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Combined sensory optimization of a prebiotic cereal product using multicomponent mixture experiments

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Abstract

An experimental design for mixtures was used to develop tasty cereal bars with prebiotic properties. Inulin (I), oligofructose (OF) and gum acacia (GA) were the prebiotic ingredients added (13.5% w/w) to cereal and fruits. The bars were analyzed by QDA (quantitative descriptive analysis) and the best formulations were determined in accordance with a preference test. GA was responsible for effects on dryness appearance of cereals flakes, hardness and chewiness while OF enhanced the brightness and crunchiness. The optimized formulations (50% I + 50% OF + 0% GA and 8.46% I + 66.16% OF + 25.38% GA) showed that blends of fibres imparted, to the bars, better textural characteristics than did each fibre alone. Syrup viscosity (greatly influenced by GA concentration) had a negative correlation ($r = -0.904$) with the preference score. The selected formulations aimed at reduction of 18–20% caloric value while providing an average increase of 200% in total fibre.

Keywords: Fibre; Cereal bars; Inulin; Oligofructose; Gum acacia; Functional foods; Bioactive ingredients

1. Introduction

Today, the industrialized countries are facing, among others, three major challenges:

- to control the cost of health care;
- to offer to their aging population a real opportunity to live, not only longer, but also better;
- to provide to more and more "busy" consumers, a choice of healthy processed or ready-to-eat foods (Roberfroid, 1999).

The development of functional foods is a unique opportunity to contribute to the improvement of the quality of food and to consumer health and well-being (Hasler, 1998; Milner, 1999).

Everybody agrees that food must taste good to gain acceptance. The other characteristics that consumers look for are: the convenience, nutrition and price of the food (Boustani & Mitchell, 1990; Bower & Whitten, 2000; Izzo & Niness, 2001; Katz, 1999). When formulating any successful product, a food company must perform consumer tests to determine which products are liked by the consumer (Yackinous, Wee, & Guinard, 1999). Consumer testing usually follows discrimination and descriptive tests and is a necessary and valuable component of every sensory programme (Stone & Sidel, 1993). These tests indicate which sensory characteristics and levels of these characteristics a product should exhibit in order to be successful in the market place.

The development of a product is essentially a problem of optimization. In the search for the best formulation,

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the main objective is to determine the optimum levels of the components or key ingredients. The ingredients are the independent variables or factors and the dependent variable or response is the objective to be optimized (maximized or minimized) (Castro, Silva, Tirapegui, Borsato, & Bona, 2003). Mixture experimental designs are suitable for food products that require a composition or a blend of key ingredients, since proportions of the ingredients in the mixture, and their levels, are dependent on each other, and the sum of all components is always one or 100% (Hare, 1974).

Energetic and cereal bars have proliferated recently, and Americans spend a little over half of their food money on food prepared for eating without much – if any – further cooking (Katz, 1999). Busy life styles and the increasing demand from consumers for meals and snacks that are quick sources of good nutrition have prompted the food industry to develop foods like nutrition bars that combine convenience and nutrition (Izzo & Niness, 2001). The cereal bars have gained an acceptance in the consumer's eyes as being "better for you" and good in nutritional terms, from the contribution of a amount of dietary fibre. The popularity of these products reflects nutritional guidelines recommending increased dietary fibre intake since low fibre consumption has been implicated as a risk factor in many diseases (Murphy, 2001). Insoluble fibre ingredients, such as bran, have traditionally been used in products such as cereal bars, breads, pasta and breakfast cereals, but the palatability of these has limited the level that can be incorporated into different systems. Soluble fibre ingredients are currently of greater interest in the formulation of "healthy" foods because they are more palatable. In addition, some can be used in food systems to thicken, add viscosity or gel (Dreher, 1999).

According to the definition of the American Association of Cereal Chemists (AACC, 2001), dietary fibres promote beneficial physiological effects, including laxation, and/or blood cholesterol attenuation, and/or blood glucose attenuation. Aside from its laxative effects, possibly the most dynamic function of dietary fibre is its fermentation, which causes a myriad of biochemical, physiological, and microbiological changes in the large intestine. The potential impact of fermentation in the intestine is helping us better understand that the entire intestine can contribute to better health if properly nourished. This belief and a growing understanding of dietary fibre fermentation helped coin the term "prebiotic". Prebiotics are food ingredients that selectively stimulate the growth and activity of bifidobacteria and lactic acid bacteria in the human intestine (Gibson, 1999; Gordon, 2002).

The most important effect of prebiotic carbohydrates is to strengthen the body's resistance to invading pathogens and, thereby, prevent episodes of diarrhoea (Cummings & Macfarlane, 2002). Research has shown that a balanced intestinal flora can provide improved regularity, stimulation of immune factors, production of digestive enzimes, and assistance in controlling the formation of free radicals (Gibson & Williams, 1999; Kummel & Brokx, 2001).

The prebiotic effects of inulin, oligofructose and gum acacia have been confirmed in previous laboratory and human trials (Cherbut, 2000; Kolida, Tuohy, & Gibson, 2002).

Inulin, oligofructose and gum acacia are soluble fibres well suited for use in diabetic or low-calorie foods. The ingredients also offer a variety of technological functional properties: water retention, enhanced viscosity for improving binding and texture, stability at different temperature levels, and a stable pH (Pszczola, 1999).

The aim of this study was to develop tasty cereal bars with prebiotic functional properties using three sources of fibres – inulin (I), oligofructose (OF) and gum acacia (GA), looking for an optimization of the texture and taste.

2. Materials and methods

2.1. Ingredients

The basic ingredients of the cereal bars (cereal flakes, dried banana pieces, brown sugar, vegetable fat, lecithin and aroma) were obtained from the local market. The fibres used were: inulin (Raftiline GR) and oligofructose (Raftilose) from ORAFTI (Belgium) and gum acacia (Fibregum) from Colloides Naturels International (France). Glucose syrup 42DE from Corn Products (Brazil) was used for bar syrup formulation.

2.2. Experimental design

The simplex-centroid design for mixtures of three components with two centroid point replications (Table 1) was used to study the effects of interactions between ingredients on sensory quality of the product. The studied variables were the concentration of inulin (I), oligofructose (OF) and gum acacia (GA). The maximum level (component proportion = 1) of each variable was 13.5% (related to total formulation) of the corresponding pure fibre. The response variables were: degree of like (DOL) and the attributes selected by trained panel to describe the bar characteristics.

2.3. Cereal bars production

Bars were manufactured in batches of 3.0 kg, according to the flowsheet shown in Fig. 1. The process was carried out in 2 steps: heated syrup (fibres + glucose syrup, brown sugar, vegetable fat, lecithin, natural flavours) was manufactured by traditional batch

Table 1
Experimental design and sensory evaluation of the cereal bars with the hedonic scale of nine points

Essay	Component proportion[a]			Hedonic score[b]
	I	OF	GA	
01	1	0	0	6.69 ± 1.8
02	0	1	0	6.67 ± 1.8
03	0	0	1	4.91 ± 1.7
04	0.5	0.5	0	7.28 ± 1.4
05	0.5	0	0.5	5.46 ± 1.9
06	0	0.5	0.5	7.00 ± 1.6
07	0.333	0.333	0.334	7.22 ± 1.4
08	0.333	0.334	0.333	6.61 ± 1.6
09	0.334	0.333	0.333	6.75 ± 1.5

I = inulin, OF = oligofructose, GA = gum acacia.
[a] Coded values I + OF + GA = 1.
[b] Arithmetic mean ± standard deviation ($n = 49$).

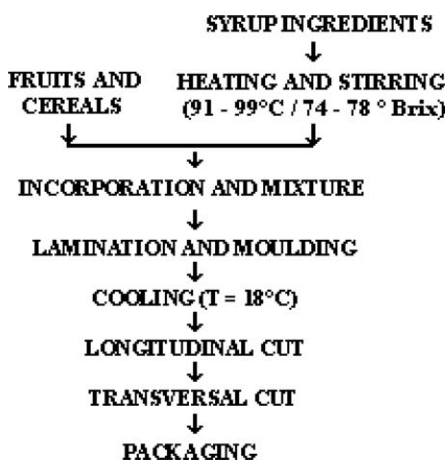

Fig. 1. Generic flowsheet for production of cereal bars.

process, and then the mixture of cereals (oat flakes and rice) and fruits (dried banana pieces and flakes) was aggregated. The proportion of syrup to the mixture of cereals and fruits was 27:73.

The fibres mixture of inulin, oligofructose and gum acacia (according to the experimental design) partially replaced the glucose syrup (w/w) aiming to obtain 50% fibre in the final syrup and cut sugar by 40%. So, fibres represented 13.5% of the total bar.

Bars were mechanically packaged in aluminium paper and stored at room temperature prior to sensory analysis.

2.4. Sensory analysis

The samples (Table 1) resulting from the experimental design were evaluated in relation to the sensory preferences – nine-point hedonic scale with anchor points, 1 (dislike very much) and 9 (like very much). The subjects were 49 young graduate students, between 18 and 26 years old, that declared themselves frequent consumers of cereal bars (consuming at least 1 bar per week). All the judges tasted the nine samples, over three sessions of three products, each one. The products were randomly presented. Regarding the centroid point, each subject received one of it at each session.

A selected and trained sensory panel, consisting of 12 judges, evaluated the nine samples using quantitative descriptive analysis (QDA); the generation of terminology and the other steps were according to ABNT NBR 14140 (1998). It used a 9 cm line scale (anchored in "none" and "very intense") and the panellists were trained during 6 sessions of 2 hours each. The repeatability, discrimination and the homogeneity of judges' scores were checked by a two-way ANOVA. The samples were randomly presented over three sessions of three products each. With regard to the centroid point, each subject received one of it at each session.

2.5. Viscosity measurement

The viscosity of the syrup was measured in a Synchro-Lectric Brookfield viscosimeter (Brookfield, United Kingdom) at the temperature of 80 °C, with angular speed of 10 rpm and spindles between numbers 5 and 7.

2.6. Nutritional values of the optimized cereal bars

The chemical composition of the optimized cereal bars formulation was determined by AOAC (2000) methods: protein (920.152), fat (920.39), fibres (985.29) and ashes (940.26). Moisture was determined by AACC (1998) method 44-40. Triplicate samples were used. The inulin and oligofructose were determined by theoretical calculation, considering the level added to the formulation (Purity degree was certified by ORAFTI-Belgium by AOAC 997.08 method). The carbohydrates were obtained by difference. As a control, bars with syrup without fibres (100% glucose syrup) were manufactured.

2.7. Data analysis

The Scheffé canonic equation (Eq. (1)) was used to model the experimental data:

$$Y = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_{12} X_1 X_2 + \beta_{13} X_1 X_3 + \beta_{23} X_2 X_3 + \beta_{123} X_1 X_2 X_3, \quad (1)$$

where Y is the studied response, β_1, β_2, β_3, β_{12},β_{13}, β_{23} and β_{123} are the regression parameters and X_1, X_2 and X_3 are the levels of fibres in the blends. Positive values for binary coefficients, β_{ij}, indicate synergistic effects while negative values represent antagonism.

Triangular contour plots were generated from the polynomial equations for each property using the software Statistica for Windows 6.0 (STATISTICA, 2002).

The model fitted for sensory preference (DOL) was used to optimize bar formulations, applying the technique of the desirability function of Derringer and Suich (1980) and/or the exhaustive computer imposition of exact grid points, which included the experimental area, with a small variation interval for each involved variable (STATISTICA, 2002). When more than one local optimum was detected, the best formulation was properly selected.

3. Results and discussion

Table 1 presents the experimental design for the nine formulations evaluated by the selected and trained sensory panel and by the consumers to obtain the average hedonic scores.

The list of attributes selected by trained panel to describe bar characteristics and their definitions are shown in Table 2. These attributes were analyzed in the QDA and the average scores obtained for the different samples are presented in Table 3.

Table 4 presents the equations and adjusted coefficients of determination of models obtained for the QDA descriptors. All the models were significant ($p < 0.01$) and did not present lack of fit. The adjusted coefficients of determination (R^2_{adj}) varied between 77% and 99%, aiming to consider the equations proper for prediction purposes. Most models were essentially linear equations. So, no binary combination was significant, except for cinnamon odour and chewiness models.

For the attributes banana odour and banana flavour, it was not possible to apply a predictive model, possibly because the samples did not present difference ($p >$ 0.600).

OF was the most important variable (highest coefficient) for the attributes brightness (Y_b), sweetness (Y_s) and crunchiness (Y_{cr}) while GA has the lowest effect (low coefficient). On the other hand, this one was responsible for higher values of the other attributes (Table 4).

The OF raises the brightness of the bars while the increase of GA concentration makes the appearance comparatively more opaque and also increases the dryness appearance of the cereals flakes.

Gum acacia contributed to enhance the cinnamon odour (Y_{ci}) and the negative coefficients corresponding to the interactions between I × OF and I × GA indicated antagonistic effects (Table 4).

Table 2
Descriptors developed for QDA of cereal bars

Descriptor term	Definition	Reference to "Very Intense"
Appearance		
Brightness	Bright aspect of the cereal bar	Peanut brazilian confection"Yoki"
Dryness of cereals flakes	Dry appearance of the cereals flakes	Cereal bar with 100% gum acacia
Flavour		
Banana volatile odour	Characteristic banana fruit odour perceived by aspiration, before the cereal bar is chewed	Dehydrated banana
Cinnamon volatile odour	Characteristic cinnamon odour perceived by aspiration, before the cereal bar is chewed	Cinnamon powder
Banana flavour	Banana characteristic flavour sensed during the chewing	Dehydrated banana
Sweetness	Perception of sweetness, associated with the presence of sugars	Sacharose solution 20%
Audition		
Crunchiness	Intensity of the sound produced during the chewing of the cereal bar	Corn flakes
Texture		
Hardness	Force required to break the cereal bar between the molar teeth	Nestlé milk chocolate bar stored at 5 °C
Chewiness	Number of chews/s required to reduce a 2 cm^3 sample to the ideal consistency for deglution	No scale was used

Table 3
Average scores[a] for each attribute examined and chewiness (no. of chews/s)

Essay	Brightness	Dryness of cereals	Banana odour	Cinnamon odour	Sweetness	Banana flavour	Hardness	Crunchiness	Chewiness (no. of chews to deglution)
1	3.61	4.08	2.33	3.01	3.36	4.07	3.53	3.24	29.33
2	5.63	1.53	2.56	2.88	4.82	3.85	2.07	6.48	24.25
3	2.33	6.32	2.66	4.78	3.23	3.93	5.04	2.56	34.08
4	4.73	2.72	1.94	2.13	4.26	3.60	2.74	4.70	25.50
5	2.25	6.24	2.93	3.43	3.45	3.94	4.42	3.39	28.42
6	3.12	5.49	2.00	4.56	3.54	3.48	3.33	4.58	29.08
7	3.47	3.72	2.53	3.18	3.78	4.24	2.72	3.53	27.75
8	3.28	5.25	2.37	3.30	3.79	3.23	2.89	4.36	27.58
9	4.13	3.96	2.82	3.47	4.08	3.31	3.59	3.67	27.50

[**]Number of chews (one chew/s) required to reduce a $2 cm^3$ sample to the ideal consistency for deglution.
[a] Scale = 9 cm.

The effects of I and OF on sweetness (Y_s) are explained because they are slightly sweet, without aftertaste (ORAFTI, 2002a, 2002b). According to Niness (1999), the oligofructose lends a sweetness profile similar to that of sucrose when used in combination with other sweeteners but with only about 30% of the sweetness. The contribution of gum acacia, that is not sweet, is to enhance the sweetness of brown sugar and glucose syrup of the formulation.

GA and I contributed to raise the hardness of the cereal bars (Fig. 2 and Table 4 – Y_h). The effect of the former could be attributed to the syrup viscosity, as will be explained later. Then, OF is the better fibre to impart desirable lower values of hardness for bars.

Samples with higher crunchiness (>6 points) were obtained in the experimental area with higher OF concentrations while inclusion of GA in the blend of fibres promoted the higher decreases in this attribute (Fig. 3).

For the attribute chewiness, as shown in Tables 3 and 4 and in Fig. 4, GA presented the highest coefficient on the regression model (Y_{ch}) and consequently is responsible for the highest score while the OF (lowest coefficient) promotes lower scores. The binary systems – I × OF and I × GA – demonstrated antagonic effects.

The majority of consumers consider chewiness a desirable attribute for cereal bars (Bower & Whitten, 2000).

Boustani and Mitchell (1990) reported that the chewy cereal bar represented the strongest growth sector. The perception of audition of crunchiness is desirable, but the preference is for chewy texture.

Bower and Whitten (2000) investigated sensory properties of cereal bars for their relative importance to consumer perception and liking. Sensory profiles were determined for 8 commercial bars, representative of the main sensory characteristics of cereal bars, including

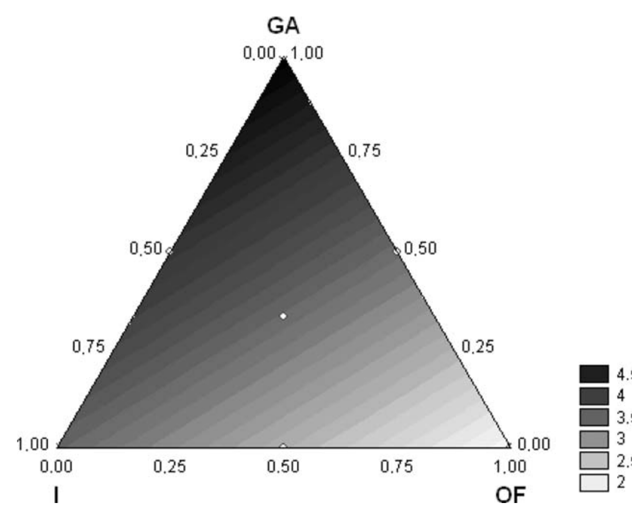

Fig. 2. Contour plot for cereal bars hardness (Y_h) for blends containing inulin (I), oligofructose (OF) and gum acacia (GA).

Table 4
Models and goodness-of-fit obtained from the QDA descriptors using statistical evaluation

Parameter	Equation	R^2_{adj}(%)	p[*]	Lack of fit (p)
Brightness	$Y_b = 3.52I + 5.48OF + 1.85GA$	83.11	0.0020	0.5539
Dryness of the cereals	$Y_d = 4.18I + 1.84OF + 7.08\ GA$	77.14	0.0050	0.6154
Cinnamon odour	$Y_{ci} = 3.00\ I + 2.88OF + 4.78GA - 3.25\ I \times OF - 1.85\ I \times GA + 2.93OF \times GA$	97.88	0.0024	0.9882
Sweetness	$Y_s = 3.54I + 4.75OF + 3.15GA$	79.80	0.0035	0.3405
Hardness	$Y_h = 3.42I + 1.82OF + 4.87GA$	82.20	0.0024	0.7230
Crunchiness (audition)	$Y_{cr} = 3.23I + 6.30OF + 2.64GA$	90.04	0.0004	0.7566
Chewiness	$Y_{ch} = 29.3I + 24.3OF + 34.1GA - 4.1IxOF - 12.0IxGA$	99.09	0.0001	0.1181

I = inulin, OF = oligofructose, GA = gum acacia.
[*] p = Probability level.

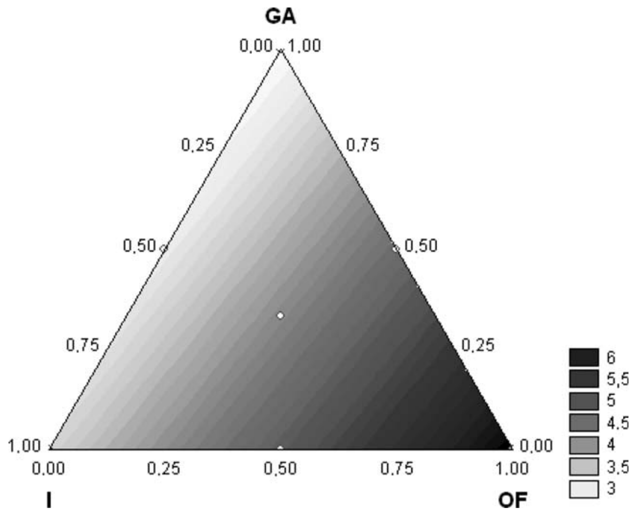

Fig. 3. Contour plot for cereal bars crunchiness (Y_{cr}) for blends containing inulin (I),oligofructose (OF) and gum acacia (GA).

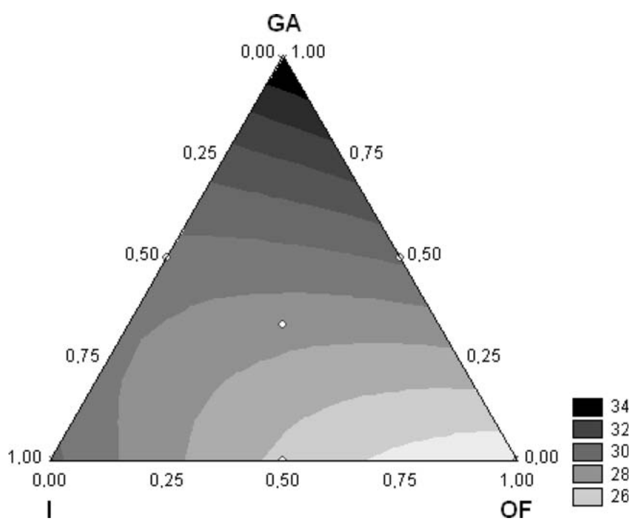

Fig. 4. Contour plot for cereal bars chewiness (Y_{ch}) for blends containing inulin (I), oligofructose (OF) and gum acacia (GA).

crunchy and chewy bars. Principal components analysis of conventional profiling data showed a distinct location of each bar type in multivariate space, separation being based on textural aspects for the hard crunchy bar and flavour dimensions for others. The majority of consumers ($n = 56$) ranked flavour as the most important characteristic influencing their purchase intent, followed by textural features, price and appearance. The "healthy image" aspect was relatively less important. Analysis of variance showed that the chewy, nutty and chocolate bars were liked most ($p < 0.01$).

In this present study, the differences of textures and appearances of cereal bars are greater than the differences between aromas and flavours, because the added fibres ingredients influenced more the texture and appearance of the cereal bar than the aroma and flavour.

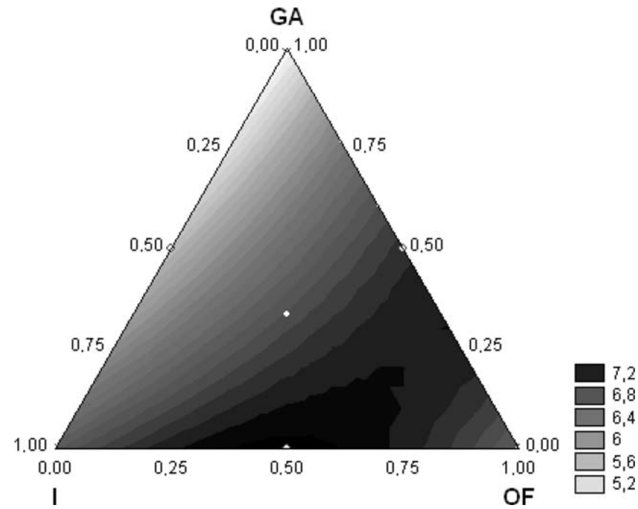

Fig. 5. Contour plot for cereal bars hedonic score (Y preference) for blends containing inulin (I), oligofructose (OF) and gum acacia (GA).

Table 1 presents the average hedonic score for the nine formulations evaluated by the 49 judges. All the samples have good degrees of like (DOL), with scores above 5.0 –"regular".

The canonical Scheffè's equation (Eq. (2)) adjusted for sensory preference or degree of like (DOL) was:

$$Y(\text{preference}) = 6.7\text{I} + 6.7\text{OF} + 4.9\text{GA} + 2.7I \times \text{OF} - 1.1I \times \text{GA} + 5.1OF \times \text{GA}, \quad (2)$$

which presented high adjusted coefficient of determination ($R^2_{adj} = 0.8854$), low coefficient of variation (4.15%) and no lack of fit. The model was significant ($p < 0.01$) with 88.54% of the variation being explained by the model. This well adjusted model was used to generate the contour plot for the sensory preference of the cereal bars (Fig. 5).

Inulin (I) and oligofructose (OF) presented stronger and similar effects on preference as demonstrated by the higher coefficients in Eq. (2). The binary systems, with I × OF and OF × GA, demonstrated synergistic effects while I × GA demonstrated an antagonistic effect.

Samples with higher preference (>7 points) were obtained in the experimental area with a higher proportion of OF in the fibres blend (Fig. 5). Several different proportions between fibre ingredients allowed similar preferences.

Applying the optimization technique of Derringer–Suich and/or the exhaustive computer imposition of grid points, two optimal formulations were detected:

$$50\%\text{I} + 50\%\text{OF} + 0\%\text{GA} \quad \text{and/or}$$

$$8.46\%\text{I} + 66.16\%\text{OF} + 25.38\%\text{GA}.$$

Table 5
The optimum values for texture responses calculated from QDA and from preference analysis

Optimization technique of Derringer–Suich	Optimum values		
	Hardness scale = 9	Crunchiness scale = 9	Chewiness no. of chews/s
From QDA: maximum crunchiness and chewiness/minimum hardness	2.84	5.08	27.55
From preference analysis	2.73	5.11	26.70

And the calculated responses of hedonic scores are 7.38 and 7.25, respectively.

Based on the importance of the texture in the proposed formulations, a simultaneous optimization (STATISTICA, 2002) of the combined texture responses of the QDA – minimum hardness, maximum chewiness and maximum crunchiness – selected the following mixture of prebiotic fibres:

$0\%I + 66.60\%OF + 33.40\%GA.$

It is of interest that the predicted optimum is quite similar to the result of the optimum mixture that was obtained from preference analysis:

$8.46\%I + 66.16\%OF + 25.38\%GA.$

The calculated responses (equations in Table 4) for hardness, crunchiness and chewiness, understood as QDA texture, and preference (Eq. (2)), applying, respectively, the optimum formulation mentioned above are very close (Table 5).

The antagonistic effect of the binary system IxGA of the Eq. (2) (Y preference) could be explained because the ingredients I and GA raise the hardness of the cereal bars (Table 3).

The texture results were similar to those obtained by Bower and Whitten (2000) for the consumer preference for less hard cereal bars and a balance between "chewiness" and "audition of crunchiness"; that results in a more pliable bar. The other desirable caractheristics were related to more brightness and less dry appearance.

The syrup viscosity could be responsible for some sensorial characteristics of the bars. The syrup containing 100% GA had a higher score – 213 times more viscous than the syrup with 100% OF and 103 times more viscous than the syrup with 100% I (Fig. 6).

The higher viscosity of syrup containing 100% GA is explained by its molecular weight, that is about 200 times higher than that of the OF. GA is considered to be a complex, highly branched, globular molecule, which is closely packed rather than linear, thus accounting for its viscosity (Glicksman, 1989).

The syrup viscosity of each sample showed a negative correlation with the sensorial preference of the cereal bars ($r = -0.904$, $p = 0.0008$) and a positive correlation with the hardness of the cereal bars ($r = 0.833$, $p = 0.0053$). Besides, the syrup viscosity showed a positive correlation with the instrumental hardness ($r = 0.792$, $p = 0.0388$) (data not presented). Then, if the viscosity of syrup is higher, the cereal bar will be harder and that is not desired by the consumer.

Further, on their contribution to sensorial characteristics of bars, the blend of the fibres proved to be very effective for technological functional properties. I and GA helped to control the cold flow of cereal mass, which helped to maintain the bar shape and packaging. The 100% OF cereal bar was sticky and very soft, the 100% I was hard and 100% GA was hard and dry (Table 3).

According Niness (1999), oligofructose can be used as part of the binder system as a humectant to keep the bar softer and more pliable over its shelf life. Brandt (2000) reported that the inulin acts as a texture modifier by holding in moisture, which helps keep the bars fresher longer.

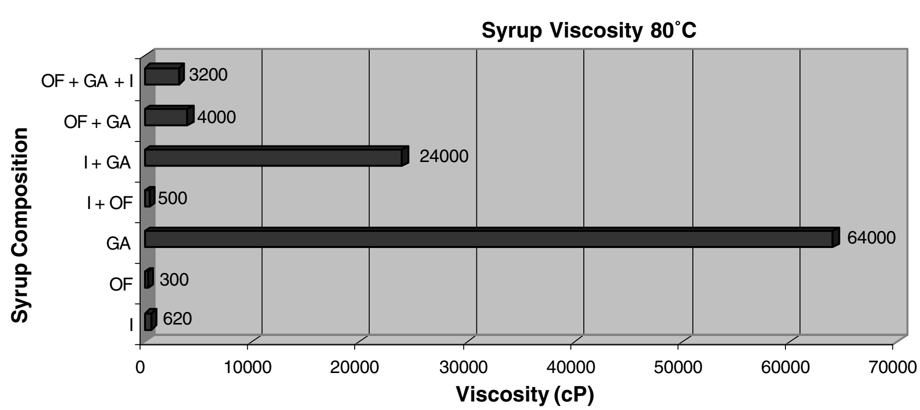

Fig. 6. Apparent viscosity at 80 °C of the syrup containing inulin (I) and/or oligofructose (OF) and/or gum acacia (GA) according to experimental design (Essays 1–7).

Table 6
Nutritional values[a] (g/100 g) of the cereal bars – the optimized formulations and the control

Nutrient	Nutritional value[a] (g/100 g)		
	Control	50%I + 50%OF	8.5%I + 66.2%OF + 25.4%GA
Moisture	5.47 ± 0.7	6.13 ± 0.4	6.18 ± 0.8
Protein	6.15 ± 0.2	6.11 ± 0.3	5.58 ± 0.2
Fat	4.13 ± 0.2	3.15 ± 0.7	2.60 ± 0.5
Carbohydrates[b]	75.7 ± 0.3	61.8 ± 0.4	61.4 ± 0.4
Ash	1.51 ± 0.1	1.40 ± 0.1	1.61 ± 0.1
Fibres[c]	7.09[d]	21.45 [7.95[d] + 13.5]	22.65 [12.55[d] + 10.1]
Energy (kcal)[e] one bar – 25 g	91.09	74.96	72.81

[a] Mean ± SD ($n = 3$).
[b] Values are obtained by difference.
[c] Sum of pure inulin + oligofructose (AOAC 997.08) additioned and the analytical fibre value of the cereal bar determined by AOAC 985.29.
[d] Analytical value by AOAC 985.29.
[e] Calculated using the Atwater factors of 4, 4, and 9 kcal/g for protein, carbohydrate and fat, respectively.

Izzo and Niness (2001) evaluated inulin with different degrees of solubility (I and OF combinations) to determine the most suitable for bar formulation. The I + OF were added at 8% of the total bar. As a control, a 5DE maltodextrin was used in place of the test. Bars were evaluated at two and seven months using a model TA.XT2 texture analyser (Texture Technologies Corp., NY). All four products tested showed lower initial hardness versus the control. Over the 7-month shelf-life test, the inulin- or OF-containing products maintained hardness similar to those initially measured, while the hardness of the maltodextrin control increased significantly.

The chemical composition of the two optimized cereal bar formulations, taking into account the preference test, showed reduction of caloric value by 18–20% compared to the control (without I, OF and GA) while providing an average increase of 200% in total fibre (Table 6).

4. Conclusion

The blend of the fibres was very effective for technological functional purposes and to improve the sensory properties of cereal bars. The 100%OF cereal bar was sticky and very soft, the 100%I was hard and 100%GA was hard and dry.

The addition of inulin, oligofructose and gum acacia in a cereal bar can cut sugar by 40% and reduce the caloric value by 18–20% while providing 200% of added fibre.

Using the resources of experimental mixture design and sensory analysis, it was possible to characterize and optimize the formulation of a nutritive, tasty and also convenient (ready to eat) product, with a claim of functional properties as source of prebiotic fibres. So this cereal bar has a good potential for the market place with the objective of bringing good health benefits to the population.

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