Quality evaluation of filled and covered wafers during storage: destructive, spectroscopic, and hyperspectral methods

Chiara Cevoli, Angelo Fabbri

Department of Agricultural and Food Sciences, University of Bologna, P.zza Goidanich 60, 47521, Cesena, FC, Italy

**Keywords.** confectionary, hyperspectral image, NIR, chemometric, packaging.

**Abstract.** The aim of this study was to evaluate the quality of a wafer based sweet product during storage by using destructive, spectroscopic, and hyperspectral methods. Two packaging types were compared. The samples were vanilla cream-filled wafers (three layers) covered by a thin layer of dark chocolate packaged by using the packaging standard adopted by the involved company and vacuum-pack made by multi-material layer (PET and aluminum). The samples were stored at 18°C (RH=50%) and analyzed after 2, 4, 5, 6, 7 and 8 months of storage. Concerning the destructive analyses, three-point bending test were used to evaluate the mechanical properties, while the water activity was measured on the most internal wafer sheets. The sensory acceptance was directly assessed by a trained staff. The samples were analyzed by a FT-NIR spectrophotometer (MATRIX™–F, Bruker Optics) in the range from 833 to 2500 nm and by a push-broom linear array hyperspectral camera working from 400 to 1000 nm (Nano-Hyperspec, Headwall Photonics). Spectroscopic and hyperspectral data were subjected to chemometric elaboration. PCA analysis was used as explorative technique to group the samples as function of packaging type and storage time, while PLS model were developed to estimate the storage time.

The water activity significantly increases during the storage and good linear relations (R2 up to 0.84) were found between water activity and mechanical parameters, confirming the dependence of the mechanical behavior on the effect of the water in water sheet. The sensory acceptance linearly decreases with the storage time; this reduction is more pronounced for the samples stored in standard packaging. The acceptance limit corresponds to wafer sheet water activity of about 0.44. This value was defined the limit to describe “good” and “compromised” wafers, in terms of sensory (textural) properties. Results suggests that adding a multi-material packaging layer, the storage time significantly increases.

PCA analysis of NIR and HSI spectra, showed a clear separation between the samples acquired at time 0 and those analyzed during the storage. Particularly for the NIR spectroscopy, the X-loadings suggested that the discrimination is mainly due to the region from 1850 to 2000 corresponding to the O-H absorbance in water. Considering only the samples acquired during the storage, the score plots showed notable sample distributions according to the storage time, passing from 2 to 8 months. PLS results showed R2 in cross-validation ranging from 0.926 (RMSECV=0.63 months) to 0.980 (RMSECV=0.36 months). The best performances were achieved considering separately the samples stored in standard and vacuum packaging, for both NIR and HIS data.