SPROUTED HULLESS BARLEY GRAINS AND THEIR APPLICATION POSSIBILITIES FOR THE FUNCTIONAL SWEET SNACKS DEVELOPMENT

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Currently, consumption of confectionery continues to grow, and there is a tendency to supplement snacks with ingredients that can be considered as functional products. The aim of this study was to evaluate the benefits of sprouted barley grains and their potential use in barley-fruit-vegetable snack production. Several samples of sweet bars with hulless barley variety 'Kornelija' flour and sprouted, crushed barley grain, dried fruit and vegetables were prepared. The chemical composition including the concentration of biologically active compounds (total concentration of phenols, flavonoids and tannins, as well as antioxidant activity) of untreated and sprouted grains was determined. The results showed that protein concentration of barley-fruit-vegetable bars varied from 8.65% to 10.85% and β -glucans concentration varied from 0.77% to 2.19%. Their nutritional value varied from 1079.33 to 1430.41 kJ. Total fibre concentration of unsprouted, 24 h and 36 h sprouted grains was 26.30%, 25.80%, and 24.60%, respectively. Total phenol concentration of unsprouted barley grains was on average 273.14 mg·100 g⁻¹ and flavonoid concentration was 290.25 mg·100 g⁻¹, and for sprouted grains — 258.98 mg·100 g⁻¹ and 256.19 mg·100 g⁻¹, respectively. The evaluators preferred bars made from ground sprouted hulless barley grains 'Kornelija' — 7.4, according to the sensory analysis — hedonic scale.

Keywords: healthy products, sprouted grains, dried fruits and vegetables.

INTRODUCTION

Hulless barley (*Hordeum vulgare* L.) offers nutritional and economic benefits for the food industry compared to hulled barley, but these advantages are not widely used in food production in the European countries. Barley grains, notably, hulless barley, is considered as an important food ingredient because of the presence of vital biochemical constituents — β -glucan, protein, phenolic compounds etc. (Arendt and Zannini, 2013). A lot of health benefits of β -glucan have been reported in literature, among them reduction of glycaemic index (Jenkins *et al.*, 2002), reduction of serum cholesterol, increased stool bulk and removal of toxic substances, and activity against colon cancer (Ahmad *et al.*, 2012). Many technological benefits of β -glucan, such as a stabilising, thickening, gelatine and emulsification agent al-

low its incorporation in functional beverages, functional bread and snack foods (Burkus and Temelli, 2000; Arendt and Zannini, 2013). In addition to β -glucan, barley contains some other bioactive compounds (phenolic compounds, tocopherols and sterols) with beneficial effects, which are currently under extensive investigation (Rico *et al.*, 2020).

In many parts of the world, grain germ and sprouted grains are used as biologically high-quality food (Nöcker, 1995). Results of previous research (Rakcejeva, 2006) show that during germination, the amount of fibre, vitamin B₂, E and niacin amounts in grain increase, and vitamin C is synthesised. Protein hydrolysis results in formation of essential amino acids in the grains during their activation. Compared to ungerminated grains, glucosamine concentration increases most rapidly in sprouted hulless barley in compari-

son to rye and wheat. Glucosamine is a glycopeptide, which are very important biologically active compounds that phylogenetically increase the body's resistance, mainly the phagocytic activity of the immune system, while secreting the immune mediator cytokinin, which promotes further development of the body's immune response (Slesarev *et al.*, 1998; Ermolaev, 2002). Saponarin, a natural flavonoid known for its antioxidant and hepatoprotective activities, is the predominant compound in barley sprouts, constituting 72% of the total polyphenol content (Seo *et al.*, 2014).

The significant advantage of 'Kornelija' is that it has both high protein and β -glucan concentration, and also grain threshability for this cultivar is high, corresponding to requirements of food barley (Bleidere *et al.*, 2013; Sterna *et al.*, 2017). Therefore, the chemical composition and technological traits of hulless barley 'Kornelija' make it an excellent raw material for functional food production.

Along with grains, also vegetables and fruits are part of a healthy daily diet. They are rich sources of vitamins, minerals, dietary fibre, as well as plant sterols, flavonoids and other antioxidants. The World Health Organisation (WHO) recommends daily consumption of more than 400 grams of fruit and vegetables (Regulation (EU). No 1169/2011). In order to provide the required amount of nutrients, it is necessary to eat plant products of different types and colour (Wang *et al.*, 2014). Red beets (*Beta vulgaris* L.) are recognised as health-promoting foods due to the presence of ingredients such as vitamins, minerals, phenolic compounds, carotenoids, ascorbic acid, and betaine. Beet supplements for various products can strengthen the protection of endogenous antioxidants, helping to protect cellular components from oxidative damage (Cliford *et al.*, 2015; Chhikara *et al.*, 2018).

Black currant (*Ribes nigrum* L.) berries are one of the richest berries, as they contain large amounts of flavonoids, vitamin C, proanthocyanidins, and anthocyanins. They are most often used in the diet as a source of vitamins, as well as in folk medicine as an antiperspirant, diuretic and antipyretic. Several studies have focused on the therapeutic potential of blackcurrants for hypertension and other cardiovascular diseases (Pirjo *et al.*, 2011; Gopalan *et al.*, 2012). The content of vitamin C in black currants is 4–5 times higher than in citrus fruits, and they are known as a source of ascorbic acid (Bordonaba and Terry, 2008).

Carrots (*Daucus carota*) contain several types of phytochemicals, including phenols, carotenoids, and polyacetylenes, which are important for our health. These compounds help reduce the risk of cancer and cardiovascular disease due to their antioxidant, anti-inflammatory, plasma lipid modification and antitumour properties (Ahmad *et al.*, 2019).

Several varieties of carrots grown in Europe have been found to be richer in carotenoids ($9.9 \pm 0.5 \text{ mg} \cdot 100 \text{ g}^{-1}$) than those originating in continental Asia ($7.9 \pm 0.4 \text{ mg} \cdot 100 \text{ g}^{-1}$) (Rakcejeva *et al.*, 2012).

Plum (*Prunus domestica* L.), black currant and quince ((*Chaenomeles japonica* (Thunb.) Lindl. Ex Spach; *Rosaceae*)) are suitable raw material for the development of functional foods from fruit and berry crops. Dried plum fruits (prunes) contain large amounts of phenolic compounds. They had been found to inhibit human low density lipoprotein oxidation *in vitro*, and thus might serve as preventive agents against chronic diseases, such as cancer and heart disease (Stacewicz-Sapuntzakis *et al.*, 2001). Prunes are sweet and therefore a good source of energy in the form of simple sugars. Additionally, the high potassium content of prunes might be beneficial for cardiovascular health. They are also an important source of boron, which is postulated to play a role in prevention of osteoporosis.

The fruits of Japanese quince are popular mainly in the Baltic States: Latvia, Lithuania, Estonia, Finland, Sweden, and Poland. Japanese quince is valuable due to its high content of nutrients and minerals for our health. Due to high levels of pectin, phenolic compounds, vitamins and organic acids, mainly malic and citric acids, they are suitable for the development of niche food products (Bieniasz *et al.*, 2017).

In today's haste, there is often a lack of time to enjoy a complete diet, and therefore, a large part of society uses snacks. The demand for snacks and consumption of confectionery continues to grow. Therefore, it is important to produce maximally healthy and full-bodied snacks using local ingredients. The bars currently available in stores are either made from nuts, puffed rice, oatmeal or wheat flour, but barley grain raw materials are not included. Also, local fruits and vegetables are rarely used to develop this type of healthy product.

The aim of study was to evaluate the benefits of sprouted hulless barley grains and their potential use in barley-fruit-vegetable snacks production.

MATERIALS AND METHODS

The material used in product development was hulless barley (*Hordeum vulgare* L.) cultivar 'Kornelija' from the harvest of 2018 grown at the Stende Research Centre (lat. 57.1412° N, long. 22.5367° E). The grain harvest was cleaned by PETKUS cleaner (Germany) with sieve dimensions of rectangular holes $2.2 \times 20 \text{ mm}$. The chemical composition of untreated and sprouted hulless barley samples was determined.

The sprouting of hulless barley 'Kornelija' was done in the Faculty of Food Technology, Latvia University of Life Sciences and Technologies. For the experiments, the grains were rinsed and soaked in water in a ratio of 1:2 (grains : water) at a temperature of $22 \pm 2 \text{ }^{\circ}\text{C}$ $24 \pm 1 \text{ h}$. After soaking, the grains were placed for germination/sprouting in a climatic chamber ICH110 (Memmert, Germany) at a temperature $35 \pm 1 \text{ }^{\circ}\text{C}$ and relative air humidity (RH) $95 \pm 5\%$ in darkness for $24 \pm 1 \text{ h}$ and $36 \pm 1 \text{ h}$ (Kince *et al.*, 2017). After germination/sprouting, the grains were dried at the

Fig. 1. Sprouted grain (A – drying of sprouted grains, B – sprouted and dried grains).

temperature $+60 \pm 2$ °C for 7 ± 1 h UF160 (Memmert, Germany) (Fig. 1).

Total phenol, total flavonoid, and total tannin concentration and antioxidant activity were determined in samples of unsprouted and 36 h sprouted grain flour used to prepare the snack, at the Institute of Horticulture.

Preparation of bars was done at the Institute of Horticulture. The appropriate raw material was selected and four recipes were developed to produce a functional product containing hullless barley variety ‘Kornelija’, i.e. a barley-fruit-vegetable snack (bar). All raw materials were processed and prepared using daily kitchen accessories and equipment. Beets and carrots were washed, cooked, peeled, grated, dried, and powdered. Dried plums and dates (*Phoenix dactylifera*) were chopped using a knife.

Japanese quince syrup was made from quince juice with added sugar, with and without addition of the sweetener Sukrin. A concentrate of Japanese quince was prepared by evaporating quince juice using a STEPHAN Universal Machine UMC 5 (Germany). The conditions for evaporation of 500 g juice were: 60 °C temperature, and four hours till soluble solids in concentrate reached 55 Brix%. Frozen black currants were thawed, dried and ground into powder. Four variants of sprouted, crushed (0.5–1 mm) barley ‘Kornelija’ grain (G) bars were produced (1vG; 2vG; 3vG; 4vG) according to the recipes given in Table 1, and four variants of hullless barley ‘Kornelija’ flour (F) bars (1vF; 2vF; 3vF; 4vF) were prepared similarly.

The energetic value was calculated for each variant. Nutrition and energy values were calculated using a specific Excel spread sheet according to data in the Regulation (EU) No. 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers.

The sensory evaluation of snacks was performed using a 9-point hedonic scale, where 9 reflected maximum appreciation (like extremely) and 0 indicated a completely displeasing attribute (dislike extremely) (See: The 9-point Hedonic Scale...). The fruit/vegetable bar samples were evaluated by 15 previously trained experts (both men and women) aged from 26 to 60 in accordance with the guidelines described in ISO 4121:2003.

Table 1. Recipes of “grain – fruit – vegetable” bar with chopped sprouted barley grains

Raw material	Variants of snack bars with sprouted, crushed grains*, g			
	1vG	2vG	3vG	4vG
‘Kornelija’, crushed	48.4	27.5	30.0	29.4
Red beets powder	6.5	–	5.0	4.9
Plums (dried, chopped)	17.7	–	–	–
Japanese quince syrup	22.6	18.0	–	–
Japanese quince syrup + Sukrin	–	–	34.0	33.3
Green buckwheat	4.8	18.0	–	–
Carrots powder	–	9.2	10.0	9.8
Honey	–	9.1	–	–
Dates (dried, chopped)	–	18.2	–	–
Black currant powder	–	–	6.0	5.9
Oat flakes	–	–	15.0	14.7
Japanese quince concentrates	–	–	–	2.0
Total	100.0	100.0	100.0	100.0

* The same recipes were prepared using untreated flour (F) instead of sprouted, crushed grains (G)

The chemical analyses (protein, fat, β -glucans, and starch) of grains, flour, and snack bars were done at the Institute of Agricultural Resources and Economics. Collected food samples, three subsamples of each batch for chemical analyses, were dried at 60 °C and then ground in mill with a 1.0 mm sieve. Protein concentration was determined by the Kjeldahl method, and conversion factor 6.25 was used to convert total nitrogen to crude protein. Fat was extracted with petroleum ether (boiling range of 40–60 °C) by Soxhlet extraction and determined gravimetrically. Concentration of β -glucans was determined in agreement with ICC Standard Method No. 168 for assessing mixed-linkage β -glucans by using Assay Kits (Megazyme Ltd.). Concentration of starch was determined by the LVS EN ISO 10520:2001 Native starch - Determination of starch content - Ewers polarimetric method.

The analysis of total phenolic, flavonoid, and tannin concentration and antiradical scavenging activity of unsprouted and sprouted hulls barley grains was done at the Institute of Horticulture.

Total phenolic concentration was determined by the photometric method using Folin-Ciocalteu reagent as described

by Singleton *et al.* (1999). The obtained absorbance (blue colour) of the analysing extract was measured at wavelength of 760 nm on a spectrophotometer UV-1800 (SHIMADZU). The total phenol concentration was expressed as Gallic acid equivalents per 100 g of fresh weight of sample (GAE mg·100 g⁻¹ FW). The total flavonoid concentration was determined spectrophotometrically by colorimetric assay using aluminium chloride (López-Perea *et al.*, 2019). The obtained absorbance was measured at wavelength 510 nm. Total flavonoid concentration was expressed as mg of quercetin equivalent of fresh weight of sample (QE mg·100 g⁻¹ FW). The total tannin concentration of the extract samples was determined spectrophotometrically using 1% K₃Fe(CN)₆ and 1% FeCl₃ absorbance measured at 720 nm (Paaver *et al.*, 2010). The total tannin concentration was expressed as mg of tannin acid of fresh weight of sample (mg TA·100 g⁻¹ FW). The antiradical scavenging activity of the sample extracts was evaluated using DPPH (1,1-diphenyl-2-picrylhydrazil radical) assay (Heimler *et al.*, 2006) with some modifications. 100 µl of the extract was added to 2.9 ml ethanolic solution of DPPH and, then, the rate of absorbance was measured at the 30th minute after mixing of reagents in a cuvette. Antioxidant activity of the sample was expressed in millimoles of Trolox equivalents (mmol TE·100 g⁻¹).

Total dietary fibre (TDF), the sugar profile and allergens (gluten and gliadin) of untreated and sprouted hulless barley were analysed in an accredited laboratory J.S. Hamilton Baltic. Dietary fibre was determined by AOAC 991.43:1994 method, total sugars by PB79/HPLC edV18.05, and gluten and gliadin by RUK 5.04-ed.II (ELISA-RIDASCREEN GLIADIN).

The data obtained in the experiments were processed using SPSS Statistics 17.0 software. The results of the study were analyzed by one-way analysis (ANOVA). The Sheffe criterion was used to identify significant differences ($p < 0.05$) between the studied samples. The tested results were ex-

pressed as means $\pm$ standard deviations for at three experimental replicates.

RESULTS

In unsprouted grains of the variety 'Kornelija', the amount of fibre was 26.3% and the amount of β -glucans – 4.38% (Table 2). After sprouting of the grains for 24 and 36 h, the fibre concentration decreased by 2.0% and 6.5%, respectively, and β -glucan levels by 5.5% and 13.3% ($p > 0.05$). The protein concentration of sprouted grains was insignificantly higher. The gluten concentration in hulless barley was reduced by 41% by germinating them for 24 h, compared to unsprouted grains, and by 55% — by germinating them for 36 h; also, the gliadin content was reduced by 41% (24 h) and 55% (36 h).

The comparison of bioactive compounds in unsprouted and sprouted grains showed that 36 h sprouting significantly decreased total flavonoid concentration ($p > 0.05$), and significantly increased total tannin concentration and antioxidant activity ($p < 0.05$) (Table 3). Total phenol concentration was in the range from 258.98 to 273.14 GAE mg·100 g⁻¹ and was not affected significantly by sprouting.

The results (Table 4) showed that protein concentration of barley-fruit-vegetable bars ranged from 7.85 g·100 g⁻¹ to 10.93 g·100 g⁻¹ and β -glucans concentration varied from 0.77 g·100 g⁻¹ to 2.79 g·100 g⁻¹ in dry matter, and nutritional value from 1079.33 kJ to 1430.41 kJ The highest concentration of protein and β -glucans was found in samples 3vG and 4vG, which contained mixed oat (*Avena sativa* L.) flakes along with barley. The fat content of the prepared snacks varied from 1.20 g to 1.84 g per 100g of product.

The produced 'Kornelija' barley-fruit-vegetable bars were subjected to hedonic sensory evaluation to obtain the opinion of the evaluators on the degree of liking of the given product.

Table 2. Chemical composition of unsprouted and sprouted hulless barley grains

Sample	Protein,	β -glucan,	Fats	Starch,	Total sugars	Total Dietary Fibre	Gliadin,	Gluten,
	Mean value $\pm$ SD, g 100 g ⁻¹						mg·kg ⁻¹	
'Kornelija' unsprouted	13.53a $\pm$ 0.28	4.38a $\pm$ 0.25	2.40a $\pm$ 0.38	62.28a $\pm$ 0.22	0.95a $\pm$ 0.4	26.3a $\pm$ 0.4	82.0	164.1
'Kornelija' 24 h sprouted	14.45a $\pm$ 0.26	4.14a $\pm$ 0.23	2.37a $\pm$ 0.38	58.02b $\pm$ 0.27	3.0b $\pm$ 0.3	20.2a $\pm$ 0.3	48.4	96.9
'Kornelija' 36 h sprouted	14.28a $\pm$ 0.25	3.80a $\pm$ 0.21	2.32a $\pm$ 0.38	55.94b $\pm$ 0.23	3.2b $\pm$ 0.3	13.0b $\pm$ 2.6	36.9	73.7

Different letters in the same line represent statistically different results ($p < 0.05$).

Table 3. The concentration of bioactive compounds and antiradical scavenging activity of unsprouted and sprouted hulless barley grains

Samples	Total phenol, GAE mg·100 g ⁻¹	Total flavonoid, QE mg·100 g ⁻¹	Antioxidant activity, mmol TE·100 g ⁻¹	Total tannin, mg TA·100 g ⁻¹
	mean $\pm$ SD			
Unsprouted grains	273.14a $\pm$ 7.93	290.25a $\pm$ 7.17	493.15a $\pm$ 5.21	1.25a $\pm$ 0.03
36 h sprouted grains	258.98a $\pm$ 11.12	256.19b $\pm$ 14.17	528.36b $\pm$ 13.2	2.08b $\pm$ 0.11

Different letters in the same line represent statistically different results ($p < 0.05$).

Table 4. Characteristic and nutritional value of snacks (100 g product)

Sample	Moisture content, %	Protein, g	β-glucan, g	Carbohydrate, g	Fibre, g	Fat, g	Salts, g	Energy, kJ
1vG	10.2	9.64	1.57	57.67	15.99	1.40	0.14	1323.99
2vG	11.3	8.65	0.77	66.80	12.92	1.20	0.14	1430.41
3vG	8.6	10.54	2.19	43.82	13.25	1.33	0.16	1079.33
4vG	8.8	10.85	2.11	43.85	13.32	1.84	0.16	1104.54

1vG Kornelija crushed grains, red beets powder, plums (dried, chopped), Japanese quince syrup, green buckwheat.

2vG Kornelija crushed grains, Japanese quince syrup, green buckwheat, carrots powder, honey, dates (dried, chopped).

3vG Kornelija crushed grains, red beets powder, Japanese quince syrup + Sukrin, carrots powder, black currant powder, oat flakes.

3vG Kornelija crushed grains, red beets powder, Japanese quince syrup + Sukrin, carrots powder, black currant powder, oat flakes, Japanese quince concentrates

Summary of the completed questionnaires of the hedonic evaluation results showed that the highest evaluation (7.4) was received by bars made with sprouted hulless barley grain, which were prepared according to the 2vG recipe (Fig. 2). Hedonic evaluation showed that in all four variants of bars grains were preferred to flour.

DISCUSSION

Grain activation is the beginning of the grain life cycle. These processes require certain conditions: sufficient humidity, light, heat, and air ambiance. The process of biological activation begins when the grain binds moisture and swells. In the endosperm, mainly hydrolytic processes take place, but in the germ — synthesis processes (Guimarães *et al.*, 2020). Temperature is an important factor in the regulation of enzyme activity; it can act in the formation of certain enzymes resulting in activation of biochemical reactions. Therefore, at stages of grain development when the growth process is intensive and the assimilates are transported to form new cell tissues and structures, the optimal temperature is essential (Jiménez and Samman, 2020). Also, germination results in increased protein concentration, total dietary fibre concentration, antioxidant activity and total phenolic concentration, while fat and carbohydrate concentration decreases (Jan *et al.*, 2016; Farooqui *et al.*, 2018). Germination also softens granular structure, and enhances the digestibility of grains and seeds (Su *et al.*, 2020).

The results of our study (Table 2) showed an increase in protein but a significant decrease in dietary fibre concentration of sprouted grains ($p < 0.05$) while the concentration of β-glucans decreased insignificantly. Farooqui *et al.* (2018) comparing non-germinated and germinated barley reported that protein concentration increased from 12.69% to 14.87%, fat concentration decreased from 2.75% to 2.10%, and total carbohydrate concentration from 68.90% to 63.79% and these results were in line with our study. Rico *et al.* (2020) reported that β-glucan levels in barley grains were close to $5 \text{ g} \cdot 100 \text{ g}^{-1} \text{ DM}$ and then decreased to a some extent during germination (reduction of 14%–22% after 84–86 h of germination with respect to the initial content)

Fig. 2. Hedonic evaluation of hulless barley Kornelija bars: 1vG, 2vG, 3vG, 4vG –

Kornelija crushed grains (1vG) or flour (1vF), red beets powder, plums (dried, chopped), Japanese quince syrup, green buckwheat.

Kornelija crushed grains (2vG) or flour (2vF), Japanese quince syrup, green buckwheat, carrots powder, honey, dates (dried, chopped).

Kornelija crushed grains (3vG) or flour (3vF), red beets powder, Japanese quince syrup + Sukrin, carrots powder, black currant powder, oat flakes.

Kornelija crushed grains (4vG) or flour (4vF), red beets powder, Japanese quince syrup + Sukrin, carrots powder, black currant powder, oat flakes, Japanese quince concentrates.

Along with the results of levels of protein, dietary fibre and other healthy substances, concentration of the allergens gliadin and gluten was also determined. Sprouting resulted in a significant decrease ($p < 0.05$) in concentration of these substances in barley grains. Gluten concentration decreased because of intensive biochemical processes initiated in grains due to the activation of enzymes of the hydrolase group, including amylolytic (α -amylase) and proteolytic (hydrolysing proteins to form polypeptides and amino acids). Intensive action of protein disulphide reductase catalyses the regeneration of disulphide bonds ($-S-S-$). The number of disulphide bonds in the gluten decreases during germination and the gluten becomes weak (Abedi and Pourmohammadi, 2020).

From results of study summarised in Table 2, it can be concluded that even 24h-sprouting of hulless barley grains resulted in a lower concentration of gluten, which was below the $100 \text{ mg} \cdot \text{kg}^{-1}$ threshold that allows to consider them as

very low gluten product (Commission Regulation No. 41/2009).

Data regarding bioactive compound changes after sprouting are controversial. Jan *et al.* (2016) reported increase of total phenolic concentration from 241 mg·100 g⁻¹ to 565 mg·100 g⁻¹ in *Chenopodium* (*Chenopodium album*) flour, while Farooqui *et al.* (2018) reported a decrease from 2.12 to 1.85 (mg ferulic acid equivalents per g) in barley flour. Similar results were obtained in a study by Kruma *et al.* (2019), which showed that germination increased total phenolic concentration and antiradical activity of cereal grains. A study by Rico *et al.* (2020) concluded that total phenolic compound and γ -aminobutyric acid concentration and antioxidant activity, determined by Oxygen Radical Absorbance Capacity, increased between 2-fold and 4-fold during sprouting, depending on germination conditions and this increase was more pronounced at higher temperatures (16–20 °C) and longer times (5–6 days). These contradictions can be explained by use of different sprouting conditions — procedure and temperature same as composition of phenolic compounds. The concentration of some phenolic compounds and the antioxidant activity were observed to decrease significantly during steeping and the early stages of germination and then increased remarkably during the later stages of germination and subsequent kilning (Lu *et al.*, 2007).

Antioxidant activity of sprouted grains increased significantly in our study from 493.15 to 528.36 mmol TE·100 g⁻¹ during germination. Similar results were obtained in other studies by using the Trolox Equivalent Antioxidant Capacity Assay, where antioxidant capacity increased from 14.10% to 18.20% (Jan *et al.*, 2016) and from 11.37% to 14.36% (Farooqui *et al.*, 2018).

Overall fat concentration in barley grain is rather low when compared to that of oats, and the greatest portion of the fats in the barley kernel is in the endosperm (Bai and Ulrich, 2008). Although fat content did not change significantly during grain sprouting, however all variants of produced snacks had comparatively low fat content (1.20–1.84 g·100 g⁻¹). Protein concentration of bars 3vG and 4vG was more than 10 g·100 g⁻¹ and dietary fibre more than 13 g·100 g⁻¹. These types of snacks with added fruits and vegetables are characterised by low calorie content and high concentration of dietary fiber and antioxidants. These kind of bars (100 g) could provide half of the daily necessary dietary fibre amount. The World Health Organisation recommends a dietary fibre intake of at least 25 g per day, including 3 g β -glucans. The loss of biologically active substances can be reduced by using effective technological methods (Perfilova *et al.*, 2020).

Hedonic scale sensory evaluation result 7.4 (like moderately) showed that germinated barley grain — fruit/vegetable bars are acceptable for human consumption in food as good healthy snacks with nutrition value 1430.41 kJ. The bars with the highest evaluation — 2vG had a good taste and were sweet enough, as noted in the comments of the

sensory evaluation questionnaires. These bars contained honey (recipe showed in Table 1), which created a pleasant taste bouquet for the sample. The evaluators preferred as best the bars made from crushed hulless barley grain ‘Kornelija’, instead bars made from flour. The consistency of the bars made from flour was drier and supposedly crumblier, and the aftertaste of these bars (from flour) was bitter, according to the evaluators.

In general, this study confirmed that hulless barley ‘Kornelija’ flour can be successfully used as wholegrain raw material in snacks. Sprouted hulless barley grains may not only replace other flour as a binder of ingredients but also become a source of both protein and dietary fibre and could be inspiration for the development of new functional food products as an alternative to commonly used cereals (wheat, rice, maize (*Zea mays*) and oat).

CONCLUSION

Sprouted hulless barley has significantly higher concentration of total sugars, total tannins and antioxidant activity, and significantly lower concentration of the allergens gliadin and gluten, in comparison with unsprouted cereals. Therefore, sprouted cereals have improved nutritive value, and potential for the development of new product such as fruits snacks. The obtained new products composed of sprouted, crushed hulless barley grains, green buckwheat, carrots powder, honey, dates, and Japanese quince syrup have not only elevated nutritive value, but also a high degree of liking (7.4).

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DIEDZĒTU KAILGRAUDU MIEŽU IZMANTOŠANAS IESPĒJAS FUNKCIONĀLU SALDO UZKODU RADĪŠANĀ

Konditorejas izstrādājumu patēriņš mūsdienās arvien pieaug. Uzkodas tiek papildinātas ar sastāvdaļām, kuras var uzskatīt par funkcionāliem produktiem. Miežus (*Hordeum vulgare* L.), īpaši kailgraudu, uzskata par svarīgu pārtikas produktu izejvielu, jo tajos ir vitāli svarīgas sastāvdaļas – β-glikāni, olbaltumvielas, fenola savienojumi u.c. Tāpēc līdztekus augļiem un dārzeņiem miežu graudi ir potenciāli piemēroti uzkodu ar funkcionālām īpašībām pagatavošanai. Daudzviet pasaulē graudu diēli un graudu diedzējumi tiek izmantoti kā bioloģiski augstvērtīga pārtika. Pētījuma mērķis bija novērtēt diedzētu miežu graudu priekšrocības un iespējas tos izmantot miežu-augļu-dārzeņu uzkodu ražošanā. Tika sagatavoti saldo uzkodu paraugi ar žāvētiem augļiem un dārzeņiem, četri veidi ar kailgraudu miežu šķirnes ‘Kornelija’ miltiem un četri ar diedzētiem miežu graudiem. Nediedzētiem un diedzētiem miežu graudiem salīdzināja ķīmisko sastāvu un bioloģiski aktīvos savienojumus — kopējo fenolu, flavonoīdu un tanīnu saturu, kā arī antioksidatīvo aktivitāti. Veica saldo uzkodu ķīmiskā sastāva un uzturvērtības novērtējumu. Lai uzzinātu patērētāju viedokli, tika veikta sagatavoto uzkodu paraugu sensorā vērtēšana, izmantojot hedonisko skalu. Rezultāti liecināja, ka olbaltumvielu saturs miežu–augļu–dārzeņu batoniņos variēja no 7,85% līdz 10,93%, β-glikānu saturs no 0,77% līdz 2,79%, to uzturvērtība variēja no 1079,33 līdz 1430,41 kJ. Kopējais šķiedrvielu saturs nediedzētiem, 24 un 36 stundas diedzētiem graudiem bija attiecīgi 26,30%, 25,80% un 24,60%. Kopējais fenolu saturs nediedzētos miežu graudos bija no 273,14 mg·100 g⁻¹, flavonoīdu saturs 290,25 mg·100 g⁻¹, savukārt, 36 h diedzētos graudos šie rādītāji bija attiecīgi 258,98 mg·100 g⁻¹ un 256,19 mg·100 g⁻¹. Novērtējums liecina, ka paraugiem, kas gatavoti no miltiem, bija sausāka un vairāk drūpoša konsistence, ar rūgtenu pēcgaršu. Uzkodu sensorais novērtējums bija 5,6–7,4 pēc hedoniskās skalas. Vērtētāji par labākiem atzina uzkodas, kuru sastāvā izmantoti diedzēti, drupināti graudi, nevis milti. Šajos batoniņos bija medus, krūmīdoniju sīrups, burkānu pulveris un dateles. Pievienotie augļi un dārzeņi nodrošināja batoniņu atšķirīgu garšu un paaugstināja to uzturvērtību. Pētījumā secināts, ka ar kailgraudu miežiem, īpaši diedzētiem, uzkodās var aizstāt tradicionālos kviešu, rīsu, kukurūzas graudus, bagātinot uzkodas ar šķiedrvielām un bioloģiski aktīviem savienojumiem.