Title: Semi-solid fibre syrup for sugar reduction in cookies

Running title: Sugar-reduced cookies with fibre syrup

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Abstract

Since sugar reduction is a pillar of international nutritional guideline, the food industry is constantly looking for new ingredients able to replace sugar technological functionality while satisfying the consumer request for clean label. Based on corn (*Zea mays*) dextrin and seed coats of chickpeas (testa of *Cicer arietinum* seed), a fibre syrup was tested as bulking agent in cookies to reach 30 and 50% sugar reduction. Cookies were characterised for their physico-chemical, rheological and sensorial attributes. Fibre syrup addition did neither hinder dough workability nor require changes in cookie production procedure. The use of the fibre syrup permitted to partially preserve the structural strength of cookies and increased their red colour index. Moreover, the fibre syrup use allowed to obtain sugar-reduced cookies qualified for "reduced in sugar" and "high in fibre" nutritional claims.

Keywords: cookies, sugar reduction, fibre, bulking agent, clean label

Introduction

Overweight and obesity are considered an epidemic concern, especially in children and teenagers, with serious long-term health effects associated with premature mortality, type 2 diabetes, cardiovascular disease, hypertension and cancer (Lin et al., 2015; Manson & Bassuk, 2003). A strategy to diminish obesity risk factor is the reduction of sugar in diet because its overconsumption has been associated with the increase of body weight and, therefore, to the related health problems (Te Morenga et al., 2012). In Europe, sugar represents ≈15%-21% and ≈16%-26% of the energy intake in adult and children, respectively (Azaïs-Braesco et al., 2017). In 2015 the World Health Organization (WHO) recommended to reduce the daily consumption of free sugars to less than 10% of the total energy intake (World Health Organization, 2015).

Cookies are a very popular food and, due to their high sugar content (on average 30-40% of the recipe), may represent a high source of sugar intake. In USA, around 15% of the children overall sugar intake derives from sweet bakery products, in particular cookies (Bailey et al., 2018), while in Europe sweet products (including cookies) contribute to around 50% to the total sugar intake of children (Azaïs-Braesco et al., 2017). More specifically, about 4-5% of the total energy intake is represented by cookies in Italian children and teenager populations (Sette et al., 2011).

Sugar has a pivotal role in cookie quality because it contributes not only to its flavour but also to its colour, structure and sensorial properties (Biguzzi et al., 2014; Chevallier et al., 2000;

Sai Manohar & Haridas Rao, 1997; van der Sman & Renzetti, 2019). The reduction of high levels of sugar is, therefore, a challenging task for food technologists. In fact, if sweetness can be adjusted by the use of intensive sweetener (e.g. sucralose, aspartame, saccharin, stevia) (van der Sman & Renzetti, 2019), other quality features linked to sugar properties are difficult to preserve. Indeed, owing to its hygroscopicity and crystallisation properties, sucrose contributes to different aspects to the final cookie quality: (i) its melting (in combination with shortening) leads to a lowering of dough viscosity and consequently allowing cookie spreading during cooking (Sahin et al., 2019; Sumnu & Sahin, 2008), (ii) its tendency to recrystalise during cooling increases product's surface hardness (Belcourt & Labuza, 2007; Gallagher et al., 2003; Pareyt et al., 2009), (iii) its involvement in the Maillard reaction contributes into the formation of colour and flavour in the final product (Davis, 1995).

Sugar reduction can be achieved using different approaches including multisensorial integration, food structure innovation, gradual sugar reduction, the use of sugar substitutes like bulking agents (Hutchings et al., 2019). This latter strategy is the most popular, (Hutchings et al., 2019) and different studies have been conducted to reduce sugar in cookies using bulking agent, including oligosaccharides, polyols and dextrins (Di Monaco et al., 2018; Struck et al., 2014; van der Sman & Renzetti, 2019). Reduced-sugar cookies obtained by substituting 30% of the sucrose with a chicory based fructo-oligosaccharide (Raftilose®) were found to have a lower hardness and a darker colour at the surface compared to standard (Gallagher et al., 2003). The use of inulin allowed to obtain consumer acceptable cookies substituting up to 25% of sucrose, while higher substitution level led to a reduction in cookie crispiness and a detrimental consumer acceptability (Laguna et al., 2013). Fructo-oligosaccharide and inulin are resistant to digestive enzymes and do not release simple sugars and, therefore, the blood glucose level (Flamm et al., 2001, Gao et al., 2016). A minimally absorbed ketohexose, tagatose would qualify to replace half of sucrose content in cookies but the latter were harder and darker than control despite a positive sensory score (Taylor et al., 2008). Besides its low caloric values, tagatose was reported to possess health-promoting effect including antidiabetic property and positive effect on gut microbiota (Roy et. al, 2018).

Clean label product is of interest to consumers looking for “natural” and “healthier” food products (Asioli et al., 2017). In this perspective, a win-win approach can be the use of dietary fibres for their bulking and humectant properties, and their nutritional benefits as a source of dietary fibre. Past studies revealed that arabinoxylans extracted from wheat bran have been successfully used to replace 30% of sugar and to increase the fibre content in cookies (Pareyt et al., 2011), while Handa and co-workers reduced sugar content up to 60% using fructoligosaccharides while increasing the total dietary fibre content (Handa et al., 2012).

In this frame, this work aimed to assess the effectiveness of a fibre syrup based on corn (*Zea mays*) dextrin and seed coats of chickpeas (testa of *Cicer arietinum* seed), as a bulking agent in cookies. Quality of sugar-reduced cookies was assessed for physicochemical properties and sensorial acceptability.

Materials and methods

Materials

The bulking agent used in this study was MELTEC®, obtained from HI-FOOD S.p.A. (Parma, Italy). MELTEC® is a fibre syrup based on corn (*Zea mays*) dextrin and seed coats of chickpeas (testa of *Cicer arietinum* seed). It is a clean label ingredient, which does not impart sweetness, with a consistency similar to honey, a gold brownish colour, with a sugar content <

1.0% (g sugar/100 g sample), a dietary fiber content ≈ 66% (g fiber/100 g sample) and a moisture content ≈ 25% (g water/100 g sample). The other ingredients used for the cookie formulations such as refined wheat flour (type 00, ash content 0.51 +/- 0.2 % dry basis, W=118 +/- 6; Molino Agugiaro e Figna, Collecchio, Italy), fresh egg (AIA, Verona, Italy), butter (Metro Chef, Parma, Italy), chemical leavening agent (Lievito Bertolini, sodium bicarbonate and disodium diphosphate, Bertolini, Brescia, Italy), sucrose (British Sugar, Peterborough, UK), were obtained from a local supermarket.

Semi-solid fibre syrup characterisation

The semi-solid fibre syrup was firstly characterised for its physicochemical properties. Fiber content was determined according to (AOAC method 2009.01, High Molecular Weight Dietary Fiber and Low Molecular Weight Dietary Fiber, McCleary et al, 2010). Brix degrees of semi-solid fibre syrup was measured using a portable refractometer HB 95 (Lega Italy, Ravenna, Italy) and water activity was determined with an Aqualab 4 TE (Decagon Devices Inc., Pullman, WA, USA) at 25 °C. Moisture content (MC, g of water/100 g of sample) was measured by drying in a forced-air oven (ISCO NSV 9035, ISCO, Milan, Italy) at 70 °C to constant weight. pH was measured with a potenziometer pH7+ DHS Food (XS Instruments, Modena, Italy). Colour analysis was performed using a Minolta Colorimeter (CM 2600d, Minolta Co., Osaka, Japan) equipped with a standard illuminant D65 and a 10° position of the standard observer. The results were obtained according to CIE Lab system. The parameters obtained were: L^* [0 (black) - 100 (white)], a^* ($-a^*$ = greenness and $+a^*$ = redness) and b^* ($-b^*$ = blueness and $+b^*$ = yellowness). At least three measurements were taken for each analysis.

Cookie preparation

For the purpose of this study from the standard recipe, sucrose content was reduced to 30% and 50% with and without the addition of the fibre syrup (Table 1). With respect to the standard recipe (S100, containing 100% of sucrose), four different sugar reduced cookies were formulated: S70 containing 70% of sucrose; S70M30 containing 70% of sucrose and 30% of fibre syrup; S50 containing 50% of sucrose; S50M50 containing 50% of sucrose and 50% of fibre syrup (Table 1). Cookie dough was prepared by mixing all the ingredients in a mixer (Kitchen Aid, St Joseph, USA) at 60 rpm for 5.5 min. Cookie dough was manually sheeted until a thickness of 4 mm and cut into pieces of shape 0.4 cm x 2 cm x 5 cm, and then baked at 180°C for 20 min in a forced convention oven (Electrolux EOB8747AOX, Stockholm, Sweden). Cookies were placed on a rack and cooled at room temperature and, then stored in a plastic bag for 24 h before the analysis. Two batches of cookies of each formulation were produced on different days.

Cookie characterisation

Nutritional composition

Macronutrients content of the different recipes of cookies was obtained using European Institute of Oncology database (European Institute of Oncology, 2015) for standard ingredients and using the nutritional information reported in the technical data sheet of the fibre syrup. Energy values (kJ and kcal) were calculated using the energy factors reported in the EU Regulation on labelling of food products (European Union, 2011) [in details: carbohydrate = 17 kJ (4 kcal); protein = 17 kJ (4 kcal); fat = 37 kJ (9 kcal); fibre = 8 kJ (2 kcal)].

Water activity and moisture content

Water activity was measured at 25 °C with an Aqualab 4 TE (Decagon Devices Inc., Pullman, WA, USA). Moisture content (MC, g of water/100 g of sample) was measured by drying the sample in a forced-air oven (ISCO NSV 9035, ISCO, Milan, Italy) at 70 °C to constant weight.

In both analyses, at least three measurements were taken for each formulation for a total of six determinations.

Texture

Texture of cookies was measured using a Food Texture Analyzer (TA1 Texture Analyzer, AMETEK, USA) equipped with a 100 N load cell. Hardness (N) was evaluated by means of a cutting test (at 2 mm/s, trigger force = 0.1 N) using a flat blade (FG/WBJ) and it was measured as the maximum force at break (N). Ten measurements were taken for each formulation for a total of twenty determinations.

Colour

Colour analysis was performed using a Minolta Colorimeter (CM 2600d, Minolta Co., Osaka, Japan) equipped with a standard illuminant D65 and a 10° position of the standard observer. The results were obtained according to CIE Lab system. The parameters obtained were: L^* [0 (black) - 100 (white)], a^* ($-a^*$ = greenness and $+a^*$ = redness) and b^* ($-b^*$ = blueness and $+b^*$ = yellowness). ΔE was also obtained using as reference the full sugar recipe cookie S100 (Limbo & Piergiovanni, 2006). At least ten determinations were performed for each formulation for a total of at least twenty determinations.

Sensory analysis

Sensory analysis of cookies was carried out using an acceptability and a rapid profiling method check-all-that-apply (CATA) tests. Cookies were coded with a three-digit random number and presented in a randomized and balanced order to 50 untrained judges. In the acceptability test a 9-points hedonic scale was used, (1=dislike extremely, 2=dislike very much, 3=dislike, 4=dislike slightly, 5=neither like nor dislike, 6=likes slightly, 7=like, 8=like very much and 9=like extremely). All the scores obtained were analysed with an ANOVA test to check significant differences among samples. Judges were allowed to drink water between samples to cleanse the palate. For CATA test judges were requested to recognize all the attributes that applied to each cookie and to their ideal version of a cookie. The attributes (excellent, good, mediocre, bad taste, crispy, crumbly, hard, soft, gummy, golden, pale, dark, very sweet, optimal sweetness, low sweet, good after taste, bad after taste) were randomly reported in the questionnaire. A correspondence test was performed on the results counting the times each attribute was identified for each sample.

Statistical analysis

Significant differences ($p \leq 0.05$) among different samples were assessed by one-way-analysis of variance (ANOVA) with a Duncan post-hoc test using an IBM SPSS statistical software (Version 24.0, SPSS Inc., Armonk, New York, USA). The contingency table of CATA dataset was obtained on the basis of samples and attributes. A correspondence analysis was performed to summarize the relationship between samples and attributes using the software Statistica (Version.13.3, TIBCO Software Inc., Palo Alto, USA).

Results and discussion

Semi-solid fibre syrup characterization

The semi-solid fibre syrup was characterised for its physico-chemical attributes, namely Brix degrees, water activity (a_w), moisture content (MC), colour and pH (Table 2). The results indicated that the fibre syrup had ≈ 75 Brix, water activity ≈ 0.88, moisture content ≈ 25 (g H_2O/ 100 g sample), and a pH of ≈ 6.4. As for colour, a^* and b^* indicated the marked presence of redness and yellowness tones, thus confirming the brownish colour. The information obtained by the characterization were used in the preliminary phases to optimize the recipes of the reformulated cookies other than to assist the discussion of the effect of the fibre syrup on physico-chemical and sensory properties of reduced-sugar cookies.

Nutritional composition

Nutritional profiles of the different cookies are reported in Table 3. Energy of all cookies was not markedly influenced by the different formulation used and it did not decrease with the decrease of sucrose in the recipe. Indeed in EU Regulation on labelling of food products (European Union, 2011), the energy conversion factor is not directly associated with the sugar content but to the total carbohydrate content which value did not diminish consistently in the cookies. All reformulated cookies presented lower sugars than the full sugar counterpart. In addition, an increased fibre content compared to the full sugar counterpart was noticed when fibre syrup was used. In particular, sugar content decreased from ≈ 23 g/100 g of the standard recipe (S100) to ≈ 17 g/100 g for S70 and S70M30, to ≈13 g/100 g for S50 and to ≈ 12 g/100 g for S50M50. In percentage, it was possible to obtain a reduction of ≈ 30% and ≈ 50% of the sugar content respectively for S30-S30M70 and S50-S50M50. Considering a cookie daily portion of 30 g (Società Italiana Nutrizione Umana, 2014), and based on the reference intake reported in the EU Regulation on labelling of food products (European Union, 2011), it can be estimated that the standard recipe (S100) may contributes to 7.6% of the daily reference intake of sugar in adult. On the contrary, the reformulated cookies lowered the contribution to ≈ 5.8% in S70, to ≈ 5.3% in S70M30, to ≈ 4.4% in S50 and to ≈ 4.0% in S50M50. In the reformulated cookies where the semi-solid fibre syrup was used, fibre content increased from ≈ 1.4 g/100 g (S100) to ≈ 6.2 g/100 g and ≈ 9.4 g/100 g for S70M30 and S50M5, respectively. Both formulations, S70M30 and S50M50, can have a dual nutritional claims, "reduced in sugar" and "high in fibre", on the basis of the EU regulation on nutritional and health claims (Euopean Union, 2006)

Cookie characterisation

In this study, sugar reduction was evaluated with and without the use of the semi-solid fibre syrup in substitution of sucrose to evaluate its technological and functional properties. All cookie doughs were easily workable, and it was not necessary to make any modifications in the cookie production process when the semi-solid fibre syrup was included in the recipe.

As reported in Table 4, a_w and MC were in the range 0.26-0.34 and 3.5-5.5 g H_2O /100 g sample, respectively, in accordance with previous results (average value are ≈ 0.3 and below 6 g/100 g respectively for a_w and MC) (Pareyt & Delcour, 2008; Curti et al., 2018), suggesting that the use of the semi-solid fibre syrup did not affect product quality and stability. Furthermore, this result underlines that such substitution maintained a low moisture content and very low water activity similarly to control product and within the same range of commercial products. Therefore, the reformulated products can be considered long shelf-life products, comparable to cookies commercially available.

Hardness of the cookies significantly decreased with the reduction of sugar when the semi-solid fibre syrup was not included in the formulation (Figure 1), as expected, as these products did not include any bulking agent in the recipes. The presence of the semi-solid fibre syrup significantly lowered hardness (13.7 ± 2.8 N for S100, 6.4 ± 1.7 N for S70M30 and 6.6 ± 1.7 N for S50M50). Interestingly, with 50% of sugar reduction, the presence of the semi-solid fibre syrup increased hardness indicating a bulking role in the formulation. Softening of the sugar reduced cookies can be explained by the absence of sugar, which crystallises during cooling, causing a hardening effect on the cookies (Gallagher et al., 2003). Similar softening effects, due to sucrose replacement on cookies, were reported when applying chicory-based oligosaccharide (Raftilose®) (Gallagher et al., 2003), stevia leaves powder (Kulthe et al., 2014) and fructoligosacharide (Handa et al., 2012). However, tagatose increased cookies hardness because tagatose is less soluble than sucrose and therefore tends to crystallise to a larger extent than sucrose (Taylor et al., 2008).

Cookies colour parameters (L^*, a^*, b^*) are reported in Table 4. Sugar reduced cookies produced without the use of the bulking agent (S70 and S50) had comparable surface lightness with S100, as indicated by the L^* value ≈ 80 in all the three samples. A darkening effect associated with a significantly decrease of L^* was observed in the presence of the semi-solid fibre syrup (≈ 75 and ≈ 78 for S70M30 and S50M50, respectively, with the latter significantly darker than the former). Surface darkening can be attributed to the intrinsic brownish colour of the fibre syrup. a^* indicates redness or greenness for positive or negative values respectively; a^* decreased with the increase of sugar reduction when the bulking agent was not included in the formulation moving from ≈ -1.43 for S100 to ≈ -1.92 for S70 and to ≈ -2.0 for S50. On the contrary, the presence of the semi-solid fibre syrup allowed to increase a^* leading to a more pronounced red colour, with a^* ≈ 1.12 and ≈ 0.48 for S70M30 and S50M50, respectively. b^* (yellowness) of the different cookies was found to be comparable with S100 in the case of S70 and S50M50 (≈ 45) while it decreased and increased in the case of S70M30 (≈ 42) and S50 (≈ 45), respectively. Overall, all sugar-reduced cookies had a distinguishable colour compared to the standard ones, with no significant differences due to different sugar reduced formulations. Based on the ΔE results only a quite distinguishable colour difference was observed for all samples with comparable values between them, in particular S70 (≈2.9), S70M30 (≈3.7), S50 (≈3.7) and S50M50 (≈3.2).

Sensory analysis

Cookie acceptability was assessed by a panel of consumers to evaluate if they may be able to perceive a difference in the reformulated products and to observe if the presence of fibre leads to a negative impact on liking as previously observed on other matrices (Biguzzi et al., 2014; Brennan & Samyue, 2004). The obtained results are reported in Figure 2. All cookies tested were liked by the consumer panel, with the most preferred S100, S70 and S50M50 samples in which quite all attributes were close to 7 (like). S70 had the lowest score of appearance, and S50M50 was found the least sweet among all formulations. The low score of the appearance in S70 increased with the use of the semi-solid fibre syrup in S70M30 from ≈ 6 (likes slightly) to ≈ 7 (like) highlighting that the high colour difference previously observed by colour analysis did not hinder consumer product acceptability. The high scores identified for S50M50, in particular for appearance and texture, highlight the efficacy of the semi-solid fibre syrup as a bulking agent. Instead, the low sweetness level perceived for S50M50 it should not be an obstacle as sweetness could be adjusted during the industrialisation step with the use of a "naturally perceived" (by the consumer) sweetener as stevia (Asioli et al., 2017). Detailed information on consumers' perception of cookies was obtained using a CATA test, as the consumers panel could select appropriate attributes for the sample from a previous specified list (Ares et al., 2014; Dooley et al., 2010).

CATA results were analysed using a correspondence analysis which output is shown in Figure 3. In the factor plane, the "IDEAL" product and the different cookies recipes are represented. The two dimensions explained ≈ 74% of the variance with dimension 1 explaining ≈ 49% and dimension 2 explaining ≈ 24%. "IDEAL" sample was described as "excellent", "golden", "good after taste", "optimal sweetness"; similar descriptors were used also for S70M30. S100 was described by the attributes "hard", "very sweet, "crispy", "dark"; S50 was described with negative indicators "crumbly", "soft", "gummy"; S70 was not discriminated by any attribute; S50M50 was described by “slightly sweet”, “mediocre”, “bad after taste”. The negative attributes indicated for S50M50 reflect the lower scores for sweetness reported in the acceptability test. In the final view to obtain sugar-reduced and high-fibre, encouraging results have been obtained combining acceptability and CATA test. Indeed, cookies in which sugar has been substitute with the semi-solid fibre syrup (S50M50) presented a better consumer outcome than cookies in which sugar has been simply eliminated (S50). The lower scores and attributes related to the taste can be adjusted with the use of sweetener in the recipe not used in this work in which the main purpose was the study of the technological effect of the semi-solid fibre syrup. These results are even more interesting if it is considered that the consumer panel was not aware of the nutritional claims accompanying the product and also because fibre-enriched products are usually associated with a general disliking (Biguzzi et al., 2014; Brennan & Samyue, 2004).

Conclusion

A semi-solid fibre syrup based on corn and chickpea fibres was used as a clean label bulking agent for sugar reduction in cookies. The semi-solid fibre syrup did not hinder dough workability and no modification in cookie preparation was necessary, the bulking agent enabled to partially preserve the structure of the sugar reduced cookie and contributed into the improvement of both nutritional and consumer acceptability profiles. Colour differences did not jeopardize consumer acceptability. As such, two products were developed in which sugar was reduced of 30% and 50% and where double nutritional claims on the label “reduced in sugar” and “high in fibre” have been reached.

Conflict of interests

AC was involved in the research as Industrial PhD student. Universities involved in this research have not received any funding.

Ethical guidelines statement

All judges were previously informed about the scope of the research and of its non-commercial purpose, as well as their anonymous and voluntary participation. Moreover, judges were informed of the composition of the cookies to exclude any allergic subject. Judges were also informed about the possible use of the data raised by the study for any scientific or informative communication.

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** In this review the different sugar replacers available for specific food categories in terms of alternative sweeteners and bulking agents have been illustrated.*

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** In this paper are reviewed the physiological basis of sweetness perception, the methods to assess the sweetness in food and the strategies available to reduce sugar in foods.*

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** This paper reviewed the technological role of sugar in biscuits and its interaction with the other ingredients in the biscuit recipe from the perspective of sugar reduction*.

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Table 1. Cookie~~s~~ formulation~~recipes (g)~~.

Ingredients (g)	**S100**	**S70**	**S70M30**	**S50**	**S50M50**
Wheat flour	100	100	100	100	100
Butter	30	30	30	30	30
Eggs	28	28	28	28	28
Chemical leaving agent	3	3	3	3	3
Sucrose	40	28	28	20	20
Fibre syrup	-	-	12	-	20

Legend: S100 =~~:~~ Sucrose 100%; S70 =~~:~~ Sucrose 70%; S70M30 =~~:~~ Sucrose 70%, fiber~~re~~ syrup 30%; S50 =~~:~~ Sucrose 50%; S50M50 =~~:~~ Sucrose 50%, fib~~re~~r syrup 50%.

Table 2. Physico-chemical properties of ~~the~~fiber~~re~~ syrup.

	~~Fibre syrup~~
°Brix	74.55 ± 0.55
a_w	0.88 ± 0.01
MC (g H_20/100 g sample)	25.03 ± 0.98
pH	6.37 ± 0.04
*L**	23.51 ± 0.15
*a**	0.34 ± 0.03
*b**	3.34 ± 0.42

All data are expressed as mean ± standard deviations

Con formato: Inglés (Estados Unidos)

Table 3. Nutritional composition based on Reg EU 1169/2011 of cookies ~~at~~ with different sucrose (S)/fib~~r~~er syrup (M) ratio (%).

	S100	S70	S70M30	S50	S50M50
Energy (kJ)	1570	1938	1899	1965	1882
Energy (kcal)	452	463	454	470	450
Fat	16.1	17.5	16.~~,~~8	18.6	17.~~,~~1
-of which saturated	15.8	17.4	16,3	18.1	16.~~,~~6
Carbohydrates	67.7	66.2	63.~~,~~5	64.8	59.9
-of which sugars	22.9	17.4	16.6	13.1	12.1
Fibre	1.4	1.6	6.2	1.6	9.4
Protein	8.6	9.4	9.1	10.0	9.3
Salt	0.1	0.1	0.1	0.1	0.1

Legend: S100 = Sucrose 100%; S70 = Sucrose 70%; S70M30 = Sucrose 70%, fiber syrup 30%; S50 = Sucrose 50%; S50M50 = Sucrose 50%, fiber syrup 50%.

Table 4. Water activity (a_w), moisture content (MC), and color (L^*, a^*, b^*, ΔE) of cookies with different sucrose (S)/fiber syrup (M) ratio (%)of cookies at variable sucrose and fibre syrup ratio.

	S100	S70	S70M30	S50	S50M50
a_w	0.32 ± 0.02ab	0.31 ± 0.02abc	0.29 ± 0.02bc	0.34± 0.02a	0.26 ± 0.02c
MC	5.47 ± 0.93a	4.55 ± 0.87ab	3.73 ± 0.76b	4.19 ± 0.55b	3.53 ± 0.73b
L^*	79.71± 0.83b	80.71 ± 1.14a	79.70 ± 0.99b	80.77 ± 0.98a	78.08 ± 0.97c
a^*	-1.,43 ± 1.01c	-1.92 ± 0.46c	1.12 ± 0.31a	-2.00 ± 0.55c	0.48± 0.55b
b^*	44.66 ± 1.62b	44.95 ± 1.28b	41.73 ± 1.17c	47.33 ± 1.84a	44.89 ± 0.79b
ΔE	-	2.86 ± 1.26a	3.87 ± 1.39a	3.68 ± 1.86a	3.19 ± 1.20a

All the data are expressed as mean ± standard deviations; different letters indicate significanttive differences in each row ($p \leq 0.05$).
Legend: S100 = Sucrose 100%; S70 = Sucrose 70%; S70M30 = Sucrose 70%, fiber syrup 30%; S50 = Sucrose 50%; S50M50 = Sucrose 50%, fiber syrup 50%.

Figure 1. Hardness of cookies with variable sucrose/fiber syrup contents. Different letters indicate significative differences among samples (p ≤ 0.05).

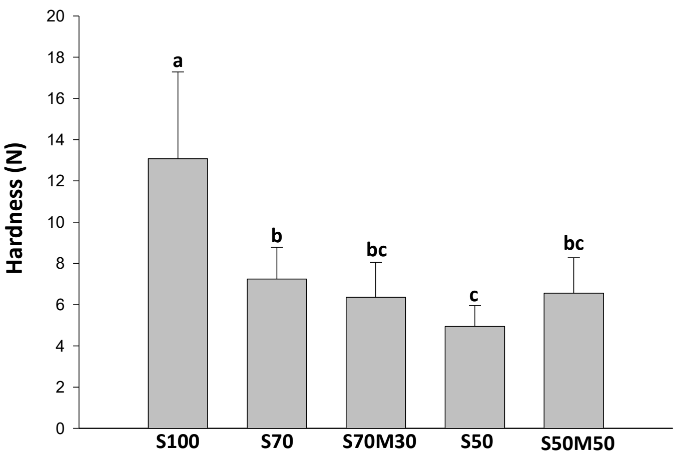

Figure 2. Sensory scores for appearance, texture, taste, sweetness, and overall acceptability of ~~short bread~~ cookies with variable sucrose/fibre syrup contents. Different letters indicate significative differences among samples ($p \leq 0.05$).

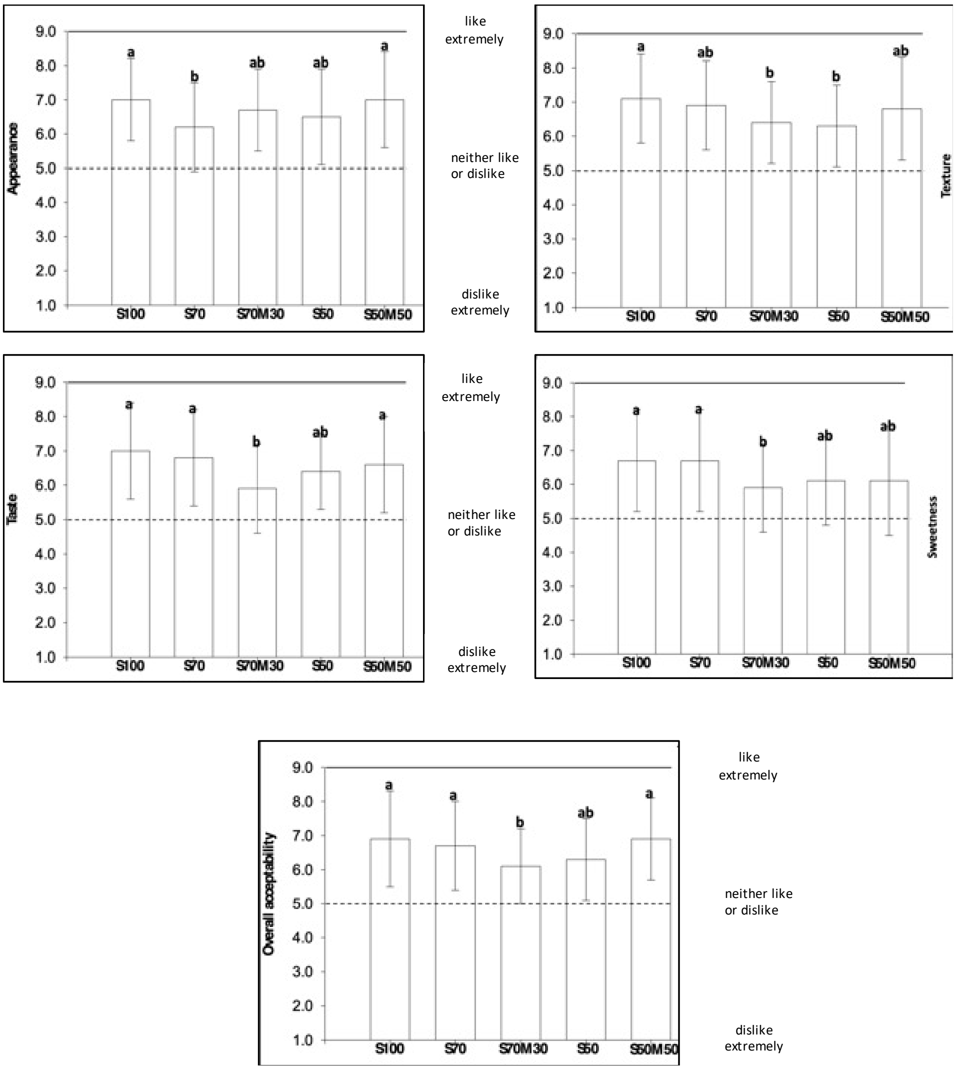

Figure 3. Correspondence analysis of the CATA test data of cookies with variable sucrose/fibrer syrup contents.