SANTA MARÍA DEL ORO, NAYARIT, MÉXICO

Non-destructive techniques to determine optimal harvesting time in mango fruit

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RESUMEN

El objetivo fue construir y validar un modelo para predecir de manera no destructiva la madurez óptima de cosecha de las principales variedades de mango para exportación. El modelo se construyó usando la aplicación artificial neural network y se validó durante 2020 y 2021 en huertos comerciales. El modelo fue promisorio ya que presentó una R^2 = 0.8487 y un RMSE = 0.9059. Los resultados de validación indicaron que el modelo fue aceptable y confirmaron que el F-751® es una herramienta viable para determinar el contenido de materia seca de cualquiera de las variedades, aunque se detectaron diferencias varietales. 'Ataulfo' mostró el mejor ajuste del modelo de predicción, en tanto que 'Keitt' tuvo el peor.

INTRODUCTION

The quality at consumption of mango fruit depends mainly on the ripeness at harvest. The development of pulp color is a good indicator of fruit maturity, however, the percentage DM has recently been used as a more precise indicator (Saranwong et al., 2004), since it is highly correlated with the final concentration of total soluble solids reached by a fruit ready for consumption. Moreover, the DM content can be determined quickly by microwave oven (Brecht et al., 2020) or by a non-destructive NIR method using a spectrometer (Walsh and Subedi, 2016). Thus, the objectives of this work were to build and validate a model to predict the DM content of main mango exporting varieties in Mexico.

MATERIALS AND METHODS

Building the model

During 2019, five groups of 40 fruit each (from unripe green to ripe and color break) were harvested from 'Tommy Atkins', 'Ataulfo', 'Kent' and 'Keitt' varieties. The 200 fruit were scanned in both cheeks (sides) with an F-750® spectrometer to obtain the DM values. The reference values were attained by a forced air oven at 60 °C for 72 h. The model was built by means of the artificial neural network application using the second derivative of calculated absorbance from diffuse reflectance in the NIR spectra from 684 to 990 nm.

Figure 1. Harvest maturity categories for 'Tommy Atkins' and fruit scanning.

Model validation

Validation was performed during 2020 and 2021 in two commercial orchards of each variety, located in Nayarit and Sinaloa states, Mexico. In each orchard, six trees were chosen, tagging 40 panicles/tree at full blooming. After 50 days, when fruit were ~5 cm length, they were individually tagged for DM determination before harvest and at two ripening stages at harvest: a) green ripe and b) fully ripe. DM was measured non-destructively using an F-751® spectrometer. For destructive samples at harvest, DM was measured with a forced air oven by drying the samples at 60 °C for 72 h. Fruit were harvested when reached 1600 Accumulated Heat Units (AHU) [green ripe] and 1750 AHU (fully ripe) for 'Ataulfo' and 'Tommy Atkins'; 1800 and 1950 AHU for 'Kent' and 2200 and 2400 for 'Keitt' (Osuna-García, 2020). DM values obtained non-destructively with the F-751® were compared against those got by the oven. Correlations between both values were run.

RESULTS AND DISCUSSION

Building the model

The performance of the model was promising since it presented an R^2 = 0.9097 and RMSE = 0.8389 for Brix (Figure 2), as well as, an R^2 = 0.8487 and RMSE = 0.9059 for DM (Figure 3). Even though the initial parameters were better for total soluble solids, the predictability of DM was higher and more consistent. So, it was decided to use only the DM content as a criterion for predicting ripening stage at harvest of the main four exporting mango varieties in Mexico.

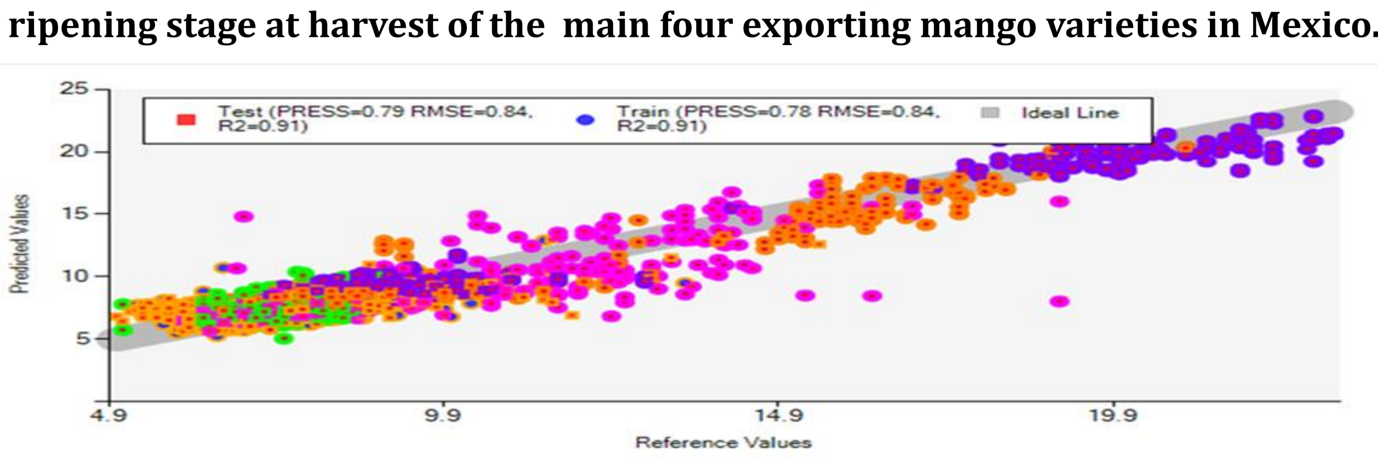


Figure 2. Performance for total soluble solids model.

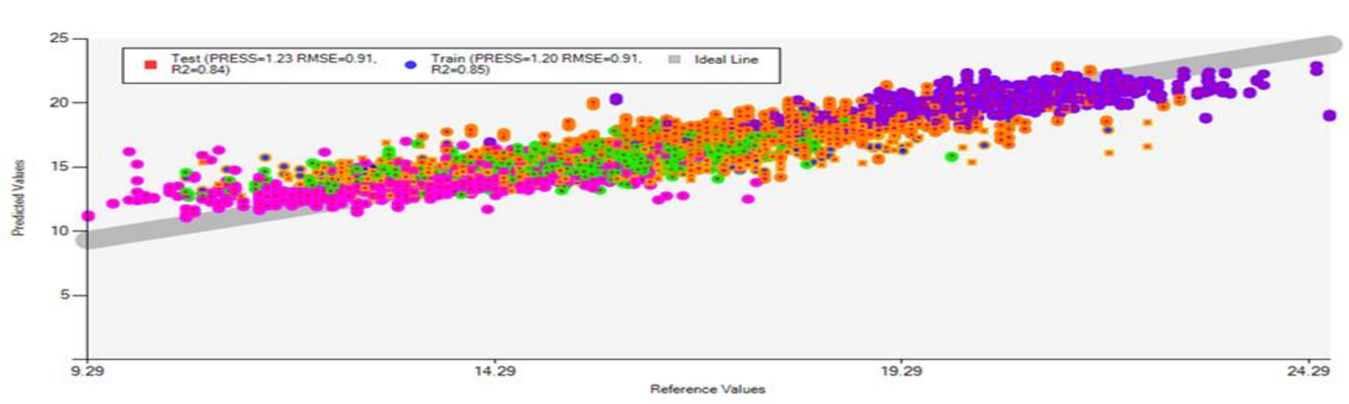
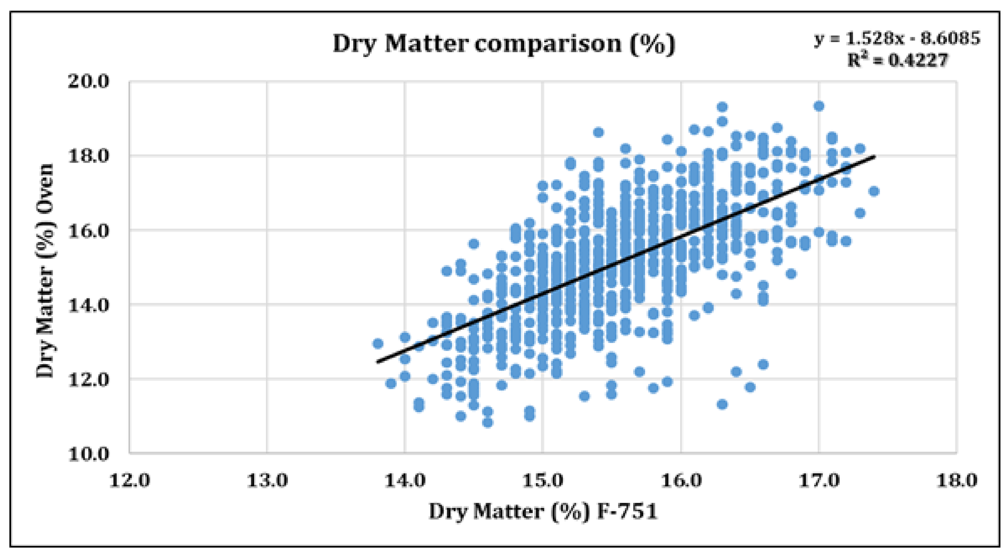


Figure 3. Performance for the dry matter model.

Model validation

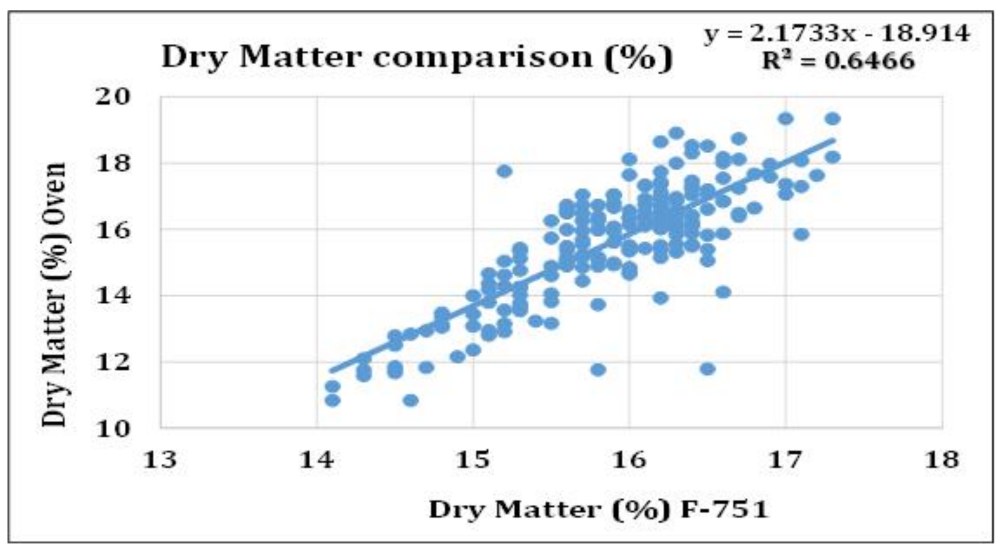
The comparison of DM content measured nondestructively with the F-751® versus the conventional oven showed that, in the general model, considering the four varieties and the two ripening degrees, a very acceptable DM average value of 15.6% was found for the spectrometer, while that obtained through traditional waving was 15.2% with an R^2 = 0.4227 (Figure 4). These results indicated the adjustments made to the model were acceptable and confirmed that the F-751® is a viable tool to determine nondestructively fruit DM content of any of the four varieties using the model generated by the artificial neural networks methodology.



	Dry Matter (%)	
	F-751	Oven
Max	17.4	19.3
Min	13.8	10.8
Average	15.6	15.2
StanDev	0.7	1.6

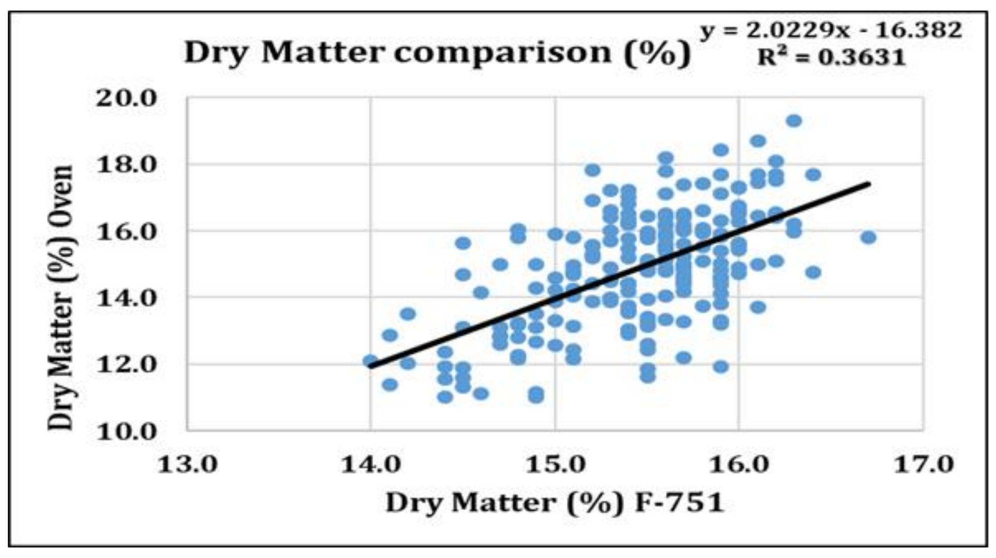
Figure 4. Prediction for the full Model considering the four varieties at both harvesting stages.

Varietal effects were detected. 'Ataulfo' showed the best fit of the prediction model with average values for the F-751® of 15.9% while for the oven were 15.6% with an R^2 = 0.6466 (Figure 5), while 'Keitt' had the worst with an average DM value of 15.5% for the F-751® and 14.9% for the oven with an R^2 = 0.3631 (Figure 6). In summary, the adjustments made to the model and spectrometer were effective, since they were able to predict acceptably the fruit DM content for all varieties with only 0.3 to 0.6 percentage points difference compared to the traditional microwave oven method.



	Dry Matter (%)	
	F-751	Oven
Max	17.3	19.3
Min	14.1	10.8
Average	15.9	15.6
StanDev	0.6	1.8

Figure 5. Prediction of the Model for 'Ataulfo' at both harvesting stages.



	Dry Matter (%)	
	F-751	Oven
Max	16.7	19.3
Min	14.0	11.0
Average	15.5	14.9
StanDev	0.5	1.7

Figure 6. Prediction of the Model for 'Keitt' at both harvesting stages.

CONCLUSIONS

The model to predict DM content of main export mango varieties in Mexico was successfully built and validated. Results indicated the feasibility of the F-751® to determine non-destructively the DM content of any of the mango varieties; although differences were detected among them. 'Ataulfo' showed the best fit of the prediction model, while 'Keitt' had the worst.

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