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CHICORY SYRUP AS A SUBSTITUTION OF SUGAR IN FINE PASTRY

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ABSTRACT

Fine pastry is a favorite snack but contains big amount fats and sugars. Sugar consumption is a major factor in the development of diabetes and obesity. Because of the growing interest in low-calorie alternatives to sucrose, producers react with different new products which can replace sugar and do not compromise the consumer acceptability of food products. This study deals with replacement of sugar with chicory oligofructose syrup, which provides same sweetness as sugar but contain over 70 % of fiber. Chicory syrup is composed of oligo-fructose and inulin. Inulin-type fructans are beneficial for immune and cardiovascular systems and its prebiotic function can protect colon health. In this study, the influence of sucrose (7 g.100g^{-1}) replacement with chicory oligofructose syrup (0; 3.5; 7 g.100g^{-1}) on the texture, specific loaf volume and sensory acceptability of biologically leavened muffins was tested. The substitution of sugar by the chicory syrup decreased specific loaf volume from 2.15 to 2.01 mL.g^{-1} while hardness, springiness and chewiness increased. There was no detrimental impact of syrup addition to cohesiveness of fine pastry muffin. It was observed that due to the syrup addition, pastry hardens faster, as showed results of hardnesss measured after 24 h. Bread crumb and crust sensory characteristics were not affected by the syrup addition. Weak impact of sugar replacement on sensory evaluation may be related to a reduced amount of the panelists involved in this study. More extensive study will, however, be performed to describe the impact of sugar replacement of fine biologically leavened muffins in more details. The results of this preliminary study shows, that the substitution of sugar by chicory syrup change textural properties and loaf volume. Despite all, based on sensory analysis the chicory syrup up to amount 7 g.100g^{-1} seems to be adequate for its use as a sugar replacer in fine pastry as biologically leavened muffins.

Keywords: inulin; chicory; muffin; sugar; texture

INTRODUCTION

In Europe, fine pastry is a favorite snack or cake consumed on various occasions by all generations. However, it contains a lot of calories, fats and sugars. According to the Commodity Decree No. 333/1997 Coll. of the Czech Republic as subsequently amended, fine pastry is defined as a bakery product obtained by heat treatment of a dough containing at least 8.2 % of anhydrous fat or 5 % of sugar on the total weight of used mill products.

Excessive sugar consumption is a major factor in the development of diabetes. This disease, along with the many other health problems associated with the rising incidence of obesity in Europe, are major concerns from a public-health perspective. There is growing interest in low-calorie alternatives to refined sucrose. Synthetic sweeteners are often regarded either as having an undesirable aftertaste or as being linked to health concerns. There is strong demand for natural sweeteners as maple, date, agave or chicory syrups.

Chicory syrup is composed of oligo-fructose and inulin. The main source of oligo-fructose and inulin used in the food industry are chicory and artichoke from Jerusalem **(Franck, 2002)**. Oligo-fructose and inulin belong to the class of carbohydrates known as fructans. Inulin-type fructans have been reported to be beneficial for colon health by selectively promoting the growth of bifidobacteria and lactobacilli probiotic bacteria **(Gibson et Roberfroid, 1995)** and cardiovascular systems by decreasing cholesterol and triglyceride levels in serum **(Kaur et Gupta, 2002).** The health benefits of oligo-fructose also include increased mineral absorption **(van den Heuvel et al., 1999)** and improved immune response and while there is evidence that oligo-fructose used as prebiotics play a role in colorectal cancer prevention **(Morris et Morris, 2012)**. In addition, according to **EFSA (2015)** health claim, chicory inulin contributes to maintenance of normal defecation by increasing stool frequency.

Oligo-fructose is more soluble than sucrose and provides about 30 to 50 % of the sweetness of table sugar. It is often used in combination with high intensity sweeteners **(Kaur et Gupta, 2002)**.

The aim of this work was to evaluate the influence of chicory syrup, as a possible substitute for sugar, on technology, textural properties and sensory quality of fine pastry, namely biologically leavened muffins. There is a deal to establish whether fine pastry sweetened by chicory syrup can be manufactured without compromising consumer acceptance.

Scientific hypothesis

We established the hypothesis that the substitution of sugar by chicory syrup does not impair textural properties, loaf volume and sensory acceptability of biologically leavened muffins.

MATERIAL AND METHODOLOGY

Chicory syrup

Chicory syrup was kindly provided by KAUMY s.r.o., Czech Republic. According to producer, the syrup energetic value is 650 kJ.100g^{-1} and contains 4.7 g.100g^{-1} of sugars and 71.3 g.100g^{-1} of fiber. The producer states that the glykemic index of the chicory syrup is GI <5, which is in comparison with sacharose GI = 65 **(Atkinson et al., 2008)** very low.

Muffins preparation

A formula for dough preparation consisted of wheat fine flour (45.5 g.100g^{-1}), water (23 g.100g^{-1}), canola oil (19 g.100g^{-1}), sweetener (sugar or chicory syrup) (7 g/100g), dry egg mélange (3.5 g.100g^{-1}), salt (1 g.100g^{-1}) and dry yeast (1 g.100g^{-1}). Three batches were baked, where the first contained only sugar **(B0Sy)**, in the other one half of the sugar was replaced with chicory syrup **(B50Sy)**, in the third one the whole amount of sugar was replaced by the syrup **(B100Sy)**. The amounts of the ingredients were related to 100 g of flour dry matter. Dry yeast was reactivated for 10 ±1 min. in a sweetener solution (35 ±1 °C). The dough ingredients were placed into the Eta Exclusive Gratus mixer bowl (Eta, a.s. CZ), mixed for 6 min and placed into a proofer for 40 min. at 35 ±1 °C and 85% relative air humidity. Then 100 g of dough was scaled into silicone muffin cups and proofed again for 20 min. at 35 ±1 °C and 85% relative air humidity. Muffins were baked for 10 min. at 200 ±5 °C in the oven MIWE cube (Pekass s.r.o. Plzeň, CZ). After baking, the mufins were stored at room temperature for 2 hours and then analyzed. Each test was performed on samples prepared at least in three replicates.

Muffin analysis

Specific loaf volume

The loaf volume was measured using plastic granulate of rape seed size. Specific loaf volume was obtained as a ratio of muffin volume and muffin weight.

Texture analysis

Textural properties of muffin crumb were measured using texture profile analysis **(TPA)** on a texture analyzer TA.XT plus (Stable Micro Systems Ltd., UK). TPA was performed on cylindrical samples obtained from the loaf crumb centre (35 mm in diameter and 15 mm in height). Three loafs from each batch were used for TPA measurement. Each loaf provided three individual samples for compression. Those samples were placed onto the analyzer base and squeezed in two cycles to 4 mm with the 75.0 mm diameter cylinder probe P/75. Test speed of probe was 1.00 mm/s. The crumb parameters (hardness, springiness, cohesiveness and chewiness) were determined using Exponent Lite software v. 4.0.13.0.

Sensory evaluation

Muffins were subjected to sensory evaluation by a panel of 10 department staff and students, both male and female between the ages of 19 – 50 years. A nine point hedonic scale was used to evaluate the characteristics of crumb and crust. Sensory score range from 1 – dislike extremely to 9 – like very much was used. For evaluating sweetness and off-flavor intensity grade 1 – no sweetness/ no off flavor and grade 9 extreme sweetness/ extreme off-flavor. An extensive sensory evaluation realized by higher number of panelists will be performed to support the preliminary results obtained in this study.

Statistic analysis

The results showed a normal distribution, therefore they were statistically analyzed using variance analysis (ANOVA). The differences were tested on $\alpha = 0.05$ significance level using Fisher LSD test. Analysis was performed using Statistica CZ9.1 software (StatSoft Ltd., Czech Republic)

RESULTS AND DISCUSSION

Specific loaf volume is largely related to the ability of gas retention of the dough during proofing and achieving crumb porosity. Lack or small pores can influent the crumb hardness and lead to reduced consumer acceptability. The substitution of sugar by the chicory syrup significantly (p <0.05) decreased specific loaf volume from 2.15 to 2.01 mL.g^{-1} (Table 1). The reduction obtained is comparable previously reported by **Wang et al. (2002)**. The possible explanation according to **Silva (1996)** is, that inulin, which is presented in chicory syrup,

Table 1 The texture characteristics and specific loaf volume of muffins with different chicory syrup/sugar ratio.

Batch	Specific loaf volume (ml.g^{-1} ±SD)	Hardness (N ±SD)	Hardness (after 24 h) (N ±SD)	Springiness (1 ±SD)	Cohesiveness (1 ±SD)	Chewiness (N ±SD)
B0Sy	2.15 ±0.06^{b}	5.3 ±0.1^{a}	5.3 ±0.1^{a}	0.84 ±0.01^{a}	0.59 ±0.01^{a}	2.62 ±0.07^{a}
B50Sy	2.01 ±0.05^{a}	6.5 ±0.2^{b}	7.3 ±0.7^{b}	0.86 ±0.01^{ab}	0.60 ±0.03^{a}	3.4 ±0.3^{b}
B100Sy	2.05 ±0.04^{a}	5.3 ±0.3^{ab}	8.1 ±0.6^{b}	0.88 ±0.02^{b}	0.63 ±0.02^{a}	3.0 ±0.3^{ab}

Note: ***values in one column with different letters are significantly different p <0.05.

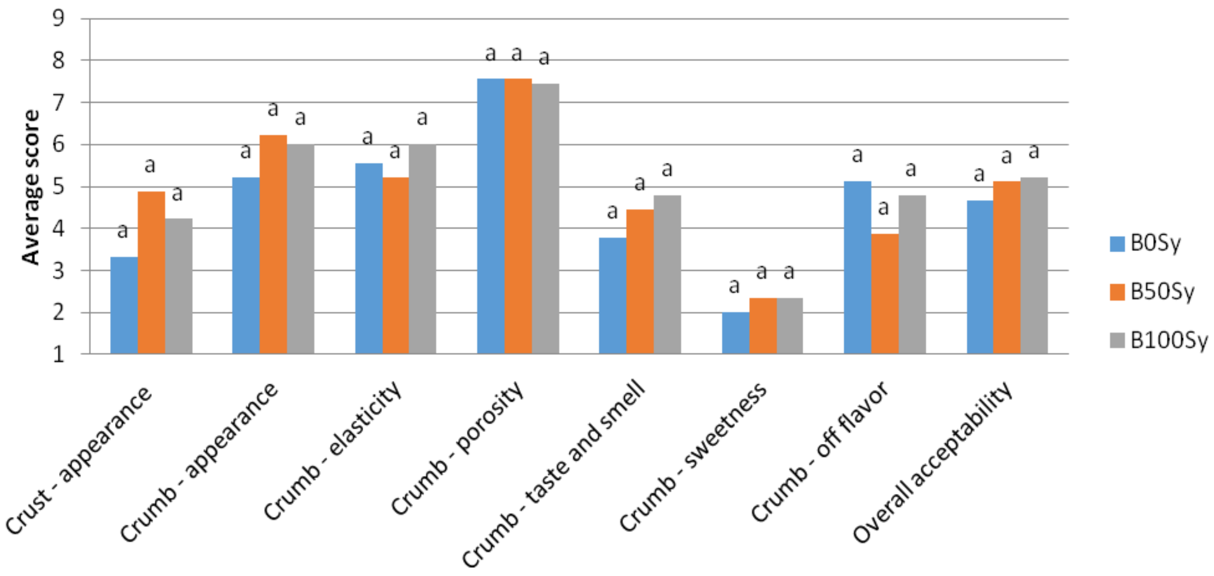

Figure 1 The sensory characteristics of muffins with different chicory syrup/sugar ratio.
Note: *the average scores of one sensory characteristic with different letters are significantly different p <0.05.

increases the viscosity of the dough and hence the volume of muffins where sucrose was replaced by syrup is lower.

Crumb hardness is correlated with the perception of freshness. Crumb hardening, which is one of the most obvious manifestations of staling, is caused by starch retrogradation as well as differences in vapor pressure between crumb and crust resulting in moisture migration **(Esteller et Lannes, 2008)**. Across the results, hardness of a control sample only with sugar B0Sy is the lowest. Higher levels of syrup increased the crumb hardness. Similar observations for bread were made by other authors where the inclusion of prebiotics increased crumb hardness (**O'Brien et al., 2003; Rössle et al., 2011**). The muffins hardness was also measured after 24 hours. The results show increasing hardening with rising syrup ratio. So with a higher syrup content, pastry hardens faster. It is in agreement with previously reported results for wheat breads, where the addition of inulin resulted in higher crumb hardness as well as an increased rate of staling **(Wang et. al, 2002; Ronda et. al., 2005; Peressini et Sensidoni, 2009; Beikzadeh et al., 2017).**

Interestingly **Korus et al. (2006)** and **Ziobro et al. (2013)** have reported, that inulin can reduce the crumb hardening rate during the storage period of gluten-free bread.

Muffin springiness and chewiness both rised with substituting sugar by syrup. The positive is that there has been no significant effect on cohesiveness.

In therms of sensory characteristics there was no significant diference between control sample with sugar and samples treated by syrup (Figure 1). Despite the higher hardness of products sweetened by chicory syrup compared to sugared products, measured during TPA, consumers did not notice a significant difference in crumb taste and overall acceptability. Although differences in sensory analysis results are not statistically significant, the average score of muffins, where sugar was completely replaced by syrup, was higher in crumb taste and smell and overall acceptability. The addition of chicory syrup has also improved the appearance of the muffin crust especially in therms of color (compared to muffins without syrup), altough not statistically significant. According to **Huebner et al. (2008); Poinot et al. (2010); Drabińska et al. (2016)** and also **Süli, 2017)** during the baking the Maillard reaction occurs, in which the reducing sugars present in the fructan chains react with amino acids, producing compounds of higher molecular weight that may influence the flavor, aroma and color of the food. The intensive caramel flavor and more brown crust color is obviously appreciated by consumers.

CONCLUSION

Based on the results of this preliminary study, we can reject the hypothesis, that the substitution of sugar by chicory syrup does not impair textural properties and loaf volume. Biologically leavened muffins with chicory syrup presented lower specific loaf volume, higher hardness, springiness and chewiness than those sweetened with sugar. There was no detrimental impact of syrup to cohesiveness. The pastry was considered to be acceptable by the sensory panel, indicating that this ingredient up to amount 7g/100g is adequate for its use as a sugar replacer in studied type of bakery product.

In further research, it would be good to determine the most appropriate ratio of sucrose and chicory syrup in order to obtain the product without compromising the crumb hardness and shelf life.

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