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Effect of polydextrose and inulin on texture and consumer preference of short-dough biscuits with chickpea flour

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ABSTRACT

Chickpea flour (ChF) was used to substitute wheat flour (WF) at the level of 20% to enrich the nutritional quality of biscuits. What is more, polydextrose (p) and inulin (i) were applied at 40% and 60% levels to substitute for sucrose (s). Instrumental methods (mechanical and acoustic) were used to evaluate the texture properties of the biscuits. The sensory evaluation was made by 50 untrained consumers. Moreover, water activity and colour of the biscuits were measured. The biscuits with 40% of polydextrose and 60% of inulin had the higher values of maximum force in comparison with biscuits without sugar replacers. The biscuits with 20% ChF and 40% polydextrose, as well as those with 60% polydextrose generated the strongest acoustic emission and achieved the highest values of energy of one acoustic event, number of acoustic events and sound amplitude. What is more, biscuits with polydextrose received the highest scores for their appearance in consumer test. On the contrary, biscuits with 20% ChF and 60% inulin obtained the lowest scores for all sensory descriptors. The study proved that the reformulation significantly affected water activity and colour of the analyzed short-dough biscuits.

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1. Introduction

In today's world, one of the major nutritional problems is the consumption of high quantities of fat and sugar, which has been associated with serious health problems. Due to a growing public interest in such products, the food industry has focused on developing low-calorie foods. The key means applied to reduce the energetic value of bakery products (including short-dough biscuits) include the use of whole-grain flours, sweeteners for partial replacement of sugar (e.g. tagatose, trehalose, inulin, oligofructose, polydextrose) (Kutyła-Kupidura et al., 2015), substances for partial replacement of fat (e.g. modified starch, dextrin, maltodextrin, inulin, polydextrose, β-glucan), as well as the addition of dietary fiber (Goldfein & Slavin, 2015; Kutyła-Kupidura et al., 2015; Lafiandra, Riccardi, & Shewry, 2014).

Short-dough biscuits consist of 3 major components: wheat flour, sugar and fat, which have influence on the quality of the final product (Sozer, Cicerelli, Heiniöa, & Poutanen, 2014; O'Briena, Chapmanb, Neville, Keogh, & Arendt, 2003). Cereal grains (including wheat) are low in protein (from 7 to 14%) and deficient in some amino acids, e.g. lysine (Claughton & Pearce, 1989; Yadav, Yadav, & Dhull, 2012). In turn, legumes are richer in proteins (18–24%) than cereal grains and contain certain amino acids such as lysine, tryptophan or methionine (Potter, 1986). Considering the above, increasing supplementation of wheat flour with other healthier flours is observed. A fine example in this case is chickpea flour, the main component of chickpea is an oligosaccharide called stachyose that constitutes 75–76% of the total raffinose-family sugars (Wieczorek & Lahuta, 2007). Chickpea contains ca. 50% of carbohydrates, 17–20% of protein characterized by the highest nutritional value among all legumes, ca. 3–4% of crude fiber and 5–6% of lipids (Saleh & El-Adawy, 2006). In addition, chickpea is a source of folic acid, tocopherols, sterols, carotenoids (especially β-carotene) (Jukanti, Guar, Gowda, & Chibbar, 2012) It is rich in B-group and F-group vitamins and many microelements: potassium, phosphorus, magnesium, zinc, selenium, manganese and even copper (Ravi & Bhattacharya, 2004; Yamsaengsung, Berghofer, & Schoenlechner, 2012). It is also important that chickpea does not contain gluten and, therefore, may be successfully applied by persons with gluten intolerance.

As mentioned earlier, short-dough biscuits are rich in sugar and fat and are extensively used in the baking industry, therefore are

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ideal candidates for sugar- or fat-replacement. There are many fat and sugar replacers on the market, however careful consideration should be given to their functionality in a variety of high sugar and/or fat products to obtain products with similar quality parameters. In sweet bakery products, sugars enables, e.g., introducing air to fat during dough preparation, it decreases dough viscosity, ensures sweetness, as well as affects structure and texture of the final products (Baltsavias, Jurgens, & van Vliet, 1999; Hicsasmaz, Yazgan, Bozoglu, & Katnas, 2003; Marzec, 2012). The sugar content in biscuits determines their hardness, crispness and volume (Marzec, 2012; Savitha, Indrani, & Prakash, 2008). In the sweet bakery products, sucrose is most often applied and may be reduced by the use of less caloric substances like for example polydextrose and/or inulin.

Polydextrose consists of approximately 89% of D-glucose, 10% of sorbitol and 1% of citric acid (Colliopoulos, John, & Tsau, 1986). As a commercially available preparation, it is a product of polycondensation and occurs in the form of a white powder with neutral taste and aroma. Polydextrose easily dissolves in water and, owing to its technological traits, may be used as a replacer of both fat and sugar (Mitchell, Auerbach, & Moppett, 2001). The average degree of polymerization (DP) of polydextrose is 12, although the range of its molecular weight is from 162 to about 20,000 (Aidoo, Depypere, Afoakwa, & Dewettinck, 2013). Polydextrose has been successfully incorporated into a wide range of foods, i.e. baked goods, confectionery, beverages as well as frozen desserts, while providing the appropriate textural and mouthfeel properties (Aidoo, Afoakwa, & Dewettinck, 2014). Whereas inulin is a mixture of oligo- and polysaccharides, which are composed of fructose units and connected by β-2,1-glycosidic bonds, whereas every chain ends with a glucose molecule. Inulin is processed by food producers to short-chain (a sweet taste resembling that of sucrose) or long-chain fructans (a neutral taste and aroma) and like polydextrose may replace, respectively, sugar and fat (Tárrega, Torres, & Costell, 2011). The use of inulin in the food industry is based on its nutritional and technological properties including mainly the improvement of textural and structural properties (Aidoo et al, 2014). Polydextrose and inulin are considered as dietary fibers, which increase the consistency of food bulk and its rapid movement through the gastrointestinal tract, but also helps in preventing constipation and possible colon and rectal cancer (Aidoo et al, 2014; Mieszkowska & Marzec, 2015).

The objective of this study was to analyze how substitution of wheat flour by chickpea flour (ChF), as well as replacement of sucrose by polydextrose and inulin effect on mechanical, acoustic and sensory properties of short-dough biscuits. Results of such an analysis would facilitate an appropriate selection of recipe ingredients to produce less caloric and more healthy biscuits acceptable by consumers.

2. Material and methods

2.1. Biscuits formulation and preparation

The biscuits were composed of the following ingredients: wheat flour - type 550 (*Polskie Młyny*, Poland), chickpea flour (*TRS*, United Kingdom), powdered sugar (*DIAMANT*, Poland), polydextrose (*Brenntag*, Poland), inulin GR (*BENEO-Orafti*, Belgium), shortening (*Kruszwica*, Poland), egg yolk, baking powder (*Bezgluten s.c.*, Poland) and tap water (Table 1).

Bulk ingredients were sieved through a screen (openings size: 1 × 1 mm), then all ingredients were mixed together using a Thermomix TM31 (Vorwerk, Germany) for 1.5 min, speed level 6. After mixing, the dough was cooled down for 15 min in a fridge (Gorenje Polska Sp. z o.o., Ożarów Mazowiecki, Poland) at 4 °C. Then, the dough was sheeted to give uniform thickness of 5 mm and baked at a temperature of 180 °C for 10 min in an industrial oven PICCOLO (Winkler Wachtel Polska Sp. z o.o., Wroclaw, Poland). The dough was taken out of the oven after 10 min and biscuits were cut out into to small rectangles of 32,5 × 25 mm (to eliminate changes in biscuits shape during further baking). Next, they were baked for another 5 min. After baking, the biscuits were cooled down and stored at room temperature in a PAPE (polyamide/polyethylene) closed bag until analysis, which was conducted after 5 days.

2.2. Water activity

The water activity was measured in three replications in AquaLab (Model CX-2) immediately before the measurement of mechanical and acoustic properties of short-dough biscuits.

2.3. Colour

The colour of biscuits was recorded in fifteen replications using the CIE L*a*b* system (Konica Minolta, CM-5). The measurement conditions were: D65 standard illuminate, 2° Standard Observer, measurement diameter: 8 mm. The lightness (L*), colour a* and b* (+a*: redness, −a*: greenness, +b*: yellowness and −b*: blueness) were measured. The chroma (C) was calculated as follows: $C = \sqrt{(a^*)^2 \cdot (b^*)^2}$.

2.4. Mechanical and acoustic properties

Mechanical properties of short-dough biscuits were determined using a penetration test in a Texture Analyzer TA.HD*plus* (Stable Micro Systems), at the speed of 0.3 mm s^{-1} (cylinder probe - 6 mm in diameter) and distance of 4 mm. The mechanical parameters: maximum force (F_{max}) and penetration work (W) were determined. The measurements were carried out in twenty replications for each type of short-dough biscuits, but five extreme values were rejected. During the test, acoustic emission was registered by the contact method using a sensor type 4381 (Brüel&Kjær, Nærum, Denmark). The signal from the sensor was amplified by 40 dB and then transmitted to analog-to-digital Adlink PCI 9112 card (Adlink Technology Inc., New Taipei City, Taiwan). The sampling frequency was 44.1 kHz. The acoustic descriptors: energy of one acoustic event (a.u.), number of acoustic events, sound amplitude (mV), and acoustic energy (a.u.), were calculated using Calculate_44 kHz_auto program (Warsaw, Poland).

2.5. Sensory evaluation

The sensory evaluation was made by 50 untrained consumers under laboratory conditions using a 5-point hedonic scale (1 – low quality, 5 – high quality). On the evaluation form, the panelists were instructed to evaluate their linking of 4 parameters (appearance, texture, sweetness, taste), as well as their overall rating of the short-dough biscuits. Water (room temperature) was used as a neutralizer between different samples.

2.6. Statistical analysis

Statistical analysis of the results was conducted using Statistica ver. 12 software (StatSoft Polska Sp. z o.o., Krakow, Poland). The analysis of variance (ANOVA) was performed. A division into homogeneous groups was carried out using the Duncan test ($P < 0.05$). In addition, the principal component analysis (PCA) was used to determine correlations between all parameters.

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