DEPARTMENT FOR INNOVATION IN BIOLOGICAL AGRO-FOOD AND FOREST SYSTEM (DIBAF)

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OPTIMIZATION OF THE ORGANIC FRUIT AND VEGETABLE DRYING PROCESS BY USING NON-DESTRUCTIVE TECHNIQUES

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THESIS TITLE

'Optimization of the organic fruit and vegetable drying process by using non-destructive techniques'

ABSTRACT

The aim of this project is the obtainment of a smart-prototype drier able to improve the hot-air drying process of organic fruits and vegetables using non-destructive technologies. Thus, a quality by design (QbD) approach has been followed in order to improve products quality and control strategy. For the intended purpose, both at-line near infrared spectroscopy (NIRS) and in-line computer vision (CV) techniques were tested. The data matrices were then subjected to chemometrics analysis in order to develop prediction and classification models able to follow up physico-chemical changes and recognise dehydration phases, respectively. Thermal (i.e. hot-water, microwave or steam blanching) and dipping (i.e. non-reducing sugar and/or ascorbic acid) pre-treatments were investigated as viable alternatives to reduce browning occurrence.

Excellent performances (R^2 = 0.91 - 0.98) were achieved in predicting physico-chemical changes (e.g. water activity, moisture content, soluble solid content, etc.) using NIRS coupled with partial least squares regression algorithm for both apple (var. Gala) and carrot (var. Romance). The prediction of colour changes using NIR wavelengths gave good results (R^2 = 0.80 - 0.87), probably due to the fact that it is an indirect measurement. Features selection led to comparable prediction performances while reducing model complexity. Similarly, partial least squares discriminant analysis PLS-DA provided from good (> 0.85) to excellent (> 0.95) results in terms of sensitivity and specificity rates for the recognition of drying phases.

Finally, computer-vision analysis showed potentiality in simultaneously monitoring morphological (e.g. area shrinkage and eccentricity), colour (CIELab) and physicochemical (moisture and drying rate) changes on apple cylinders during the process. Indeed, linear regression models gave excellent results (R^2 = 0.993-0.999) in predicting changes in moisture content on the basis of the area shrinkage.

The results confirm the feasibility of an accurate smart-control of the drying process based on non-destructive technology and set the basis for a scale up of the process.