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USE OF SUGAR BEET MOLASSES IN PROCESSING OF GINGERBREAD TYPE BISCUITS: EFFECT ON QUALITY CHARACTERISTICS, NUTRITIONAL PROFILE, AND BIOAVAILABILITY OF CALCIUM AND IRON

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In order to investigate the possibility of using sugar beet molasses in creating nutritionally improved gingerbread type biscuits, several biscuit variants were prepared in which 25%, 50%, or 100% of honey was replaced with molasses. The substituted biscuits were significantly higher in proteins and ash. Both partial and total replacement of honey with molasses resulted in significant increase of K, Ca, Mg, and Fe content in relation to the control. Total potassium and calcium contents in the enriched variants were in range of 409.1–1177.3 g/100 g d.b. (meeting 7.8–22.4% of DRIs for K) and 70–112 g/100 g d.m. (6–10% of DRIs for Ca), respectively, whereas control contained 150.4 g/100 g d.b. K and 31.17 g/100 g d.b. Ca. In the modified biscuits, iron content increased by 25–132%. Relative bioavailabilities varied from 26.58–39.37% for iron and approximately 28% for calcium. In relation to the control, relative Ca availability increased by 20%, whereas relative Fe bioavailability decreased by approximately 32% in the variant with totally replaced honey. Considering all investigated quality traits, substitution of up to 50% of honey in gingerbread biscuit formulation could be recommended.

Keywords: biscuit, sugar beet molasses, quality, Ca bioavailability, Fe bioavailability.

Biscuits are today viewed not only as a high energy food but a feasible base for the design of nutritious and functional foods. Numerous new processing methods and unconventional ingredients have been proposed to achieve the final goal of product enrichment that would provide adequate intake of nutrients and/or beneficial influence on health without impairment of the product's sensory properties.

Nutrient deficiencies are known to be great public health problems in developing countries. However, recent studies on the nutritional status of populations showed that insufficient intake of many macro- and micronutrients remains a problem even in overabundant countries like the USA and Switzerland. In the recent report of U.S. Department of Agriculture and U.S. Department of Health and Human Services (2010), the intakes of a number of nutrients have been found insufficient enough to be of public health concern for the general population. Among the critical nutrients, potassium, calcium, and iron were listed. An earlier review of the nutritional status of Swiss population revealed a lower intake of Ca among many different population groups and latent iron deficiency in 11% of women (Eichholzer, 2003). Hence, the enrichment of food with minerals remains an important part of the efforts to improve the nutritional pattern of diets.

The present research was designed to study the effect of honey replacement with sugar beet molasses in gingerbread type biscuits in order to develop a formulation which is nutritionally improved and provides acceptable quality characteristics. Molasses is a concent-

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rated, liquid runoff syrup of the sugar refining process which can be used as natural sweetener. It mainly consists of a mixture of sugars, non-sugars, and water with high content of solids (often >80%) of which about 50% is saccharose (OLBRICH, 1963; HIGGINBOTHAM & MCCARTHY, 1988). The non-sugar part of molasses (accounting for 20% in beet molasses and 12–18% in cane molasses) is very divergent: it consists of nitrogen containing substances (proteins, amino acids, betain (in beet molassses only), organic bases, melanoidines) and non-nitrogen containing substances (organic acids, pectins, galactans, dextrans, caramelization products). Moreover, both beet and cane molasses contain relatively large amounts of minerals and vitamins. Major minerals include potassium, calcium, magnesium, and sodium. Potassium accumulates in molasses and account for up to 75% of total minerals (HIGGINBOTHAM & MCCARTHY, 1998). In beet molasses, potassium and calcium typically range from 20–60 g kg^{-1} and 1–15 g kg^{-1}, respectively (HIGGINBOTHAM & MCCARTHY, 1998). It may also contain appreciable amounts of iron (27–100 mg kg^{-1}) (HIGGINBOTHAM & MCCARTHY, 1998). Among vitamins, vitamins of B group and biotin are the most abundant and are in fully bioavailable form (HIGGINBOTHAM & MCCARTHY, 1998). As some authors claim that molasses is much nutritious than honey, it was supposed that the gradual replacement of honey with beet molasses would improve the mineral pattern of gingerbread biscuits. ŠUŠIĆ and SINOBAD (1989) claim that, at the same solid matter content, beet molasses has up to 3000% more protein and beneficial nitrogen-containing substances; 4000% higher amount of minerals and 3800% higher B vitamins content than honey. Besides outstanding nutritional composition and sweet taste, molasses may perform other useful functions in products, such as colorant, flavour intensifier, leavening and buffering agent, or humectant (HICKENBOTTOM, 1996).

In the light of the above effort, to better characterize the value-adding potential of beet molasses regarding mineral pattern of biscuits, bioavailability of calcium and iron in the tested formulations was assessed. Calcium and iron were chosen as target minerals because their availability from food is frequently impeded by the presence of various inhibitory compounds while the availability of potassium in food is less limited and may be considered high (approximately 90%).

1. Materials and methods

1.1. Material

The biscuit ingredients were from commercial sources: wheat flour (ash content (0.51% dry basis (d.b.)), wholemeal rye flour (ash content 1.68% d.b.), honey, sugar, vegetable fat, baking soda, lecithin, cinnamon). Sugar beet molasses was acquired from the sugar factory "TE-TO" AD, Senta (Serbia).

Molasses was from a single lot taken during the 2010 campaign.

1.2. Biscuit preparation

Gingernut type biscuit formulations are given in Table 1. In variants 10M and 20M, 25% and 50% of the initial amount of honey was replaced with sugar beet molasses, respectively, whereas in 40M variant, honey was completely replaced with molasses. The preparation of biscuits was carried out using a procedure described in detail in FILIPČEV and co-workers (2011).

Table 1. Composition of gingerbread type biscuits

Ingredients (g)	Honey replacement (%)			
	0	25	50	100
	Control (0% molasses)	Biscuit 10M (10% molasses)	Biscuit 20M (20% molasses)	Biscuit 40M (40% molasses)
Wheat flour	90	90	90	90
Rye flour	10	10	10	10
Honey	40	30	20	0
Molasses	0	10	20	40
Sugar	20	20	20	20
Vegetable fat	30	30	30	30
Baking soda	2	2	2	2
Cinnamon	2	2	2	2
Lecithin	1	1	1	1
Water	10	10	10	10

1.3. Chemical composition

Chemical composition analysis of the biscuits was performed according to standard A.O.A.C. procedures (A.O.A.C., 2000) to determine moisture (method 926.5), ash (method 930.22), crude protein (method 950.36), fat (method 935.38), reducing sugar as invert before hydrolysis (method 975.14), and total dietary fibre (method 958.29). Starch content was determined according to the ICC (1994). Minerals were determined by atomic absorption spectrophotometry (method 984.27) on a Varian Spectra AA 10 (Varian Techtron Pty Limited, Mulgvare Victoria, Australia).

1.4. Estimation of iron and calcium in vitro availability

In vitro availability of iron and calcium from different biscuit variants was estimated by their digestibility under simulated physiological conditions. A sample of 0.3 g was mixed with 3 ml of deionised water (each biscuit sample was analysed in six replications prepared in duplicates). A simulated gastric fluid (SGF) was prepared by mixing 0.1 M HCl and 2 g l^{-1} NaCl to pH 2 and adding pepsin A (Sigma, 2913 U mg^{-1} solid) containing 0.32 g enzyme per 100 g. The SGF was then 4 times concentrated and well vortex before adding to the sample. One millilitre of concentrated SGF was added to 3 ml of sample solution. Then the sample was incubated with shaking in a water bath at 37 °C. After 2 h of incubation, the pH of the solution was raised to 6.8–7.0 by adding 6% $NaHCO_3$, and 1 ml of 0.4% pancreatin (Sigma) was added to the sample solution. After that the sample was incubated for another 4 h at 37 °C. Then the sample was centrifuged at 4000 r.p.m. for 30 min and decanted through medium-hardness filters. The supernatant was collected. The filtrate was evaporated and mineralized.

1.5. Sample mineralization and element determination

Microwave digestion procedure was applied using ETHOS1 Advanced Microwave Digestion System (Milestone, Italy). The 0.3 g of solid or liquid sample was ashed in the mixture of 7 ml 65% HNO_3 and 1 ml 30% H_2O_2 (p.a. grade, Carlo Erba, Italy), increasing the temperature gradually to 200 °C. The mineralized samples obtained in this way were transferred to measuring flasks (25 ml capacity).

Elements were determined by inductively coupled plasma-optical emission spectrometry (ICP-OES). A Thermo Scientific iCAP 6500 Duo ICP (Thermo Fisher Scientific, Cambridge, UK) spectrometer was used. Calcium and iron were determined under the following conditions: power (1150 W), axial plasma view, nebulizer gas flow (0.50 l min^{-1}), auxiliary gas flow (0.5 l min^{-1}), coolant gas flow (12 l min^{-1}), and analysis pump rate (50 r.p.m.). The analytical wavelengths used were 315 887 nm (Ca^{2+}) and 240 488 nm (Fe^{2+}). The following calibration standard was used: Multi-Element Plasma Standard Solution 4, Specpure® (Alfa Aesar GmbH & Co KG (Germany)). All calibration curves had correlation coefficients greater than 0.99.

1.6. Physical properties of biscuits

The physical properties determined were weight, thickness, diameter, and spread. Spread was calculated as the ratio of diameter and thickness. Density was calculated as the ratio of weight and volume. Volume was calculated by approximating the cylinder volume using the biscuit geometrical parameters.

1.7. Instrumental texture analyses of biscuits

The texture properties of biscuits were evaluated on a TA.XT2 Texture Analyzer (version TA.XTPlus, Stable Micro Systems Ltd., Surrey, UK). Biscuit hardness and fracturability were estimated by plotting the force/distance curve during biscuit penetration with a 2 mm cylinder probe. Biscuit hardness was calculated as the area under the curve and fracturability was the linear distance. The apparatus was set at 1.0 mm s^{-1} pre-test speed, 0.5 mm s^{-1} test speed, 10.0 mm s^{-1} post-test speed, 20 mm travel distance, and 5 g trigger force. A 5 kg load capacity was used. Measurements were conducted five times in X pattern on each sample analysed. Each biscuit variant was tested in five replications.

1.8. Colour determinations

A handheld Chroma meter (CR-400/410, Konica, Minolta, Japan) was used for colour determinations. The apparatus was calibrated using the Minolta white calibration standard (CM –A70). Measurements were conducted on the upper surface of the biscuits. L*a*b* values were collected at two points on the biscuit surface. Chroma (C*) and hue (H*) were calculated using the equations: $C^*=(a^{*2}+b^{*2})^{1/2}$ and $H^*= \text{arctg}\ (b^*/a^*)$. A measurement set included 5 samples of each biscuit variant.

1.9. Sensory evaluation

The sensory evaluation of biscuits was conducted by a six-member panel of experienced and trained judges. Each biscuit variant was rated on a 1–9 intensity scale for appearance (round–flat), crumb structure (dense–porous), flavour intensity (weak–strong), sweetness (low–high), aftertaste (weak–strong), and over-all acceptability (dislike very much–like very much).

1.10. Statistical analysis of data

Data were analysed using one-way ANOVA to study the differences between the formulations. Honestly significant differences were calculated by the Tukey's test at the significance of P≤0.05. All statistical analyses were performed using Statistica 10 data analysis software system (StatSoft Inc., Tulsa, Oklahoma).

2. Results and discussion

2.1. Nutritional characteristics

The evaluation of nutritional characteristics showed that the molasses substituted biscuits were significantly higher in ash and protein content and significantly lower in reducing sugars and fibre content (Table 2). Both partial and total replacement of honey with sugar beet molasses resulted in prominent increase of macro and microelements (K, Ca, Mg, and Fe) (Fig. 1). This is due to the high concentration of these minerals in molasses. Amounts of total potassium varied from 150.4 g/100 g d.b. (control biscuit) to 409.1–1177.3 g/100 g d.b. (molasses substituted biscuits) covering from 2.9% (control) to 7.8–22.4% of DRIs set for potassium. Sugar beet molasses is also a good source of calcium; addition of 10-40% molasses flour basis provided calcium in the range of 70–112 g/100 g d.m. which can meet 6–10% of DRIs for Ca, whereas control biscuit would cover around 2% of DRIs for Ca. Other ingredients used for biscuit fortification provided Ca in the range of 57–58 mg/100 g (fenugreek) (Hooda & Jood, 2005), 30–70 mg/100 g (pearl millet flour) (Singh et al., 2006). Iron increased from 1.94 mg/100 g d.b. (in control) to 2.43–2.89 mg/100 g d.b. (in biscuits with partially substituted honey), i.e. to 4.52 mg/100 g d.b. (biscuit with totally substituted honey). The amounts of iron found in the biscuits (with partial and total substituted honey) would meet around 30% and 50% of DRIs for males, respectively. Manganese and zinc contents did not vary over the analysed biscuits, whereas copper was lower in the biscuits with molasses. It could be concluded that incorporation of molasses greatly improves the mineral pattern of biscuits. In the earlier work on the incorporation of sugar beet molasses in bread, Filipčev (2009) reported that bread made from refined wheat flour enriched with 5–10% molasses flour basis had higher contents of potassium and calcium than those reported for wholegrain wheat bread, and had improved potassium to sodium ratio, which demonstrates the value-adding potential of molasses as an ingredient in baking.

Table 2. Effect of honey replacement by molasses on proximate composition of gingerbread type biscuits

Biscuit	Moisture (mg/100 g)	Ash (mg/100 g d.m.)	Proteins (mg/100 g d.m.)	Fat (mg/100 g d.m.)	Starch (mg/100 g d.m.)	Reducing sugars (mg/100 g d.m.)	Fibres (mg/100 g d.m.)
Control	$10.35^{a,b}$	1.06^{a}	7.46^{a}	7.61^{a}	44.24^{a}	17.20^{d}	4.63^{b}
10M	10.03^{a}	1.47^{a}	8.09^{b}	7.56^{a}	43.96^{a}	12.98^{c}	4.48^{b}
20M	$10.40^{a,b}$	1.55^{b}	9.16^{c}	7.67^{a}	43.26^{a}	8.25^{b}	3.87^{a}
40M	10.61^{b}	1.60^{b}	10.82^{d}	7.56^{a}	41.69^{a}	1.44^{a}	3.67^{a}

^{a,b,c} Mean values within a column with different superscripts differ significantly at P<0.05

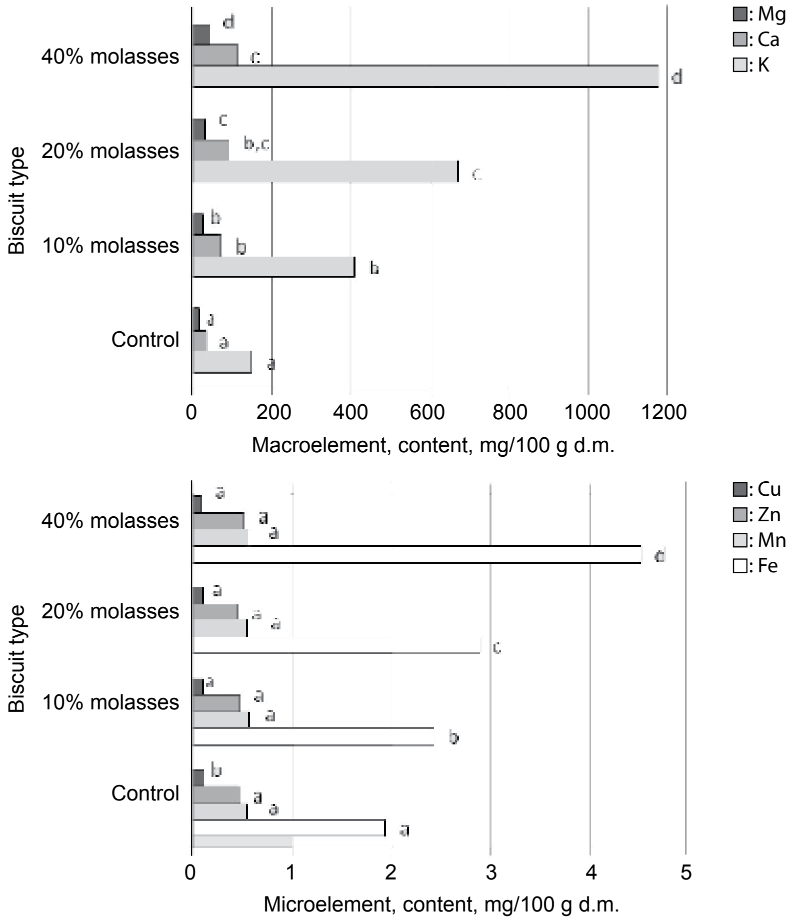

Fig. 1. Effect of honey replacement by molasses on macro- and microelement content in gingerbread type biscuits. Different letters indicate significance ($P<0.05$).

2.2. Effect on iron and calcium in vitro availability

Total and available iron and calcium contents as well as their relative bioavailabilities are presented in Table 3. As expected, molasses addition significantly increased the contents of total and available iron in the samples. Relative bioavailabilities ranged between 26.58–39.37% in the gingerbread biscuit samples and were significantly lower than that found in the commercial fortified product (60.07%), but are in the range common for confectionery products. SULIBURSKA and co-workers (2011) found that relative bioavailabilities for iron in various non-fortified and fortified commercial cookie types ranged from 18.76% to 74.11%. JOOD and co-workers (2001) and VITALI and co-workers (2007) reported average iron availability of around 39% in biscuits made with the addition of wholegrain flour. Therefore, iron bioavailability from gingernut type biscuits can be considered satisfactory. Effect of substituting honey with molasses in ginger bread type biscuits in relation to biscuit of control formulation is displayed in Fig. 2. As compared to the control, it is evident that increasing molasses substitution levels prominently increased total iron contents (by 48.9–132.5% for 20 and 40% molasses, respectively), but the amounts of iron released during the in vitro digestion were much less affected (46–56.9%) which means a 31.7% lowering of relative iron bioavailability in the biscuits made with 40% molasses, although honestly significant difference between the control and molasses substituted biscuit was not registered. This result implies to the presence of some naturally occurring compounds in molasses which are able to chelate iron. Most common inhibitors of dietary iron are phytic acid, phenolic compounds, calcium, and proteins of soy and milk (HURRELL, 2002). Molasses is abundant in calcium. There is no data on the presence of phytic acid in molasses but since beet molasses contains phosphate cation only in traces (0.05-0.35% d.m.) (HIGGINBOTHAM & MCCARTHY, 1998), it is not likely to be a source of phytic acid. However, molasses contains coloured compounds like melanoidines, phenolics, melanins, caramel, etc. (OLBRICH, 1963; ŠUŠIĆ & SINOBAD, 1989; HIGGINBOTHAM & MCCARTHY, 1998). According to HIGGINBOTHAM and MCCARTHY (1998), most of the colour in both sugar and cane molasses is derived from the reaction of the small amount of invert sugar present (less than 1%) and available amino acids, and the thermal degradation of saccharose. Hidroxymethylfurfural (HMF), a product of Maillard reaction, has been found in beet molasses in doses up to 20 mg kg^{-1} (HIGGINBOTHAM & MCCARTHY, 1998). Some of the aforementioned coloured compounds are reported to exert chelating abilities. MORALES and co-workers (2005) found that melanoidines extracted from various food (coffee, beer, wine) show low iron-binding ability. MESÍAS-GARCÍA and co-workers (2009) concluded that iron bioavailability was reduced in diets richer with HMF. Hence, the lowering of iron bioavailability in biscuits with 40% molasses might be due to the iron binding potential of calcium and coloured compounds. Nevertheless, as a source of non-heme iron, the molasses substituted biscuits are comparable to wholegrain biscuits and biscuits enriched with amaranth (VITALI et al., 2007) by providing approximately 1 mg/100 g of available iron.

Similarly were affected the total and available calcium contents in the molasses substituted biscuits but with much higher magnitudes of increase: when compared to the control, total calcium increased by 191.0–258.3% and available calcium increased by 245.9–325.6% in the biscuits with 20% and 40% molasses, respectively. In contrast to iron, the content of total available calcium was not negatively affected by increasing molasses levels so relative calcium availability was higher by approximately 20% in the molasses containing biscuits (Fig. 2). It seems that melanoidines did not exert negative effect on the calcium availability. This can be supported by the findings of MESÍAS and co-workers (2009) who reported that diets rich in Maillard reaction products did not affect dietary calcium bioavailability. The relative calcium bioavailability in the analysed gingernut type biscuits (24–28.6%) was higher but not significantly in comparison to commercial biscuits (18.7%) (Table 3). The obtained values for relative bioavailability of Ca correspond to the lower range of relative Ca bioavailabilities reported by VITALI and co-workers (2007, 2011): 24.4% (in biscuits with carob)–60% (in biscuits with refined wheat flour) and 26.4–39% in biscuits enriched with pseudocereal/inulin mixtures, respectively. With amounts of available calcium ranging from 23.24–28.60 mg/100 g, biscuits substituted with molasses can be considered as better sources of calcium than the commercial biscuits.

Table 3. Total and in vitro available iron and calcium contents in gingerbread type biscuits and a commercial fortified biscuit

Biscuit type	Total Fe (mg/100 g)	Total Fe available (mg/100 g)	Relative Fe availability (%)	Total Ca (mg/100 g)	Total Ca available (mg/100 g)	Relative Ca availability (%)
Control	1.74[a,b]	0.68[a]	39.37[a]	27.94[a]	6.72[a]	24.05[a]
20M	2.59[b]	1.00[b,c]	38.61[a]	81.30[b]	23.24[b]	28.59[a]
40M	4.04[c]	1.08[c]	26.58[a]	100.125[b]	28.60[c]	28.56[a]
Commercial biscuit[d]	1.39[a]	0.84[a,b]	60.07[b]	49.57[a]	9.27[a]	18.70[a]

[a,b,c] Mean values within a column with different superscripts differ significantly at $P<0.05$.
[d] Fortified with Fe gluconate and $CaCO_3$. Labelled to contain 3.30 mg/100 g Fe and 106.0 mg /100 g Ca

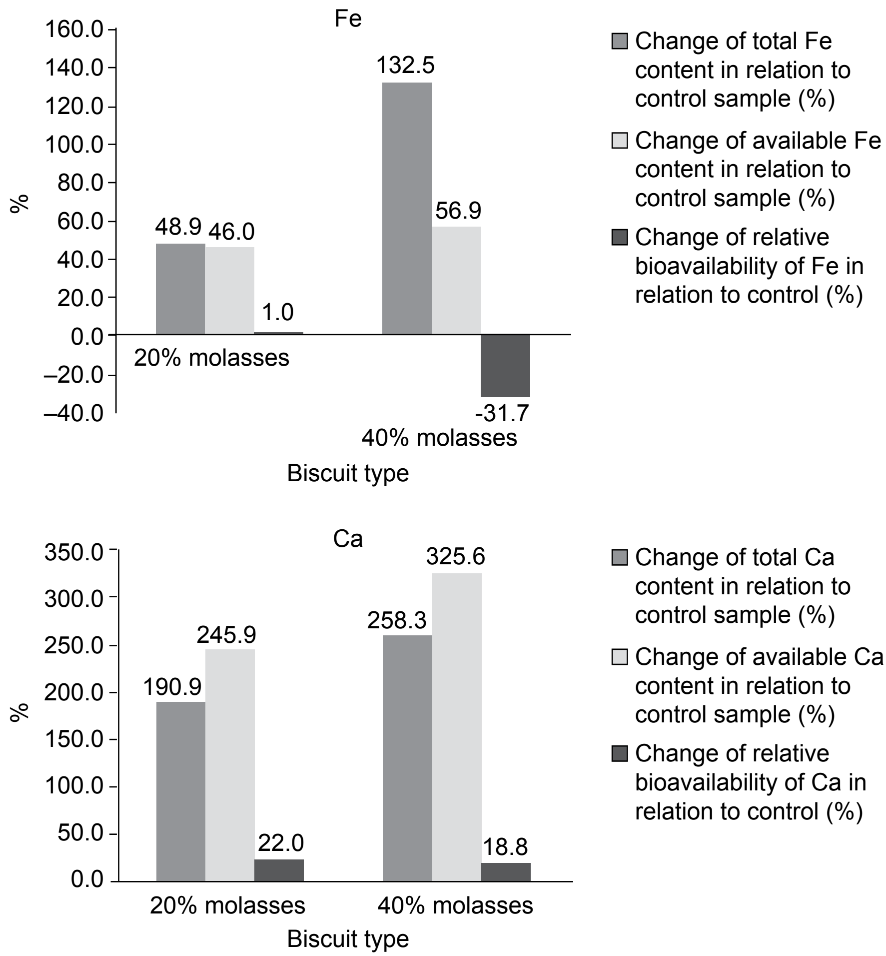

Fig. 2. Effect of honey replacement by molasses in gingerbread type biscuit formulation on content and availability of iron and calcium

Table 4. Effect of honey replacement by molasses on biscuit geometry and textural properties

Biscuit	Weight (g)	Height (mm)	Diameter (mm)	Spread	Density (g cm^{-3})	Hardness (1 day)	Fracturab. (1 day)	Hardness (30 days)	Fracturab. (30 days)	Hardness (60 days)	Fracturability (60 days)
Control	28.38^{a}	17.93^{b}	66.48^{a}	3.71^{a}	0.46^{a}	1922.51^{a}	466.22^{a}	8236.35^{a}	2757.40^{a}	10399.35^{a}	3487.41^{a}
10M	30.80^{a}	18.70^{a,b}	67.64^{a}	3.62^{a}	0.46^{a}	1709.80^{a}	396.98^{a}	7957.99^{a}	2939.38^{a}	10076.37^{a}	4067.05^{a,b}
20M	28.48^{a}	17.72^{a}	67.26^{a}	3.80^{a}	0.45^{a}	1859.07^{a}	505.35^{a}	8922.58^{a}	3210.31^{a}	10569.20^{a}	4510.95^{a,b}
40M	29.28^{a}	16.70^{a}	70.73^{b}	4.24^{b}	0.45^{a}	1781.48^{a}	454.31^{a}	8772.17^{a}	3097.53^{a}	10545.65^{a}	4978.75^{b}

^{a,b,c} Mean values within a column with different superscripts differ significantly at $P<0.05$

Table 5. Effect of honey replacement by molasses on colour parameters of biscuits

Biscuit	Molasses level	L*	a*	b*	C*	H*
Control	0	51.02^{c}	14.95^{c}	41.10^{d}	43.74^{d}	70.01^{a}
10M	10%	48.46^{b,c}	13.04^{b}	34.12^{c}	36.53^{c}	69.08^{b}
20M	20%	42.39^{a}	15.13^{d}	31.98^{b}	35.38^{b}	64.66^{b}
40M	40%	47.18^{b}	9.56^{a}	25.85^{a}	27.56^{a}	69.72^{b}

^{a,b,c} Mean values within a column with different superscripts differ significantly at $P<0.05$

2.3. Physical and texture characteristics

Changes in physical and textural properties of gingernut type biscuits upon gradual substitution of honey with molasses are displayed in Table 4. Substitution of up to half of the amount of honey (biscuits with 20% molasses) did not significantly influence biscuit geometry and spread. However, total replacement of honey with molasses increased biscuit expansion. The addition of molasses had no influence on the density of biscuits either. Hardness and fracturability of biscuits were also not significantly influenced by the increasing molasses content. During one and two months storage, hardness and fracturability significantly increased in all samples including control in comparison to the initial values, but there were no significant differences within the biscuit variants except for the variant with totally replaced honey, which exerted the highest fracturability after the second month.

2.4. Colour

Colour data for the sugar beet molasses substituted biscuits (Table 5) showed that the biscuits were darker (lower L* values). Increasing molasses content reduced the saturation index (C*) which is a measure of colour intensity, i.e. colourfulness. The biscuit with 40% molasses had the darkest but mute colour with an intense grey nuance. The biscuits which contained honey had more vivid colour without gray tones which could be probably associated with the presence of more reducing sugars available for Maillard reactions during baking; molasses, unlike honey, contain very small amounts of reducing sugars. Hue angle (H*) ranged from 64.66 to 70.01 and was significantly lower in the substituted biscuits. Molasses significantly influenced the presence of yellow and red tone. Increasing molasses content decreased the yellow tone with a clear downward trend, whereas the red tone was decreased in the biscuit variant with 40% molasses but in others no clear trend was evident.

2.5. Sensory analysis

Figure 3 shows the sensory properties of gingerbread biscuits substituted with sugar beet molasses. Most affected sensory parameters by substitution of honey with molasses were appearance, aftertaste, and overall acceptance. They were significantly decreased in the variant with totally replaced honey. Addition of molasses produced more flat biscuits. Increased molasses content tended to reduce the intensity of sweet taste and produced mild aftertaste, perceived as a combination of bitter and burnt sensations, which was acceptable in variants with up to 20% molasses. The presence of molasses increased the flavour intensity of biscuits. Crumb structure was less affected with increasing molasses content with a weak tendency towards dense structure. Overall acceptance was high for the biscuit variants with up to 20% molasses, i.e. half substituted honey.

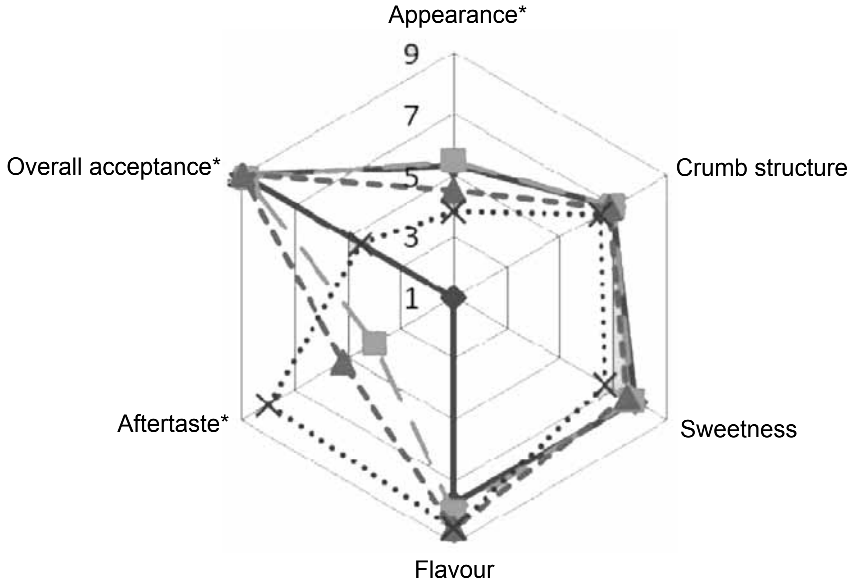

Fig. 3. Effect of honey replacement by molasses on sensory characteristics of biscuits.
—◆—: Control; —■—: 10% molasses; - ▲ -: 20% molasses; ···×···: 40% molasses

3. Conclusions

Molasses substituted gingerbread biscuits were found to be nutritionally improved as they contained significantly higher content of minerals and proteins. The biscuits were high in those minerals which have been recently implied by authorities to be a public health concern due to insufficient dietary uptake in the general population – K, Ca, and Fe. Molasses containing biscuits were excellent sources of potassium, calcium, and iron covering approximately 7.8–22.4%, 6–10% and 30–50% of DRIs (for males), respectively. Regarding bioavailabilities, iron and calcium relative bioavailabilities were in ranges typical for biscuits. In comparison to the control, calcium relative bioavailability was higher by 20% in the biscuits made with molasses, whereas iron bioavailability decreased by 30% in the biscuit variant in which honey was completely replaced by molasses. Nevertheless, with contents of available iron around 1 mg/100 g, molasses substituted biscuits can be viewed as a moderate source of non-heme iron in the diet.

Regarding physical, textural and sensory analysis, it was found that the biscuits with partial replacement of honey with molasses were not significantly affected and manifested high overall acceptance.

The final conclusion is that sugar beet molasses can be used to partially replace up to 50% of honey in gingerbread type biscuits to obtain a product with improved nutritional characteristics and acceptable textural and sensory properties.

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