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Studying the nectarine ripening process with near-infrared spectroscopy

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Introduction

Understanding the ripening process helps ensure that consumers have access to high-quality, fresh nectarines. By identifying the factors that affect ripening, growers and handlers can optimize their practices to produce fruits that meet consumer demands. In addition, proper control of the ripening process can enhance the fruit's quality and increase its shelf life, minimising food waste and maximizing economic value [1].

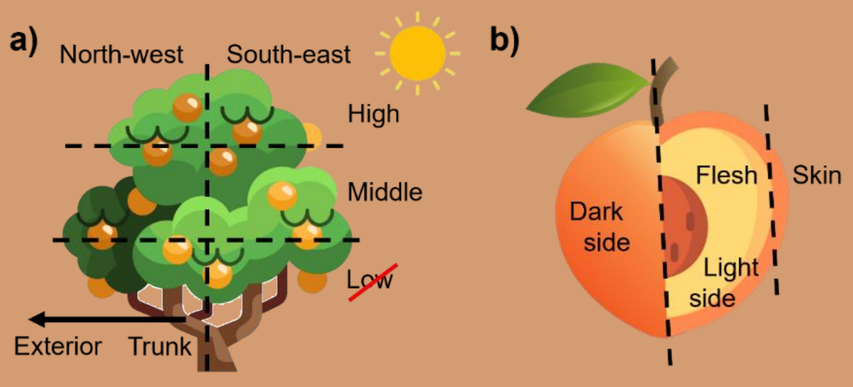
Aim of study

- To understand the ripening process of nectarines, helping to ensure that consumers have access to high-quality products.
- To determine the significant factors in nectarine ripening, in order to control or manage them for a better-quality product.
- Studying the suitability of infrared spectroscopy and multivariate analysis to monitor this biological process.

Materials and Methods

Experimental design

Once a week for 11 weeks the following sampling was carried out, collecting 4 nectarines for each positional condition and two spectral replicates in each point of the fruit [2].



ANOVA-Simultaneous Component Analysis (ASCA)

ASCA is a multivariate statistical method that combines analysis of variance (ANOVA) and simultaneous component analysis (SCA) to identify and interpret significant variation patterns in datasets with a systematical design [3].

In the present work the following factors and their binary interactions have been studied:

$$X = X_{Week} + X_{Orientation} + X_{Height} + X_{Prominence} + X_{Face} + E$$

Measurements

Spectrometre

ThermoFisher Antaris FTNIR 800-2600 nm

Reference analyses

- Weight
- Penetromy
- pH
- TSS (ºBrix)
- Total Acidity

Partial Least Squares Regression (PLSR)

Partial Least Squares Regression (PLSR) is a regression technique that combines features of principal component analysis and multiple linear regression to model the relationship between predictor variables and a response variable, with an emphasis on capturing the maximum covariance between the two sets of variables.

Results

Ripening factor assessment

To assess the factors that have a significative effect on the ripening process an ASCA is performed on all the dataset, with a week-wise unfolding. From the spectra of peeled nectarines is concluded that NIR penetrates enough into the fruit to not have to do a destructive analysis.

Raw nectarines

Factor	Effect (%)	*p*-value
Week	82.56	0.001*
Orientation	0.01	0.303
Height	0.10	0.002*
Prominence	0.18	0.001*
Face	0.04	0.048*
Residuals	17.10	

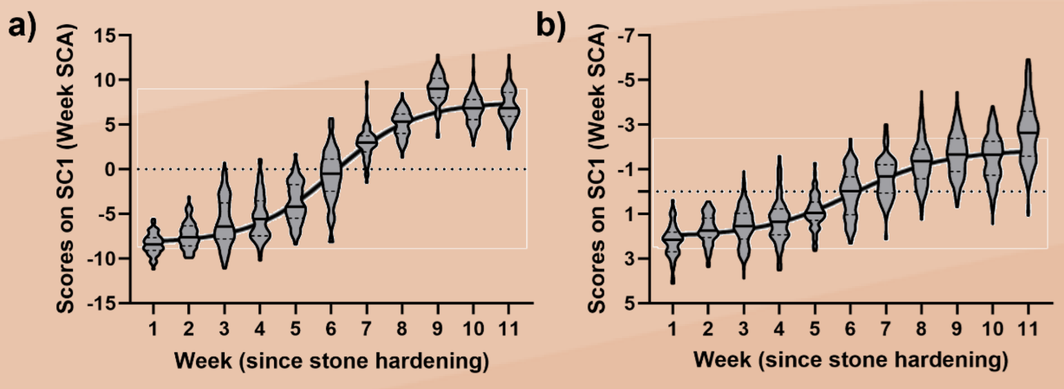
Peeled nectarines

Factor	Effect (%)	*p*-value
Week	89.42	0.001*
Orientation	0.06	0.001*
Height	0.12	0.001*
Prominence	0.03	0.019*
Face	0.01	0.166
Residuals	11.28	

*Even if some binary interactions are significative, they are not shown for interpretability purposes.

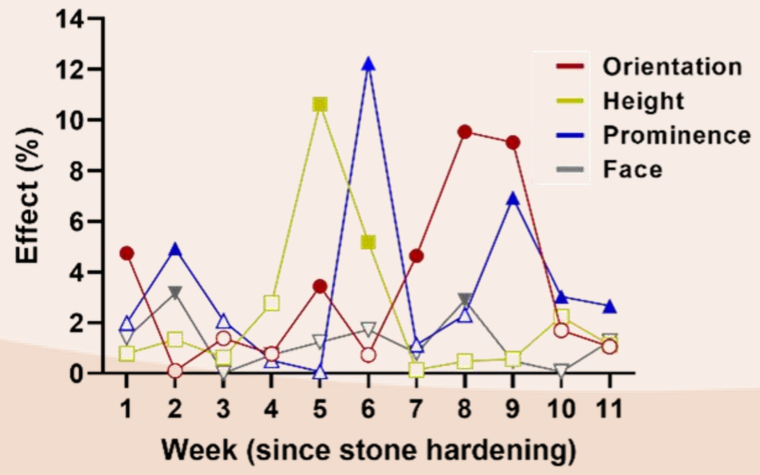
Maturity over time

Scores evolution of the SC1 of the week factor over time are shown a) without preprocessing and b) using SNV. Both curves show a sigmoid evolution, analogous to the evolution of quality parameters during ripening. Additionally, the scores of the SNV preprocessed model exhibit a growing dispersion, which is related to the removal of the spectral scattering, that leaves only the biological variance.



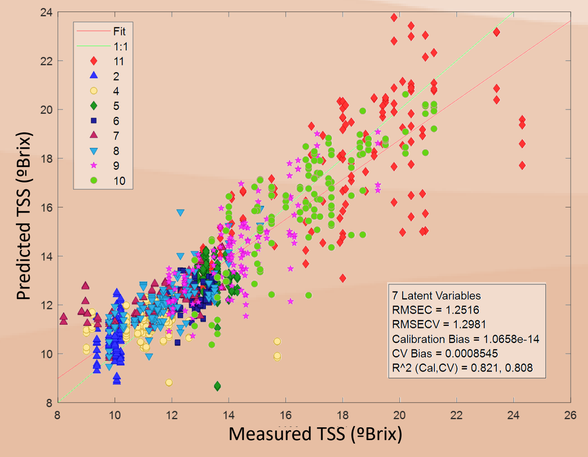
Influence of the factors over time

By doing one ASCA model per sampling day, the effect of the week on the maturity of the fruit is removed. By doing this the positional factors and their evolution over time can be studied and asessed.



Physcochemical parameter prediction

Quality parameters of nectarines were successfully predicted without peeling the skin. PLSR models with spectra preprocessed with S-G smoothing and SNV showed the best results.



Parameter	$RMSE_{CV}$	R^2_{CV}
TSS (ºBrix)	1.3	0.81
Weight	29	0.83
pH	0.13	0.73
Penetromy	1.36	0.63
T. Acidity	0.63	0.13

Conclusions

- Nectarines exposed to direct sunlight ripened faster than shaded ones, with those at the top of the tree and on the sunny side ripening the fastest.
- Despite the differences in ripening speed, all nectarines had similar maturity and properties at the end of the ripening process.
- The position of nectarines on the tree plays a significant role in their ripening process and quality, highlighting the importance of considering this factor during handling and storage.

This study emphasizes the need for growers and post-harvest handlers to consider the position of nectarines when collecting and handling them, in order to ensure optimal ripening and to maintain fruit quality.

References

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