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Raman spectroscopy for distinguishing the composition of table-top artificial sweeteners

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Abstract

Raman spectroscopy excited at 1064 nm was used to measure a selection of artificial sweeteners that are commonly used in low-calorie diets. Aqueous solutions with different sweetener concentrations in the 5%-30% w/w range were analyzed, and a multivariate data processing of spectroscopic data was used to building a classification map. This map showed an excellent clustering according to the sweetener composition, indicating excellent potentials of Raman spectroscopy for the assessment of food quality.

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Keywords: Raman spectroscopy; chemometrics; artificial sweeteners; low-calorie

1. Motivation

Nowadays, artificial sweeteners contribute to consumer choice, since a growing number of people choose finished products that are prepared with these sugar substitutes or use them in food and drinks. Their sweetening capacity is hundreds of times higher than that of sugar, and the very little energy content, a few kcal per gram, can be regarded as negligible. They can be used with complete confidence, on their own or in combination with other sugars, thanks to scientific studies which have demonstrated the total safety and to the many worldwide laws that indicate the amounts that can be used, and the type of labelling. Consequently, many consumers increasingly

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address their preference to artificial sweeteners with respect to natural sugars for weight maintenance or reduction, dietary needs, or for a better oral health [1].

Optical spectroscopy is currently emerging as a modern and "green" analytical technique for intact food analyses, thanks to the non-destructive nature of light measurements which enable rapid checks without making use of reagents or chemical treatments, thus avoiding the problem of waste disposal [2]. While absorption and fluorescence spectra show broad peaks resulting from the convolution of the many overlapping bands, which are poorly resolved for the purposes of multicomponent analysis, Raman spectra show sharp bands that identify the molecular composition, and can immediately lead to the detection of multiple components and to their quantification [3].

The objective of this paper is to assess how Raman spectroscopy can be used for analyzing different types of artificial sweeteners. Previous papers presented the use of FT-Raman spectroscopy for determining the composition of artificial sweeteners [4], and for quantifying aspartame [5,6]. In this paper, many popular table-top artificial sweeteners were selected, and measurements using a dispersive-Raman instrument were carried out on aqueous solutions with different sweetener concentrations. Principal Component Analysis was used for the dimensionality reduction and multivariate processing of spectroscopic data. This simple and straightforward data processing made it possible to build a classification map that showed an excellent clustering according to the composition of the sweeteners.

2. The table-top artificial sweeteners analyzed

Table I summarizes the table-top artificial sweeteners considered in this study, together with their main ingredients, and the codes given for their rapid identification. They are made of popular "hard" sweeteners, such as aspartame, sucralose, and sodium saccharin, mixed with other "soft" sweeteners, such as erythritol, sorbitol and dextrose. Other additives which are used as stabilizers are typically based on corn, cellulose, and calcium silicate. Another sweetener made of the leaves of the Stevia plant is included: it is popular in Central and South America, and was approved in Europe in November 2011, thus becoming a modern and increasingly used 0-calorie sweetener.

Aqueous solutions with sweetener concentration of 5%, 10%, 20%, and 30% w/w were prepared, and then spectroscopically analyzed.

Table I. The collection of table-top sweeteners analyzed.

Code	Brand	Sweetener	Other Ingredients
SP	Splenda	Sucralose, Dextrose	Maltodextrins
ED	Easy Diet	Dextrose, Sodium cyclamate, Sodium saccharin	
LD	Light day	Sucrose, Sodium cyclamate, Acesulfame K	
PF	Peso Forma	Aspartame (3%), Dextrose	
DI	Dietor	Mannitol, Sorbitol, Fructose, Sodium saccharin	
TS	Tropicana Slim	Sorbitol, Aspartame	Corn powder
SM	Stevia Misura	Erythritol, Rebaudioside-A	Cellulose powder
SX	Sweetener	Sucralose	
SL	Sweet'n Low	Dextrose, Sodium saccharin	Tartar cream, Calcium silicate
EQ	Equal Original	Dextrose, Aspartame, Acesulfame K	Maltodextrins
AC	American Coffee Services	Dextrose, Saccharin	Maltodextrins
CL	Caless	Maltitol, Erythritol, Sucralose	Calcium silicate
SS	Sugar Substitute	Dextrose, Calcium saccharin (4%)	Silicon dioxide (< 2%)
SW	Sweet Light	Sucrose, Aspartame, Acesulfame K	
CA	Candrel	Dextrose, Aspartame, Acesulfame K	Silicon dioxice
NZ	Natrena	Aspartame (3.1%)	Maltodextrins (96.9%)
PA	Palsweet	Erythritol, Acesulfame K	Reduced maltose starch syrup
SU	Surari	Sucrose, Aspartame, Acesulfame K	
DT	Diete.tic	Erythritol, Sodium Cyclamate, Sodium Saccharin, Acesulfame K	