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Use of isomaltulose to formulate healthy spreadable strawberry products. Application of response surface methodology

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Pelargonidin-3-glucoside (PubChem CID: 443648)
Citric acid (PubChem CID: 311)
Potassium sorbate (PubChem CID: 23676745)
1,1-Diphenyl-2-picrylhydrazyl radical (DPPH) (PubChem CID: 2735032).

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ABSTRACT

Response surface methodology (RSM) was applied to optimize the formulation of a 50 Brix spreadable strawberry product with healthier sugars and a high percentage of fruit. A central composite design was applied to analyse the influence of four independent variables on the quality parameters. Each of the variables was analysed at five different levels (X_1: % of isomaltulose (0, 12.5, 25, 37.5 and 50%), X_2: % of pectin (0.5, 1, 1.5, 2 and 2.5%), X_3: % of citric acid (0, 0.25, 0.5, 0.75 and 1%) and X_4: time of thermal treatment (0, 5, 10, 15 and 20 min). Physicochemical properties, microbiological stability, antioxidant properties (anthocyanin content and antioxidant activity) as well as optical and mechanical properties were considered for the optimization. The influence of storage time on the above parameters was also evaluated. Percentages of pectin and citric acid were the variables that most influenced the measured parameters. In general terms, high levels of these two variables (2% pectin; 0.75% citric acid) resulted in greater antioxidant activity, consistency and adhesiveness values. The optimal formulation to obtain a spreadable strawberry product was fresh strawberry, 50% fructose, 50% isomaltulose, 1% citric acid and 1.5% pectin; the ingredients were mixed, and heated to 85 °C, and the product was stable after 90 days stored at room temperature.

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1. Introduction

Nowadays, fruit is receiving ever more attention because of to its high functionality and nutritional value. Among all the available fruits, strawberries are especially interesting due to their content in fibre, minerals, vitamins and other functional compounds such as phenols, many of which have healthy properties. However, strawberries are very seasonal and have a high water content that makes them very perishable (Gillman et al., 1995; Cavanah, Hipwell, & Wilkinson, 2003; Dhiraj, Vattem, & Shetty, 2005).

On the other hand, 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, milk based 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 (colorants, flavour enhancers, bulk agents. etc.). Therefore, there is an increased interest for the food industry in developing new processed fruit products with sensory characteristics not very different from those of fresh fruit. For example strawberry spreads, whose characteristics are closer to fresh fruit than other processed products. The main difference between a spreadable fruit product and a jam is that in the former, the step of 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 (B.O.E. 04/07/07, 2003, whereas there is no restriction related to sugar content for spreadable fruit products. On the other hand, since sugar consumption is related to health problems such as obesity, one of the goals of the food industry is the replacement of traditional sugars with natural healthier sugars, which have low glycaemic indexes among other functional properties (Sloan, 2005; Peinado, Rosa, Heredia, & Andrés, 2008; Peinado, Rosa, Heredia, Escriche, & Andrés, 2013). Isomaltulose is a disaccharide that is commercially manufactured enzymatically from sucrose via bacterial fermentation. It is especially indicated for children and senior citizens as it does not produce caries, and moreover is slowly released in the blood (Matsuyama, Sato, & Hoshino, 1997; Schiweck, Munir, Rapp, Schenider, & Bogel, 2000; Lina, Jonker, & Kozianowski, 2002). Therefore, isomaltulose could be a healthy replacer of sucrose in the development of fruit products.

Since consumers base their choices on the external aspects of the products as well as on their nutritional and functional value, the best formulation of a spreadable strawberry product would be one which provides acceptable colour and texture, but also a large amount of antioxidants. Regarding colour, a brilliant red colour is associated with "freshness" and "healthiness" as opposed to dark red, which may lead to rejection of the product (Cordenunsi, Nascimento, & Lajolo, 2003). Colour stability of this kind of product is affected by temperature, pH, oxygen, sugar content, ascorbic acid and metals (Withy, Nguyen, Wrolstad, & Heatherbell, 1993). The major pigments in strawberries are pelargonidin-3-glucoside and cyanidin-3-glucoside, which have been reported to have a great contribution to the total antioxidant activity of these products (Wang & Jiao, 2000; Wang & Lin, 2000). The degradation of these pigments may result in discolouration of the product. During processing they can be hydrolysed, and degraded to anthocyanidin and sugar. The anthocyanidins are unstable when exposed to light and are more easily oxidized than the anthocyanin, and consequently more susceptible to browning reactions (Herrmann, 1972). The total amount of these pigments is important for the stability of the colour of the product as well as for their contribution to the total antioxidant activity (Wang & Jiao, 2000; Wang & Lin, 2000). Anthocyanin may react with ascorbic acid, resulting in degradation of both components (Francis, 1985). Finally, 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, De Cindio, & D'Antona, 2001; Renard, Van de Velde, & Vischers, 2006).

The aim of this work was to analyse the influence of four independent variables on the quality parameters of 50 Brix spreadable strawberry products after 24 h and 90 days of storage. Each of the variables was analysed at five different levels (X_1: % of isomaltulose (0, 12.5, 25, 37.5 and 50%), X_2: % of pectin (0.5, 1, 1.5, 2 and 2.5%), X_3: % of citric acid (0, 0.25, 0.5, 0.75 and 1%) and X_4: time of thermal treatment (0, 5, 10, 15 and 20 min). Physicochemical properties, microbiological stability, antioxidant properties (anthocyanin content and antioxidant activity) as well as optical and mechanical properties were considered for the optimization. Response surface methodology (RSM) was applied to optimize the formulation.

2. Material and methods

2.1. Raw material

Fifteen batches of Strawberries (*Fragaria vesca,* Camarosa), were acquired in a local supermarket between February and

Table 1 – Independent variables and levels of the 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.

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