TECHNOLOGICAL PROPERTIES OF PEA AND BUCKWHEAT FLOURS AND THEIR BLENDS

Ilze Beitane, **Gita Krumina-Zemture**, **Martins Sabovics**
Latvia University of Agriculture
Ilze.Beitane@llu.lv

Abstract

Pea and buckwheat flours are gluten free and have high nutritional value; therefore they are advisable for frequent consumption. The addition of pea and buckwheat flours to products changes their nutritional value and technological properties significantly. The aim of the research was to investigate the starch content, colour and rheological properties of pea and buckwheat flours and their blends.

Results showed that pea flour had a higher content of starch than wheat and buckwheat flours, pea-buckwheat flour blends and formed the largest part of dry matter. The peak, holding, final, breakdown and setback viscosities of buckwheat flour, in turn, were significantly higher than those of wheat (control) and pea flours. Buckwheat flour provided higher peak, holding, final, breakdown and setback viscosities and lower starch gelatinization temperature in flour blends. The highest lightness was demonstrated by the control sample, whereas the lowest by the buckwheat flour which had the highest redness value a^* comparing with other flours and blends. Pea flour showed significantly higher yellowness b^* in comparison with other samples, with the exception of flour blend with 60%PF + 40%BF. Colour values could be changed significantly by blending buckwheat and pea flours. It is possible to increase L^* and b^* values of buckwheat flour with pea flour and a^* value of pea flour with buckwheat flour in flour blends. Results of farinograph showed that buckwheat flour was characterized by a long development time, high stability and high farinograph quality number (FQN), whereas pea flour and pea-buckwheat flour blends had short development time, low stability and low FQN.

Key words: pea, buckwheat, viscosity, rheological properties.

Introduction

Most health organizations encourage frequent consumption of legumes (Leterme, 2002) due to their nutritional value. Legumes are rich in starch, protein and dietary fibre with significant amounts of vitamins and minerals (Piecyk et al., 2012; Tharanathan and Mahadevamma, 2003). It is important to understand how the benefits of legumes could be used to produce new products. Many factors, such as the nutritional value, physical, functional and organoleptic properties of legumes, are important by producing new products.

The starch content of pea flour range between 30-50% of the dry matter (Ratnayake et al., 2002; Sadowska et al., 2003). The slow and reduced digestibility of legume starch has been attributed to its amylose activity (Tharanathan and Mahadevamma, 2003). Generally, legume starches contain about 24-65% of amylose (Chung et al., 2008; Hoover and Sosulski, 1991) and processing of legumes may lead to an increase in the net resistant starch content which may have important effects on human physiology (Edwards, 1993). Apart from the energy contribution of starch (it provides the major source of physiological energy of human diet), another important role of starch in most of the processed food systems is to contribute to the texture and, as a result, to the organoleptic properties of food (Tharanathan and Mahadevamma, 2003). Legume starches exhibit a wide variation in swelling power and solubility (Ratnayake et al., 2002). The swelling factor of smooth pea starches ranges from 4 to 27 in the temperature range 50-95 °C (Ratnayake et al., 2001). The swelling properties and gelatinization are controlled in part by the molecular structure of amylopectin, starch composition and granule architecture (Tester, 1997).

Buckwheat is recognised as an important functional food in China, Japan and Taiwan (Lin et al., 2008). Buckwheat has gained an excellent reputation for its nutritious qualities in the human diet (Wijngaard and Arendt, 2006): a well balanced amino acid composition, gluten free, resistant starch and antioxidant activity. Starch content of buckwheat ranges from 69-87% in dry matter (Hatcher et al., 2008). Buckwheat, which is added to food, can provide beneficial health effects and prevent food from oxidation during processing (Lin et al., 2009). However, the addition of buckwheat into products changes their physical, functional and organoleptic properties. Torbica et al. (2010) reported that an increase in the amount of buckwheat flour resulted in longer dough development time due to the increase in fiber content which requires longer period of time to absorb water. Buckwheat starch granules are small (Hatcher et al., 2008); therefore they exhibit high water absorption due to large surface area (Dexter and Matsuo, 1979). Conversely, Hatcher et al. (2008) reported about the differences in the physically-chemical properties of buckwheat and cereal starches and indicated a greater swelling and gelling tendency for buckwheat starch than for wheat starch. Buckwheat flour possesses poor protein quality from the technological point of view (Mariotti et al., 2008); therefore it is required to mix buckwheat with other cereals.

The aim of the research was to investigate the starch content, colour and rheological properties (viscosity, consistency, water absorption, dough development time, dough stability and degree of softening) of pea and buckwheat flours and their blends.

Materials and Methods

Materials

Pea (*Pisum sativum* L.) flour (moisture content 9.2%, protein 20.9 g, lipid 1.8 g, total carbohydrates 59.6 g and energetic value 338.0 kcal / 1435.0 kJ in 100 g), buckwheat (*Fagopyrum esculentum*) flour (moisture content 13.3%, protein 12.0 g, lipid 3.0 g, total carbohydrates 62.0 g and energetic value 345.0 kcal / 1446.0 kJ in 100 g) were obtained from Fasma, Lithuania. Fine wheat flour (moisture content 12.1%, protein 11.0 g, lipid 1.1 g, total carbohydrates 72.6 g and energetic value 352.0 kcal / 1494.0 kJ in 100 g) as control was purchased from Dobeles Dzirnavnieks, Latvia.

Five flours and their blends were analysed (Table 1). Flour blends were chosen based on the results of previous research (Beitane et al., 2014).

Table 1

Description of flours and their blends

Code	Sample
Control - WF	100% Wheat flour
PF	100% Pea flour
BF	100% Buckwheat flour
40%PF + 60%BF	40% Pea flour and 60% Buckwheat flour
60%PF + 40%BF	60% Pea flour and 40% Buckwheat flour

Establishing the starch content

The content of starch in flour was established using a modified MEBAK Diastatic Power (EBC) 3.1.4.6 method with SCHOTT manual volumetric titrator, 20-mL capacity (Jacob, 2011). The measurements were performed in triplicate. The starch content of flour blends was calculated using findings of pea and buckwheat flour according the proportion of flour blends.

Evaluation of dough viscosity

Viscosity of the pea and buckwheat flours and their blends were evaluated using Viscograph –E (Brabender® GmbH&Co KG, Germany). Parameters recorded were starch gelatinization temperature (SGT), peak viscosity (PV), trough viscosity (TV), final viscosity (FV), holding viscosity (HV), breakdown viscosity (BDV, which is calculated PV-TV) and setback viscosity (SBV, which is calculated FV-TV). The measurements were performed in triplicate.

Colour measurement

Colour measurements of flours and their blends were carried out in quintuple using CIE Lab system. The obtained results were expressed in terms of CIE L^*, a^* and b^* values, where L^* measures brightness, a^* represents the red – green coordinates and b^* measures the blue – yellow coordinates.

Evaluation of rheological properties

The rheological properties of the pea and buckwheat flours and their blends were examined using Farinograph®-AT (Brabender® GmbH&Co KG, Germany) according to the ICC method 115/1, AACC method 54-21 and ISO 5530-1. Parameters recorded were consistency, water absorption, dough development time, dough stability, degree of softening and farinograph quality number. The measurements were performed in triplicate.

Statistical analysis

The results were analysed using the analysis of variance (ANOVA). T-test was applied to compare the mean values, and p-value at 0.05 was used to determine the significant differences. Mean ± standard deviation of three replicates was used.

Results and Discussion

The addition of legumes into cereal based products could be a good alternative for increasing their intake (Gómez et al., 2012; De la Hera et al., 2012) and their nutritional value. It is known that the nutrients content of raw materials has an effect on the functional

Table 2

Carbohydrates and starch content of flours and their blends

Flours, their blends	Carbohydrates, g 100 g^{-1} (Data of producer)	Starch, g 100 g^{-1}	Starch content in dry matter, %
Control - WF	72.60	51.25±0.06	58.3
PF	59.60	55.55±0.02	61.2
BF	62.00	45.57±0.03	52.6
40%PF + 60%BF	61.04	49.56	56.1
60%PF + 40%BF	60.56	51.56	57.8

properties of the final product. Several research papers (Debet and Gidley, 2006; Nelles et al., 2000) report that a lower lipid and protein content of cereals is associated with a higher peak viscosity, indicative of higher starch swelling. Starch content of flour influences the technological properties of products. Total carbohydrates and starch content of wheat as control sample, pea and buckwheat flours and their blends as well the starch content in dry matter are shown in Table 2.

Evaluating the data displayed in Table 2, it was obvious that pea flour had the highest content of starch (55.55 ± 0.02 g 100 g^{-1}) in comparison with other flours and their blends and formed the largest part (61%) of dry matter. The obtained results were comparable to those reported in other research papers. Similar results were reported in Kaushal et al. (2012) stating that the starch content of pigeonpea flour was 52.41 ± 0.01 g 100 g^{-1}, and in Chung and Liu (2012) concluding that the total starch content of pea flour was 48.8-50.2 g 100 g^{-1}. Literature usually reports a higher starch content of buckwheat (e.g. 65.52-78.09% in dry matter in Qin et al. (2010) or 69-87% in dry matter in Hatcher et al. (2008)) comparing with the results of this research. The differences in starch content of buckwheat flour could be explained by different cultivars, determination methods and growth conditions. The starch content could be increased by blending buckwheat flour and pea flour, achieving a value similar to the control sample.

The pasting properties of starch are significantly influenced by genetic effects: a smaller amylose chain length and a lower proportion of DP (degree of polymerization) 6-12 branch chains of amylopectin would lead to a low setback and a low viscosity at the end of cooling cycle (Ratnayake et al., 2001). The significant differences of viscosity of flours and their blends are presented in Table 3.

Significant differences in the viscosity of flours and their blends were identified. The peak, holding, final, breakdown and setback viscosities of buckwheat flour were significantly higher than those of wheat (control) and pea flours. Izydorczyk et al. (2014) reported similar results stating that buckwheat starches exhibit distinctive pasting profiles with shorter peak time, and much higher peak, setback and final viscosity values compared with cereal starches. Pea flour showed similar results with control as regards peak and setback viscosity. By blending pea flour with buckwheat flour it has shown coherence. As the percentage of buckwheat flour in the blend increased, the values of peak, holding, final and breakdown viscosities increased, too. The peak, holding, final and breakdown viscosities of both flour blends were significantly higher ($p<0.05$) than those of pea flour. The highest setback viscosity was demonstrated by buckwheat flour and flour blend with 40%PF + 60%BF. The highest final and setback viscosity of buckwheat flour could be explained by a large proportion of DP 6-12 branch chains of amylopectin (Ratnayake et al., 2001). The low setback viscosity of control and pea flour indicated their lower tendency to retrograde (Kaushal et al., 2012). The lowest breakdown and setback viscosities of pea flour suggest that it has a high resistance to

Table 3

Viscosity of pea and buckwheat flours and their blends

Flours, their blends	PV (BU)	HV (BU)	FV (BU)	BDV (BU)	SBV (BU)	SGT (°C)
Control - WF	1227.0[a]	1188.5[a]	1062.5[a]	721.5[a]	557.0[a]	58.3±0.1
PF	1257.0[a]	2083.5[b]	1739.5[b]	75.0[b]	557.5[a]	67.2±0.3
BF	4430.5[b]	4452.0[c]	4413.0[c]	1506.5[c]	1347.0[b]	64.6±0.1
40%PF + 60%BF	3379.5[c]	4101.0[c]	3670.5[d]	1070.0[a]	1361.0[b]	64.2±0.2
60%PF + 40%BF	2946.0[c]	3776.5[c]	3305.0[d]	827.5[a]	1186.5[c]	66.9±0.2

PV: Peak viscosity, HV: Holding viscosity, FV: Final viscosity, BDV: Breakdown viscosity, SBV: Setback viscosity, SGT: Starch gelatinization temperature.
Viscosity with different superscripts in a column differ significantly ($p<0.05$)

Table 4

The *L, *a** and *b** value intensity of flours and their blends**

Flours, their blends	*L**	*a**	*b**
Control - WF	94.30±0.05[a]	-1.99±0.01[a]	10.52±0.08[a]
PF	92.37±0.18[a]	-2.39±0.02[b]	19.37±0.09[bc]
BF	88.18±0.21[b]	-0.19±0.04[c]	10.70±0.12[a]
40%PF + 60%BF	90.17±0.13[ab]	-1.99±0.03[a]	15.05±0.10[c]
60%PF + 40%BF	91.40±0.17[ab]	-2.37±0.02[a]	17.09±0.11[c]

Values with different superscripts in a column differ significantly ($p<0.05$)

Table 5

Rheological properties of pea and buckwheat flours and their blends

Flours, their blends	Consistency, %	Water absorption, %	Development time (dough), min	Stability (dough), min	Degree of softening, FU	FQN
Control - WF	491±17	61.80±0.87	2.40±0.07	8.54±1.11	41±1	59±3
PF	205±6	52.50±0.75	1.13±0.11	1.12±0.07	59±1	37±2
BF	435±11	60.45±0.11	14.58±0.43	9.25±0.20	67±4	152±6
40%PF + 60%BF	461±6	50.34±0.03	1.44±0.03	1.26±0.09	79±2	26±1
60%PF + 40%BF	497±8	49.84±0.20	1.31±0.09	0.56±0.07	138±4	20±2

FQN – Farinograph quality number

retrogradation and therefore would form stable paste (Kaushal et al., 2012). Pea flour and flour blend with 60%PF + 40%BF had the highest starch gelatinization temperature. It could be associated with the fact that a greater amount of protein in pea flour could induce increased protein starch interaction, which could cause retardation toward swelling, thereby increasing the starch gelatinization temperature (Chung and Liu, 2012). By blending buckwheat and pea flours it was possible to change the viscosity significantly ($p<0.05$) depending on final product. Buckwheat flour provided higher peak, holding, final, breakdown and setback viscosities in flour blends.

Colour characteristics of different flours depend on the botanical origin of plants and on the composition of flour. Colour values of different flours and blends are summarized in Table 4.

The highest lightness (indicated by $L*$) was exhibited by the control sample (i.e. wheat flour), whereas the lowest was shown by buckwheat flour which had the highest redness value (indicated by $a*$) comparing with other flours and blends. Pea flour, in turn, showed significantly higher yellowness (indicated by $b*$) in comparison with other samples, with the exception of the flour blend with 60%PF + 40%BF. Similar results were reported in Izydorczyk et al. (2014) for buckwheat flour where $L*$ values ranged from 87.9 to 91.3, $a*$ values from -0.7 to -1.5 and $b*$ values from 6.0 to 12.2 depending on cultivars. Conversely, Qin et al. (2010) indicated that the common buckwheat flour $L*$ value was 71.87 ± 0.16, $a*$ value 1.95±0.10 and $b*$ value 8.36 ± 0.11. Comparing colour values of pea flour with literature the results of research were close to the findings by Kaushal et al. (2012) where $L*$ value of pigeonpea was 89.50 ± 0.225, $a*$ value -0.15 ± 0.145 and $b*$ value 22.32 ± 0.381.

Colour values could be changed significantly by blending buckwheat and pea flours. It was possible to increase $L*$ and $b*$ values of buckwheat flour with pea flour and $a*$ value of pea flour with buckwheat flour in flour blends.

Rheological characteristics of flours and their blends are presented in Table 5.

Farinograph measurements showed that the consistency of wheat flour (control), buckwheat flour and pea-buckwheat flour blends was similar, whereas pea flour indicated significantly lower consistency which conflicted with findings in other paper. Mohammed et al. (2012) reports that chickpea flour consistency is 608 ± 5.56% and a similar value for wheat flour consistency (491 ± 4.58%). The differences could be explained by determination problems, because the farinograph curve of pea flour did not reach 500 FU. The same problem was with buckwheat flour, whereas the farinograph curves of pea-buckwheat flour blends reached 500 FU. The addition of buckwheat to pea flour resulted in an increase of the consistency of the flour blends.

Evaluating the water absorption of flour and their blends, in case of buckwheat flour the value was similar to that of the control sample (wheat flour) and both values were significantly higher comparing with other samples. Research results showed that the blending of pea and buckwheat flours did not result in an increase of water absorption in blends. In literature, Mohammed et al. (2012) and Sadowska et al. (2003) indicated that water absorption increased with increasing amount of chickpea/pea flour added in wheat flour. For the purposes of the present research, pea and buckwheat flours were blended which could be the reason for result differences in comparison with literature.

Dough development time was significantly longer for buckwheat flour than the control, pea flour and flour blends. Similar tendencies were reported by Torbica et al. (2010) about buckwheat flour, where dough development time was significantly longer comparing with wheat flour, which could be related to a higher fiber content of buckwheat flour. It was interesting to note that the development time of flour blends was not influenced by buckwheat flour. It could be explained by changes of starch and protein proportion in flour blends. Torbica et al. (2010) came to similar conclusions: the blending of rice and unhusked buckwheat flours, which development time were 8.76 and 5.93 min respectively, provided shorter development time (2.6-3.75 min) in flour blends.

As concerns the dough stability, it appears that the wheat (control) and buckwheat flours exhibited significantly higher stability and resistance to mechanical mixing values than pea flour and pea-buckwheat flour blends. This coincides with the findings of literature saying that wheat, husked and unhusked buckwheat flour have high stability – 11.78 min, 10.96 and 5.66 min, respectively. Evaluating dough stability of blends it could be concluded that the presence of buckwheat flour in blends did not result in a high dough stability and increasing the content pea flour from 40% to 60% lead to a decrease of dough stability in flour blends. It could be related to changes of fiber composition in flour blends. Similar conclusions were reported by Sadowska et al. (2003), Kohajdová et al. (2013) and Mohammed et al. (2012) stating that dough stability decreased as the substitute level of chickpea/ pea increased.

In the case of buckwheat and pea flours the degree of softening was higher comparing with the control sample and it increased significantly with increasing the amount of pea flour in blends. Similar changes in dough characteristics were observed by Mohammed et al (2012) and Sadowska et al. (2003) when blending wheat flour with chickpea/pea flour.

Research results showed that buckwheat flour could be marked as strong flour, because Mohammed et al. (2012) indicated that strong flours were characterized by a long development time, high stability with a small degree of softening, and high FQN, while poor flour weakened quickly, resulting in low quality number FQN.

Conclusions

1. Pea flour had a higher content of starch (55.55 ± 0.02 g 100 g^{-1}) than other flours and their blends and formed the biggest part (61%) of dry matter. The starch content could be increased by blending buckwheat flour and pea flour, achieving a value similar to the control sample.
2. Buckwheat flour provided higher peak, holding, final, breakdown and setback viscosities in flour blends.
3. Colour values could be changed significantly by blending buckwheat and pea flours. It is possible to increase L^* and b^* values of buckwheat flour with pea flour and a^* value of pea flour with buckwheat flour in flour blends.
4. Buckwheat flour was characterized by a long development time, high stability, and high farinograph quality number, whereas pea flour and pea-buckwheat flour blends had short development time, low stability and low farinograph quality number.

Acknowledgements

Research has been supported by the National research programme "Agricultural Resources for Sustainable Production of Qualitative and Healthy Foods in Latvia" (AgroBioRes) (2014–2017), project No. 4 Sustainable use of local agricultural resources for qualitative and healthy food product development (FOOD).

References

1. Beitane I., Krumina-Zemture G., Murniece I. (2014) Sensory, colour and structural properties of pancakes prepared with pea and buckwheat flours. In: *Foodbalt 2014: 9th Baltic Conference on Food Science and Technology "Food for Consumer Well-Being"*: conference proceedings, Jelgava, Latvia, May 8-9, 2014. E. Straumite (ed). Latvia University of Agriculture, Faculty of Food Technology, Jelgava: LLU, pp. 234-238.
2. Chung H.J., Liu Q. (2012) Physicochemical properties and *in vitro* digestibility of flour and starch from pea (*Pisum sativum* L.) cultivars. *International Journal of Biological Macromolecules*, 50, pp. 131-137.
3. Chung H.J., Liu Q., Donner E., Hoover R., Warkentin T.D., Vanderberg B. (2008) Composition, molecural structure, properties, and *in vitro* digestibility of starch from newly released Canadian pulse cultivars. *Cereal Chemistry*, 85, pp. 471-479.
4. De la Hera E., Ruiz-Paris E., Oliete B., Gómez M. (2012) Studies on the quality of cakes made with wheat-lentil composite flours. *LWT – Food Science and Technology*, 49, pp. 48-54.
5. Debet M.R., Gidley M.J. (2006) Tree classes of starch granule swelling: influence of surface proteins and lipids. *Carbohydrate Polymers*, 64, pp. 452-465.
6. Dexter J.E., Matsuo R.R. (1979) Effect of starch on pasta dough rheology and spaghetti cooking quality. *Cereal Chemistry*, 56, pp. 190-195.
7. Edwards C.A. (1993) Interactions between nutrition and intestinal microflora. *Proceedings of Nutrition Society*, 52, pp. 375-382.
8. Gómez M., Doyagüe M.J., de la Hera E. (2012) Addition of pin-milled pea flour and air-classified fractions in layer and sponge cakes. *LWT – Food Science and Technology*, 46, pp. 142-147.

9. Hatcher D.W., You S., Dexter J.E., Campbell C., Izydorczyk M.S. (2008) Evaluation of the performance of flours from cross- and self-pollinating Canadian common buckwheat (*Fagopyrum esculentum* Moench) cultivars in soba noodles. *Food Chemistry*, 107, pp. 722-731.
10. Hoover R., Sosulski F.W. (1991) Composition, structure, functionality and chemical modification of legume starches. *Canadian Journal of Physiology and pharmacology*, 69, pp. 79-92.
11. Izydorczyk M.S., McMillan T., Bazin S., Kletke J., Dushnicky L., Dexter J. (2014) Canadian buckwheat: A unique, useful and under-utilized crop. *Canadian Journal of Plant Science*, 94, pp. 509-524.
12. Jacob F. (2001) *MEBAK, Raw Materials, Barley, Adjuncts, Malt, Hops and Hop Products. Collection of Brewing Analysis Methods of the Mitteleuropäische Brautechnische Analysenkommision*. MEBAK, pp. 182-186.
13. Kaushal P., Kumar V., Sharma H.K. (2012) Comparative study of psysicochemical, functional, antinutritional and pasting properties of taro (*Colocasia esculenta*), rice (*Oryza sativa*) flour, pigeonpea (*Cajanus cajan*) flour and their blends. *LWT – Food Science and Technology*, 48, pp. 59-68.
14. Kohajdová Z., Karovičová J., Magala M. (2013) Rheological and qualitative characteristics of pea flour incorporated cracker biscuits. *Croatian Journal of Food Science and Technology*, 5, pp. 11-17.
15. Leterme P. (2002) recommendations by health organizations for pulse consumption. *British Journal of Nutrition*, 3, pp. 239-242.
16. Lin L.-Y., Liu H.-M., Yu Y.-W., Lin S.-D., Mau J.-L. (2009) Quality and antioxidant property of buckwheat enhanced wheat bread. *Food Chemistry*, 112, pp. 987-991.
17. Mariotti M., Lucisano M., Pagani M.A., Iameti S. (2008) Macromolecular interactions and rheological properties of buckwheat-based dough obtained from differently processed grains. *Journal of Agricultural and Food Chemistry*, 56, pp. 4258-4267.
18. Mohammed I., Ahmed A.R., Senge B. (2012) Dough rheology and bread quality of wheat-chickpea flour blends. *Industrial Crops and Products*, 36, pp. 196-202.
19. Nelles E.M., Dewar J., Bason M.L., Taylor J.R.N. (2000) Maize starch biphasic pasting curves. *Journal of Cereal Science*, 31, pp. 287-294.
20. Piecyk M., Wołosiak R., Drużynska B., Worobiej E. (2012) Chemical composition and starch digestibility in flours from Polish processed legume seeds. *Food Chemistry*, 135, pp. 1057-1064.
21. Qin P., Wang Q., Shan F., Hou Z., Ren G. (2010) Nutritional composition and flavonoids content of flour from different buckwheat cultivars. *International Journal of Food Science & Technology*, 45, pp. 951-958.
22. Ratnayake W.S., Hoover R., Shahidi F., Perera C., Jane J. (2001) Composition, structure and psysicochemical properties of starches from four field pea (*Pisum sativum* L.) cultivars. *Food Chemistry*, 71, pp. 189-202.
23. Ratnayake W.S., Hoover R., Warkentin T. (2002) Pea starch: Composition, structure and properties – A review. *Starch - Stärke*, 54, pp. 217-234.
24. Sadowska J., Błaszczak W., Fornal J., Vidal-Valverde C., Frias J. (2003) Changes of wheat dough and bread quality and structure as a result of germinated pea flour addition. *European Food Research and Technology*, 216, pp. 46-50.
25. Tester R.F. (1997) Influence of growth conditions on barley starch properties. International Journal of Biological Macromolecules, 21, pp. 37-45.
26. Tharanathan R.N., Mahadevamma S. (2003) Grain legumes – a boon to human nutrition. *Trends in Food Science and Technology*, 14, pp. 507-518.
27. Torbica A., Hadnadev M., Dapčević T. (2010) Rheological, textural and sensory properties of gluten-free bread formulations based on rice and buckwheat flour. *Food Hydrocolloids*, 24, pp. 626-632.
28. Wijngaard H.H., Arendt E.K. (2006) Buckwheat. *Cereal Chemistry*, 83, pp. 391-401.