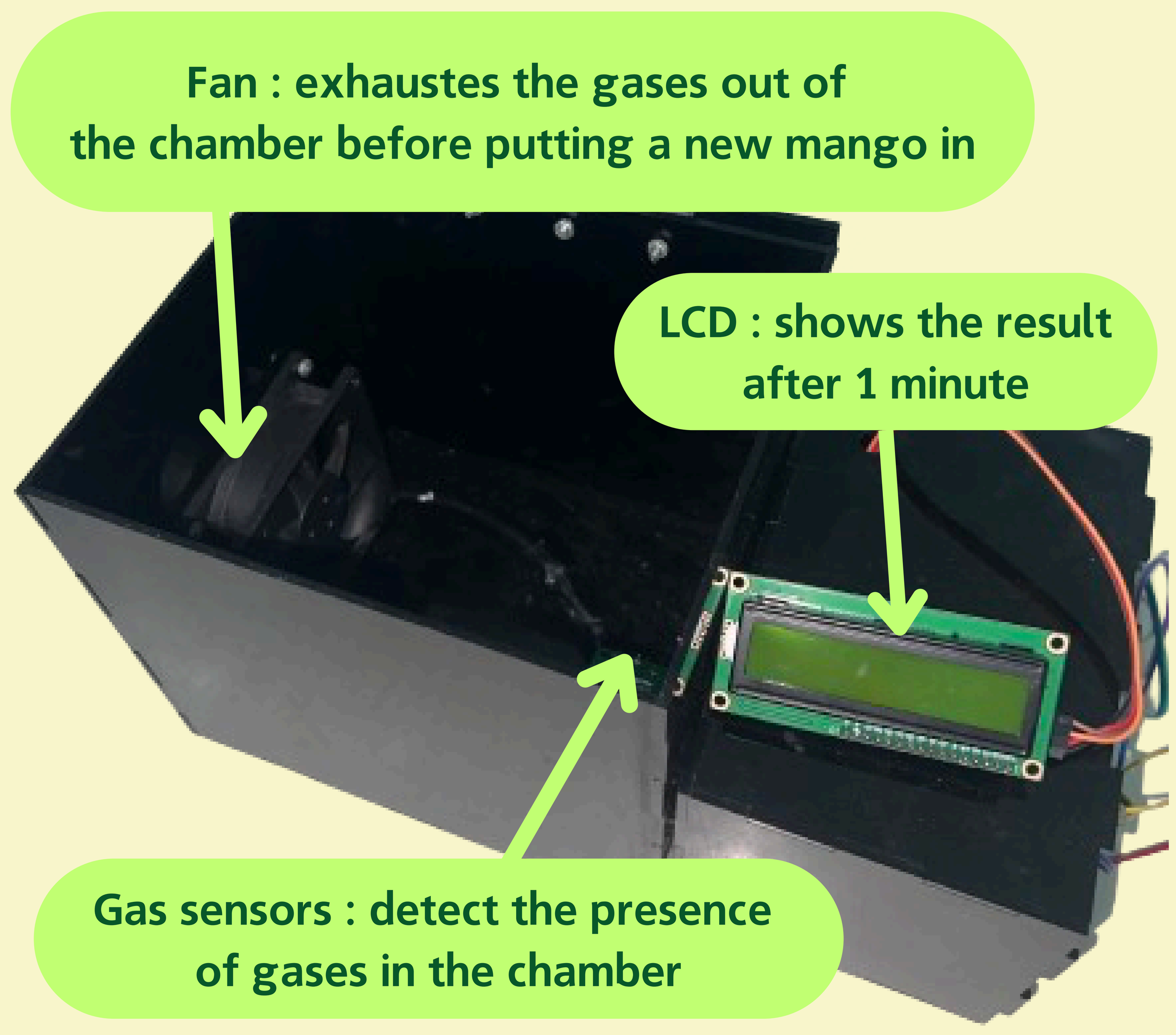
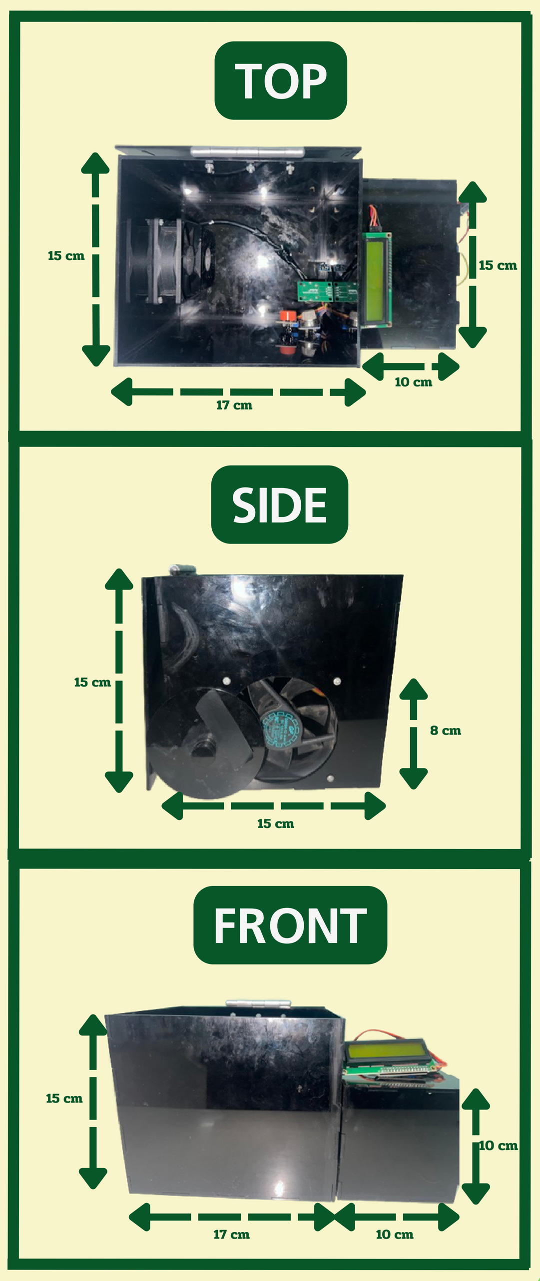
Introduction

The traditional method of sorting mangoes and not knowing the proper time for sale leads to decreased value and damage to them, eventually turning them into food waste.

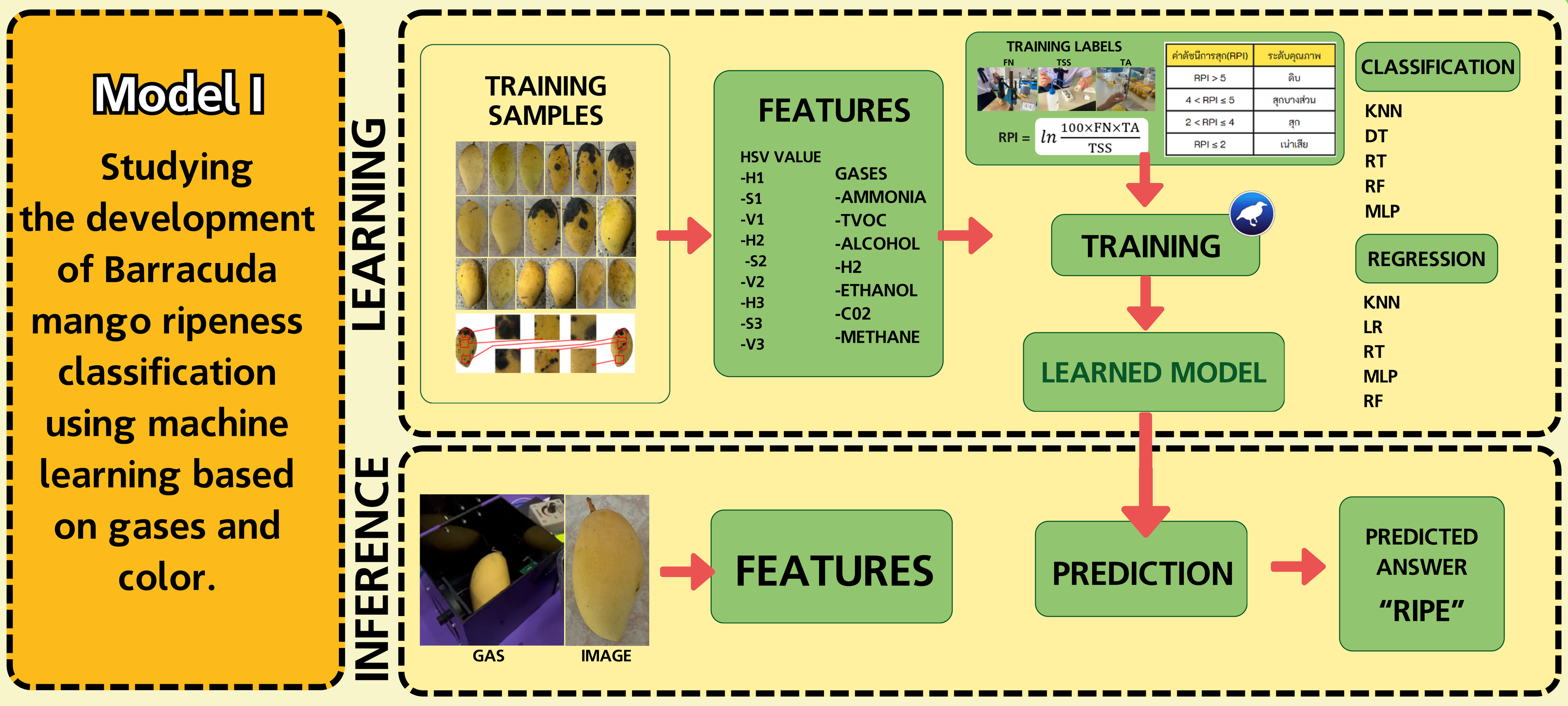


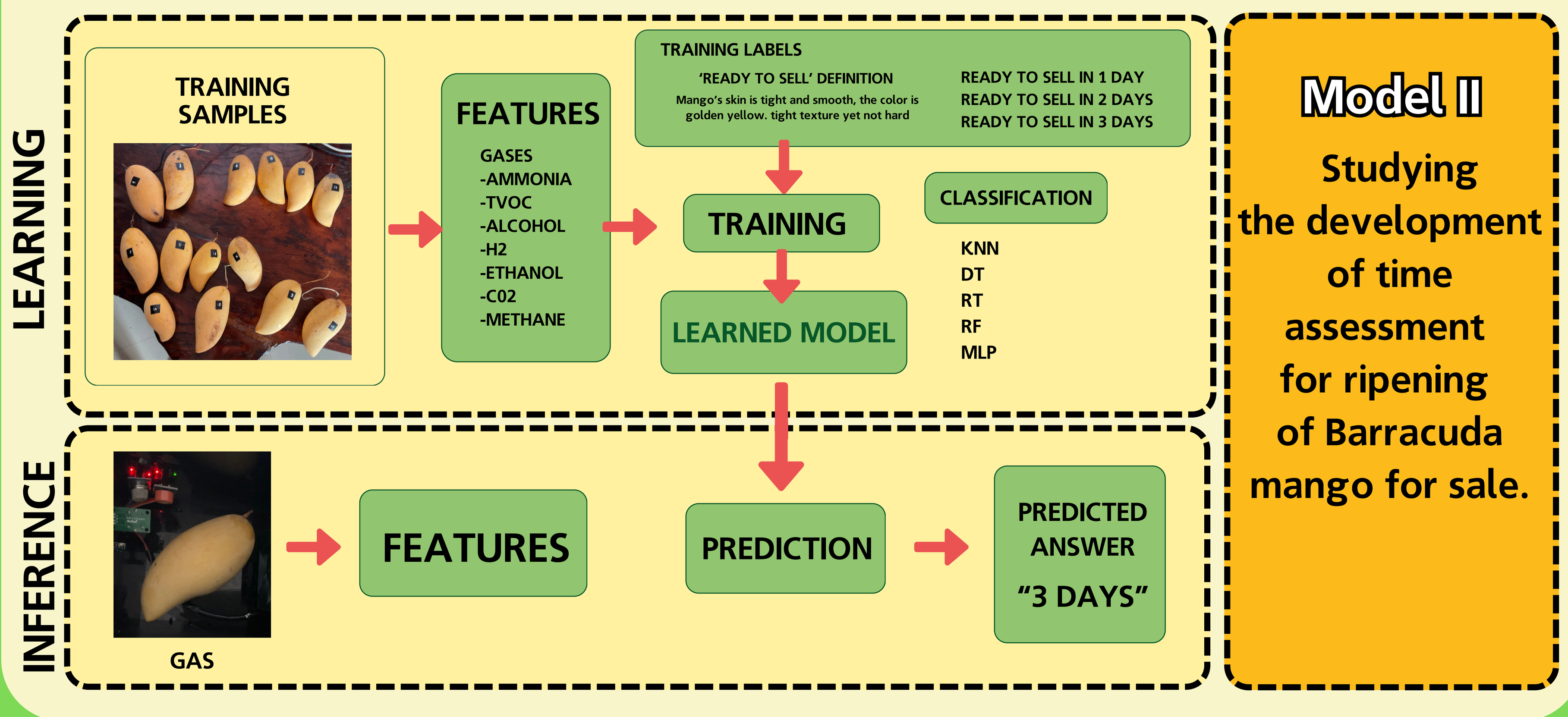
Prototype





Methods





Results and Discussion

Model I

CLASSIFICATION

Classification model performance with gas data from mangoes.

Alg.	Measure (n=171)					
	ACC(%)	P	R	F-1	ROC	MCC
KNN	93.5673	0.937	0.936	0.935	0.990	0.914
DT	92.3977	0.925	0.924	0.924	0.963	0.899
RT	95.9064	0.959	0.959	0.959	0.971	0.944
MLP	81.8713	0.817	0.819	0.815	0.917	0.749
RF	97.076	0.971	0.971	0.970	0.997	0.961

The Random Forest algorithm achieved the highest accuracy at 97.076%, followed by the Random Tree algorithm at 95.9064%.

Confusion Matrix of Random Tree for classifying ripeness of mangoes.

RT	Predicted rotten	Predicted ripe	Predicted partially ripe	Predicted raw
Actual rotten	32	1	0	0
Actual ripe	0	58	1	1
Actual partially ripe	1	0	41	0
Actual raw	0	2	1	33

Confusion Matrix of Random Forest for classifying ripeness of mangoes.

RF	Predicted rotten	Predicted ripe	Predicted partially ripe	Predicted raw
Actual rotten	31	0	0	2
Actual ripe	0	57	1	2
Actual partially ripe	0	1	40	1
Actual raw	1	1	1	33

REGRESSION

Regression experiments using machine learning to classify Barracuda mango.

Alg.	Measure (n=171)				
	CC	MAE(m)	RMSE(m)	RAE(%)	RRSE(%)
KNN	0.9344	0.3614	0.5855	26.4085	35.9295
DT	0.7804	0.6836	1.0159	49.9564	62.3452
LR	0.6979	0.856	1.1596	62.5563	71.1625
MLP	0.876	0.6391	0.8072	46.7083	49.5366
RF	0.9495	0.2965	0.5215	21.6691	32.0037

The efficiency of regression models from learning algorithms on total soluble solids (TSS) of mangoes data.

Alg.	Measure (n=171)				
	CC	MAE(m)	RMSE(m)	RAE(%)	RRSE(%)
KNN	0.9423	0.4445	0.6698	30.3758	33.4232
RT	0.9162	0.2325	0.8294	15.8866	41.3872
LR	0.6114	1.129	1.5852	77.1495	79.0988
MLP	0.6809	1.2455	1.6075	85.1105	80.2114
RF	0.959	0.3755	0.5978	25.6573	29.8302

The efficiency of regression models obtained from various algorithms on the learning data as shown in the table.

plausible to measure Total Soluble Solids (TSS) or the sweetness of Barracuda mango by using regression model.

data	Alg.	Measure (n=144)					
		ACC(%)	P	R	F-1	ROC	MCC
HSV data	KNN	65.9259	0.667	0.659	0.656	0.939	0.538
	RT	100	1.000	1.000	1.000	1.000	1.000
	RF	100	1.000	1.000	1.000	1.000	1.000
GAS data	KNN	87.4074	0.875	0.874	0.873	0.966	0.822
	RT	93.3333	0.934	0.933	0.933	0.955	0.908
	RF	94.8148	0.951	0.948	0.949	0.993	0.928
HSV + Gas data	KNN	95.5556	0.900	1.000	0.947	1.000	0.941
	RT	90.5105	0.985	0.985	0.985	0.990	0.980
	RF	100	1.000	1.000	1.000	1.000	1.000

Combining gas and HSV color data achieves 95.5556% accuracy, higher than using only HSV or gas data for the training.

With the high accuracy and ability to use if-else commands for rapid operation, Random Tree model is selected to develop ripeness measurement software for Barracuda mangoes.

Model II

Classification model performance with gas data from mangoes.

Alg.	Measure (n=180)					
	ACC(%)	P	R	F-1	ROC	MCC
KNN	78.0952	0.781	0.781	0.773	0.883	0.619
DT	84.2857	0.848	0.843	0.838	0.913	0.734
RT	84.2857	0.850	0.843	0.846	0.890	0.774
MLP	81.8713	0.817	0.819	0.815	0.917	0.749
RF	85.7143	0.853	0.857	0.852	0.948	0.772

The Random Forest algorithm achieved the highest accuracy at 85.71%, followed by the RT and DT algorithms at 84.29%.

The researchers selected the Random Tree model to develop a ripeness assessment tool for Barracuda mangoes.

Confusion Matrix of Random Forest for classifying ripeness of mangoes.

RF	Predicted 1 DAY	Predicted 2 DAYS	Predicted 3 DAYS
Actual 1 DAY	117	6	0
Actual 2 DAYS	7	54	5
Actual 3 DAYS	0	12	9

Confusion Matrix of Random Tree for classifying ripeness of mangoes.

RT	Predicted 1 DAY	Predicted 2 DAYS	Predicted 3 DAYS
Actual 1 DAY	116	5	2
Actual 2 DAYS	2	52	12
Actual 3 DAYS	1	11	9

Confusion Matrix of Decision Tree for classifying ripeness of mangoes.

DT	Predicted 1 DAY	Predicted 2 DAYS	Predicted 3 DAYS
Actual 1 DAY	112	10	1
Actual 2 DAYS	9	56	1
Actual 3 DAYS	1	11	9

Conclusions

Model I

The classification model works with high accuracy.

Gases and colors can measure mango ripeness with 95.5556% accuracy.

Gases can measure mango sweetness with 0.959 accuracy.

The Random Tree algorithm is suitable for development as once trained, it uses if-else as classification rules, making it simpler and more convenient.

Gases and colors of mangos enable consumers to buy mangoes based on their preferences and desired ripeness levels.

Model II

- Gases can predict the time when mangoes are ready for selling with 85.7143% accuracy, ensuring that mangoes reach their destination ripe and ready for consumption, maximizing their quality and market value.
- Reducing mango waste by predicting optimal selling time aligns with SDGs, specifically Goal 2 on agricultural research and technology development for productivity in developing countries, and Goal 12 on reducing food loss in production and supply chains by 2030.

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