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STAR DUST MEMORIES, OR HOW TO DETECT ALLERGEN TRACES IN POWDER FOODS

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ABSTRACT

Allergies and food intolerances are at the forefront of institutional interest (European Regulation No 1169/2011) for their impact on consumer health. Allergies to peanuts and other nuts and gluten intolerance, makes production processes involving mixtures of powders a great concern for the industry, given the need to indicate the existence of traces of any of them. The food industry requires non-destructive and non-invasive methods of quantification that meet sensitivity requirements but also specificity levels. Optical methods such as NIR spectrophotometry or hyper-spectral image are currently some of the technologies that show potential success. This is the context of this paper that evaluates how to use NIR spectroscopy (900-1600nm) to detect traces of 15 different kinds of nuts and 20 other flours.

Keywords: Food allergen, Hyper-spectral image, NIR spectra, Chemometry, Nuts

INTRODUCTION

Nuts in general are concentrated sources of dietary energy, as well as sources of unsaturated fatty acids, various micronutrients, and fiber (Gray, 2013). However, over recent decades they have increasingly been found to induce adverse health effects with allergenic reactions. Allergenic conditions arising from the consumption of nuts is generally thought to be life long and typically severe (Fleischer et al., 2005). The need for recognition of allergies has been rising in the industrialized world since the middle of the last century. No definite treatment is yet available for nut and seed allergies (Willison et al., 2014). The major allergenic compounds in tree nuts, like peanuts and other seeds, have been identified as seed storage proteins (Kulis, 2011). Two commonly used detection methods are Enzyme-Linked Immunosorbent Assay (ELISA) (Platteau et al., 2011) and Real Time Polymerase Chain Reaction (RT PCR) (López-Calleja et al., 2013). However, these methods are costly, and require time and chemical experimental skills, which make them difficult to implement in food manufacturing processes. Dietary avoidance is the primary strategy used to avoid these allergies and requires the ability to identify peanuts or tree nuts (Hostetler et al., 2012). On the other hand, manufacturing industries dealing with the processing of multiple powder food products present a substantial risk for the contamination of powder foods with traces of tree nuts and other adulterants. Such cross contamination might result in unintentional ingestion of nuts by sensitized consumers. The need for an in-line system to detect nut traces at the early stages of food manufacturing is thus crucial for both people allergic to nuts and food manufacturers. Current food and beverage applications of NIR are dominated by proximate quality assessment, and research focused on this aspect of near infrared analysis is very active. The method is relatively inexpensive, rapid, preserves the sample and is able to measure several constituents concurrently. The objective of this research is to specify different flours and nuts using NIR spectroscopy.

MATERIAL AND METHODS

Fifty samples of nuts and flours from different origins were bought from a grocery store in Madrid, Spain (Table 1). Three grams of each sample was weighed and put into a round plastic container for spectroscopic measurement. The sample was pressed with a Chatillon (DISMAE, Model-DPP) to achieve 1.41 kg / cm^2 (or 98 N with a 30 mm flat plate), to make it compact and produce an even surface. Near Infrared (NIR) spectral measurements were made using a Hamamatsu photonic multi-channel spectrometer (Japan): C7473 and PMA-1 respectively. The detector is a 10 mm In Ga As type, usable in the wave length range between 900 nm and 1600 nm.

Table 1. Different nuts and flour samples used for analysis. The presence of gluten and origin is indicated; for flours w stands for the power level.

Powder products			
With Gluten		Ground nuts	
Spelt Intergral	Spain	California Almond without skin	USA
Persian Integral	Spain	Walnut Eco	Spain
Wheat 80-120W	Spain	Raw Cashew	India
Persian	Spain	California Almond with skin	USA
Barley	Spain	Common Almond	Spain
Wheat 120-140W	Spain	Almond	Spain
Spelt	Spain	Marcona organic almond	Spain
Oats Integral	Catalunya	Walnut	Chile
Wheat 300-380W	Spain	Eco hazelnut	Spain
Wheat 220-260W	Spain	Pecan nut	Unknown
Rye	Spain	Macadamia	Australia
Wheat Integral	Spain	Walnut	Usa
Rye Integral	Spain	Peanuts with skin	Argentina
Wheat 350-400W	Spain	Pistachio with skin	Unknown
Without Gluten		Pine nuts	Spain
Golden flax	Ukrain	Blanching pistachio	Iran
Grits rice Integral	Spain	Pine nuts	China
Toasted soy	China	Coquito nuts	Brazil
Brown flax	Italy	Peanut without skin	Argentina
Soy	China	Sunflower seed	USA
Cassava	Brazil		
Corn	Italy		
Buckwheat	Holland		
Chickpea flour	Turkey		
Toasted Sesame	Unknown		
Rice	Spain		
Poppy seed	Unknown		
Sesame	Unknown		
Chia	Unknown		
Rapeseed	Spain		

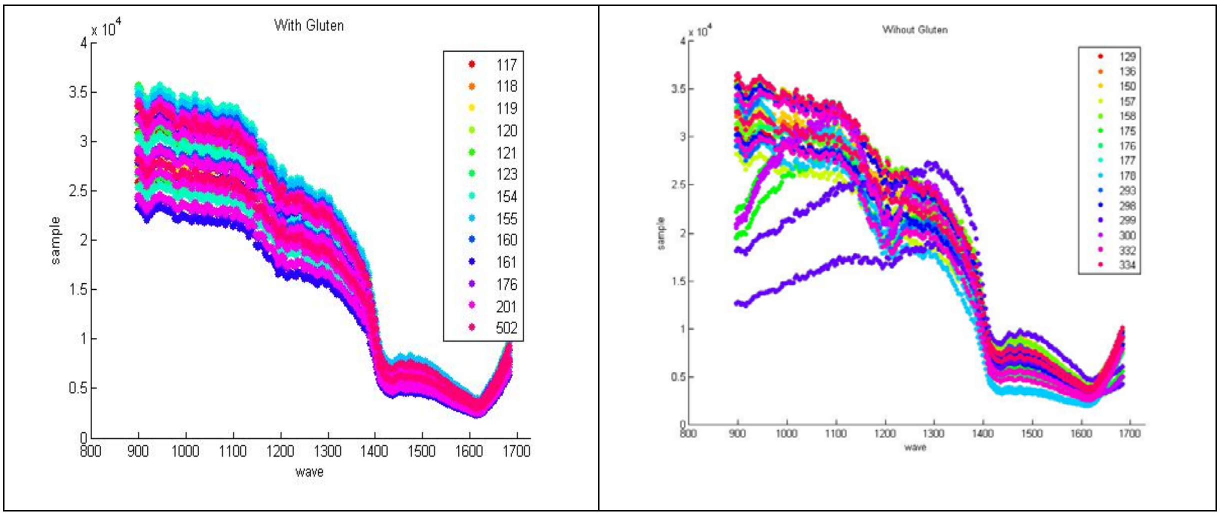
Spectral data were collected using Hamamatsu software. The room temperature during the measurements was kept steady between 21°C and 23°C. The instrument was calibrated with a white reference (barium sulphate plate) and dark current spectra were taken before acquiring measurements of the samples, and then the relative reflectance was computed subtracting the dark current from each raw spectrum and dividing the result by the white reference minus the dark current spectrum. NIR spectra were focused on the sample, where it would penetrate and interact with the sample, and then be reflected.

Spectral data were collected for three replicates at different levels of intensity for all types of the samples. NIR spectral data were analyzed using Matlab R2013 software. PCA analysis was performed on the data for the sample to develop the separation between the samples.

RESULTS AND DISCUSSION

Strong NIR absorption bands near 1400 nm - 1440 nm have often been applied to the quantitative analysis of water concentration in foods. Absorption bands at 1454 nm are related with O-H stretch overtone bond. Figure 1 (a) and (b) show the representative graphs of raw NIR spectra for gluten flours and non-gluten powders including different nuts. The spectral signature for lipids (around 1100 nm – 1300 nm) can be seen in Figure 1(b) which have a deeper valley than Figure 1(a), showing the occurrence of lipids. Some absorbance bands occur in Figure 1(b) but not in 1(a) at 1210 and 1220 nm; and 1420nm and 1430nm correspond to the oil content and protein respectively (William and Noris.,1987).
Figure 2 shows the plot of PCA 2 vs PCA 3 for the nuts (green squares) and flour (red dots) samples. It can be seen that, flours samples are well separated from nuts and located opposite one another. With help of PCA, NIR can classify nuts and flour samples based on chemical compositions differences such as the protein, fiber and lipid contents. The nuts with more protein and more fiber are scattered towards the right side (having higher value for PC2), otherwise it will scattered towards the left side (lower value for PC2). The fatty acid composition for different nuts is unique leading to more dispersion in PC plot (larger area covered by green dots), as can be seen for the nuts as compared to flour (red circles). Peanuts are grouped together within the nut area, which means that discriminant functions can be trained as to guarantee specificity in detection of allergens (not all nuts promote an allergenic reaction).

Figure 1. Raw spectra of NIR for (a) samples with gluten and (b)samples without gluten

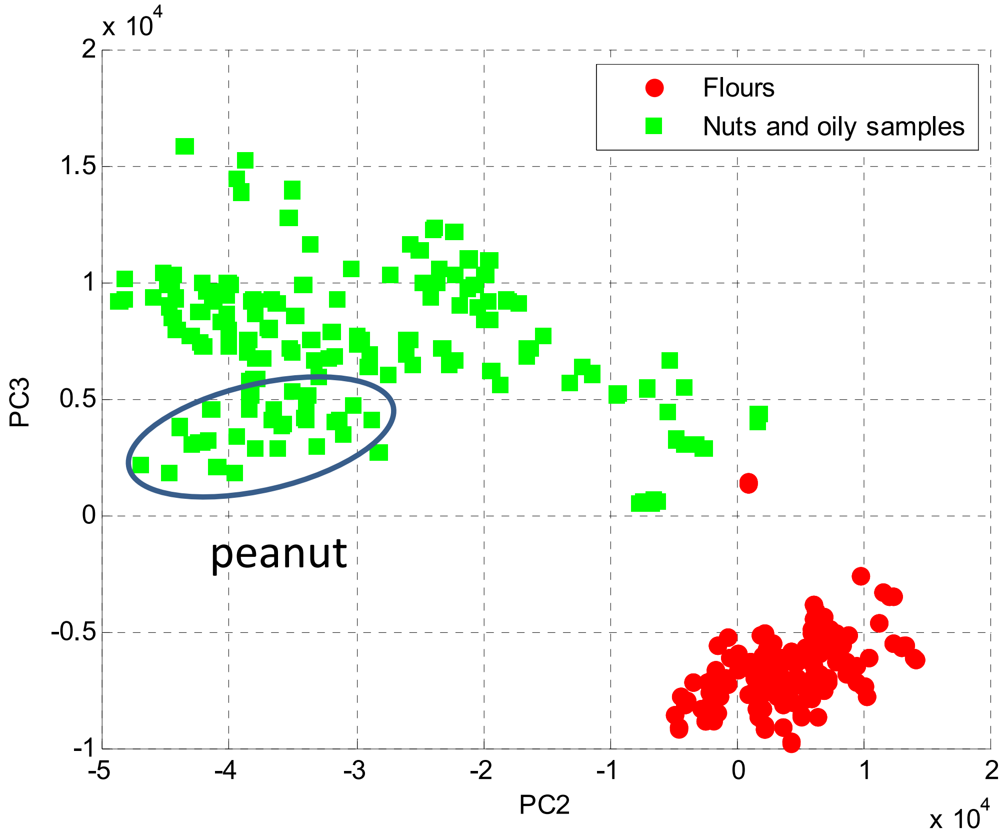


(a) (b)

CONCLUSIONS

NIR reflectance spectroscopy combined with PCA could be a useful tool for the analysis of adulteration of nuts in the powders. The PCA is a promising approach for segregation between the nuts and flours. NIR measurements are procedurally simple and can considerably reduce the time required for measurements with the specific results. The use of NIR spectroscopy described in this paper would effectively specify the component in the powder, thus detecting the adulteration of the powder by nuts. At present, more work is needed to be done for differentiate between flours and nuts.

Figure 2. PCA 2 against PCA 3



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