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Technological, phytochemical and sensory profile of honey biscuits made from buckwheat, rye, spelt and wheat flour

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RESEARCH ARTICLE

Abstract

Honey biscuit is a worldwide traditional bakery product with a long shelf-life. The aim of the study was to analyse the properties of honey biscuits made from buckwheat, rye, spelt and wheat flour. The biscuits were subjected to physical (hardness and brittleness, oxidation stability), chemical (dry matter content, water activity, crude protein, ash content, fat content, crude fibre content, concentration of mineral elements) and sensory evaluations (general appearance, honey flavour and taste, overall flavour, aftertaste, texture, tenderness). The hardness of biscuits ranged from 768.95 (wheat) to 1,631.53 N (spelt), while their brittleness (dimensionless) oscillated between 476.96 (wheat) and 1,353.26 (spelt). The oxidation stability was found to be the highest in the sample prepared from buckwheat flour (1.80 h). The dry matter content ranged from 91.27 to 91.96% without exceeding 20%. The water activity varied between 0.32 and 0.40 (dimensionless) in accordance with the relevant legislative requirements. The crude protein oscillated between 2.27 and 4.26% while the fat content ranged from 7.89 to 11.71% in the rye and buckwheat products, respectively. The ash content varied between 0.85 (wheat biscuits) to 1.04% (buckwheat biscuits) however the crude fibre content was found to be similar in all analysed samples (~0.5%). P, K, S, Ca and Mg were the most abundant chemical elements detected in the samples, while a possible contamination with heavy metals was negligible. According to the sensory evaluation all biscuits were given very good marks with the wheat and buckwheat biscuits receiving the highest scores.

Keywords: bakery product, cereal flour, honey, oxidation stability, mineral elements

1. Introduction

Honey biscuits are one of the oldest food products known to humanity, dating back to Ancient Egypt, Greece and Rome. Their popularity lives on, especially during Christmas and Easter holidays. The composition of the honey biscuit has undergone various changes, most notably the addition of new ingredients (such as spices), depending on the food trends of the time. The advantages of honey biscuits comprise their good taste, high energy content and nutritional quality, reasonable price and a good shelf life at room temperature (Al-Marazeeq and Angar, 2017). The small scale-production or home-based craft business of honey biscuits, which has never grown into an industrial production, has helped to preserve the authenticity of the product and to keep its high-quality nutritional value. The exact recipe will never be unveiled as it has always been carefully protected and passed down in Slovak families for generations.

Besides the excellent taste, texture, scent and brittleness, the honey biscuit contains diverse nutrients necessary to support a proper functioning of the body. Its high fibre content is necessary for the body's production of energy, digestion, anti-cancer and antioxidant defence mechanisms. The quantity of fat in honey biscuits is not high which is why the product meets the criteria set for dietetic foods. Honey biscuits also contain vitamins and mineral compounds such as K, Na, Ca, Mg, P, Zn, etc.

The biscuit regularly appears in the top ten of daily consumed foods because of its availability and convenience to be enjoyed as a snack (Jauharah *et al.,* 2014). Despite its affordability, ease of handling and nutritional value, the content of proteins and dietary fibre in the honey biscuit is not high enough. Attempts have been made to improve the nutritional quality and functionality of cookies due to the consumers' expectations for healthier, more natural and functional products (Masoodi and Bashir, 2012). Replacing refined wheat flour with high-nutritive alternatives, such as buckwheat, rye and spelt flour in biscuits manufacturing could contribute to increasing consumers' daily nutritional intake (Frost *et al.,* 2011). Buckwheat, rye and spelt can be more efficient sources of protein and dietary fibre of vegetable origin and of good quantity in addition to other nutrients such as carbohydrates, mineral compounds and vitamins with compare to refined wheat flour. Cereals contain a wide variety of bioactive compounds exhibiting antioxidant properties, which have been of interest for decades. However, an increased attention in such components has been observed in recent years because of their importance in the prevention of diseases mediated by free radicals (Fatrcová-Šramková *et al.,* 2010). Recently, several modifications to the biscuit recipes have been tested, primarily in relation to the addition of buckwheat flour due to the widespread trend of a healthier lifestyle. Such new products could become a good alternative to traditional baked goods, particularly for people suffering from gluten intolerance.

The aim of the present work was to compare nutritional value and sensory acceptance of honey biscuits made from classical refined wheat flour, spelt, rye and buckwheat flour.

2. Materials and methods

Chemicals

All the chemicals used were of analytical grade and were purchased from Sigma-Aldrich (St. Louis, MO, USA) and CentralChem (Bratislava, Slovakia).

Preparation of biscuits

The honey biscuits were prepared following an old family recipe (Hercegová). The ingredients were purchased from a local market and included wheat flour (T-650; 500 g), buckwheat flour (500 g) rye flour (T-960; 500 g) and spelt flour (T-630; 500 g), powder sugar (from sugar beet; 190 g), butter (125 g), sodium bicarbonate (2 g), honey (multi-flower; 100 g), cinnamon (2 g) and eggs (120 g). Each type of biscuit was made from one flour type and baked separately. Altogether four types of biscuits were prepared and contained either wheat, buckwheat, rye or spelt flour. After kneading the dough was allowed to rest for 60 min. at +4 °C. The dough was rolled by a roller to obtain a thickness of approximately 6-7 mm. The desired shapes of biscuits were cut out of the dough and formed by hand. Subsequently, the biscuits were egg washed and baked at 170 °C for 15 min. in a traditional brick oven. After cooling for 30 min., the biscuits were packed to polyethylene zipper reclosable food plastic bags and stored at +21 °C and 50% relative humidity. Finally, their physical, chemical and sensory characteristics were evaluated.

Physical evaluation

The physical evaluation of honey biscuits was done using the texture analyser TA.XT2 Plus (Stable Micro Systems, Godalming, UK), according to a standard program and a compression rate of 5 mm/s. A sample of biscuits with a height of 2 cm and a diameter of 1.5 cm was pressed to reach a 50% deformation by a P/20 aluminium cylinder probe with a diameter of 2 cm, in two cycles with a 5 s delay. Two independent measurements were done for each sample. The resulting hardness [N] and brittleness [dimensionless] of the biscuits were used as indicators of textural characteristic. The calculations were performed using the attached Texture Exponent software (Stable Micro Systems). The analysis was performed 24 h following baking.

Chemical evaluation

Dry matter, ash and protein contents were determined following the standard AACC method 08-01 (AACC, 1996).

The nitrogen content was measured using the semi micro-Kjeldahl method. Nitrogen was converted to protein using the conventional factor of 5.7 for wheat and spelt flour and 6.25 for rye and buckwheat flour.

Crude fibre content was evaluated by the Ancom^{200} Fiber Analyser (ANKOM Technology Corp., Fairport, NY, USA) according to the producer – one gram (W_2) of the sample was weighted into a special filter bag (W_1 – bag tare weight; F57, ANKOM). The samples were defatted with petroleum ether, air-dried and placed into the analyser; 2,000 ml of 0.1 M sulphuric acid were added, and the samples were hydrolysed at 100 °C for 45 min. Subsequently the samples were washed with hot distilled water 3 times. Afterwards, 2000 ml of 0.1 M potassium hydroxide were added, and the samples were hydrolysed at 100 °C for 45 min.. The samples were then washed with hot distilled water 3 times. Water was gently pressed from the bags and the samples were soaked in acetone for 5 min., removed, air-dried and placed into the oven at 105 °C (WTB, Binder, Tuttlingen, Germany) for 2 h. After cooling to room temperature, the bags were re-weighted and ashed at 550 °C in pre-weighted crucibles for 2 h. The ashed crucibles were weighted to calculate the loss of weight of organic matter (W_3). Crude fibre content (%) was calculated using the following formula: [W3 – (W1 × C1) / W2] × 100; C1 – ash corrected blank bag factor (running average of loss of weight on ignition of blank bag/original blank bag).

Fat content was assessed with the Ancom XT15 Fat Extractor (ANKOM) according to the producer instructions – the sample (1.5 g, W1) was weighted into a special filter bag (XT4, ANKOM) and dried in an oven (WTB, Binder) at 105 °C for 3 h to remove the moisture prior to the extraction. The samples were placed into a desiccant pouch for 15 min., re-weighted (W2) and extracted with petroleum ether at 90 °C for 60 min. Subsequently the samples were removed and dried in an oven at 105 °C for 30 min., placed into a desiccant pouch and re-weighted (W3). The fat content (%) was calculated using the following formula: [(W2 – W3) / W1] × 100.

Water activity (aw) was measured using a portable Aw meter (Lab Master-aw, Novasina AG, Lachen, Switzerland), calibrated according to the manufacturer's recommendations.

The oxidative stability was determined in the 892 Rancimat apparatus from Metrohm (Herisau, Switzerland) according to ISO 6886:1997 (ISO, 1997) utilising a sample of 0.5±0.01 g. All samples were studied at 120 °C, under a constant air flow (20 l/h). The induction times were printed automatically by the apparatus software with an accuracy of 0.005.

The amount of mineral elements was analysed by the ICP-OES method (ICP-OES spectrophotometer, Thermo iCAP Dual 6500, USA) – the samples (0.2 g) were subjected to mineralisation under high pressure, in HNO_3 65%, super pure. The samples were weighed and placed in Teflon vessels which were then filled with 8 ml of nitric acid and sealed tightly. For each group of nine samples, during the microwave dissolution process, the rotor of the digestion system was additionally filled with a blank sample comprising 8 ml of nitric acid alone. The samples were digested for 1 h, with the applied algorithm of temperature increase as specified for biological samples, without exceeding 200 °C. This was carried out using Ethos One microwave digestion system from Milestone. The vessels were opened after the mineralisation process had been completed and the samples with acid had been brought to room temperature. The samples were cooled down to room temperature and supplemented with water to the volume of 50 ml. The obtained detection threshold for each element was not lower than 0.01 mg/kg (with the assumed detection capacity of the measuring apparatus at a level exceeding 1 μg/kg). The measurements were performed with ICP-OES spectrometer, Thermo iCAP Dual 6500 with horizontal plasma, and the capacity of detection along and across plasma flame (Radial and Axial). Before measuring each batch of 11 samples the method was calibrated with the use of certified Merck models. The measurement result for each element was compensated to account for the measurement of elements in the blank sample. In each case a 3-point calibration curve was used for each element, with optics correction applying the method of internal models, in the form of yttrium and ytterbium ions, at the concentrations of 2 mg/l and 5 mg/l, respectively.

Sensory characteristic

The organoleptic properties of the prepared biscuits were determined by a taste panel consisting of 25 evaluators (25 to 65 years; 15 women and 10 men). The participants were asked to evaluate the general appearance, honey flavour, honey taste, overall taste, overall flavour, aftertaste, texture and tenderness. The ratings were registered on a 7-point hedonic scale, ranging from 7 (like extremely) to 1 (dislike extremely) for each characteristic.

Statistical analysis

All experiments were carried out in triplicate and the results reported are expressed as means with standard deviations. The experimental data were subjected to the analysis of variance (Duncan's test), at the confidence level of 0.05, using the SAS (2009) (SAS Institute Inc., Cary, NC, USA) software.

3. Results and discussion

Physical evaluation

The texture analyser measures the texture and quantifies the physical properties of the product based on a pressure test. With respect to hardness the biscuits could be placed in the following order (Table 1): spelt honey biscuit (1,631.53±15.26 N) > buckwheat honey biscuit (1,613.02±23.85 N) > rye honey biscuit (1,578.72±16.21 N) > wheat honey biscuit (768.95±11.32 N). It means that the biscuit made with wheat flour was the softest while the samples prepared from the spelt and buckwheat flour were the hardest. Hardness is a textural property most important in the evaluation of baked goods because of

Table 1. The results of physical evaluation of tested honey biscuit samples.[1]

Sample	Hardness (N)	Brittleness (dimensionless)	Oxidation stability (h)
Buckwheat honey biscuit	1,613.02±23.85[a]	1,190.96±22.12[b]	1.80±0.19[a]
Spelt honey biscuit	1,631.53±15.26[a]	353.26±11.13[d]	1.09±0.12[b]
Rye honey biscuit	1,578.72±16.21[b]	1,348.66±19.15[a]	1.65±0.23[a]
Wheat honey biscuit	768.95±11.32[c]	476.96±12.17[c]	0.79±0.05[b]

[1] Mean ± standard deviation; different letters in column denote mean values that statistically differ one from another.

its close association with human perception of freshness (Karaoğlu and Kotancilar, 2009). According to Seyhun *et al.* (2003), the increased hardness of the crumb could be attributed to the amylose and amylopectin recrystallisation, formation of complexes between starch and proteins, redistribution of water between the components of the product and to other events which may occur in the baked product during storage.

In relation to brittleness (dimensionless) the biscuits may be listed in the following order (Table 1): rye honey biscuit (1,348.66±19.15) > buckwheat honey biscuit (1,190.14±22.12) > wheat honey biscuit (476.96±12.17) > spelt honey biscuit (353.26±11.13). The highest brittleness was recorded in the rye honey biscuit which was accompanied with the highest moisture content (Table 2). High moisture could increase the brittleness of the biscuit as a result of migration of the moisture from the centre to the surface causing breakage. These results could also be affected by other factors such as open and irregular structure of the sample, protein denaturation, and a decrease of the water-holding capacity, solubilisation and coagulation of the proteins. Improvements in brittleness and hardness were achieved by Ganorkar and Jain (2014) who revealed that the incorporation of linseed flour, for example into wheat flour, increased the hardness and brittleness of the biscuits. This effect was achieved due to a higher content of water, fibre and protein, which resulted in a stickier dough with a reduced tensibility.

In case of a decreasing oxidation stability the biscuits were placed in the following order (Table 1): buckwheat honey biscuit (1.80±0.19 h) > rye honey biscuit (1.65±0.23 h) > spelt honey biscuit (1.09±0.12 h) > wheat honey biscuit (0.79±0.05 h). In the food industry, the oxidation stability is one of the basic parameters for the quality control of raw materials such as oils and fats as well as products containing fats and oils. The sensitivity of fats towards oxidative reactions depends on the amounts of unsaturated fatty acids, the concentration and type of antioxidants, temperature, availability of oxygen and the presence of beneficial trace elements. The oxidative stability of fats and oils in their pure form were assessed with the Rancimat device and the results were plotted onto the oxidative stability graph, exhibiting the water conductivity and its dependence on time. The drawn curve depicts the radicals accumulated during the oxidation of fats as well as the generation of secondary oxidation products such as ketones, aldehydes, alcohols, lactones, hydrocarbons, esters and formic acid, which increases the conductivity of water. The induction time for the buckwheat honey biscuit was the highest (1.80 h). Buckwheat is generally rich in antioxidants, particularly flavonoids and lignans. As such, we may assume that these compounds had a positive impact on the prolongation of the oxidation stability. Higher oxidation stability was also detected in rye honey biscuits. In comparison to wheat, rye is known to contain more antioxidants. Gumul *et al.* (2007) reported that among cereals, special attention should be paid to rye, due to its specific chemical composition, i.e. high content of soluble dietary fibre, including soluble pentosans, mineral compounds (Ca, Fe, I, F) and phenolic

Table 2. The results of the chemical evaluation of the tested honey biscuit samples.[1]

Sample	Moisture content (%)	Water activity (dimensionless)	Crude protein content (%)	Ash content (%)
Buckwheat honey biscuit	8.07±1.21[a]	0.32±0.11[a]	4.26±0.32[a]	1.04±0.07[a]
Spelt honey biscuit	9.04±0.95[a]	0.38±0.08[a]	4.14±0.15[a]	0.96±0.08[ab]
Rye honey biscuit	9.44±0.99[a]	0.39±0.05[a]	2.27±0.51[b]	1.03±0.11[a]
Wheat honey biscuit	8.73±0.74[a]	0.40±0.07[a]	2.59±0.25[b]	0.85±0.03[b]

[1] Mean ± standard deviation; different letters in column denote mean values that statistically differ one from another.

acids, belonging to polyphenols. Rye grains contain particularly high concentrations of ferulic acid (four times higher when compared to wheat grains), sinapic, caffeic, *p*-coumaric and vanillic acid.

Chemical evaluation

Determination of the moisture content in food is of great importance in order to ensure a proper technological quality, consistency (texture) and hygienic compliance related to durability due to a long shelf-life of bakery products. The moisture content ranged from 8.07±1.21 to 9.44±0.99% (Table 2). The tested honey biscuits contained more than 80% of dry matter and less than 20% of water which is typical for products with a long shelf-life. Khouryieh and Aramouni (2012) reported that the addition of linseed flour can significantly reduce the moisture content in honey biscuits that could be helpful to create a product with a longer shelf-life.

Water activity is a critical parameter for the quality assessment of bakery products, and it is based on balancing the moisture between the microclimate above the sample and the sample itself (Kieslingerová and Bartl, 1993). Water activity in the tested samples (Table 2) ranged from 0.32±0.11 to 0.4±0.07 (dimensionless). Such values are in accordance with the Slovak legislation (2014), according to which the requirements for confectionery products and pastries are set to be less than or equal to 0.65.

The crude protein content in the tested samples (Table 2) ranged from 2.27±0.51 to 4.26±0.32% and the highest value was detected in the buckwheat sample. The protein content within the buckwheat grains has been reported to vary between 12 and 18.9% with a well-balanced amino acid composition as well as a relatively high lysine concentration – the first limiting amino acid in cereals. In addition, a comparative analysis of buckwheat grain proteins with those of other cereals indicates that buckwheat has higher amounts of arginine and tryptophan. Buckwheat grains contain a specific group of thiamine-binding proteins which act as transporters of vitamin B_1. At the same time, these proteins stabilise B_1 during technological processing (Wronkowska *et al.*, 2010). A higher crude protein content was also observed in the sample prepared with spelt flour. Bojňanská and Frančáková (2002) reported that spelt contains more proteins in the aleurone layer of the kernel than common bread wheat. The National Nutrient Database (USDA, 2014) states that the protein content in honey biscuits must be ~3.9 g per 100 g. The recommended daily dose of protein is 44 g, which is set for adults with a weigh of 80 kg and carrying out a normal day-to-day activity. Proteins are one of the essential nutrients whose intake is highly necessary. However, the composition of amino acids, especially the availability of peptide bonds of the protein for the digestive enzymes and other important biological factors, must be taken into consideration when assessing the need for protein intake.

The ash content affects the quality of the flour and it ranged from 0.85±0.05 to 1.04±0.07% (Table 2) in the tested samples. The whole technological process of milling is controlled and depends on the ash content (Muchová *et al.*, 2011) while on the other hand the ash content in the product depends also on other recipe components. According to the National nutrient database (USDA, 2014) the ash content in honey biscuits is set at 1.8 g per 100 g which corresponds to our results.

The fat content (Table 3) in the tested samples ranged from 7.89±0.41 to 11.71±1.15%. Fats are important in the diet because of their slow digestion that prevents the feeling of hunger. Fats contribute to the physical and chemical properties of the dough including flour coloration, which is why their content is important for the production of biscuits (Zálešáková *et al.*, 2014). Fats stabilise gas in the dough that is achieved by interactions of polar lipids from the gas-water lipid layer with gas molecules, thereby prolonging the retention time of the gas in dough (Goesaert *et al.*, 2005). The fat amount in the cereal grains is generally low and most of the fat in the honey biscuits comes from the butter. The honey biscuits in the present study did not contain high amounts of fat which is why they could be considered to become a dietetic food (Codex Alimentarius of Slovakia, 2011).

The crude fibre content (Table 3) was similar (~0.5%) in all tested samples. The term 'crude fibre' refers to the sum of

Table 3. Fat content and crude fibre content in the tested honey biscuit samples.[1]

Sample	Fat content (%)	Crude fibre content (%)
Buckwheat honey biscuit	11.71±0.41[a]	0.50±0.02[a]
Spelt honey biscuit	8.23±0.14[b]	0.54±0,05[a]
Rye honey biscuit	7.89±0.41[b]	0.54±0,01[a]
Wheat honey biscuit	11.26±0.56[a]	0.55±0.05[a]

[1] Mean ± standard deviation; different letters in column denote mean values that statistically differ one from another.

cellulose, hemicellulose and lignin in foods. Typically, the crude fibre ranged from 0.48 to 0.50% in all types of flour used in the present study. Similar results were reported by Pereira *et al.* (2013) evaluating a traditional Spanish biscuit Maria made from wheat flour. The composition of fibre is important from a nutritional point of view. Insoluble fibre does not undergo fermentation in the digestive tract and does not provide energy for the organism, however it does help to increase the volume of the stool by irritating the digestive tract, resulting in the elimination of waste created in the intestine during digestion.

The assessment of the mineral elements present in the buckwheat honey biscuit showed (Table 4) it was rich in sodium, phosphorus, potassium. In this sample was detected the highest value of magnesium, sulphur, zinc and copper. These mineral compounds are very important for normal human body functions, but very often are limited in our diet. Incorporation of buckwheat flour for biscuits processing can be one of the means to increase amount of these compounds. According to Hussain *et al.* (2017) buckwheat is rich mainly for iron, calcium, zinc and magnesium. These authors evaluated mineral composition of buckwheat muffins supplemented with wheat flour and found that amount of iron, calcium, potassium and zinc in buckwheat muffins decreased with the increased in wheat flour supplementation levels.

Spelt honey biscuit (Table 4) was also rich in sodium, phosphorus, potassium, sulphur and magnesium. Amount of phosphorus, potassium, magnesium, manganese and zinc was higher with compare to biscuits made from classical refined wheat flour. Compared to wheat, spelt has on average, 30-60% higher concentrations of iron, zinc, copper, magnesium, and phosphorus (Ruibal-Mendieta *et al.,* 2005).

The rye honey biscuit (Table 4) was similarly rich in sodium, potassium, phosphorus, sulphur, and magnesium. In this sample was detected the highest amount of sodium and manganese. Wheat honey biscuit (Table 4) was also rich in sodium, phosphorus, potassium, sulphur and magnesium, but amount of these mineral compounds was the lowest with compare to other prepared biscuits. Interesting finding was that in this sample was found the highest value of iron, which is necessary for normal blood function. Role of macro- and micro-elements in our diet is very important. The various metabolic disease are related to our daily life style (lifestyle disorders), notably an unbalanced energy rich diet lacking fibre and protective bioactive compounds such as mineral compounds and phytochemicals. Today it is agreed according to food pyramid that cereals especially bran and germ parts are consider to major source of mineral compounds, which is protective for our body (Gani *et al.,* 2012). Mineral compounds are required for normal growth; cellular activity and oxygen transport (Fe), fluid balance and nerve transmission (K) as well as the regulation of blood pressure and strengthening of bones (Ca and K) (Taiwo *et al.,* 2017). From our results, we can conclude that the biscuits could serve as a source of macro- and micro-elements and not contain contaminants – heavy metals in concentration which may indicate potential harm to consumer health.

Table 4. Mineral elements in tested honey biscuit samples.[1]

Mineral element (µg/g)	Buckwheat honey biscuit	Spelt honey biscuit	Rye honey biscuit	Wheat honey biscuit
Sodium (Na)	2,901.23±11.13^{d}	3,228.73±12.01^{c}	3,671.23±3.58^{a}	3,347.89±6.21^{b}
Phosphorus (P)	2,743.89±9.81^{a}	1,290.89±9.32^{c}	1,367.14±8.77^{b}	969.48±4.11^{d}
Potassium (K)	2,484.17±4.31^{a}	1,241.75±7.93^{c}	1,682.42±9.21^{b}	936.42±4.77^{d}
Magnesium (Mg)	1,413.33±3.35^{a}	406.51±5.01^{b}	380.92±2.04^{c}	269.75±1.16^{d}
Sulphur (S)	1,093.71±3.52^{a}	873.04±8.41^{c}	697.63±5.39^{d}	918.38±5.06^{b}
Iron (Fe)	14.26±1.01^{b}	1.35±0.28^{d}	8.84±0.01^{c}	18.14±0.29^{a}
Manganese (Mn)	10.88±0.97^{ab}	10.83±0.42^{b}	12.58±1.11^{a}	7.38±0.33^{c}
Zinc (Zn)	7.96±1.12^{a}	2.89±0.11^{c}	4.03±0.21^{b}	0.63±0.03^{d}
Copper (Cu)	2.82±0.07^{a}	0.94±0.07^{b}	0.91±0.03^{bc}	0.85±0.01^{c}
Chrome (Cr)	0.58±0.03^{b}	n.d.	1.45±0.09^{a}	n.d.
Cadmium (Cd)	0.08±0.01^{a}	n.d.	0.05±0.01^{b}	0.07±0.01^{ab}
Molybdenum (Mo)	n.d.	n.d.	n.d.	n.d.
Nickel (Ni)	n.d.	n.d.	1.22±0.03^{b}	1.94±0.17^{a}
Lead (Pb)	n.d.	n.d.	n.d.	0.06±0.01^{a}
Aluminium (Al)	n.d.	n.d.	3.37±0.38^{a}	1.08±0.08^{b}
Strontium (Sr)	n.d.	n.d.	n.d.	n.d.

[1] Mean ± standard deviation; different letters in column denote mean values that statistically differ one from another; n.d. = not detected.

Sensory characteristic

A total of 25 evaluators participated in the sensory analysis of honey biscuits. Results of the assessment showed no significant differences in the sensory ratings (Figure 1).

The buckwheat honey biscuit was rated as dominant in the overall flavour category by the participants. The texture was rated as 'good' with the worse tenderness properties that could be affected, for example, by a small shape of the biscuit or by the typical buckwheat characteristics. The biscuit had a standard pleasant honey flavour and it tasted good. Another flavour was found in this sample, namely caramel with a touch of rum truffles. It is important to note that buckwheat has a specific taste often rejected by consumers who are not familiar with it. However, in the case of honey biscuits, the rich sweet taste in combination with the spices successfully masked the buckwheat aroma, which has led to excellent scores for the taste and aftertaste. Similar results were published by Filipčev *et al.* (2011) who tested honey biscuits containing 50% of buckwheat flour and the evaluators signed that such biscuits were very attractive and would increase the diversity of biscuit products with improved nutritional quality on the market.

Rye honey biscuit had an attractive appearance, texture and typical honey flavour and aroma. The aftertaste was not exceptional, but it was also rated as good. The use of rye flour for honey biscuits could be found in the oldest recipes on the record. Rye flour prolongs the softness due to a high amount of non-starch polysaccharides found in rye.

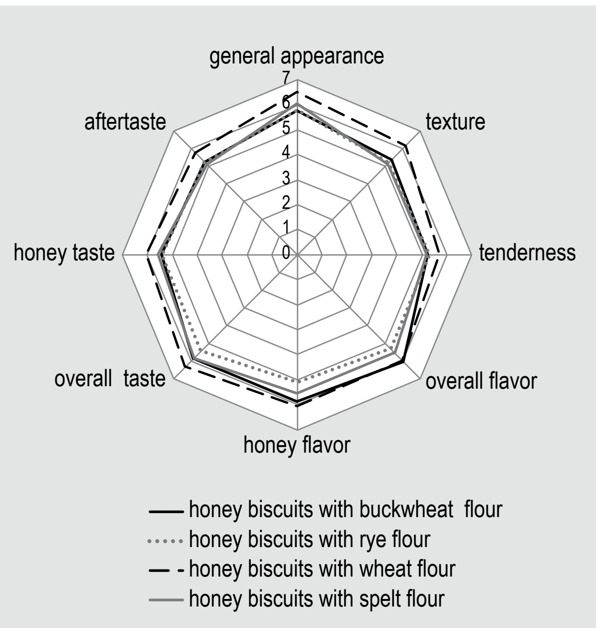

Figure 1. Results of sensory characteristic of tested honey biscuits.

The honey biscuit prepared with spelt flour received a very well rated overall appearance, texture and tenderness. The evaluators tagged this sample as the one with the least amount of honey flavour and smell. The aftertaste was not very distinctive either. Another non-typical taste of butter and milk was also found in this sample.

The wheat honey biscuit was absolutely the most favourite for the assessors and achieved the best evaluation in almost all categories (except the overall flavour). The majority of points were gained for tenderness and overall appearance.

4. Conclusions

The results of this study shown that the honey biscuits made from buckwheat, rye, spelt and wheat flour are bakery products with good quality and long term shelf-life. High percentage of dry matter and low water activity are the main parameters which insure the long shelf-life of the honey biscuits. The products meet the parameters of a dietetic food because of low percentage of fat. Results showed that honey biscuit can be successfully made not only from wheat flour, but also from rye, spelt and buckwheat flour. Honey biscuits made with buckwheat, rye and spelt flour contained high protein content, mineral elements (mainly magnesium, sulphur, zinc and copper), expressed higher oxidation stability and good sensory characteristic. Honey biscuits can be a good opportunity to introduce buckwheat, rye and spelt to human nutrition in the form of convenient ready-to-use food product by replacing a part of refined wheat flour with buckwheat, rye and spelt flour.

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