Acta Sci. Pol., Technol. Aliment. 12(2) 2013, 223-229
pISSN 1644-0730 eISSN 1889-9594 www.food.actapol.net/

TEXTURAL AND SENSORY PROPERTIES OF THE SWEET CZECH CHRISTMAS BREAD WITH SUGAR SOLUTIONS*

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ABSTRACT

Background. The effect of sugar solutions, commonly used for preparing and improving quality of ice creams, that have a similar effect on the sweet Czech Christmas bread was checked.
Material and methods. Commercial wheat flour T 512 ingredients were used for preparing dough and final products. Sugar solutions A, B were used as sweeteners for sucrose. Texture properties of dough and the sweet Czech Christmas bread were measured on the TA-XT Plus Texture Analyzer. The sweet Czech Christmas bread was subjected to sensory evaluation.
Results. Dough firmness did not differ from each other or the control dough. The sweet Czech Christmas bread with partial substitutions of sucrose with the sugar solution A (containing 77.50 g of sugar in 100 g of sugar solution; 77.5°Brix ±1.5) had the same firmness as the control sample after baking and 3- day storage. Products with partial substitutions of sucrose with higher amounts of sugar solution B (40-50 $g \cdot kg^{-1}$), which contained 80 g of sugar in 100 g of sugar solution; 80°Brix ±1.5, had higher firmness after the 3rd day of storage. No difference was found among samples with partial substitutions of sucrose with the sugar solution B after baking. Sensory analyses did not show any significant changes in monitored characteristics (taste, sensation when swallowing, sweetness, dryness, pliancy, crispness, gumminess, saliva-absorbing capacity and quality).
Conclusions. Partial substitution of saccharose by these sugar solutions is not preferable for the sweet Czech Christmas bread. There is no evidence of the same effect of sugar solutions on bakery products.

Key words: firmness, pliancy, product, sweetness

INTRODUCTION

Fresh bakery products have a relatively short shelf-life. A number of physical and chemical changes occur during their storage. The process is known as staling. Loss of freshness, an increase in crumb hardness and a decrease in flavour and aroma causes loss of consumer acceptance [Selomulyo and Zhou 2007]. Bakers prevent the loss of moisture and starch retro-gradation by applying some additives for example emulsifiers which are able to act as dough conditioners and bread softeners [Pečivová et al. 2010], or arabic gum from acacia tree and pectin from apple which can improve the quality of the final bakery product [Pečivová et al.

*This work was kindly supported by a project of the Czech Ministry of Education, Youth and Sports (Grant no. MSM 7088352101).

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2011]. But there are also other additives such as sugar solutions, which are able to modify the texture of dough and sensory properties of bakery products.

Sucrose is a highly labile in acid medium, and acid hydrolysis is more rapid than with other oligosaccharides. An important reaction of sucrose, which is common with other sugars, is the formation of insoluble compounds with calcium hydroxide. Sucrose is highly soluble over a wide temperature range. This property makes sucrose an excellent ingredient for syrups and other sugar-containing foods.

Sucrose, which is a disaccharide, can be broken down into a 1:1 mixture of dextrose (glucose) and laevulose (fructose), known as invert sugar [Jackson 1995]. Invert sugar has a lower tendency to crystallize, when compared to sucrose [Jackson 1995], and is also considered a low cost product. It is frequently used in the food industry to reduce sucrose crystallisation in high viscosity solutions, compared to solutions containing sucrose alone. While sucrose itself is saturated at 67% solids, a 50/50 mixture with invert sugar becomes saturated at 76% solids [Veiga-Santos et al. 2007].

Sugar also influences for example the development of cake structure and determines layer cake volume and contour by increasing the gelatinization temperature of starch [Abboud and Hoseney 1984, Baker et al. 1990, Ngo and Taranto 1986]. Gordon et al. [1979] also found a similar trend in delaying starch gelatinization in cakes formulated with 42% sucrose. These cakes gelatinized in the range of 82-91°C instead at 55-75°C, as expected for the same starch-water mixture without sucrose. They hypothesized that sugars interact with starch molecule chains in the amorphous regions of the starch granules, thereby increasing the energy required for starch gelatinization. Thus, sugar influences starch swelling, water availability, and air cell stability during structural development of cake crumb [Baker et al. 1990].

The application of maltodextrins as anti-staling agents for wheat bread was already studied by few authors [Defloor and Delcour 1999, Miyazaki et al. 2004]. Miyazaki et al. [2004] concluded that the retrogradation of starch in crumb during storage was significantly retarded if lower molecular weight dextrins were used as compared with high molecular weight dextrins [Defloor and Delcour 1999]. Defloor and Delcour [1999] observed that different concentrations of maltodextrin preparations with average degree of polymerization, varying between 4 and 66, reduced DSC staling endotherm in baked and stored bread dough [Miyazaki et al. 2004].

The sugar solutions A and B are gels which are normally used for producing ice cream. Ice cream is softer, more plastic and has more stable consistency with these sugar solutions. Moreover, additions of the sugar solutions B and A (have lower sweetening) increase dry matter of ice cream and thus cause slower freezing of ice cream. Because of enhancing effect on quality of ice cream, the sugar solutions B and A were used for prolongation of pliancy, adjustment of sweetening and improving texture of the sweet Czech Christmas bread. Thus the aim of this work was to investigate the influence (whether all or none) of partial replacement of sucrose by sugar solutions (the sugar solutions A or B) on quality of bakery products (the sweet Czech Christmas bread).

MATERIAL AND METHODS

Materials

A commercial wheat flour T 512 (moisture – 13.5%, ash – 0.55%, gluten as an amount of wet gluten in DM – 34.1%, falling number – 296 s, P – 71 mm H_2O, L – 105 mm, P/L – 0.68, W – 21.8 mJ, I_e – 49.5%, Mills Kojetín s.r.o., Kojetín, Czech Republic) was used. Alveograph analysis (Chopin – Tripette & Renauld, France) was used for determination of basic characteristics according to the methods ISO 5530-4 [2002].

Ingredients. Salt (Solivary Trade, s.r.o., Prešov, Slovakia); saccharose (Považský sugar, a.s., Trenčianska Teplá, Slovakia), yeast (*Saccharomyces cereviseae Hansens* (Uniferm GmbH&Co. KG, Werne, Germany); refined rape-seed oil (rape, erucic acid – maximum 0.4%, from Master Martini CE s.r.o., Prague, Czech Republic); egg melange (mix yolk and white from chicken eggs, from Velkopavlovické poultry plants, a.s., Velké Pavlovice, Czech Republic) were used for preparing dough and final products (the sweet Czech Christmas bread).

Additives. Sucrose, which is obviously added to the sweet Czech Christmas bread, was replaced in certain circumstances by the sugar solution A-Revolution cream (contain 77.50 g of sugar in 100 g of sugar solution; 77.5°Brix ±1.5) or by the sugar solution B-Revolution fruit (contain 80 g of sugar in 100 g of sugar solution; 80°Brix ±1.5) which were made of invert sugar syrup, glucose syrup, maltodextrin, both from Irea S.r.l., Gallarate, Italy. The sugar solution B was stiffer gel in comparison to the sugar solution A. Both had white-yellowish colour, sweet and creamy consistency (form-gel). The sugar solutions are well applied into dough and are dissolved and mixed better into dough than ordinary sucrose. Invert sugar contained in products is obtained by acid hydrolysis.

Methods

Preparing of dough. The dough samples were prepared in four independent replicates from 1000 g of wheat flour T 512, into which 490 ml·kg^{-1} of water, 20 g·kg^{-1} of salt, 60 g·kg^{-1} of yeast, 100 g·kg^{-1} of oil, 10 g·kg^{-1} of egg melange and 120 g·kg^{-1} of sucrose (control sample – A) or a corresponding amount of a mixture of sucrose (100-70 g·kg^{-1}, the samples B-E) and of a the sugar solution A or the sugar solution B (20-50 g·kg^{-1}) were added. Exact ratios are stated in Table 1.

Table 1. Ratios of sucrose and sugar solutions (A, B) in the sweet Czech Christmas bread

Additions	Sample				
	A	$B_{A/B}$	$C_{A/B}$	$D_{A/B}$	$E_{A/B}$
Sucrose, g·kg^{-1}	120	100	90	80	70
Sugar solutions A and B, g·kg^{-1}	0	20	30	40	50

A – control sample (final product only with sucrose), B_A-E_A – samples with additions of sugar solution A, B_B-E_B – samples with additions of sugar solution B.

Baking. The dough samples were mixed for 8 minutes in the spiral stirring machine (ALBA, spol. s.r.o., Hořovice, Czech Republic) and left to stand for 50 minutes at temperature 30°C, cut into six separate pieces (c. 92 g each). The six pieces were used to plait a typical final form of the sweet Czech Christmas bread of about 552 g. Then, the pieces of dough were put into the trug, on a baking tray and left to rise for 30 minutes at a temperature of 35-40°C and at a humidity of 60% in the proofer (KA-E1V, Kornfeil, s.r.o. Čejč, Czech Republic). The final form of the sweet Czech Christmas bread was spread with an egg melange and then baked in the Rotomax rotary gas furnace (Rotomax, Kornfeil, s.r.o. Čejč, Czech Republic) for 26 minutes at a temperature program: (1-5 min at 190°C, 5-23 min at 165°C, 23-26 min at 175°C and 26-27 min at 190°C).

Texture analysis of dough and the sweet Czech Christmas bread. The texture of the samples of dough and the sweet Czech Christmas bread was evaluated by using a TA-XT Plus Texture Analyzer (O.K. SERVIS BioPro, s.r.o., Prague, Czech Republic), and conducting a "measure of force in compression" test with a AACC 36 mm cylinder probe with radius (P/36R). The analyser was set at a 'return to start' cycle, a pre-test speed of 1 mm·s^{-1}, a test speed of 1.7 mm·s^{-1}, a post-test speed 10.0 mm·s^{-1} and a distance of 6.25 mm. Firmness is defined in this method as the force (Newtons) required to compress the product by a pre-set distance (i.e. force taken at 25% compression of 25 mm). A 25% compression of 25 mm thick sample = 6.25 mm compression distance at which point the compression force value (CFV) is taken.

Measurement samples of dough. In order to achieve a complete description of the dough quality needed for baking technology, a deformation measurement was used, by means of which the influence of ratios of sucrose + different additions of the sugar solution A or B on the textural properties of dough was specified.

Four portions (100 g each) of each of the four replicates of dough was put to the four plastic bowls and left to stand for 60 minutes in the cooling chamber at the temperature 18 ±2°C. Each sample in the plastic bowl was measured. All the dough samples were measured in triplicate

Measurement samples of the sweet Czech Christmas bread after baking and 3 days after baking. One half of the sweet Czech Christmas breads was sliced to 25 mm thick slices immediately after backing (7 slices) and the other half of the sweet Czech Christmas breads was sliced after three days (another 7 slices). The samples were stored in a plastic bag at room temperature 25 ±2°C. All the slices were measured in triplicate.

Sensory analysis of the sweet Czech Christmas bread. The aim of the sensory analysis was to evaluate how different ratios of sucrose to the sugar solutions A or B influenced the sensory characteristics of bakery products. Sensory evaluation (taste, sensation when swallowing, sweetness, dryness, pliancy, crispness, gumminess, saliva-absorbing capacity and quality of the product) was performed by 15 panelists at the level of "a selected assessor" according to ISO Standard No. 8586-1 [1993] within the sensory laboratory equipped in accordance with ISO Standard No. 8589 [1988] in Tomas Bata University in Zlín, Faculty of Technology and in Topek, s.r.o., Topolná, Czech Republic. In each round, 5 samples of the sweet Czech Christmas bread (control sample A and samples B, C, D and E, see Table 1 for their composition) were presented anonymously at room temperature (25 ±2°C) in each run. All the sensory analyses were conducted 3 times.

Statistical analysis. A non-parametric analysis of variance Kruskal-Wallis test was applied for the evaluation of the individual sensory properties (taste, sensation when swallowing, sweetness, dryness, pliancy, crispness, gumminess, saliva-absorbing capacity and quality) [Agresti 1984]. The results of texture analyses were statistically evaluated by STATISTICA CZ (Statsoft, Inc., Tulsa, USA), version 9.1. Differences among the comparisons had to achieve $P < 0.05$ to show significance in all cases.

RESULTS AND DISCUSSION

Textural analysis

Textural analysis of dough. Table 2 shows that dough with the additions of the sugar solutions A and B did not influence the firmness of dough in comparison with the control dough. It can be said that dough with partial substitution sucrose to sugar solutions had the same firmness as the control dough. Our results are not in agreement with the authors [Jackson 1995] who claimed that inverted sugar had a lower tendency to crystallize in comparison to sucrose. Sugar solution (A, B) containing inverted sugar did not decrease firmness of dough (dough did not become extensible owing to inverted sugar in the sugar solutions).

Textural analysis of the sweet Czech Christmas bread after baking and 3 days after baking. Table 3 shows those final products (the sweet Czech Christmas bread) with partial substitutions sucrose to the sugar solution A or B had the same firmness as control sample after baking. It can be said that sugar solutions did not change pliancy in final product (the sweet Czech Christmas bread).

Table 2. Textural characteristics of dough with different additions of the two sugar solutions (A, B)

Samples	Mean compression force 'Firmness' (N)	
	sugar solution A	sugar solution B
A	9.1 ±1.3^a	9.1 ±1.3^a
$B_{A/B}$	9.5 ±0.9^a	9.9 ±1.3^a
$C_{A/B}$	9.1 ±0.8^a	9.7 ±1.3^a
$D_{A/B}$	9.4 ±1.5^a	9.8 ±1.3^a
$E_{A/B}$	9.5 ±1.9^a	10.3 ±1.6^a

A – control sample (final product only with sucrose), B_A-E_A – samples with additions of sugar solution A, B_B-E_B – samples with additions of sugar solution B.

The individual additions of the sugar solution A did not increase firmness of final products in comparison with the control sample 3 days after baking. It can be stated that final product with partial substitutions sucrose to sugar solution had the same pliancy/dryness (or freshness) as the control product only with sucrose. Our results are not in agreement with the authors Baker et al. [1990] who stated that the crumb structure was the most compact for the non-emulsified cake made with sucrose solution. Our results are not in agreement with the uthors [Jackson 1995, Veiga-Santos et al. 2007] who stated that inverted sugar (which is present in the sugar solution A) reduces sucrose crystallisation in high viscosity solutions, compared to solutions containing sucrose alone [Jackson 1995, Veiga-Santos et al. 2007]. This may be explained by the production of different type of the product than the cake (different technology, different ingredients and additives). Additionally, sugar solutions did not contain only invert sugar, but also further glucose juice and maltodextrine.

Final products (the sweet Czech Christmas bread) with partial substitutions sucrose to 40-50 $g \cdot kg^{-1}$ of the sugar solution B had higher firmness in comparison to products with partial substitutions sucrose to 20-30 $g \cdot kg^{-1}$ and the control product. It can be said that with

Table 3. Textural characteristics of the sweet Czech Christmas bread with different additions of sugar solutions A and B after baking and 3 days of storage

Mean compression force 'Firmness' (N)	Types of sugar solutions	Samples				
		A	$B_{A/B}$	$C_{A/B}$	$D_{A/B}$	$E_{A/B}$
After baking	A	5.3 ±0.9^{a}	5.2 ±0.5^{a}	5.1 ±0.9^{a}	5.6 ±0.8^{a}	5.9 ±0.5^{a}
	B	5.3 ±0.9^{a}	5.1 ±0.6^{a}	5.2 ±0.7^{a}	5.2 ±0.5^{a}	5.5 ±0.3^{a}
After 3 days of storage	A	23.0 ±1.6^{a}	23.6 ±1.5^{a}	23.3 ±0.9^{a}	24.2 ±2.5^{a}	24.4 ±1.7^{a}
	B	23.0 ±1.6^{a}	21.7 ±1.5^{a}	22.2 ±1.0^{a}	24.2 ±0.8^{b}	26.0 ±1.4^{b}

A – control sample (final product only with sucrose); B_A-E_A – samples with additions of sugar solution A, B_B-E_B – samples with additions of the sugar solution B.

increasing additions of the sugar solution B, firmness increased. Our results are not in agreement with Miyazaki et al. [2004] who stated that the retro-gradation of starch in crumb during storage was significantly retarded if lower molecular weight dextrins were used. This can be explained by the difference in the ratio of maltodextrine in our sugar solution B and the presence of other sugar components in the sugar solution. But our results are in agreement with authors [Abboud and Hoseney 1984, Baker et al. 1990, Ngo and Taranto 1986] who found that sugar influences the development of cake structure and determines layer cake volume and contour by increasing the gelatinization temperature of starch.

Sensory analysis of the sweet Czech Christmas bread

The influence of partial substitution sucrose to individual additions of sugar solutions (the sugar solution A or B) on the sensory characteristics of final products (the sweet Czech Christmas bread) after baking was studied. All the samples with partial substitutions of sucrose with both sugar solutions (the samples B-E), except for the control sample (the sample A) were evaluated for the following characteristics: taste, sensation when swallowing, sweetness, dryness, pliancy, crispness, gumminess, saliva-absorbing capacity and quality.

A statistically non-significant difference ($P > 0.05$) was found in the all sensory characteristics such as taste, sensation when swallowing, sweetness, dryness, pliancy, crispness, gumminess, saliva-absorbing capacity and quality at the level of significance of 5% (Table 4). It can be said that sensory assessors were not be able to recognize no improvement or deterioration in observed characteristics among individual product. They evaluated these products as good as product with only sucrose (control sample). Our results are not in agreement with the authors Baker et al. [1990] who found that the sucrose-solution cakes were very uniform in cell structure, coarse, crumbly, and fragile. But the cake made with crystalline sucrose had a coarse crumb with some open cell areas and larger capillary pores. The difference is probably due to the addition of different composition of sugar solution, producing different product, using a different technology of dough preparation and baking, etc.

CONCLUSION

Sugar solutions such as the sugar solutions A and B, which are normally used for preparing ice cream, were used for preparing final bakery products. These sugar solutions in individual ratios were used as partial substitutions of sucrose which is normally added to the final product (the sweet Czech Christmas bread).

The results obtained by the texture measurement of dough with partial substitutions sucrose to sugar solutions the sugar solution A and the sugar solution B did not differ from one another or from the control dough in firmness. The same conclusion can be said about final products (after baking or on the 3rd day after baking) in comparison with the control product or among these products. All samples had the same firmness.

Table 4. Results (expressed as median) of the sensory analysis of the tested sweet Czech Christmas bread with additions of the sugar solution A (samples B_A-E_A) or the sugar solution B (samples B_B-E_B) after baking

Characteristics	Median values									
	samples									
	A_A	B_A	C_A	D_A	E_A	A_{B*}	B_B	C_B	D_B	E_B
Taste	3^a	2^a	2^a	2^a	2^a	3^a	3^a	3^a	3^a	3^a
Sensation when swallowing	3^a	3^a	3^a	3^a	3^a	3^a	3^a	3^a	3^a	3^a
Sweetness	3^a	3^a	3^a	3^a	3^a	3^a	3^a	3^a	4^a	4^a
Dryness	3^a	3^a	3^a	4^a	4^a	4^a	4^a	3^a	3^a	3^a
Pliancy	3^a	3^a	3^a	3^a	3^a	3^a	3^a	3^a	3^a	3^a
Crispness	3^a	4^a	4^a	3^a	3^a	3^a	3^a	3^a	3^a	3^a
Gumminess	3^a	3^a	3^a	3^a	3^a	3^a	3^a	3^a	3^a	3^a
Saliva-absorbing capacity	3^a	3^a	3^a	2^a	3^a	2^a	2^a	2^a	2^a	3^a
Quality	3^a	2^a	2^a	2^a	2^a	2^a	2^a	2^a	3^a	3^a

$A_{A/B}$ – control sample (final product only with sucrose).
Hedonic scales used. Taste: 1 – very good to 5 – very bad. Sensation when swallowing: 1 – very good to 5 – very bad. Sweetness: 1 – very significant to 5 non-significant. Dryness: 1 – very dry to 5 very wet. Pliancy: 1 – very high to 5 very low. Crispness: 1 – very crisp to 5 tough. Gumminess: 1 – very high to 5 hardly noticeable.
Saliva-absorbing capacity: 1 – very good to 5 – very bad. Quality: 1 – excellent to 5 very bad.
Median values having the same superscript letter in each column are not significantly different ($P \geq 0.05$); each group was evaluated separately.

On the other hand, partial substitutions of sucrose with the sugar solution B in higher additions (40-50 $g \cdot kg^{-1}$) increased firmness of the final product in comparison with the control product and products with partial substitutions of sucrose with 20-30 $g \cdot kg^{-1}$ on the 3rd day after baking.

The results of the sensory analyses showed that sensory assessors did not evaluate differences in monitoring characteristics (taste, sensation when swallowing, sweetness, dryness, pliancy, crispness, gumminess, saliva-absorbing capacity and quality). They evaluated those products as good as the products with only sucrose (control sample).

In conclusion, glucose or fructose solutions are usually added or used to many food products. They are able to regulate sweetening or change visco-elastic (textural) properties of ice cream, or non-chocolate confectionery. But partial substitutions of sucrose with the sugar solution B or the sugar solution A did not especially influence bakery products (the sweet Czech Christmas bread). Bakery products with partial substitutions of sucrose with the sugar solution A had the same sensory and textural properties after baking and on the 3rd day after baking. On the other hand, the sweet Czech Christmas bread with higher additions (especially with 50 $g \cdot kg^{-1}$) had higher firmness in comparison with the control product and products with partial substitutions of sucrose with 20-30 $g \cdot kg^{-1}$ on the 3rd day after baking.

Improved textural properties of the dough and observed sensory properties of the sweet Czech Christmas bread were not confirmed. In contrast, the sweet Czech Christmas bread quickly lost freshness (after 3 days of storage) after addition of higher amount of sugar solution B. Summarizing it can be stated that the partial substitution of saccharose by these sugar solutions is not preferable for this kind of baking products.

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Received – Przyjęto: 12.10.2012 Accepted for print – Zaakceptowano do druku: 28.02.2013

For citation – Do cytowania

Boudová Pečivová P., Kubáň V., Mlček J., Rop O., 2013. Textural and sensory properties of the sweet Czech Christmas bread with sugar solutions. Acta Sci. Pol., Technol. Aliment. 12(2), 223-229.