

Abstract

Multispectral imaging for the detection of surface defects in an industrial bread-making process

Mario Li Vigni¹, José Manuel Prats Montalban², Frans van den Berg³ and Marina Cocchi^{1*}

¹Dept of Chemistry, University of Modena and Reggio Emilia, Modena, 41125, Italy

²Dept. of Applied Statistics, Operations Research & Quality, Universidad Politécnica de Valencia, Valencia, 46022, Spain

³Dept. of Food Science, University of Copenhagen, Frederiksberg, 1958, Denmark

*Corresponding author: marina.cocchi@unimore.it

Introduction

Bread production from an industrial point of view requires that the final product complies with a strict set of specifics, often related to its visual appearance, such as crust color homogeneity. Whenever the production goes beyond several thousands of bread loaves per day, human control is virtually impossible and computer-aided image analysis tools must be considered. The potential of multispectral imaging, including NIR channels, can help in improving the information related to bread final quality. Texture is also important in determining the physical structure of bread under normal process conditions. So, it can be useful to analyse or compress the spectral information, afterwards including textural (or spatial) information in it. By defining the latent space of well-manufactured breads, it is possible to monitor abnormal behaviour and detect where possible defects are located.

Materials and Methods

Bread loaf samples baked in an industrial bread-making plant were provided so that a representative amount of both “in specification” and “defective” products were available. Defective products differed in terms of defectiveness, e.g. presence of darker / paler surface areas, bubbles, spots and scratch patterns. The VideometerLab system was used to acquire images from 430 to 970 nm, obtaining 18-channel images, of which 8 belong to the NIR region (850-970 nm). The proprietary Videometer software, together with homemade routines, was employed to import the hyperspectral images into MATLAB. A new procedure coupling 2D-Wavelet decomposition and Multivariate Image Analysis (MIA) has been used for image analysis.

Results and Discussion

MIA has been applied to unfolded 2D-WT decomposition score images coming from MCR or PCA analysis. Analysis of score plots and related Q and T2 maps based on normal product images allowed distinction between normal regions and defective ones, with great enhancement of the detection of normally hard to identify defects such as the presence of pale colour spots. The spectral information could be used to identify, although in a qualitative way due to the limited number of channels considered, the chemical nature of some of these defects in order to better evaluate the product surface.

Conclusion

The potential of a 2D-wavelet and MIA approach to NIR multispectral imaging has been shown to assist the evaluation of bread loaves to particular crumb colour and homogeneity requirements, thus allowing a faster selection in product quality control tasks.