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# Influence of processing on the volatile profile of strawberry spreads made with isomaltulose

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ABSTRACT

A new strawberry spread formulated with fructose and isomaltulose (replacing sucrose partially or totally) and a high percentage of fruit was developed in line with the new trend of healthier products. This work studies the influence of some process variables (percentage of sugar, pectin and citric acid, and time of thermal treatment) on the volatile profile of these spreads with different formulations. The ripeness of the raw strawberries influences the concentrations of some of the compounds in the spreads, such as isobutyl acetate, butyl butyrate, 3-hexen-1-yl acetate or propan-2-ol. The process conditions have an important effect on the volatile profiles. Most of the esters and alcohols decreased whereas 13 new compounds appear, mostly furans (furfural, 2-acetylfurane, 5-methyl furfural, mesifurane) and aldehydes (octanal, nonanal, decanal and benzaldeyhde). In general, the spreads formulated with sucrose-isomaltulose that contained higher levels of pectin and citric acid gave better results in the preservation of the original aromatic compounds in raw strawberries.



## 1. Introduction

Recently, the population of developed countries has modified its nutritional habits as a consequence of new life styles. In fact, many studies have reported that the new eating habits related to this life style are causing health problems. An example is the relationship established between fast food with obesity and diabetes 2 (Frank & Vasanti, 2010; Fraser & Edwards, 2010; Jeffery, Baxter, Mcguire, & Linde, 2006; McPhail, Chapmanb, & Beagan, 2011; Pereira et al., 2005). From this point of view, the development of new products such as fruit spreads formulated with healthier sugars like fructose and isomaltulose would be interesting for certain groups of the population such as children and senior citizens. These products should not have undesirable effects like caries and diabetes (related with sugar consumption), and therefore would be more appropriate for these niches of the population than traditional jams.

Fruit is a food group which is receiving more attention among the population due to its interesting and healthy properties such as high functional and nutritional value, being rich in fibre, minerals, vitamins and terpens antioxidant compounds (Cavanah, Hipwell, & Wilkinson, 2003; Dhiraj, Vattem, & Shetty, 2005; Gillman et al., 1995). Among the wide variety of available fruits, one of the most valued is the strawberry, not only because of its high content in vitamins and minerals, but also because of its organoleptic characteristics such as taste and aroma. Strawberries are rich in vitamin C, sometimes in an even higher concentration than oranges. They are also rich in minerals (iron, iodine, calcium, phosphorus, magnesium and potassium (Ávila et al., 2009) and more than 33 identified organic acids, for example: citric, malic, oxalic and folic, (Rizzolo, Lombardi, Lovati, Tagliabue, & Testoni, 1995:Forney, Kalt, McDonald, & Jordan, 1996; Azodanlau, Darbellay, Luisier, Villettaz, & Amado, 2003; Azodanlau, Darbellay, Luisier, Villettaz, & Amado, 2004). Strawberries are very problematic for industrial processing as they are seasonal, and have a high water content which makes them very perishable. Besides, strawberry has healthy, sensory characteristics which make it a very attractive fruit for processing. Therefore, the food industry has an increased interest in developing new kinds of processed fruit products whose sensorial characteristics are not very different to the fresh fruit. This could be the case of strawberry spreads, as they present some characteristics similar to fresh fruit but on the other hand are more stable than the fresh product since the $a_w$ and the moisture of the product are reduced. The big difference between a fruit spread and a jam is that in a fruit spread cooking to reach a final soluble solid content is avoided, as it provokes the greatest changes from a nutritional, sensorial and functional point of view. Moreover, a jam must have at least 45 °Brix, whereas a spread fruit does not have any restriction related to sugar content (BOE 04/07/07; RD: 863/2003). Additionally, these spreadable products might be considered healthier when the sucrose is replaced by other sweeteners such as isomaltulose, a sugar especially indicated for children and senior citizens as it does not produce caries, and more-

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over is slowly released in the blood (Lina, Jonker, & Kozianowski, 2002; Matsuyama, Sato, & Hoshino, 1997; Schiweck, Munir, Rapp, Schenider, & Bogel, 2000).

The food industry is more and more concerned with the elaboration of healthier food products without forgetting the importance of taste and flavour, since they are very important characteristics from the consumers' point of view. These attributes which can be quantified in terms of the volatile profile are important for both the fresh and the processed product. In the case of strawberries, more than 360 volatile compounds have been identified, including esters and acids, together with alcohols, ketones, lactones and aldehydes in minor quantities (Forney, 2001; Larsen, Poll, & Olsen, 1992). Esters, which are responsible for the fruity, floral aroma make up more than 25% of the total mass of the volatiles in this ripe fruit (Forney, 2001; Gomes da Silva & Chaves das Neves, 1999; Maarse, 1991). Aldehydes and furanones also play important roles in strawberry aroma (Bood & Zabetakis, 2002; Forney, 2001), as well as Terpenic and sulfuric compounds, which have an important impact on the characteristic aroma of red berries even though they only represent a small portion of the volatile compounds (Dirinck, De Pooter, Willaert, & Schamp, 1981; Azodanlau et al., 2003; Azodanlau et al., 2004).

The aim of this work was to analyse the influence of the different process variables (wt.% of isomaltulose, wt.% of pectin, wt.% of citric acid and time of heat treatment) on the volatile profile of different strawberry fruit spreads made using healthier sugars such as isomaltulose or fructose to replace sucrose partially or totally.

## 2. Material and methods

### 2.1. Raw material

Fifteen batches of raw strawberries (*Fragaria vesca*, Camarosa) acquired in a local supermarket, where used for the present work. The experimental work was performed between February and June of 2010. Each batch of strawberries was sorted in order to eliminate damaged fruit and group the samples in terms of colour, shape and ripeness. Then they were cut and washed in chlorinated water to eliminate possible field residues.

### 2.2. Methodology

#### 2.2.1. Formulation of the spreadable products

Following the surface-response methodology, a statistical central composite design $2^4$ + start (Gómez & Gómez, 1984; Kaur, Wani, Oberoi, & Sogi, 2008) was applied to analyse the influence of four independent variables $X_1$ (% of isomaltulose), $X_2$ (% of pectin), $X_3$ (% of citric acid) and $X_4$ (time of heat treatment) on the volatile profile of spreadable strawberry products (Table 1). Two kinds of strawberry spreads were formulated following two identical replicates of the design. One group of samples containing sucrose and isomaltulose (as sucrose was considered to be the reference sugar) and a second group formulated with fructose and isomaltulose (both considered healthy sugars). The target concentration of the final product was 50 °Brix, therefore the sweetness of the sugars was not a determinant parameter when the different mixtures where made to formulate the products. These mixtures between two sugars were needed since the solubility of isomaltulose does not permit the required final sugar concentration of 50 °Brix (Kaga & Mizutani, 1985; Schiweck, Munir, Rapp, Schenider, & Bogel, 2000).

The formulation of the products was the result of the implementation of dry osmotic dehydration studied previously (Peinado, Rosa, Heredia, & Andrés, 2008; Rosa, Peinado, Heredia, & Andrés, 2008). In this case, the product was directly formulated by mixing the ingredients in the correct proportions to reach the established concentration of 50 °Brix, therefore, avoiding the typical equilibrium stage which takes place during osmotic dehydration. The amounts of raw strawberry and sugar needed were calculated according to the correspondent mass balance and they were dependent on the soluble solids content in the raw strawberries. The ingredients in the spreadable strawberry products were: strawberries, sugars (sucrose or fructose, and isomaltulose), pectin (as a gelling agent), potassium sorbate at a fixed concentration of 500 ppm (as a microbiological preserver) (Castelló, Fito, & Chiralt, 2006; Karabulut, Lurie, & Droby, 2001) and citric acid (as a colour preserver). Once the ingredients were mixed, the product was heated until it reached 85 °C. This temperature was necessary to make "hot canning" effective, as well as to allow the pectin to dissolve and then gel, so that the gel structure would not break up during storage. Then, the product was placed in glass jars and some of the samples, depending on the statistical design, were heated for 5, 10, 15 or 20 min in a bath of boiling water. Finally, they were stored at room temperature for 24 h before the correspondent analyses were performed.

**Table 1**
Independent variables and their level used for central composite design.

| Independent variables | Symbol[c] | Coded variable levels | | | | |
|---|---|---|---|---|---|---|
| | | −2 | −1 | 0 | 1 | 2 |
| Isomaltulose (%)[a] | $X_1$ | 0 | 12.5 | 25 | 37.5 | 50 |
| Pectin (%)[b] | $X_2$ | 0.5 | 1 | 1.5 | 2 | 2.5 |
| Citric acid (%)[b] | $X_3$ | 0 | 0.25 | 0.5 | 0.75 | 1 |
| Heat treatment time (min) | $X_4$ | 0 | 5 | 10 | 15 | 20 |

[a] % of isomaltulose in the total amount of sugar mix (sucrose-isomaltulose or fructose-isomaltulose).
[b] In final product.
[c] Symbol with which each independent variable is cited in the text.

### 2.3. Physicochemical analyses

All the physicochemical analyses were carried out on raw strawberry puree, and the final spreads. All measurements were carried out in triplicate. The moisture content was determined gravimetrically by drying to a constant weight in a vacuum oven at 60 °C (method 20.103 AOAC, 1980). Soluble solids content (°Brix) was measured with a refractometer at 20 °C (ATAGO 3 T). For the strawberry spread, dilution at a ratio of 4 g water for each gram of sample was necessary. Water activity ($a_w$) was determined with a dew point hygrometer (FA-st lab, GBX) and pH was determined with a pH-meter (SevenEasy, Mettler Toledo).

### 2.4. Volatile compound analysis

Aromatic compounds were extracted by purge and trap thermal desorption (Torres, Chiralt, & Escriche, 2012). 20 g of raw strawberry or strawberry spread spiked with 200 µl 2-pentanol (10 µg/ml as an internal standard), were placed in a purging vessel flask and left in a water bath at 45 °C for 20 min. During this time, purified nitrogen (150 ml min$^{-1}$) was forced through a porous filter placed at the bottom of the vessel, producing a stream of bubbles which passed through the sample drawing the volatile compounds. These were trapped in a 100 mg porous polymer (Tenax TA, 20–35 mesh) packed into a glass tube placed at the end of the system. A total of 3 extracts were obtained for each sample. The volatile compounds were subsequently thermally desorbed using a direct thermal desorber (TurboMatrix TD, Perkin ElmerTM, CT-USA). Desorption was performed under a 10 ml min$^{-1}$ helium flow at 240 °C for 10 min. The volatiles were then cryofocused in a cold trap at −30 °C and transferred directly onto the head of the capillary column by heating the cold trap to 250 °C (at a rate of 99 °C/s).