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Fruit fillings development: A multiparametric approach

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ABSTRACT

Fruit fillings were formulated with native tapioca starch (TS), modified waxy corn starch and a mixed system of TS plus low-methoxyl pectin, two quantity of fruit and replacement of sucrose with polydextrose and intense sweeteners.

The twelve formulations were characterized with quantitative descriptive analysis and rheological and extrusion tests. Overall liking (OL) and liking of some sensory attributes were evaluated with a consumer panel (n = 100). The right level of the consistency, sweetness, acidity, and fruit flavour of each sample was evaluated with "just-about right" scales and analysed by Penalty Analysis. Hierarchical cluster analysis was applied to detect consumer groups with different preference profiles. Three clusters were found: one cluster did not like intense sweeteners; another, preferred the characteristics of the TS samples, and the third cluster did not show marked tendencies, suggesting that formulations should be adapted to each scenario.

1. Introduction

New product development is a suitable strategy for building competitive advantage and long-term financial success in today's global food markets. Nowadays, the food market is increasingly segmented. Incorporating the 'voice of the consumer' at early stages of the process has been identified as a critical success factor; however, it is often poorly executed (Van Kleef, Van Trijp, & Luning, 2005). Among other things, this requires studies to discover whether the population's perception of the target product is segmented and which versions of a product need to be developed.

In the present study, two factors were varied for formulating fruit fillings: 1) the gelling agent, and 2) sucrose or its replacement by alternative sweeteners, with the resulting benefit of lower calorie content. Sucrose in fruit fillings provides a number of techno-functional properties; 1 g of sucrose contributes 4 calories. Substituting other sweeteners for sucrose is a challenge for researchers and industry, since in addition to the sweetness, other sensory attributes may be modified. The industry frequently uses sweetener blends taking advantage for sweeteners that exhibit different flavour profiles, particularly if one of them is bitter, creating an improved flavour profile. According to Basu, Shivhare, and Singh (2013) stevioside and sucralose can be used in combination without compromising taste; residual bitterness from the stevia has been reported (Prakash, DuBois, Clos, Wilkens, & Fosdick, 2008), being important to use Stevia with more rebaudioside (Cadena et al., 2013). As sweeteners do not contribute texture other substances such as polydextrose are used as bulking agents. Polydextrose has similar technical properties to sucrose except for sweetness. It provides 1 cal/g (Schirmer, Jekle, Arendt, & Becker, 2012) and has been successfully incorporated into a wide range of sugar-reduced foods, providing the bulk, appropriate texture and mouthfeel qualities (Aidoo, Afoakwa, & Dewettinck, 2014).

The sensory quality of fruit fillings includes a number of attributes like balance of sweetness and sourness, colour, fruit flavour, medium firmness and a homogeneous gel-like texture, among others. Gel texture depends, of course, on the gelling agent selected. For the present study, three different gelling systems were selected; native tapioca starch (TS) alone, a combination of TS and pectin and a modified waxy corn starch, based on previous studies (Agudelo, Varela, Sanz, & Fiszman, 2014a, 2014b). Pectin is primarily used in the jam since it occurs naturally in fruit, and MWCS is also used Just-about-right (JAR) scales identify whether an attribute is too high or too low in a product. The consumer ratings indicate the direction of formulation change.

The aims of the present study were to approach fruit filling development from a consumer-driven perspective, studying how

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consumer and sensory techniques can guide the final characteristics of products that have good acceptability.

2. Materials and methods

2.1. Ingredients

The ingredients employed were TS (moisture content 13.7 g/100 g, Sucroal, Cali, Colombia), citric acid and sodium citrate (Sucroal, Cali, Colombia), highly cross-linked waxy corn starch, hydroxypropylated and phosphated (C) (moisture content 12.3 g/100 g, Polartex 6716, Cargill, Martorell, Spain), low methoxyl pectin (P) (33–37% esterified, moisture content 12 g/100 g, OB700, Cargill, Martorell, Spain), anhydrous calcium chloride (Panreac, Barcelona, Spain), polydextrose (PD) (moisture content 3.2 g/100 g, Stalite III, Tate & Lyle, Decatur IL, USA), rebaudioside B (stevioside, purity greater than 95%, Sucroal S.A., Cali, Colombia), sucralose (Tate & Lyle, Jurong Island, Singapore) and sucrose (S) (table sugar, Hacendado, Valencia, Spain). Fruit purée (F) was obtained from canned peach halves in syrup (6.5° Brix, pH 3.8, Hacendado, Valencia, Spain). The final moisture content of the fruit purée was 92 g/100 g.

2.2. Model system and fruit filling preparation

The samples were prepared in a food processor (Thermomix 31, Wuppertal, Germany) at pH 3 and containing 35 g/100 g total soluble solids (sucrose or PD) and 6 g/100 g of the thickener system. Three thickener systems were employed: C, TS, and P (TS with pectin) (0.6 g/100 g of the total hydrocolloid system on a dry-weight basis) and calcium ions (60 mg/g of pectin). The first step was to add the sucrose or PD to part of the water. The fruit purée was also added (25 g or 50 g/100 g) when corresponding. The mixture was heated to 60 °C and stirred for 5 min. The pectin was first dispersed in water (magnetic stirrer, 80 °C) until totally dissolved, then allowed to cool to 60 °C before adding it to the corresponding mixture, continuing to stir while heating for another 2 min. The sweeteners were then added when corresponding. Once the mixtures had been prepared, the temperature was increased to 90 °C and stirring continued for further 30 min. Calcium chloride, dissolved in a small amount of water reserved for this step, was added to the pectin mixtures. The pH was adjusted to 3.0 (±0.2), using citric acid and sodium citrate buffer solutions, and stirring and heating continued for a further 5 min. The samples were transferred to plastic containers and held in refrigeration (8 °C) for 24 h (Table 1).

2.3. Linear viscoelastic properties

The linear viscoelastic properties were studied (20 °C) with a controlled stress rheometer (AR-G2, TA Instruments, Crawley, England), using serrated plate–plate geometry (40 mm diameter, 1-mm gap). The samples equilibrated between the plates for 10 min. Silicone oil was used to prevent drying out. Frequency sweeps were performed from 10 to 0.01 Hz (strain amplitude value inside the linear region). The storage modulus (G′), loss modulus (G″) and loss tangent ($\tan\delta = \tan G''/G'$) were recorded.

2.4. Extrusion test

Extrusion test was performed with a texture analyser (TA-XT Plus, Godalming, England) with a 50-mm diameter back extrusion cell (A/BE Rig). The settings were: 10-mm gap, 10-mm/s speed, 10-g trigger point, and 15-s test duration. The samples were stabilized in the extrusion cylinder in a water bath (25 °C, 10 min) before measurement. The maximum extrusion force (Fmax, in N) and the area under the curve (AUC, in N.s) were obtained, as indices of firmness and consistency, respectively.

2.5. Sensory tests

All the sensory tests were performed in a sensory laboratory with individual booths with data acquisition (Compusense five release 5.0 software, Guelph, Ontario, Canada).

2.5.1. Quantitative descriptive analysis (QDA)

The twelve samples (Table 1) were assessed through QDA. A 10-assessor panel (seven woman, aged 20–45 years), selected the descriptors (Checklist Method, Lawless & Heymann, 1998); their appropriateness and definitions were discussed in four 1-h sessions and a consensus was reached (Table 2). The panellists attended eight 1-h training sessions until reaching a consensus with 10-cm unstructured scales. A complete block experimental design was used in duplicate (12 samples, 6 sessions, 4 samples per session). In each session, 30 g of each sample were put in small plastic cups (60-mL capacity) identified with a random three-digit code and served in random order across panellists. The panellists were instructed to

Table 1
Composition of the different fruit filling formulations (pH 3, 35° Brix).

Sample code	Ingredient							
	Tapioca starch (TS) g/100 g	Pectin (P) g/100 g	$CaCl_2$[a] g/100 g	MWCS (C) g/100 g	Fruit (F) g/100 g	Sucrose (S) g/100 g	Polydextrose (PD) g/100 g	Sweetener mix[b] g/100 g
C25FS	0	0	0	6	25	26	0	0
C25FPD	0	0	0	6	25	0	26	0.26
TS25FS	6	0	0	0	25	26	0	0
TS25FPD	6	0	0	0	25	0	26	0.26
P25FS	5.33	0.60	0.067	0	25	26	0	0
P25FPD	5.33	0.60	0.067	0	25	0	26	0.26
C50FS	0	0	0	6	50	20	0	0
C50FPD	0	0	0	6	50	0	20	0.17
TS50FS	6	0	0	0	50	20	0	0
TS50FPD	6	0	0	0	50	0	20	0.17
P50FS	5.33	0.60	0.067	0	50	20	0	0
P50FPD	5.33	0.60	0.067	0	50	0	20	0.17

$CaCl_2$ = Calcium chloride, MWCS = Modified Waxy Corn Starch, C = Control.
[a] The calcium salt dosages correspond to 60 mg of calcium ion per g of pectin.
[b] The sweetener mix is a 50:50 blend of stevia and sucralose.