https://doi.org/10.17221/11/2022-CJFS

The influence of the addition of instant rice mash on the textural properties of rice bread

Monika Augustová[1], Iva Burešová[1], Rafaela Čuljak[1,2], Vikendra Dabash[1]*

[1]Department of Food Technology, Faculty of Technology, Thomas Bata University in Zlín, Zlín, Czech Republic
[2]Department of Natural Resources, Nutrition and Health, Faculty of Health Studies, Nutrition and Health, University of Modern Science – CKM, Mostar, Bosnia and Herzegovina

**Corresponding author: buresova@utb.cz*

Citation: Augustová M., Burešová I., Čuljak R., Dabash V. (2022): The influence of the addition of instant rice mash on the textural properties of rice bread. Czech J. Food Sci., 40: 352–358.

Abstract: The effect of instant rice mash (IRC) addition to rice bread was evaluated. Six samples containing different amounts of IRC (0, 10, 20, 30, 40, and 50%) were added to rice dough. Quality parameters (baking loss, specific volume, and textural properties) were evaluated. Texture properties were analysed in fresh bread and in bread after 24 h of storage. Additions of 10% and 20% of IRC increased baking loss from 15% to 22%, and the specific volume of rice bread from 1.5 mL g^{-1} to 2.1 mL g^{-1} (10% of IRC) and 1.9 mL g^{-1} (20% of IRC). Increasing additions of IRC significantly decreased the hardness and chewiness of both fresh bread and bread stored for 24 h. By adding IRC, the cohesiveness of rice bread was increased. These findings are useful for increasing the quality of rice bread by adding IRC to rice dough.

Keywords: pastry; gluten-free; starch; quality; texture

Rice is the most commonly used raw material for producing gluten-free products. Due to its colour, bland taste and hypoallergenic and good processing properties, it is the most frequently used material in bread production (Dalbhagat et al. 2019). Rice doughs, unlike wheat doughs, contain higher amounts of water which has a significant effect on the quality of rice dough and bread (Santos et al. 2021). The higher water content in rice dough contributes not only to a higher volume but also to a higher baking loss (Md Yonus et al. 2021; Santos et al. 2021). In general, rice doughs are characterised by a small volume with very small pores. The volume of rice dough is smaller several times in comparison with wheat doughs, as rice doughs are not able to retain sufficient amounts of leavening gas. The crumb of rice bread is characterised by a harder texture (Bender and Schönlechner 2020).

Due to its high rice starch content, rice grain is one of the main sources of starch (Höfer 2015). Rice starch is the main constituent of rice flour (Hu et al. 2020). An undamaged starch granule could absorb around 40% of its own weight. This absorption volume could be further increased by damaging the starch granules by grinding, which is able to absorb up to twice the water of its own weight (Cauvain 2017). The percentage of the damaged starch in fine rice flour is around 8% (Cauvain 2017; Han et al. 2021). Another type of starch is resistant starch. Resistant starches have health-promoting physiological effects on the human body; these starches are not digested in the small intestine,

Supported by the Tomas Bata University, Czech Republic (Project No. IGA/FT/2021/003).

https://doi.org/10.17221/11/2022-CJFS

but they pass into the large intestine. In the large intestine, they are partially metabolised by the gut microbiome. Cooked food that was subsequently cooled has a higher content of resistant starches compared to freshly cooked food (Wen et al. 2022). Rice flour is also used as a raw material for extrusion technology, which can produce instant rice mash (IRC), among other products (Bao and Bergman 2017). Properties of rice flour are modified due to thermal and mechanical stress on the material when the extrusion technology is used. At high temperatures, the gelatinisation of the starch granules occurs as the starch granules lose their crystallinity and structural organisation. Concurrently, gelatinised starch increases the viscosity of the extruded material. The use of high temperatures causes the development of the protein structure. The smaller size of the parts allows the present water to enter the internal structure, thus increasing the absorption of the extruded material. In addition, damaged gelatinised starch granules and denatured proteins have a higher water absorption capacity, which leads to the ability of IRC to form gels (Copeland et al. 2009; Ganesan and Rajauria 2020). Upon cooling, starch granules are re-associated to form new bonds (retrogradation). Retrogradation is very important when bread is stored. During retrogradation, amylopectin is the most important component. All starches contain more amylopectin than amylose, and thus retrogradation is associated with the formation of amylopectin chains. During the staling process, amylose retrogrades faster than amylopectin. Amylopectin retrogradation lasts for several weeks in storage and contributes to long-term rheological and structural changes (Qian and Zhang 2013; Bao and Bergman 2017). The complexes between amylose and the hydrophobic chain of fatty acids from lipids are formed (Qian and Zhang 2013). Rice starch retrogradation is based on the formation of hydrogen bonds between amylose and amylopectin molecules. After saturation, intermolecular connections between amylopectin molecules could occur through hydrogen bonds (Roman et al. 2020).

The gel formed from wheat proteins is essential for the dough's ability to trap leavening gas. Therefore, it can be hypothesised that the gel created from extruded rice mash could replace and partly mimic these properties of the wheat gel.

The aim of this study was to enhance the properties of rice dough by adding IRC to improve the properties of rice bread. It is hypothesised that IRC could be a suitable alternative to improving the quality of rice bread. IRC could replace the absence of gluten in the rice bread and improve its structure by creating a three-dimensional structure to improve its properties. By adding IRC, we intend to achieve a higher specific volume and decrease the baking loss of rice bread. Increased resilience, cohesiveness, springiness, and decreased adhesiveness, hardness and chewiness could be achieved by adding IRC to rice bread.

MATERIAL AND METHODS

Material

White fine rice flour and IRC were provided by Extrudo Bečice s.r.o., Týn nad Vltavou, Czech Republic. The content of damaged starch was not measured. According to Han et al. 2021, the content of damaged starch granules in fine rice flour is around 8%. The composition of rice flour in 100 g of dry matter was: fat 0.6 g, carbohydrates 74 g, fibre 1 g, protein 9 g. The composition of IRC in 100 g of dry matter was: fat 0.4 g, carbohydrates 74 g, protein 8.8 g, fibre 1.3 g. IRC was prepared according to Honců et al. (2016). IRC was blended with rice flour to obtain 100 g of rice flour or mixture (0, 11, 25, 43, 67, and 100 g) (Table 1).

Preparation of gluten-free bread

A total of 24 loaves of bread were prepared. A loaf was prepared from each formula in four replicates.

Table 1. Formulas used in bread production (g)

Formula	Sample No.					
	I	II	III	IV	V	VI
Rice flour	180	160	140	120	100	200
Instant rice mash	20	40	60	80	100	0
Water	220	220	220	220	220	220
Salt	3	3	3	3	3	3
Yeast	3.6	3.6	3.6	3.6	3.6	3.6
Sugar	3.72	3.72	3.72	3.72	3.72	3.72

https://doi.org/10.17221/11/2022-CJFS

The formula was prepared by blending flour and mash (200 g) with water (220 g), salt (3 g), yeast (3.6 g), and sugar (3.72 g) (Table 1). The yeast was activated in a sugar solution at 35 ± 2 °C for 10 ± 1 min. The mixture was kneaded with an Eta Exclusive Gratus mixer (Eta a.s., Czech Republic) for approximately 5 ± 1 min. The dough was kneaded at 600 rpm (speed 3). After kneading, the dough was divided into four parts and placed into the baking moulds. Four samples of formed bread were prepared from each formula. The dough was proofed at 30 ± 2 °C for 20 ± 2 min. The loaves of bread were baked in a MIWE cube electric oven (Pekass s.r.o., Czech Republic) at 180 ± 5 °C for 20 ± 2 min. After baking, the loaves of bread were cooled at a room temperature of 23 ± 3 °C for 120 ± 5 min, and subsequently, measurements of baking loss, specific volume, and texture profile analysis were performed. The loaves of bread were stored apart for 24 ± 1 h at 23 ± 3 °C and 65% humidity in a plastic bag.

Methods

Measurement of bread texture characteristics. The texture profile analysis was determined on a TA.XT plus texture analyser (Stable Micro Systems Ltd., United Kingdom). A total of 24 loaves of bread were used for the analysis. Four loaves of bread were analysed from each formula. Two loaves of bread of each formula were used to determine the textural properties of fresh bread. Two loaves of bread of each formula were used to determine the textural properties of the bread after 24 h in storage. Each bread was cut into 1 cm slices using a disc slicer. The sample was then cut from the centre of the slice with a diameter of 35 mm and a height of 10 mm. Afterwards, the sample was placed onto the test area of the analyser and subsequently pushed to a depth of 75.0 mm by a cylindrical P/75 probe with 75 mm diameter. The probe speed was 1.00 mm s^{-1}. Each sample was measured in seven repetitions. The evaluated parameters were: resilience, adhesiveness, springiness, cohesiveness, hardness, and chewiness. Hardness is the top of the peak at first compression. Springiness is the ability of a sample to return to its original condition after the first compression, where the sample was let rest for a period of time. Cohesiveness is the resistance of a sample to a second deformation. Resilience is the ability to obtain the original height before deformation. The chewiness is the energy necessary to chew a sample in the mouth until it is ready to be swallowed (Ozturk and Mert 2018).

Specific volume measurement. After cooling, the volume of the samples was measured. The volume of gluten-free bread was measured according to the American Association of Cereal Chemists (AACC) Method 10-05.01. The volume of the loaves was determined using rapeseed-sized plastic granules. The average volume was based on three values after subtracting the maximum and minimum values from three measurements. The specific volume of the rice bread was calculated from the volume and weight of the sample (Honda et al. 2021). Specific volume (mL g^{-1}) was then calculated using this formula:

$$\textit{Specific volume} = \frac{\textit{Average of volume}_{bread}}{\textit{Weight}_{bread}} \frac{(\text{mL})}{(\text{g})} \quad (1)$$

Measuring baking loss. The dough sample was weighed before and after baking. The baking loss was calculated from the values obtained using this formula:

$$\textit{Baking loss} = \frac{\textit{Weight}_{dough} - \textit{weight}_{bread}}{\textit{Weight}_{dough}} \times 100 \quad (2)$$

Statistical data analysis. The significance of differences between samples was determined by analysis of variance (ANOVA) at a significance level of α = 0.05 using the Fisher least significant difference (LSD) test. Statistical analysis was performed using Statistica CZ13 software (StatSoft CR, Ltd., Czech Republic).

RESULTS AND DISCCUSION

Specific bread volume. By adding 30% of IRC, a higher specific bread volume was achieved; however, the additions of 10% and 20% of IRC resulted in the highest significant ($P < 0.05$) increase in specific bread volume (Table 2). The same amount of water was added to each formula. As the amount of IRC in individual formulas increased, so did the amount of water absorbed. It is presumed that the water content of the rice doughs has a significant effect on bread volume due to the high ability of IRC to hydrate (Qian and Zhang 2013). Bread with 10% and 20% of IRC contained a too low amount of IRC. The higher water content of the rice dough contributes to a higher specific volume (Santos et al. 2021). Due to the lower amount of rice mash, a large amount of water was not hydrated by the rice mash. A higher amount of unabsorbed water could cause thinner crust hardening and larger pore size (Prasert and Suwannaporn 2009). It could be assumed that the structure of rice doughs with the additions of 10% and 20% of IRC was created mainly from rice starch, in which the IRC was dispersed. Due to the larger pore size in rice

https://doi.org/10.17221/11/2022-CJFS

Table 2. Specific bread volume and baking loss

Rice mash (%)	Specific bread volume (mL g^{-1})	Baking loss (%)
0	1.5370 ± 0.006[a]	15.000 ± 0.4[a]
10	2.1000 ± 0.2[b]	22.000 ± 2[b]
20	1.9300 ± 0.02[b]	22.000 ± 2[b]
30	1.7341 ± 0.0004[c]	16.200 ± 0.1[a]
40	1.5300 ± 0.06[a]	14.620 ± 0.007[a]
50	1.5200 ± 0.07[a]	14.100 ± 0.4[a]

[a–c]Data with different superscript letters within columns are significantly different ($P < 0.05$)

dough and the lower amount of rice mash, a higher specific bread volume was achieved. Each formula was prepared from a different ratio of rice flour and IRC, and a constant amount of water. It could be assumed that due to the higher ability of IRC to absorb water, the consistency and stability of the dough could increase after hydration (Zhao et al. 2021). It might be expected that in bread with low addition of rice mash, no compact gel would form in the entire formula. During baking, water migrated from the dough through the crust of the bread, and thus the structure of the dough collapsed (Huang et al. 2017). Rice doughs with higher additions (40% and 50% of IRC) contained an excessive amount of IRC. To achieve a higher specific volume of bread, it is necessary that the dough will have a sufficient viscosity (Sahin et al. 2020). By adding a higher amount of rice mash, a much denser dough was created. Denser dough retarded the formation of larger pores and thus a lower volume was reached (Sahin et al. 2020). It could be caused by gelatinised rice starch contained in the rice mash and thus the formed gas was not able to accumulate and expand in the dough. To stabilise the rice dough, additives are used which ensure a higher viscosity, and thus the ability to retain the leavening gas has increased in rice doughs (Farkas et al. 2021). It could be assumed that the bread dough with higher addition of IRC created the rice dough of high density.

Baking loss. Additions of 10% and 20% of IRC have resulted in the highest significant ($P < 0.05$) increase of baking loss. The effect of other additions of IRC was not significant (Table 2). The bread with 10% and 20% of IRC could be deficient in the amount of IRC, because these doughs were composed mainly of rice flour. During grinding of rice grains, the starch granules are damaged and therefore they have a higher hydrating ability (de la Hera et al. 2014). Due to the low amount of rice mash and the content of damaged starch a non-compact structure was created. Water migrated between gelatinised starches and hydrogen bonds were rearranged. The formation of cracks and pores in the rice dough allowed the water to enter quickly (Prasert and Suwannaporn 2009). At high temperatures, the bonds in the rice dough have dehydrated during baking and a high amount of water has evaporated from the dough. Moreover, due to the high amount of water, a strong crust was created on the surface of the bread with 10% and 20% of IRC. Adding IRC could cause the crust of the bread to be slightly harder than the centre during baking (Sahin et al. 2020). After baking, loaves of bread were cooled for 2 h. After cooling, the water migrated between the bread crust and the bread crumb and thus a significant part of the water evaporated (Huang et al. 2017). It should be noted that additions of 10% and 20% of IRC contained a low amount of IRC. It is presumed that the water migrated between biopolymers, and hydrogen bonds were rearranged, thereby disrupting the structure of rice dough further. Until the baking phase, the leavening gas was retained in the dough and the bread had a dissatisfactory shape. During baking, the higher water content decreased the viscosity of the dough, which caused the dough structure to collapse, thus increasing the baking loss (Zhao et al. 2021). The result suggested that the bread with the addition of 30% of IRC contained an optimal amount of water for creating an integrated structure. This indicated that the formed structure is also efficient in retaining available water in its structure, thus preventing a high baking loss during baking the bread. Conversely, additions of 40% and 50% of IRC contained a too high amount of IRC. This leads to a reduction of water, which was used for hydration of the IRC instead; therefore, the baking loss was decreased. These findings suggest that the quality of rice bread has been affected by the presence of IRC. The results showed that a lower percentage of IRC in rice bread increased the baking loss by evaporating a higher amount of water from the rice bread.

Texture characteristics of bread. The hardness and chewiness of both fresh bread and bread stored for 24 h were the most influenced characteristics (Table 3). Increasing the amount of IRC tended to decrease the hardness and chewiness of fresh bread. An exception was bread with 40% of IRC, in which increased chewiness and hardness were observed. It can be expected that during the formation of the dough, the rice mash absorbed the added water, which was incorporated into the dough structures. This indicated that increasing the amount of IRC resulted in a softer structure, and thus

https://doi.org/10.17221/11/2022-CJFS

it decreased the chewiness and hardness of fresh bread. During storage, the hardness of the crumb and the moisture of the crust increased. The rapid migration of moisture resulted in the dried bread, therefore leading to the higher hardness of the crumb (Huang et al. 2017). It could be assumed that the IRC is able to bind and retain water in the bread and thus decrease its hardness and chewiness. According to Han et al. 2021, the volume of damaged starch granules in fine rice flour is around 8%. It could be assumed that damaged starch granules, together with undamaged starch granules, absorbed moisture, and thus decreased the hardness and chewiness of the stored bread, even if the differences in crumb springiness were not significant (Table 3). The results demonstrated that increasing the amount of IRC had a negative effect on rice bread resilience. Higher additions of IRC (30, 40, and 50%) not only caused a higher density of the dough, but also worsened its ability to return to its original position. After 24 h in storage, resilience was increased in bread with 50% of IRC from 33.0% to 36.5%. It should be noted that the same amount of water was used in all formulas. The amount of water that is present in rice dough had a very important role (Monteau et al. 2017). Rice doughs usually contain a higher amount of water, and thus these doughs are more fluid (Bender and Schönlechner 2020). It could be supposed that due to a higher hydration ability of IRC, a very compact structure of rice dough with higher additions of IRC was created, which negatively affected rice bread resilience. Due to the higher ability of rice mash to absorb water, the consistency of the dough after hydration could increase (Zhao et al. 2021). However, the created compact structure had a positive effect on bread cohesiveness. The highest cohesiveness was established in fresh bread with the addition of 20% of IRC. Due to the presence of IRC, the cohesiveness of rice bread stored for 24 h was decreased in all additions. It could be assumed that during storage the hydrogen bonds could be broken, and due to bread staling, the water was redistributed within the structure. This leads to the formation of a rubbery structure (Copeland et al. 2009); therefore, the cohesiveness of rice bread was increased. Additions of 10% and 40% of IRC resulted in the highest significant (P < 0.05) increase of fresh bread adhesiveness, whereas the formulas with 20% and 30% of IRC significantly decreased the adhesiveness of fresh bread. This result indicated that the bread with 20% and 30% of IRC contained an optimal amount of water to decrease the adhesiveness. Gelatinised starch and denatured protein in IRC in bread with the lower addition of IRC were able to hydrate all added water, possibly leading to lower bread adhesiveness. As mentioned before, the breads with the lowest additions of IRC exhibited the highest baking loss. On the other hand, available water in breads with higher additions (40% and 50%) of IRC could be present in the bread structure, leading to higher adhesiveness. Moreover, the surface of the rice bread with the addition of 40% and 50% of IRC became slightly harder during baking than the centre (Huang et al. 2017). This caused crust hardening, which blocked water vapour evaporation during baking (Prasert and Suwannaporn 2009).

Table 3. Effect of instant rice mash (IRC) addition on individual parameters of rice bread

IRC (%)	Bread	Resilience (%)	Stickiness (N)	Springiness (%)	Cohesiveness (%)	Hardness (N)	Chewiness (N)
0	fresh	47 ± 6^{fgh}	-2 ± 2^{bcd}	78 ± 27^{ab}	83 ± 7^{b}	9 ± 4^{cd}	593 ± 367^{de}
10	fresh	47 ± 1^{fgh}	-3 ± 2^{ab}	91 ± 3^{b}	84 ± 2^{b}	9 ± 3^{cd}	646 ± 150^{e}
20	fresh	48 ± 6^{g}	-1 ± 2^{cd}	72 ± 28^{a}	89 ± 7^{c}	5 ± 3^{ab}	334 ± 233^{ab}
30	fresh	41 ± 2^{cde}	-1 ± 2^{cd}	88 ± 2^{ab}	85 ± 2^{bc}	4 ± 2^{ab}	327 ± 71^{ab}
40	fresh	38 ± 1^{bc}	-3 ± 2^{abc}	85 ± 2^{ab}	84 ± 1^{bc}	5 ± 3^{ab}	328 ± 151^{abc}
50	fresh	33 ± 4^{a}	-2 ± 1^{abcd}	81 ± 5^{ab}	86 ± 1^{bc}	2 ± 2^{a}	153 ± 81^{a}
0	24 h storage	43 ± 0.3^{def}	-2 ± 1^{bcd}	83 ± 2^{ab}	75 ± 1^{a}	16 ± 2^{e}	973 ± 83^{f}
10	24 h storage	46 ± 2^{fgh}	-2 ± 1^{abcd}	89 ± 2^{ab}	83 ± 2^{b}	9 ± 1^{cd}	640 ± 49^{e}
20	24 h storage	46 ± 2^{fgh}	-2 ± 1^{abcd}	87 ± 4^{ab}	82 ± 1^{b}	8 ± 1^{cd}	559 ± 34^{cde}
30	24 h storage	43 ± 1^{efh}	-3 ± 1^{a}	87 ± 3^{ab}	83 ± 1^{b}	6 ± 1^{bc}	449 ± 62^{bcde}
40	24 h storage	39 ± 2^{bcd}	-2 ± 0.2^{abcd}	85 ± 4^{ab}	82 ± 1^{b}	5 ± 2^{ab}	316 ± 98^{ab}
50	24 h storage	37 ± 0.1^{abc}	-1 ± 2^{bcd}	84 ± 3^{ab}	82 ± 2^{b}	4 ± 1^{ab}	272 ± 39^{ab}

$^{a–h}$Data with different superscript letters within columns are significantly different (P < 0.05)

https://doi.org/10.17221/11/2022-CJFS

The highest adhesiveness among stored breads was achieved in the bread with the addition of 30% of IRC. The added water could be absorbed by rice starch and could increase adhesiveness. As for breads with higher additions of IRC, the water migrated from the crumb to the crust and became immobile as more and more water moved into the crystalline structure of amylopectin. During storage, amylopectin is recrystallised and water is redistributed (Huang et al. 2017). Amylopectin molecules form a three-dimensional structure through hydrogen bonds. It can be observed both in the formation of the final structure and in the staling of bread (Huang et al. 2017; Roman et al. 2020).

CONCLUSION

IRC affected the textural properties of rice bread. The lowest additions of IRC increased specific bread volume; however, these additions concurrently increased baking loss. The addition of 30% of IRC was characterised by making the dough properties optimal for increasing the quality of rice bread. In addition to the positive textural properties, bread with 30% of IRC added had higher volume and lower baking loss. The increasing amount of IRC significantly decreased the hardness and chewiness of both fresh bread and bread stored for 24 h. The higher hydration ability of gelatinised starch granules and denatured proteins had a great influence on the quality of rice bread. The addition of IRC bound the added water to the structure through hydrogen bonds of the dough and thus improved its textural properties. The addition of IRC significantly affects the distribution of water during storage and thus prolongs the freshness of the bread. IRC could be a suitable alternative to conventional additives that improve the quality of rice bread by partially mimicking the missing gluten in the rice dough.

REFERENCES

Bao J., Bergman C.J. (2017): Rice flour and starch functionality. In: Sjöö M., Nilsson L. (eds.): Starch in Food. 2nd Ed. Cambridge, United Kingdom, Woodhead Publishing Ltd.: 373–419.

Bender D., Schönlechner R. (2020): Innovative approaches towards improved gluten-free bread properties. Journal of Cereal Science, 91: 102904.

Cauvain S.P. (2017): Raw materials. In: Cauvain S.P. (ed.): Baking Problems Solved. 2nd Ed. Amsterdam, Netherlands, Elsevier: 33–144.

Copeland L., Blazek J., Salman H., Chiming Tang M. (2009): Form and functionally of starch. Food Hydrocolloids, 23: 1527–1534.

Dalbhagat C.G., Mahato D.K., Mishra H.N. (2019): Effect of extrusion processing on physicochemical, functional and nutritional characteristics of rice and rice-based products: A review. Trends in Food Science & Technology, 85: 226–240.

de la Hera E., Rossel C.M., Gomez M. (2014): Effect of water content and flour particle size on gluten-free bread quality and digestibility. Food Chemistry, 151: 526–531.

Farkas A., Szepesvári P., Németh R., Bender D., Schoenlechner R., Tömösközi S. (2021): Comparative study on the rheological and baking behaviour of enzyme-treated and arabinoxylan-enrich gluten-free straight dough and sourdough small-scale systems. Journal of Cereal Science, 101: 103292.

Ganesan A.R., Rajauria G. (2020): Cereal-based animal feed products. In: Pojić M., Tiwari U. (eds.): Innovative Processing Technologies for Healthy Grains. 1st Ed. Hoboken, US, Wiley-Blackwell: 199–226.

Han C.M., Shin J.B., Kwon J.B., Kim J.S. (2021): Comparison of morphological and physiochemical properties of a floury rice variety upon pre-harvest sprouting. Foods, 10: 746.

Honda Y., Inoue N., Kurita M., Okunishi T. (2021): Alpha-glutelin degradation and its hydrolase by protease enhance the specific volume of gluten-free rice starch bread. Journal of Cereal Science, 102: 103338.

Höfer R. (2015): Sugar- and starch-based biorefineries. In: Pandey A., Höfer R., Larroche C., Taherzadeh M., Nampoothiri K.M. (eds.): Industrial Biorefineries & White Biotechnology. Amsterdam, Netherlands, Elsevier: 157–235.

Honců I., Sluková M., Vaculová K., Sedláčková I., Wiege B., Fehling E. (2016): The effect of extrusion on the content and properties of dietary fibre components in various berley cultivars. Journal of Cereal Science, 68: 132–139.

Hu W.X., Chen J., Xu F., Chen L., Zhao J.W. (2020): Study crystalline, gelatinisation and rheological properties of japonica rice flour as affected by starch fine structure. International Journal of Biological Macromolecules, 148: 1232–1241.

Huang L., Chen X., Rui X., Li W., Li T., Xu X., Dong M. (2017): Use of fermented glutinous rice as a natural enzyme cocktail for improving dough quality and bread staling. The Royal Society of Chemistry, 7: 11394.

Md Yonus N.S.H., Omar F.N., Hafid H.S., Mohammed M.A.P., Baharuddin A.S., Wakisaka M. (2021): Experimental and numerical study of wheat and rice doughs. Journal of Food Engineering, 311: 110712.

Monteau J.Y., Purlis E., Besbes E., Jury V., Le-Bail A. (2017): Water transfer in bread during staling: Physical phenomena and modelling. Journal of Food Engineering, 211: 95–103.

https://doi.org/10.17221/11/2022-CJFS

Ozturk O.K., Mert B. (2018): The effect of microfluidization on rheological and textural properties of gluten-free corn breads. Food Research International, 105: 782–792.

Prasert W., Suwannaporn P. (2009): Optimization of instant jasmine rice process and its physicochemical properties. Journal of Food Engineering, 95: 54–61.

Qian H., Zhang H. (2013): Rice flour and related products. In: Bhandari B. (ed.): Handbook of Food Powders: Processes and Properties. 1st Ed. Cambridge, United Kingdom, Woodhead Publishing Ltd.: 553–575.

Roman L., Reguilon M.P., Martinez M.M., Gomez M. (2020): The effects of starch cross-linking, stabilization and pre-gelatinization at reducing gluten-free bread staling. LWT – Food Science and Technology, 132: 109908.

Sahin A.W., Wiertz J., Arendt E.K. (2020): Evaluation of a new method to determine the water addition level in gluten-free bread systems. Journal of Cereal Science, 93: 102971.

Santos F.G., Fratelli C., Muniz D.G., Capriles V.D. (2021): The impact of dough hydration level on gluten-free bread quality: A case study with chickpea flour. International Journal of Gastronomy and Food Science, 26: 100434.

Wen J.J., Li M.Z., Hu J.L., Tan H.Z., Nie S.P. (2022): Resistant starches and gut microbiota. Food Chemistry, 387: 132895.

Zhao F., Li Y., Li C., Ban X., Cheng L., Hong Y., Gu Z., Li Z. (2021): Co-supported hydrocolloids improve the structure and texture quality of gluten-free bread. LWT – Food Science and Technology, 152: 112248.

Received: January 14, 2022
Accepted: August 16, 2022
Published online: September 19, 2022