



Detection of multiple adulterants in tomato paste using near infrared spectroscopy



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INTRODUCTION

- Tomato concentrate is one of the best-selling tomato-based products
- Economically motivated food adulteration problems arise frequently due to increasing market demands
- The common adulterants are targeted to dilute, to improve the soluble solid content, the rheological properties or the visible color of the product
- The complex nature of some adulterants can outmaneuver detection with conventional methods



AIM OF THE RESEARCH

The study aims to apply NIRS and aquaphotomics to detect and predict low concentrations of ground paprika seed, sugar and salt in tomato concentrates.

MATERIALS AND METHODS

- Tomato concentrates (T) were adulterated with ground paprika seed (P) -0.5, 1, 2, 5, 10%w/w-, sugar (C), salt (S) -0.5, 1, 2, 5%w/w- and with their potential combinations: T, C, S, WP, CS, WPC, WPS, WPCS
- Distilled water (W) was added to the samples containing paprika seed powder at specified concentrations
- Each sample was prepared in triplicates and MetriNIR benchtop spectrometer (740 nm-1700 nm) was used to collect 3 consecutive scans using a thermoregulated cuvette
- The spectra were pretreated with Savitzky-Golay smoothing and MSC in the 1300-1600 nm wavelength range
- Linear discriminant analysis (LDA) and partial least squares regression (PLSR) were used to classify and predict the adulterants and their concentration levels
- Aquagram was used to visualize changes in spectral patterns as a result of adulteration

RESULTS

1. LDA classification of tomato paste adulteration

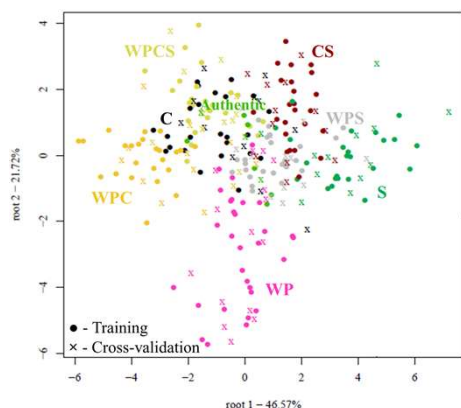


Figure 1: Discrimination of different adulterations in tomato pastes after spectral pretreatments and 3-fold cross-validation

2. PLSR predictions of tomato paste adulterations

Table 1: PLSR prediction of adulterant concentrations after spectral pretreatments and validation with leaving one sample out

Adulterant	Components	R^2_C	RMSEC	R^2_{CV}	RMSECV
Paprika seed	6	0.947	0.526	0.935	0.584
Sugar	5	0.933	0.429	0.918	0.475
Salt	5	0.982	0.224	0.978	0.248
Water	6	0.947	0.789	0.935	0.875
Tomato paste	13	0.971	1.125	0.961	1.298

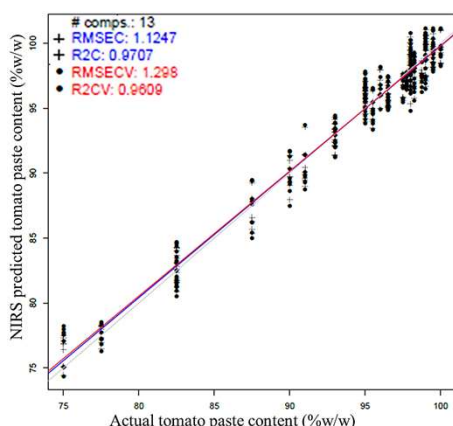


Figure 2: PLSR model to predict tomato paste content

3. Spectral patterns in tomato paste adulteration

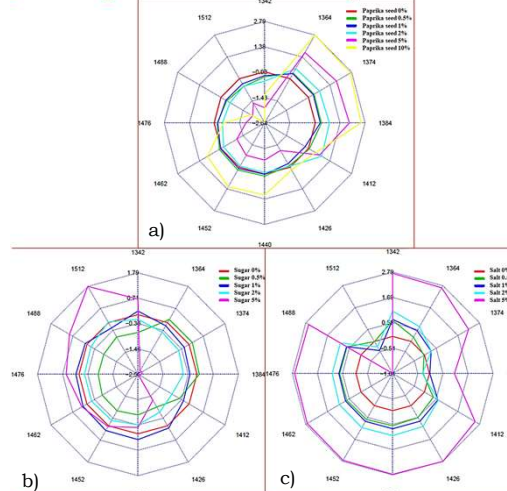


Figure 3: Aquagrams of tomato paste samples with simple adulteration
a) Paprika seed powder; b) Sugar; c) Salt

DISCUSSION

- The different adulterant combinations were discriminated in LDA with a 91.11% for recognition and 57.99% for prediction (Figure 1)
- The samples adulterated with paprika seed powder were discriminated in LDA with an accuracy of 98.89% for recognition and 65.46% for prediction.
- The LDA prediction accuracy for paprika seed, sugar, salt and water concentration was 77.74%, 71.35%, 95.32% and 77.74% respectively
- The PLSR models could estimate the added adulterant concentration with R^2 close to 1 and error less than 1 for all the investigated adulterants (Table 1, Figure 2)
- The aquagram WAMACs showed trends that correlated to adulteration patterns (Figure 3)

CONCLUSION

- NIR spectroscopy combined with the aquaphotomics methods was proven to be an effective technic for detecting single or multiple adulteration in tomato pastes
- The method most accurately classified the different adulteration levels of the samples containing salt
- The PLSR models predicted the adulterant concentration with high accuracy and low error

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