OPTICAL, MECHANICAL AND SENSORIAL PROPERTIES OF STRAWBERRY SPREADABLE PRODUCTS FORMULATED WITH ISOMALTULOSE

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Abstract

Current consumption trends are forcing companies to develop new healthier products to satisfy consumer demand. Therefore, a novel spreadable strawberry product, formulated using osmotic dehydration, with healthy sugars and a high fruit percentage could be an interesting product. Dry Osmotic Dehydration (DOD) can be used to remove water and add sugar in the elaboration of this type of product. Moreover, a concentrated solution rich in volatile compounds, vitamins and water soluble minerals is generated by the water out-flow. The aim of this work was to evaluate the optical and mechanical properties, as well as the sensorial attributes (colour, spreadability, taste with and without bread, cohesiveness and the global preference) of 30 ºBrix strawberry spread-products. A total of 18 different spread-products were obtained according to the type of sugar (isomaltulose or sucrose), the elaboration method (wet (W) or dry (D) osmotic dehydration with (D1) or without (D2) external liquid phase removal) and the percentage of pectin used for their formulation. The results showed neither influence of pectin percentage nor of type of sugar on the colorimetrical coordinates (L*, a* and b*). Nevertheless, dry osmotic dehydration with external liquid phase removal seemed to better preserve the characteristic fresh strawberry colour.

Regarding texture, lower liquid phase volume and higher fruit-solution ratios led to spread- products with higher consistency and cohesiveness values (consistency values: 5.5 ± 0.4 vs 2.9 ± 0.1 (1 % of pectin), 6.92 ± 0.08 *vs* 4.3 ± 0.3 (1.5 % of pectin), 10 ± 1 *vs* 5.2 ± 0.3 (2 % of pectin); cohesiveness values: 0.82 ± 0.07 *vs* 0.32 ± 0.04 (1 % of pectin), 1.21 ± 0.04 *vs* 0.72 ± 0.08 (1.5 % of pectin), 1.8 ± 0.3 *vs* 1.00 ± 0.06 (2 % of pectin)), as well as the use of sucrose instead of isomaltulose at 2% of pectin (consistency values: 9.02 ± 0.13 *vs* 7.9 ± 0.3 (W), 11.3 ± 0.4 *vs* 9.60 ± 0.02 (D2); cohesiveness values: 1.78 ± 0.03 *vs* 1.56 ± 0.09 (W), 2.16 ± 0.09 *vs* 1.80 ± 0.12 (D2)). Concerning sensorial evaluation of spread-products formulated with isolmaltulose, the taste was the parameter which conditioned the global preference by panelists. Regarding spreadability, the products ranging from 4 to 5 N·s for consistency, and 0.6 to 0.9 N·s for cohesiveness were the most appreciated.

Keywords: Isomaltulose, Dry Osmotic Dehydration, optical and mechanical properties, sensory evaluation, Pairwise Friedman ranking test, Correspondence Analysis.

1. Introduction

Nowadays, consumers want products with good taste and flavour, but moreover, they need to be healthier and with good nutritional and functional value. Besides, these aspects, sometimes it is also required that these food products do not produce undesirable effects, related for example with sugar consumption, as caries and diabetes Pereira *et al.*, 2005; Jeffery *et al.*, 2006; Frank & Vasanti, 2010; Fraser & Edwards, 2010; McPhail *et al.*, 2011). Therefore, the development of new products which satisfy consumer expectations is becoming a priority goal of the food industry.

From this point of view, the development of new products such as spreadable fruit could be interesting since they present some characteristics similar to fresh fruit, but on the other hand are more stable than the fresh ones as the a_w (water activity) and the moisture of the product are reduced. The big difference between a spreadable fruit product and a jam is that in the former, 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 ºBrix, whereas a fruit spread does not have any restriction related to sugar content (BOE 04/07/07; RD: 863/2003)

Wet Osmotic Dehydration is a widely extended technique for the processing of fruits and vegetables, due to the high quality of the products obtained when compared with other drying methods (Fito *et al*., 1998; Lazarides *et al*., 1999; Nieto *et al*., 2004; Pani *et al*., 2008). One of the most important advantages of osmotic dehydration is the use of low temperatures, so that water removal takes place without phase exchange, and therefore damage to colour, taste and aroma is minimized (Moraga *et al*., 2000; Moreno *et al*., 2000). Moreover, this technique promotes the biosynthesis of key aroma compounds in fruit such as strawberries (Zabetakis & Holden, 1997; Escriche *et al*., 2001; Talens, 2002), pineapples (Pino *et al.,* 1999) and kiwis (Bereiter, 2001). All of this, together with acidity reduction and an increase in the concentration of solutes (sugars), may contribute to improving the taste of acidic and/or sour fruit such as grapefruit.

On the other hand, during osmotic dehydration, besides the loss of water, some natural compounds, such as pigments, aromas, acids, minerals and vitamins are released into the solution (Valdez-Fragoso *et al*., 1998; Dalla-Rosa & Giroux, 2001; García-Martínez *et al*., 2002a). The reutilization of the osmotic solution would mean an accumulation of these compounds and, from this point of view, its use as an ingredient in the formulation of new products could be an interesting alternative. In fact, there are some authors who propose osmotic dehydration for the elaboration of jam without heat treatment (Shi *et al.*, 1996; García-Martínez *et al.*, 2002b), and semi-concentrate products (such as canned liquid products, carbonated beverages, fruits juices, etc). (Gonzáles-Mariño *et al.*, 2001, Dalla-Rosa & Giroux, 2001). However, some disadvantages related to the handling of large volumes of osmotic solutions and high water consumption should be considered. Dry Osmotic Dehydration (DOD) might be an option since the volume of solution generated is considerably lower than the volume managed in the wet method. Previous studies have demonstrated that there is also a greater concentration of aromatic compounds, and soluble vitamins and minerals, as this solution comes from the product itself (Doménech & Escriche, 2009). DOD consists of covering the product with a solid osmotic agent (avoiding the use of a solution), and leaving this to perform for a period of time provoking the egress of water from the interior of the product. So, as in traditional osmotic dehydration, the obtained product would be more stable than the fresh one as it has decreased moisture content and water activity (Rosa *et al.*, 2008; Peinado *et al.*, 2009).

Strawberries are especially interesting because of their content in fibre, minerals, vitamins and other functional compounds such as phenols, many of which have healthy properties. Nevertheless, strawberries in general have a very significant seasonality and a high water content that make them very perishable. Recent food trends (fast food and ready-to-eat food) have resulted in a decrease in the consumption of fresh fruit especially among young people. Although there is a wide range of processed fruit products, such as juices, milky beverages or concentrates, it is important to note that many of them have low fruit content, which in many cases is replaced with a large amount of additives.

On the other hand, since sugar consumption is directly related to health problems like obesity, one of the goals of the food industry is the development of natural sugar control and low glycemic foods (Sloan, 2005; Peinado *et al*., 2008). Nowadays there are products which replace common sugar with non-caloric sweeteners (glutamate, saccharin, aspartame and polyols (sorbitol) among others). Polyols have a characteristic sweet taste, but the energetic value (calories) of the product is lower when compared with foods containing sucrose (Riku & Yrjö, 2001). There is another possible sucrose replacer in the market, isomaltulose, which might help to decrease the insulinemic response provoked by other foods. It is found in small amounts in honey and sugar cane (Siddiqui & Furgala, 1967; Low & Sporns, 1988; Barez *et al*., 2000) but can be easily obtained from sucrose by means of an enzymatic process (Weidenhagen & Lorenz, 1957; Mauch & Schmidt-Berg-Lorenz, 1964; Schiweck, 1980, Schiweck *et al*., 1990).

Finally, it should be said that colour and texture are sensorial parameters of great interest in the food industry since consumers base their choices on the external aspects of the products, and most of the time they look for products similar to the fresh ones. For example, regarding the colour characteristics of this kind of product, a brilliant red colour is desired by consumers who associate this aspect with "freshness" and "healthiness" as opposed to a dark red colour which may led to rejection of the product (Cordenunsi *et al*., 2003). Moreover, regarding texture, this kind of product usually requires the addition of pectin to achieve an adequate gel consistency, so the amount of pectin depends on the amount of sugars and acids as well as the kind of fruit (Rauch, 1987; Gabriele *et al*., 2001; Renard *et al*., 2006).

The aim of this work was to analyze the influence of processing variables, type of sugar (sucrose or isomaltulose), elaboration method (dry or wet osmotic dehydration, and percentage of fruit), and pectin percentage (1, 1.5 and 2 %) on the mechanical and optical properties of 30 ºBrix strawberry spreadable products. Sensorial response and analytical data obtained by instrumental measurements were also compared.

2. Material and Methods

2.1. Raw material

Strawberries (*Fragaria vesca,* Camarosa), acquired in a local supermarket between March and June but always from the same supplier that has different controlled production areas in different zones of Spain. After carrying out a visual selection in terms of colour, shape and level of ripeness to eliminate damaged fruit and homogenise the sample, the strawberries were cleaned and they were cut into cubes of approximately 1 cm^3.

Samples were dipped in chlorinated water to eliminate possible pesticide residues, and then they were cut into cubes of approximately 1 cm^3.

2.2. Methodology

Figure 1 shows the flow chart of the processing conditions depending on the different variables to get the strawberry spreadable products. As it can be seen, the process was carried on in two stages:

Equilibrium of the samples:

Two osmotic agents were used, sucrose (as reference sugar) and isomaltulose (98 %) (Diexpa S.A., Spain). Samples were equilibrated using two osmotic dehydration processes. Wet Osmotic Dehydration (WOD), traditional osmotic dehydration in which samples were immersed in 40 ºBrix hypertonic solutions, and Dry Osmotic Dehydration (DOD) in which samples were directly covered with the solid osmotic agent (sucrose or isomaltulose). This last method is similar to the dry salting process commonly applied to meat and fish products. Osmotic dehydration was carried out until samples achieved

30 ºBrix (equilibrium concentration). The appropriate fruit-solution ratio was calculated with the correspondent mass balance. The process was carried out 25 ºC. The final point control was determined by refractometry measuring the soluble solids concentration in the osmotic solution.

Jellification

Once equilibrium was reached, the dehydrated fruit was separated from the osmotic solution in order to formulate different spreadable products. The ingredients in the formulations were: dehydrated strawberry, osmotic solution, apple pectin (1, 1.5 or 2 %) as a gelling agent and potassium sorbate at a fixed concentration of 500 ppm (as a microbiological preserver) (Karabulut *et al*., 2001; Castelló *et al*., 2011). According to the different proportions of dehydrated strawberry-osmotic solution and dehydration method (wet or dry) three different strawberry spreads were elaborated: W, spreads obtained by means of WOD and formulated with a dehydrated fruit-osmotic solution ratio of 70:30; D1, spreads obtained by means of DOD and formulated with the total amount of dehydrated fruit and final osmotic solution obtained and D2, spreads obtained by means of DOD and formulated with a dehydrated fruit-osmotic solution ratio of 70:30.

Finally, depending on the different variables (type of sugar, elaboration method and pectin percentage) 18 different strawberry spreads were formulated (table 1). Products were homogenized with a mixer for 3 minutes. Then they were stored for 24 hours at 25 ºC to allow correct gel stabilization before performing the analysis. All the analyses in each of the samples were carried out by triplicate.

2.3. Analytical determinations

2.3.1. Physicochemical analyses

All measurements were carried out in triplicate. Moisture content was determined gravimetrically by drying to constant weight in a vacuum oven at 60 ºC (method 20.103 AOAC, 1980). Soluble solids content (ºBrix) was measured, in previously homogenized samples, with a refractometer at 20 ºC (ATAGO 3 T), (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). pH was determined with a pH-meter (SevenEasy, Mettler Toledo).

2.3.2. Colour

Instrumental measurements of colour were conducted at room temperature in a Minolta spectrophotometer (model CM-3600d), placing the strawberry spread in a 20 mm thick, transparent plastic cell and using a black plate as the background to standardize the measurements. Visible absorption spectra were recorded between 380 and 770 nm by reflectance to obtain tristimulus values of CIEL*a*b*, using illuminant D_{65} and standard observer (10° visual field) as references.

2.3.3. Texture

Objective determinations of strength and consistency were measured with the back-extrusion test using a texturometer TA/XT/PLUS Texture Analyser and the accessory Back extrusion cell with 35 mm ring (García-Martínez *et al.*, 2002b; Sesmero *et al.*, 2007).

The back-extrusion test consisted of making a circular base embolus 35 mm in diameter through the sample contained in a cylindrical glass vessel, at a constant speed of 1 $mm \cdot s^{-1}$. For all the assays the embolus covered the same distance to the bottom of the vessel and the amount of sample was the same.

This assay provides a typical curve with two characteristic areas. The above area of the curve (A_{1-2}) is taken as a measurement of **consistency**, while the negative area (A_{2-3}) is an indication of the **cohesiveness** and also consistency/viscosity of the sample (Sesmero *et al.*, 2007).

2.3.4. *Sensory evaluation*

A Friedman Pairwise Ranking Analysis was used to evaluate the consumer preferences of the formulations (Meilgaard *et al.*, 1999; Escriche *et al.,* 2001; González-Tomás *et al.*, 2004). This test was chosen as it is particularly useful for a relatively inexperienced panel (non trained panellists) to evaluate sets of three to six samples considering a single attribute each time. 20 subjects constituted the panel which performed the sensory evaluation. The selected samples for this evaluation were presented to each of the subjects, in all possible paired combinations.

The selection of the sensory attributes was based on the characteristic criteria of the samples as well as some previous experiments carried out on similar products (Abdullah & Cheng, 2001; Levaj *et al.*, 2010). The panellists were asked which of the two presented samples they preferred, according to each of the different attributes to be evaluated, in the following order: colour (under white light), spreadability (spreading the product on bread), taste (eating the product with a teaspoon), cohesiveness (sticky feeling in mouth), taste with bread (eating the product once it has been spread on bread) and the global preference.

In order to establish the existence of significant differences between the samples, the statistical function T Friedman was calculated by means of equation (I). These results were compared with the tabulated X^2=7.81 (α=0.05) with (t-1) degrees of freedom (Meilgaard *et al.,* 1999).

$$T= (4/p\cdot t)\cdot \sum_{i=1}^{t} R_i^2 - (9\cdot p\cdot [t-1]^2) \qquad (I)$$

where,

p=number of panellists

t=number of samples (t=4)

R_i=rank sum for each evaluated attribute

Afterwards, the HSD (Tukey's honestly significant difference) was calculated to establish between which samples these differences lay, (equation II) (Meilgaard *et al.*, 1999):

$$HSD=q_{\alpha,t,\infty}(p\cdot t/4)^{1/2} \qquad (II)$$

where,

$q_{\alpha,t,\infty}$=value in table T4

p=number of panellists

t=number of samples (t=4)

2.3.5. Statistical analysis

Statgraphics Centurion was used to perform the statistical analyses. Analyses of variance (multifactor ANOVA) were carried out to estimate the significance effect of the process variables (kind of sugar, elaboration method and % of pectin) on the final product. Furthermore a Correspondence Analysis (CA) was performed to establish the relationship between the selected samples and the evaluated sensory attributes. This graphical tool establishes the association structure between categorical variables (McEwan & Schlich, 1991/92; Guerrero *et al.*, 2010; Beh *et al.*, 2011).

3. Results and Discussion

3.1. Physicochemical characterization of spreadable products

The composition of the strawberry spreads in terms of water activity (a_w), soluble solids content (x^{ss}), moisture content (x^w) and pH is shown on table 1. It can be observed that there were no significant differences between the different spreads in terms of soluble solids content or pH, as they were all formulated to reach a final concentration of 30 ºBrix. Nevertheless, a_w exhibited different values depending on the sugar used in the formulation. These differences might be the result of the different configuration of the sugar molecules, so despite the equal molecular size, the higher solubility leads to a reduction of a_w.

3.2. Influence of the formulation on the optical and mechanical properties of the spreadable strawberry products

Table 2 shows the colorimetric coordinates of the different products obtained. In general, the strawberry spreads showed lower values of L*, a* and b* when compared with fresh strawberries, independently of the process variables. Therefore, lower Chroma ($C^* = (a^{*2}+b^{*2})^{1/2}$), L* values (darkening of samples) and a slight decrease in hue ($h^* = \text{arctg}\,(b^*/a^*)$) were observed too. This decrease in the colorimetric coordinates after the formulation process might be due to the higher soluble solids content of strawberry spreads compared with fresh strawberries, and/or the degradation of the red anthocyanin pigments, which are the principal phenolic compounds responsible for the strawberry colour (Francis, 1985). In fact, García-Viguera *et al.*, 1999, pointed out that anthocyanins are very sensitive to oxidation when exposed to light and oxygen.

As it can be seen, there was no clear trend for the colorimetrical coordinates (L*, a* and b*), with respect to the sugar used or the pectin percentage. On the other hand, the elaboration method D2 (DOD removing liquid phase) seemed to be the method which better preserved the colour of fresh strawberries. Dervisi *et al.*, (2001) point out that the percentage of pectin seems to have an influence on the colour of different jams. Moreover, Withy *et al.,* (1993) suggest that red colour stability is affected by different factors such as temperature, pH, oxygen concentration, and sugar, acid and metal content. The influence of the different ingredients on the food system does not only depend on their concentration or distribution within the different system phases but also on the different component interactions. This determines the differences in the results shown in this work.

Figure 2 shows the values of consistency and cohesiveness of the different evaluated products. As could be expected, the higher the percentage of pectin, the higher the consistency and cohesiveness values. The elaboration method also presented an influence on texture parameters, probably not only because of the different fruit-solution proportions but also because of the different amounts of liquid phase depending on the dehydration methods (WOD or DOD). Lower liquid phase levels and higher fruit-solution ratios lead to spreadable fruit products with higher consistency and cohesiveness values. Finally there were differences in the mechanical properties depending on the sugar used; the fruit spreads formulated with sucrose being the ones with the highest values for texture parameters. It is important to point out that the differences observed as a result of the different sugars and the different elaboration methods became more important as the pectin percentage increased. Thus, products formulated under D2-S-2 conditions (DOD removing liquid phase- sucrose - 2 % Pectin) achieved the highest consistency and cohesiveness values; while jellification of the products containing 1 % of pectin was not enough to give products with similar values of consistency and cohesiveness to those presented by commercial jams. These results suggest different behaviour in the food matrix depending not only on the different ingredients but also on the different proportions and interactions. (Rauch, 1987; Dervisi *et al*., 2001; Renard *et al*., 2006)

The statistical analyses (ANOVA) confirmed the results discussed above. Table 3 shows the statistical results for the homogeneous groups depending on the different process variables. Regarding the colour parameters, it can be said that neither the sugar used nor the pectin percentage had a significant effect (p_{value}< 0.05) on the colour of the different products, while the elaboration method seemed to be the only parameter which produced differences in the colorimetric coordinates. As commented above, the D2 method seemed to preserve the colour of fresh strawberries best. On the other hand, the sugar used, the elaboration method and the percentage of pectin had a significant effect (p_{value}< 0.05) on the texture of the different products.

3.3. Sensory evaluation

Of the 18 possible formulations, only four strawberry spreads with isomaltulose were selected to carry out the sensory evaluation (Table 4). Sucrose formulations were not selected for the following reasons: Firstly, the instrumental results did not show important differences between those spreadable strawberry products formulated with sucrose and those formulated with isomaltulose. Secondly, one of the principal interests of this study was to discern the sensory perception of consumers when sucrose was totally replaced with isomaltulose. Finally, it was not considered appropriate to compare sucrose and isomaltulose formulations in terms of sweetness as sucrose is twice as sweet as isomaltulose (Schiweck, 1980; Hawai *et al*., 1989; Lina *et al*., 2002). Wet Osmotic Dehydration formulations (W) were not selected as the mechanical and optical results obtained with this method were not very different from those obtained with Dry Osmotic Dehydration eliminating liquid phase (D2). Moreover, the former dehydration method produces much higher volumes of generated osmotic solution, with the consequent disadvantages from an environmental point of view. Finally, products containing 1 % pectin were also avoided as this pectin level produced spreads which were not consistent and cohesive enough to allow the typical jelly texture presented by commercial jellies and spreads. Therefore, a total of 6 pairs, corresponding to all the possible pairings of the 4 products, were evaluated by the panellists.

Table 4 shows the results of the pairwise ranking test for the sensory evaluation of the four spreadable strawberry products selected. It shows the number of times that each row sample was preferred to each column sample for each attribute. The first step in the Friedman analysis is to compute the rank sum for each sample. In this case the rank sums were obtained by adding the sum of row frequencies to twice the sum of the column frequencies (Table 5). The most preferred samples have the lowest values on the ranking scale, and the least preferred the highest values, depending on the evaluated attribute. In order to evaluate whether there were significant differences between the four samples for each of the evaluated attributes, the statistical function T Friedman was obtained as mentioned in material and methods (Escriche *et al.,* 2001; González-Tomás *et al*., 2004). As these T values were higher than the tabulated X^2=7.81 (α=0.05) in all cases (except for colour), there were significant differences between the four samples for all the other evaluated attributes with a significance level of 95 % (Meilgaard *et al*., 1999).

Once it was demonstrated that significant differences existed between the samples, it was necessary to discover where the differences lay. For this reason, the HDS (which indicates whether two samples are significantly different) was calculated, as explained in material and methods. There are significant differences between two spreadable products, for each attribute, when the difference between their rank sum values is higher than the HDS (16.23). On the contrary, when the difference between the rank sum values is lower than the HDS (16.23), there is no significant difference between the two samples for this attribute. In Table 5, the indices “a” or “b” are used to indicate homogeneous groups (Meilgaard *et al*., 1999).

Regarding colour, panellists did not notice significant differences between the different spreadable products. Nevertheless formulation D1-1.5 was the one with the best evaluated attributes in terms of adhesiveness, taste, taste with bread and global appreciation, though its spreadability obtained the lowest value. This formulation showed significance differences with formulation D2-2 which attained the worst evaluated attributes in terms of adhesiveness, taste, taste with bread and global appreciation, but the best spreadability value. These results were not surprising as they were the spreadable products with the greatest differences in their process variables.

A Correspondence Analysis was conducted to better understand the relationship between the preferences of the subjects and the evaluated attributes from a descriptive point of view. Figure 3 shows the two dimension plot of sample scores and compound loadings obtained by means of the correspondence analysis. The first two dimensions explained 95.57% of the total variance (Dimension 1, 56.61% and Dimension 2, 38.96 %). The attributes which contribute the most to the global preference “*global*” were cohesiveness, taste, and taste with bread, as they are located close to each other on the right side of the plot. Given their proximity to these attributes, the spreadable products formulated by means of D1 (Dry Osmotic Dehydration without eliminating liquid phase) were the ones which were preferred. On the other hand, spreadability was the attribute which contributed least to the global preference of the product, this attribute being located on the left side of the plot, together with spreadable products formulated by means of D2 (Dry Osmotic Dehydration eliminating liquid phase). Moreover, there were no differences between the colour of the different formulations (values of C* and h* were very similar) since this attribute was located at the top of the plot and did not really contribute to the panellists' choices.

Finally, with the aim of observing the relation between the mechanical parameters obtained by means of instrumental analyses, and the sensorial preferences, these instrumental values were plotted in Figure 3. It shows, how the most appreciated values of mechanical properties were those ranging from 4 to 5 N·s for consistency, and 0.6 to 0.9 N·s for cohesiveness, while higher values of both parameters were not appreciated by the panellists.

4. Conclusions

The type of sugar, the fruit-solution proportion and the pectin percentage have a high influence on the texture (consistency and cohesiveness) of the spreadable strawberry products. Of these, the sucrose products with more fruit and high pectin percentage had the highest values for texture, as expected. Regarding instrumental measurements, colour does not seem to be affected by the different variables, though the spreadable strawberry products obtained with "Dry Osmotic Dehydration eliminating the liquid phase" (D2), seem to be more similar to fresh strawberries. Global preference was mainly influenced by taste and texture, the most appreciated products being those obtained without eliminating the osmotic solution and containing intermediate levels of pectin. These results suggest that spreadable products made with isomaltulose could have a good acceptability among consumers. Nevertheless, further research would be interesting to establish the self-life of the product. For instance a mild heat treatment such as pasteurization, once the final spread is formulated, may be indicated to give more durability to the product without decreasing its quality.

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Table 1. Average physicochemical composition of strawberry spreadable products depending on type of sugar, elaboration method and pectin percentage (n=3).

30 Brix			x^w	x^{ss}	a_w	pH
	Elaboration	**% Pectin**				
			Sucrose			
1		1	0.665 (0.002)	0.320 (0.009)	0.952 (0.002)	-
2	W	1.5	0.6580 (0.0004)	0.325 (0.004)	0.9550 (0.0006)	3.663 (0.012)
3		2	0.6667 (0.004)	0.323 (0.002)	0.9550 (0.0012)	3.56 (0.02)
4		1	0.6703 (0.0004)	0.326 (0.005)	0.9490 (0.0012)	-
5	D1	1.5	0.6640 (0.0009)	0.309 (0.006)	0.9480 (0.0012)	-
6		2	0.6688 (0.0012)	0.327 (0.003)	0.952 (0)	3.62 (0)
7		1	0.687 (0.002)	0.306 (0.002)	0.9530 (0.0006)	3.633 (0.006)
8	D2	1.5	0.6823 (0.002)	0.302 (0.003)	0.958 (0.002)	3.617 (0.006)
9		2	0.663 (0.002)	0.26 (0.02)	0.9470 (0.0012)	-
			Isomaltulose			
10		1	0.73 (0.06)	0.31 (0.02)	0.9700 (0.0006)	3.753 (0.006)
11	W	1.5	0.6775 (0.0012)	0.266 (0.006)	0.967 (0.002)	3.547 (0.012)
12		2	0.6766 (0.0012)	0.29 (0.02)	0.971 (0.002)	-
13		1	0.699 (0,002)	0.278 (0.007)	0.9670 (0.0006)	3.580 (0.012)
14	D1	1.5	0.6905 (0.0012)	0.293 (0.014)	0.968 (0.002)	3.637 (0.012)
15		2	0.6890 (0.0008)	0.3019 (0.003)	0.9640 (0.0006)	-
16		1	0.706 (0.005)	0.277 (0.003)	0.9640 (0.0006)	-
17	D2	1.5	0.691 (0.003)	0.283 (0.008)	0.9720 (0.0006)	-
18		2	0.719 (0.002)	0.29 (0.02)	0.9710 (0.0012)	3.660 (0.012)

Mean (standard deviation)

Table 2 Values of the colorimetrical coordinates (L^*, a^*, b^*), chroma (C^*) and hue (h^*) of raw strawberries and the different spreadable products depending on the different variables

			L^*	a^*	b^*	C^*	h^*
Raw strawberries			35.77 (0.09)	23.1 (0.2)	9.98 (0.09)	25.2 (0.2)	23.3 (0.2)
Sucrose							
1		1	37.211 (0.008)	15.6 (0.2)	6.42 (0.13)	16.9 (0.2)	22.3 (0.2)
2	W	1.5	31.2 (0.2)	17.9 (0.3)	7.569 (0.108)	19.4 (0.3)	22.9 (0.4)
3		2	31.353 (0.106)	19.7 (0.2)	8.9 (0.2)	21.7 (0.3)	24.5 (0.2)
4		1	30.1 (0.3)	17.2 (0.5)	8.5 (0.3)	19.2 (0.6)	26.33 (0.09)
5	D1	1.5	32.2 (0.3)	17.3 (0.3)	8.1 (0.2)	19.1 (0.4)	25.2 (0.2)
6		2	30.31 (0.09)	15.39 (0.02)	7.0 (0.04)	16.90 (0.03)	24.428 (0.103)
7		1	31.4 (0.2)	18.4 (0.5)	7.9 (0.2)	20.1 (0.5)	23.2 (0.2)
8	D2	1.5	31.3 (0.2)	19.2 (0.3)	8.4 (0.2)	21.0 (0.3)	23.6 (0.2)
9		2	33.6 (0.4)	18.7 (0.7)	8.5 (0.4)	20.5 (0.8)	24.6 (0.2)
Isomaltulose							
10		1	31.6 (0.2)	16.7 (0.4)	6.5 (0.2)	17.9 (0.4)	21.3 (0.2)
11	W	1.5	32.2 (0.2)	16.7 (0.4)	7.7 (0.2)	18.4 (0.5)	24.8 (0.2)
12		2	33.2 (0.3)	17.1 (0.2)	7.6 (0.2)	18.8 (0.2)	23.9 (0.5)
13		1	30.2 (0.2)	16.3 (0.6)	7.6 (0.3)	18.0 (0.8)	25.16 (0.05)
14	D1	1.5	30.62 (0.05)	17.03 (0.13)	7.68 (0.14)	18.7 (0.2)	24.3 (0.2)
15		2	37.5 (0.3)	15.2 (0.4)	6.7 (0.2)	16.6 (0.5)	23.7 (0.1)
16		1	31.4 (0.2)	19.3 (0.4)	9.0 (0.3)	21.3 (0.5)	25.1 (0.2)
17	D2	1.5	34.3 (0.2)	19.6 (0.2)	8.91 (0.13)	21.5 (0.2)	24.5 (0.2)
18		2	30.38 (0.09)	15.30 (0.13)	6.09 (0.03)	16.5 (0.2)	21.7 (0.07)

Variables: elaboration method (*W* wet osmotic dehydration, *D1* dry osmotic dehydration without eliminating the liquid phase, *D2* dry osmotic dehydration eliminating the liquid phase); type of sugar (*S* sucrose, *I* isomaltulose); and pectin percentage (1, 1.5 and 2 g pectin/100 g) (n=3)

Values are presented as mean (standard deviation)

Table 3 Homogeneous groups identified from the ANOVA factorial performed depending on the elaboration method (W, D1 or D2); type of sugar (S or I); and pectin percentage (1, 1.5 and 2 g pectin/100 g)

	Sugar		Elaboration method		% Pectin	
Colorimetric coordinates						
	S	32.1 (0.3) (a)	W	32.8 (0.4) (a)	1	32.0 (0.4) (a)
*L**			D1	31.8 (0.4) (a)	1.5	32.0 (0.4) (a)
	I	32.4 (0.3) (a)	D2	32.1 (0.4) (a)	2	32.7 (0.4) (a)
	S	17.72 (0.13) (b)	W	17.72 (0.16) (b)	1	17.24 (0.16) (a)
*a**			D1	16.40 (0.16) (a)	1.5	17.96 (0.16) (b)
	I	17.02 (0.13) (a)	D2	18.41 (0.16) (c)	2	16.90 (0.16) (a)
	S	7.94 (0.09) (b)	W	7.47 (0.12) (a)	1	7.66 (0.12) (a)
*b**			D1	7.61 (0.12) (a)	1.5	8.07 (0.12) (b)
	I	7.54 (0.09) (a)	D2	8.14 (0.12) (b)	2	7.48 (0.12) (a)
Texture values						
	S	6.4 (0.4) (b)	W	6.7 (0.5) (b)	1	4.6 (0.5) (a)
Consistency			D1	4.2 (0.5) (a)	1,5	6.0 (0.5) (b)
	I	5.6 (0.4) (a)	D2	7.1 (0.5) (b)	2	7.4 (0.5) (c)
	S	1.12 (0.08) (b)	W	1.2 (0.1) (b)	1	0.7 (0.1) (a)
Cohesiveness			D1	0.7 (0.1) (a)	1.5	1.0 (0.1) (b)
	I	0.97 (0.08) (a)	D2	1.3 (0.1) (b)	2	1.5 (0.1) (c)

Values are presented as mean (standard deviation)

W wet osmotic dehydration, *D1* dry osmotic dehydration without eliminating liquid phase, *D2* dry osmotic dehydration eliminating liquid phase, *S* sucrose, *I* isomaltulose

Same letters in parentheses mean no significant difference

Table 4 Pairwise ranking test: number of times that each row sample was selected as to have better attributes than each column sample

	D1-1.5	D1-2	D2-1.5	D2-2
Cohesiveness				
D1-1.5	–	10	17	15
D1-2	9	–	12	16
D2-1.5	2	7	–	13
D2-2	5	4	5	–
Taste				
D1-1.5	–	12	19	14
D1-2	8	–	9	13
D2-1.5	0	11	–	13
D2-2	6	7	4	–
Colour				
D1-1.5	–	10	9	9
D1-2	7	–	11	9
D2-1.5	9	7	–	12
D2-2	8	9	5	–
Spreadability				
D1-1.5	–	7	6	6
D1-2	13	–	6	7
D2-1.5	14	14	–	8
D2-2	14	13	9	–
Taste with bread				
D1-1.5	–	11	16	15
D1-2	8	–	9	10
D2-1.5	3	11	–	11
D2-2	5	8	6	–
Global				
D1-1.5	–	12	16	13
D1-2	8	–	9	10
D2-1.5	4	11	–	14
D2-2	7	10	5	–

Pectin percentage, 1.5 and 2 g pectin/100 g

D1 dry osmotic dehydration without eliminating the liquid phase, *D2* dry osmotic dehydration eliminating the liquid phase)

Table 5 Rank of the different attributes obtained by Friedman test

	D1-1.5	D1-2	D2-1.5	D2-2
Colour	76 (a)	79 (a)	78 (a)	82 (a)
Cohesiveness	74[a] (a)	79[a] (a)	90 (ab)	102[a] (b)
Taste	73[a] (a)	90 (ab)	88 (ab)	97[a] (b)
Spreadability	101[a] (b)	94 (ab)	78[a] (a)	78[a] (a)
Taste (bread)	74[a] (a)	87 (ab)	87 (ab)	91[a] (b)
Global	79[a] (a)	93 (ab)	89 (ab)	96[a] (b)

Pectin percentage, 1.5 and 2 g pectin/100g; HSD=16.2339 ($p<0.05$), $q_{\alpha,t,\infty}$ being 3.65

Same letters in parentheses mean no significant difference

D1 dry osmotic dehydration without eliminating the liquid phase, *D2* dry osmotic dehydration eliminating liquid phase

[a] Values in the same row with significant differences (95 %)

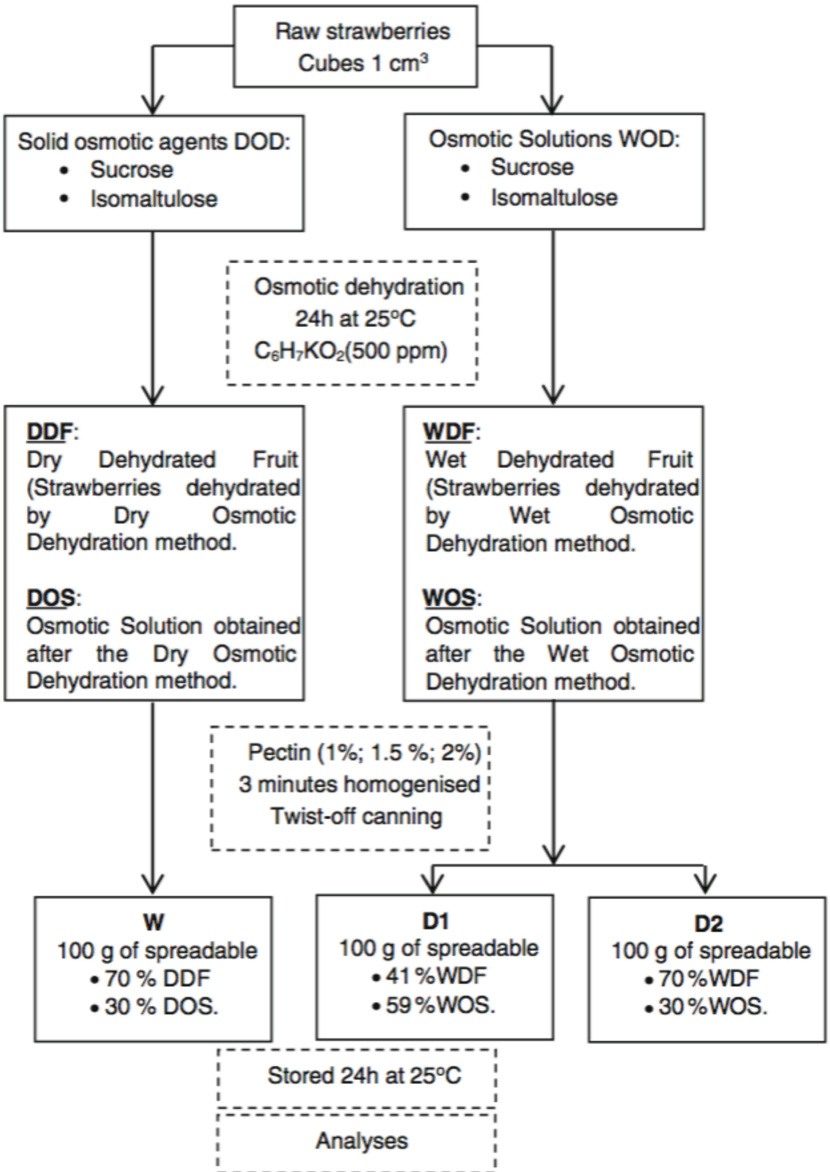

Figure 1: Flow chart of the processing conditions

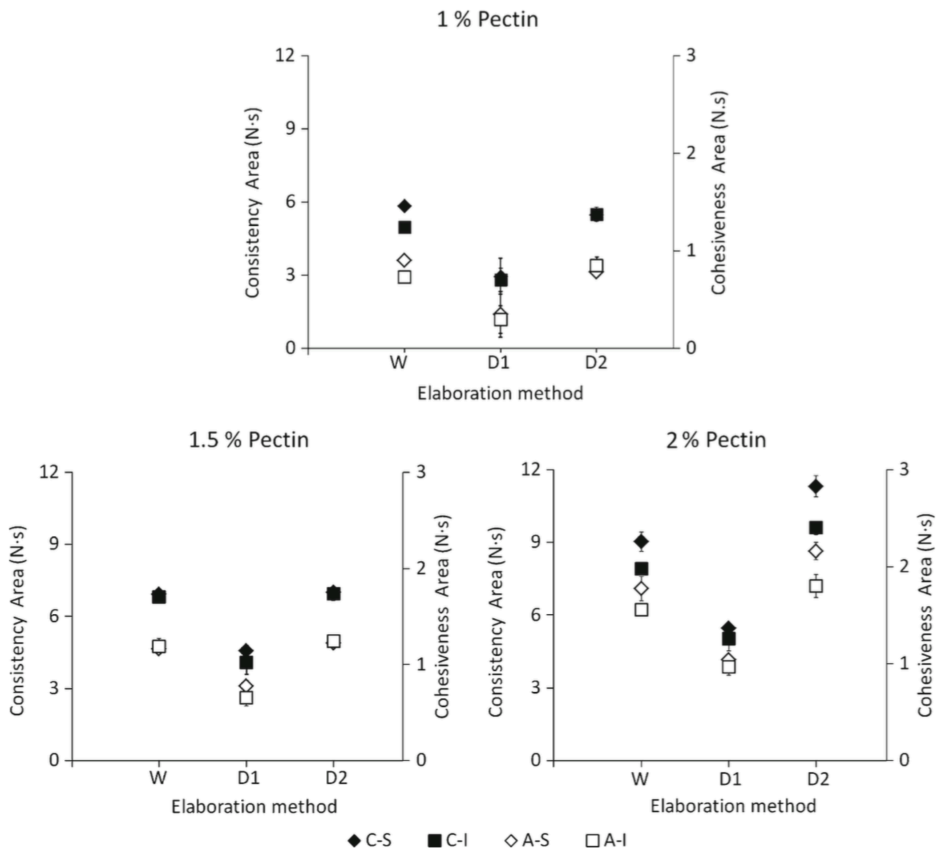

Figure 2: Values of consistency (C: positive area of curve Force *vs*. time (N·s)) and cohesiveness (A: negative area of curve Force *vs*. time (N·s)) of strawberry spreads considering elaboration method (W: *Wet Osmotic Dehydration*; D1: *Dry Osmotic Dehydration without eliminating liquid phase*; D2: *Dry Osmotic Dehydration eliminating liquid phase*), type of sugar (S: Sucrose; I: Isomaltulose) and pectin percentage (1, 1.5 and 2 %).

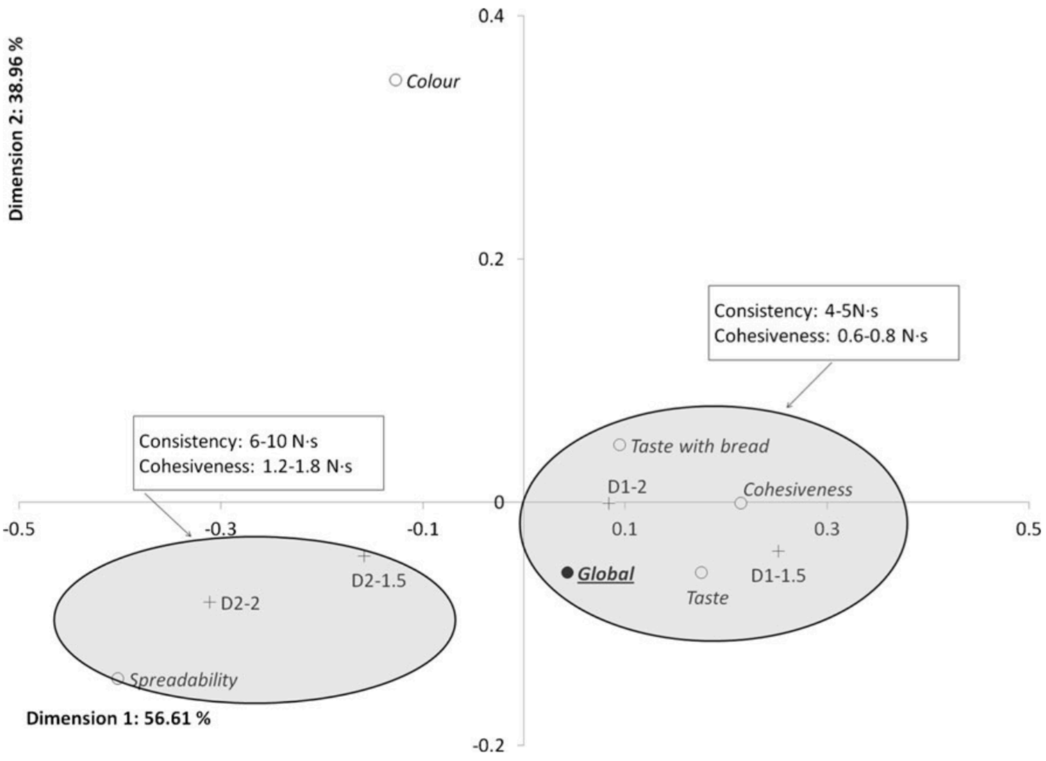

Figure 3: Two-dimensional correspondence plot (95.57% of the total variance: Dimension 1, 56.61 % and Dimension 2, 38.96 %), obtained from performing the correspondence analysis for the four selected samples considering the elaboration method (D1: *Dry Osmotic Dehydration without eliminating liquid phase*; D2: *Dry Osmotic Dehydration eliminating liquid phase*), and pectin percentage (1.5 and 2 %).