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Rheological properties of dough and quality characteristic of wheat whole grain bread added with black chokeberry (*Aronia melanocarpa*)

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***Abstract* — The effect of black chokeberry flour on the rheological properties of wheat dough made from whole wheat flour and the main physical characteristics of the baked bread were investigated. From the study, it was found that with the increase in the amount of chokeberry flour added, the dough formation time did not change in a wide range, the water absorption and the dough formation time increased compared to the control sample. With the addition of chokeberry flour (up to 10%) acceptable results were found for most organoleptic and physical bread characteristics. The sensory profile shows that as the chokeberry flour increases, the performance of the bread deteriorates significantly, and this is significantly pronounced at the higher amounts of the additive (above 10%). In the sensory evaluation, the appearance, color and general acceptance of the bread obtained with the addition of 5% chokeberry flour showed remarkably higher values than the control and the other samples.**

***Keywords* — whole wheat flour, chokeberry, chokeberry flour, rheological properties, sensory characteristics.**

I. INTRODUCTION

Bread is one of the most important foods of the modern person, and due to its large consumption, it is necessary to modernize its production in order to obtain high-quality products. In recent years, people's interest in special and enriched types of bread and bakery products has been increasing more and more often. Consumer preferences are for whole grain, multigrain and functional types of bread, which are rich in B vitamins, vit. C, dietary fiber and mineral substances.

According to Özdemir and Özkan, 2020, chokeberry fruit can be called a functional food due to its rich chemical composition and high antioxidant activity, and can be successfully used in the treatment of chronic and degenerative diseases.

Aronia fruits, as well as its press, are rich in phenolic compounds with a pronounced antioxidant and antimicrobial effect. Added to various bakery products, they enrich them with dietary fiber, organic acids, sugar, fat, protein, minerals (especially zinc, potassium) and vitamins (vitamin C) and have a good health effect on the health of consumers.

Özdemir and Özkan 2020, prove that the chemical composition of chokeberry fruits and pomace varies widely depending on the cultivation method, fruit maturity, and harvest time, habitat and storage method.

It was found that the color of the dough and the bread medium changed as the amount of black chokeberry flour added increased. These changes are due to the anthocyanidins and pigments contained in chokeberry flour.

In addition to increasing the nutritional value of bread enriched with black chokeberry flour, its shelf life is also increased due to the demonstrated antimicrobial activity of the flour (Yoon, Kim, Eom, 2014).

The mass of baked bread enriched with chokeberry flour depends on the amount of flour added. Yoo et al. 2014, prove that with an increase in the amount of chokeberry flour, the mass of the bread increases, and the specific volume decreases. The reason for the increase in the mass of the bread is the water-holding capacity of the dietary fiber contained in the chokeberry flour, and the specific volume of the bread decreases due to dilution of the gluten.

Lee, 2017 found that the rate of fermentation processes in the dough with the addition of chokeberry flour were weaker and the resulting bread had a smaller volume, compared to that of the control.

It has been proven that the technological losses are the highest in the control sample, and with the increase of Aronia flour, they decrease. This is due to the fact that the volume of the bread does not increase with the addition of chokeberry flour and the difference in the volumes before and after baking is not large. (Yoon, Kim, Eom, 2014).

The addition of chokeberry flour also affects the aroma of the finished bread. [Lee, 2017]. The enriched bread with the addition of chokeberry flour has a lower content of starch and protein content, at the expense of increased content of total sugars, minerals (Mg, Ca, Cu) and fat (Filipović et al., 2021).

Petković et al., 2020 prove that the production of bread with the addition of chokeberry flour up to 10% significantly improves the health of the consumer and such bread has functional properties.

Therefore, the aim of the present study was to explore the effects of black chokeberry (*Aronia melanocarpa*) on rheological properties of dough and quality characteristic of wheat whole grain bread.

II. MATERIALS AND METHODS

Materials

For the preparation of the bread samples, the following raw materials were used:

• Wheat flour type 1850 with a moisture content of 12.3%;

• Black chokeberry flour with a moisture content of 9.8%;

• Drinking water - compliant with Ordinance No. 9 of the Ministry of Health of March 16, 2001;

• Pressed yeast - compliant with BDS - 483 – 90;

• Table salt – compliant with the Ordinance (PMS No. 23/2001) on the requirements for the composition and characteristics of salt for food purposes/ SG No. 11/2001.

Methods

Preparation of dough and bread samples

Kneading was performed by a one-phase process of dough preparation to obtain a dough with a homogeneous mass and an initial temperature of 26 – 27 ℃. First, knead the mix of wheat flour and black chokeberry flour, yeast, salt and water in kneading machine (Labomix 1000, Hungary). The control sample was prepared only with wheat flour type 1850 and the other bread samples tested were prepared with black chokeberry flour replacing 5, 10 and 15% of wheat flour. The dough thus prepared matured for 40 – 45 min at 30 °C. Then the dough was divided into pieces of 230 and 440 g. After shaping, the dough was subjected to a final fermentation at 32 ℃ for 30 – 35 min in a fermenting chamber (Tecnopast CRN 45-12, Novacel Rovimpex Novaledo Trento, Italy). The dough was then baked in an electric floor oven Salva E-25 (Salva Industrial S.L.U., Lezo, Spain), preheated to a temperature of 200 ℃, for 18 – 25 min. After baking, the breads were allowed to cool for 3 h at room temperature. The bread formulations are given in Table 1.

TABLE 1. Formulations of bread samples

Raw materials	Bread samples			
	Control sample of bread	Samples of bread with black chokeberry flour		
Whole wheat flour, g	500	475	450	425
Black chokeberry flour, g	-	25	50	75
Water, ml	280	280	280	280
Yeast, g	10.0	10.0	10.0	10.0
Salt, g	6.5	6.5	6.5	6.5

Farinograph properties of the doughs

The following dough characteristics were determined by a farinograph (Brabender GmbH&Co. KG, Duisburg, Germany): water absorption (%), development time (min), stability (min), degree of softening (FU) and consistency (FU), with AACC Method 54-21.02.

Water absorption properties (%) – on a Brabender farinograph until the formation of a dough with a consistency of 500 FU, ICC Standard No. 115/1; Rheological properties of dough with a farinograph according to the following indicators: formation time (min), stability (min), elasticity (BU), softening (BU) and consistency (BU), according to the adopted methodology BDS ISO 5530 – 1:2004, Wheat flour. Physical properties of dough. Determination of water capacity and rheological properties using a farinograph.

Degree of immersion – Degree of dough immersion (K60), PE – according to the degree of immersion of a calibrated body in dough, placed in the sleeve of an automatic penetrometer (AP-4/2) [Vangelov, Karadzhov, 1993];

Determining the quality of the resulting bread

Physical properties of the resulting bread

- mass and volume of the bread – according to generally accepted methods;

- dimensional stability (H/D) – in relation to the height to the diameter of the floor bread (Vangelov, Karadzhov, 1993);

- specific volume – specific volume, cm^3/g – according to the ratio of the volume to the mass of the bread (Vangelov, Karadzhov, 1993);

- losses during firing – according to generally accepted methods

Sensory analysis – ISO 6658:2017, ISO 6658:2017; Sensory analysis of the bread samples obtained was performed using the descriptive panel method, consisting of 25 panelists (52% women and 48% men) aged 22–60 years who were familiar with the sensory analysis of foods but not specifically trained in evaluation of breads with this enrichment component.

The panelists were asked to rate the finished breads on eight parameters – shape, crust color, core color, porosity, aroma, chewiness, taste and aftertaste. The intensity of each indicator is on a nine-

point hedonic scale (9 – extremely good; 1 – extremely bad).

Statistical analysis:

For all samples, the analyses were carried out at least in triplicate and the results are expressed as the mean values and ± standard deviations (SD). Statistical evaluation was performed by using one-way analysis of variance (ANOVA).

III. RESULTS AND DISCUSSION

Influence of chokeberry flour on the rheological properties of dough

Degree of immersion of the obtained tests (control and working samples).

The degree of immersion of the dough is an important parameter because it is directly related to its working condition and the consistency of the dough, to predict the behavior of the dough in the technological cycle of bread production.

Figure 1 traces the variation in the degree of immersion of the obtained tests.

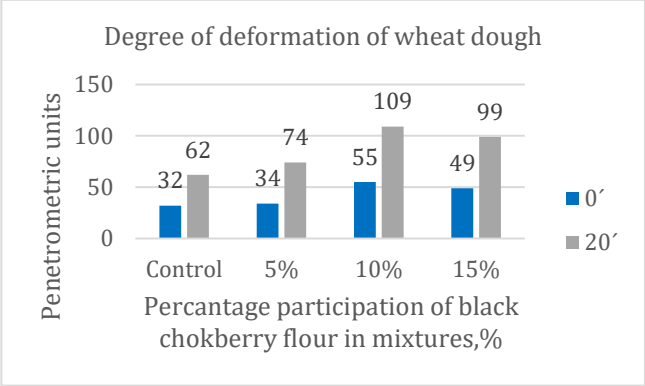

Fig. 1. Variation in the immersion rate of whole wheat flour and black chokeberry flour dough

It is established from the figure 1, that the doughs obtained with the addition of chokeberry flour at 10 and 15% have the highest consistency, compared to the control and that with the addition of 5%. Increasing the percentage of added chokeberry flour leads to a deterioration in the consistency of the dough. The determination of the rheological properties of the dough is important in the technological operations for obtaining bread.

TABLE 2. Farinograph properties of wheat dough with addition of black chokeberry flour

Samples	Consistency, F.U.	Dough development time, min	Stability, min	Dough softening F.U.
WCS	500	3.5	16.5	0
5	480	2.5	15.5	0
10	480	2.5	15.5	20
15	420	2.0	9.5	60

From the data in table 2, it is found that with the addition of 5.0 and 15.0% chokeberry flour, the dough consistency values decrease compared to the control.

It can be seen that for dough with the addition of 5.0% and 10.0% chokeberry flour, the dough consistency values are 480 F.E., i.e. only 20 units less than the control, due to the weaker influence of the percentage of addition in the dough due to the influence of dietary fiber and anthocyanins on the structure of the gluten molecule and its quality (Korenets et.al). Similar results were obtained by Kolesarova et al., when determining the rheology of the dough with elderberry,chokeberry. The addition of 15% chokeberry flour reduced the water absorption values of wheat flour and black chokeberry flour mixtures, which is probably due to the different gelatinization rate of the starch and the stability of the gel formed. Ghendov-Moşanu Aliona, (2022) determined the rheological properties of the dough with the addition of chokeberry and rosehip flour in amounts of 1.5%, 3% and 5% of the wheat flour mass. The added fruit flours significantly affect the increase in the elasticity of the dough, which leads to the formation of a dough with maximum resistance to deformation.

With an increase in the percentage of chokeberry flour added, a decrease in dough formation time was observed, compared to the control, due to the weakening effect of dietary fiber on the structure and stability of the prepared doughs (Jacobs et al. 2015; Han, HM, & Koh, BK 2011).

In the sample, the addition of chokeberry flour at 5% improved the stability of the dough, albeit slightly. In the samples with 10 and 15% chokeberry flour, the stability of the dough decreases, which determines the higher values of dough relaxation.

Figure 2 traces the water absorption properties of the flour blends versus the control.

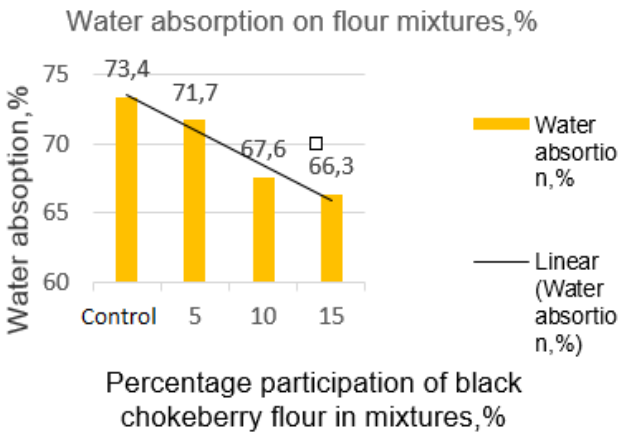

Fig. 2. Water absorption properties of whole wheat flour and black chokeberry flour blends

From the obtained data, it is evident that with an increase in the percentage of chokeberry flour (10 and 15%), the water absorption capacity of the obtained mixtures decreases. In the sample with the addition of 5% chokeberry flour, the difference in the water absorption capacity of the mixture compared to the control was 2.4%. The linear nature of the changes in the water absorption of the wheat flour is due to the proportional replacement of a portion of the wheat flour with black chokeberry flour. Similar results regarding the water absorption properties of flour were obtained by Koshak and Pokrashinskaya (2020), who added 5.0% black chokeberry flour to a mixture with wheat flour with a low wet gluten yield in the preparation of wheat bread and pasta. In our opinion, this effect on flour water absorption is due to the chemical and granulometric composition of black chokeberry flour.

General characteristic of breads – mass, volume, specific volume, dimensional stability, sensory analysis)

Floor bread

In order to obtain a comprehensive assessment of the influence of added chokeberry flour on the quality of the bread, the volume and mass of the ground bread were determined. The obtained results are shown in Table 3.

TABLE 3. Volume and mass of floor bread with addition of chokeberry flour

Bread samples	Masse, g ± SD	Volume, cm^3 ± SD
WCS	208.6 ± 0.88	510 ± 1.98
5	207.2 ± 0.85	495 ± 1.78
10	204.6 ± 0.98	410 ± 1.88
15	204.5 ± 0.87	400 ± 1.86

Table 3 shows that the addition of chokeberry flour leads to changes in the volume and mass values of the breadcrumbs. In breadcrumbs supplemented with 5% chokeberry flour, the values for the volume and mass of the breadcrumbs approached the control.

When increasing the percentage of chokeberry flour added, a decrease in volume was observed, and it was highest in the sample with the addition of 15% chokeberry flour (21.5%) compared to the control.

This confirms the conclusions made as a result of the rheological characteristics of the dough, that the largest amount of chokeberry flour leads to a deterioration of the rheology (stability and relaxation) of the dough, and hence the quality of the bread.

The specific volume of the loaf of bread is determined, which expresses the relationship between volume and mass, and helps to determine the quality of the bread.

In fig. 3 shows the specific volumes of the control and experimental samples for flat bread and loaf bread.

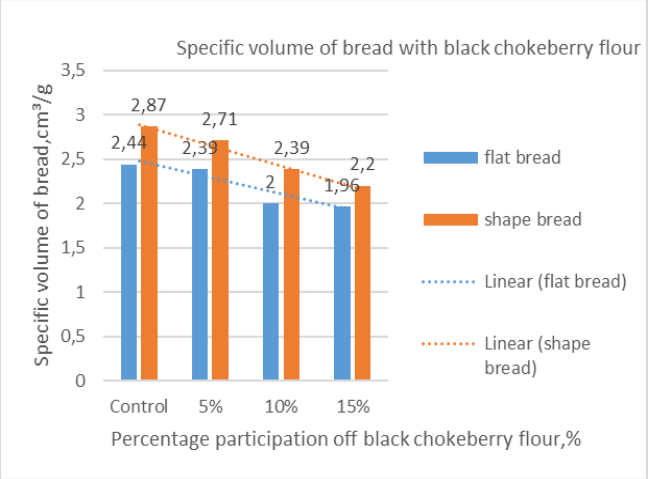

Fig. 3. Specific volume of whole wheat bread with black chokeberry flour

From figure 3 it is clear that the values of the specific volume of wholemeal bread with an added amount of chokeberry flour of the control and that with the addition of 5% flour are close and are the highest – 2.44% for the control and 2.39% for bread addition of 5% flour. Increasing the percentage of chokeberry flour added (10 and 15 %) resulted in a decrease in specific volume, to 2.00 and 1.96 cm^3/g, respectively. The linear nature of the change in the specific volume of the floor bread and shape bread is due to the larger amount of black chokeberry flour additive in the experimental samples. With an increase in the amount of additive, the amount of dietary fiber increases, which is a prerequisite for a decrease in the specific volume of the floor and shaped bread. This is probably due to the higher amount of fiber added with chokeberry flour. There is a similar trend of reduction of the specific volume and of the shaped bread.

Yoon et al. for example, indicate that the specific volume of the bread decreases. In their research, this team, for example, found that at a percentage of 0%, 1%, 3%, 5% and 10% of black chokeberry flour, the specific volume of the bread decreases in row 4.82 ±1.69; 4.46 ±0.06; 3.98 ±0.02; 3.95 ± 0.012.17 ±0.02.

The shape retention of the obtained bread samples was determined and it was determined by the ratio between the height and the diameter of the bread after baking. In fig. 4 shows the shape retention of the control and test samples of bread

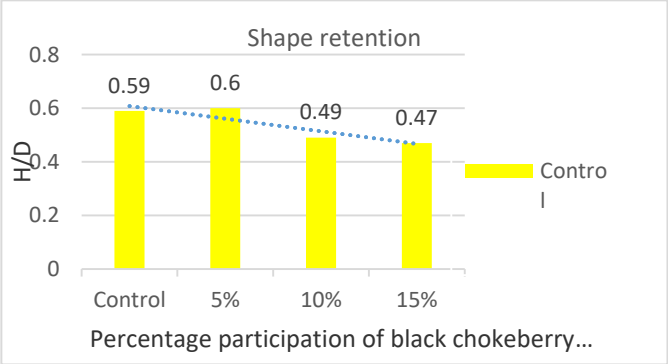

Fig. 4. Shape retention (H/D) of wholemeal bread with black chokeberry flour

It can be seen that in the sample with the addition of 5% chokeberry flour, the shape retention of the floor bread increased slightly and was close in value to that of the control. In the samples with 10 and 15% addition of chokeberry flour, the shape retention of the bread decreased significantly, compared to the control, as found by other scientific groups (Catana, M. et al.; Huang et.al).

The nature of changes in the shape retention of the prepared floor bread in the direction of decreasing values of this indicator is due to the increase in the amount of black chokeberry flour added to the dough. This is due to the negative effect of dietary fiber, additionally introduced with this enrichment component, on the physical parameters (length and height of the bread) on which the shape retention of the prepared bread ultimately depends.

TABLE 4. Technological losses of floor bread

Samples	Technological losses, % ± SD
WCS	9.30 ± 1.96
5	9.91 ± 1.86
10	11.04 ± 1.76
15	11.09 ± 1.86

Table 4 presents the technological losses in the preparation of floor bread. It was established that all samples with the addition of chokeberry flour had higher losses than the control sample, and in the sample with 15% flour addition, they were the largest - 11.09%.

Shaped bread

In order to determine the effect of added chokeberry flour on the quality of bread loaf, the volume and mass of the bread loaf were determined. The obtained results are shown in Table 5.

TABLE 5. Volume and mass of shape bread with addition of chokeberry flour

Bread samples	Masse, g ± SD	Volume, cm^3 ± SD
WCS	400.9 ± 1.46	1150 ± 1.36
5	402.3 ± 1.86	1090 ± 1.96
10	396.2 ± 1.96	945 ± 1.56
15	390.0 ± 1.86	870 ± 1.86

From the obtained results for the mass and volume of bread, it can be seen that increasing the percentage of chokeberry flour leads to insignificant changes in these parameters.

It can be noted that the volume of all bread samples are lower than those of the control (1150 cm^3). Lowest values for volume (870 cm^3) was observed in the bread loaf sample with the addition of 15% chokeberry flour.

Similar results for mass reduction were observed in its determination of shaped bread. An exception is the mass of shape bread with the addition of 5% chokeberry flour, which increased slightly compared to the control.

The technological losses of and shaped bread were determined (table 6).

TABLE 6. Technological losses of shape bread

Samples	Technological losses of shape bread, % ± SD
WCS	8.89 ± 1.46
5	8.57 ± 1.56
10	9.95 ± 1.86
15	10.23 ± 1.86

It can be seen that here, too, technological losses increase as the percentage of chokeberry flour added increases, with the exception of loaf bread with the addition of 5% chokeberry flour. Hyang-Sik et al. (2014) in their study of bread enrichment with chokeberry fiber preparation at 1%, 3%, 5%, and 10% levels noted that there were significantly lower weight losses as the amount of black chokeberry flour preparation added increased, as in our breeding, the trend is similar with the higher percentage of black chokeberry flour addition.

Sensory profile of bread with added chokeberry flour

Sensory analysis plays an important role in characterizing the quality of food products. Results of a sensory analysis of bakery products showed that the addition of chokeberry flour did not have a negative effect on the sensory characteristics (Fig. 5).

The resulting bread was evaluated by 25 independent analysts after they were familiar with the research methodology. The obtained results are presented in Figure 5.

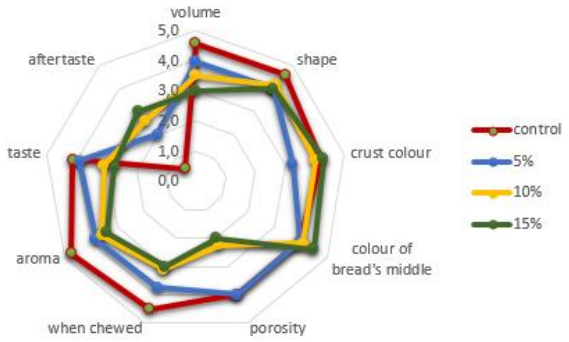

Fig. 5. Sensory profile of wheat bread with black chokeberry flour

After the test laboratory firing is done a sensory profile was made on the floor bread based on the visual characteristics of sliced bread, using the control sample for comparison.

The color of the bread center of the control sample is yellowish, characteristic of bread obtained from wheat flour type 1850. In the experimental samples, the shade of color is more saturated and belongs to the red range. The control sample has a characteristic aroma, and in the experimental samples a sufficiently intense chokeberry aroma is detected.

From the figure, it can be seen that the volume of experimental samples has satisfactory results, with the highest rating given to the control sample. All samples compared to the control obtained lower volume values, with the closest values being the sample with 5% chokeberry. As the amount of aronia meal increases, the volume values decrease. Regarding the shape indicator, the control sample stands out with the highest values, but the experimental samples give a lower result compared to it, and the differences between the experimental samples and the control are minimal.

An increase in the intensity of skin and core staining was observed in the samples with 10 and 15% black chokeberry flour compared to the control. This is due to the greater amount of pigments introduced into the dough together with the increased percentage of additives.

The highest values were obtained by the control for sponginess and the lowest by the sample with 15% chokeberry flour added, which is probably due to the weakening effect of the additive on the quality and quantity of wet gluten in the mixtures.

According to a larger percentage of the respondents, the chewiness was impaired, with the highest values for the control sample, and the lowest for the experimental sample with 15% addition of black chokeberry flour.

The aroma, taste and aftertaste of the control sample and the experimental samples show similar results, and here again the highest values of these indicators are obtained by the control sample, and the values of these indicators for the experimental samples change smoothly compared to the control sample in the direction of decreasing the values of these indicators, as the lowest ones are given for the experimental sample with 15% black chokeberry flour.

From the sensory profile made between all the samples, the following dependencies can be deduced: there is a trend leading to a deterioration of the quality indicators of the experimental samples of baked bread compared to the control sample, due to the inserted additive. After the sensory analysis, it was found that, according to the analysts, the addition of chokeberry flour in the amount of 5.0% achieved the best results compared to the control sample. Petković et al. (2020) proved that the best sensory characteristics were obtained with 5% substituted flour with chokeberry powder. The new nutritional bread has an increased level of biologically active substances with a positive effect on human health.

Good sensory characteristics for bread with the addition of chokeberry flour, also obtained Fundagül E. (2023). Consumers show a growing interest in functional foods with health benefits, which prompts manufacturers to develop new food products.

IV. CONCLUSIONS

Based on the obtained results, it is established that chokeberry flour is a source for bread enrichment and can be an alternative for obtaining new products, with a partial replacement of wheat flour. The best results for volume, mass, shape stability of floor and mold bread were observed for bread with the addition of 5% chokeberry flour. By increasing the amount of chokeberry flour added, the dough forming time did not change, water absorption and dough development time increased compared to the control sample. Increasing the percentage of aronia flour worsens the bread's indicators in terms of the structure of the middle and the color of the cut surface of the bread. In the sensory evaluation, the appearance, color and general acceptance of the bread added with 5% chokeberry showed remarkably higher values than the control and the other samples.

IV.REFERENCES

[1] Borisova I. L. (2018), Technology for obtaining high-protein "diabetic" bread designed for specific health needs, Journal of Mountain Agriculture on the Balkans, 251-260, Research Institute of Mountain Stockbreeding and Agriculture, Troyan.

[2] Vangelov A., Gr. Karadjov (1993), "Bread and pasta technology", manual for laboratory exercises, Zemizdat, Sofia.

[3] T.N. Tertychnya, E.Yu. Manukovskaya, N.N. Fonina, V.I. Orobinsky, E.E. Kurchaeva, I.V. Majulina., The use of black rowan berries in technology of bread of high nutritional value - Bread products, 2014 - elibrary.ru.

[4] Amoah Isaac, Carolyn Cairncross, Arno Sturny, Elaine Rush (2018), Towards improving the nutrition and health of the aged: the role of sprouted grains and encapsulation of bioactive compounds in functional bread, International Journal of food science technology.

[5] Banjari I., Andreja Misir, Katarina Šavikin, Stela Jokic, Maja Molnar, HKS De Zoysa and Viduranga Y. Waisundara (2017), Antidiabetic Effects of Aronia melanocarpa and Its Other Therapeutic Properties, Faculty of Food Technology Osijek, Josip Juraj Strossmayer University of Osijek, Osijek, Croatia, Institute for medicinal plants research “Dr Josif Panc̆ic´”, Belgrade, Serbia, Department of Food Technology, Faculty of Technology, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.

[6] Brand Mark, Aronia: Native Shrubs With Untapped Potential, University of Connecticut, 2010.

[7] Brand Mark H., Bryan A. Connolly, Lanfang H. Levine, Jeffrey T. Richards, Stacey M. Shine, Lashelle E. Spencer, Anthocyanins, total phenolics, ORAC and moisture content of wild and cultivated dark-fruited Aronia species, Volume 224, 2017, p. 332-342.

[8] Filipović Vladimir, Marko Petković, Jelena Filipović, Igor Đurović, Nemanja Miletić, Jovana Radovanović, Ivana Filipović (2021), Nutritional attributes of wheat bread fortified with convectively dried chokeberry powder, Acta Agriculturae Serbica, 26 (51),p. 55–62 , 2021.

[9] Fundagül E.(2023).Physicochemical,sensory, and bioacttive properties of gluten-free puddings with aronia.The Journal of Food Volume 48, Issue 2,p. 243 – 255.

[10] Hardin JW, The Enigmatic Chokeberries (Aronia, Rosaceae), Vol. 100, no. 3 (May - June, 1973), p.178-184 (7 pages), Department of Botany, North Carolina State University, Raleigh, North Carolina, 1973.

[11] Hawkins J., C. Hires, C. Baker, L. Keenan, M. Bushm (2021), Daily supplementation with aronia melanocarpa (chokeberry) reduces blood pressure and cholesterol: a meta analysis of controlled clinical trials, Journal of Dietary Supplements, Volume 18, 2021- issue 5.

[12] Jurendic T., M. Ščetar (2021), Aronia melanocarpa Products and By-Products for Health and Nutrition: A Review, Bioquanta Ltd. for Research and Development, Faculty of Food Technology and Biotechnology, University of Zagreb, Croatia, 2021.

[13] Jurikova T., J. Mlcek, S. Skrovankova, D. Sumczynski, J. Sochor, I. Hlavacova, L. Snopek, J. Orsavova (2017), Fruits of Black Chokeberry Aronia melanocarpa in the Prevention of Chronic Diseases, Institute for teacher training, Faculty of Central European Studies, Constantine the Philosopher University in Nitra, Drazovska, Nitra, Slovakia, Department of Food Analysis and Chemistry, Faculty of Technology, Tomas Bata University in Zlín, nám. TG Masaryka, Zlín, Czech Republic, Department of Viticulture and Enology, Faculty of Horticulture, Mendel University in Brno, Valticka, Lednice, Czech Republic, Language Centre, Faculty of Humanities, Tomas Bata University in Zlín, nám. TG Masaryka, Zlín, Czech Republic.

[14] Kolesarova et al. (2021). Scavenging Properties of Plant-Derived Natural Biomolecule Para-Coumaric Acid in the Prevention of Oxidative Stress-Induced Diseases. MDPI journals.

[15] Korenets Yurii, Iuliia Goriainova, Radion Nykyforov, Iryna Nazarenko, Olga Simakova (2017), The study of influence of aronia additives on functional-technological properties of wheat flour. Department of technology in a restaurant economy and hotel and restaurant business Donetsk National University of Economics and Trade named after Mykhailo Tugan-Baranovsky, Ukraine.

[16] Koshak Z., Pokrashinskaya A. (2020) Chokeberry powder as an improver for pasta. Harčova nauka ì tehnologìâ 2020 v.14 no.1.

[17] Kulling S. , H. Rawel , Chokeberry (Aronia melanocarpa) – A Review on the Characteristic Components and Potential Health Effects, Department of Food Chemistry, Institute of Nutritional Science, University of Potsdam, Nuthetal (OT Bergholz-Rehbrücke), Germany.

[18] Lee Seon-gu (2017), Preference Evaluation of High Functional Spelled Flour Bread added with Aronia Powder, Culinary Science & Hospitality Research, Volume 23, 2017-Issue 2, p..181-188.

[19] Özdemir K., Esra Eroğlu Özkan, Chemical composition and biological activities of aronia sp. berries , Acıbadem Mehmet Ali Aydınlar Üniversitesi, Eczacılık Fakültesi, Farmakognozi Anabilim Dalı, İstanbul, Türkiye.

[20] Park Eo Jin, Quality Characteristics of Sulgidduk added with Aronia (Aronia melanocarpa) Powder, Dept. of Hotel, Food Service and Culinary Art, Catholic Sangji College, Gyeongbuk, Korea, 2014.

[21] Petković Marko, Vladimir Filipović, Jelena Filipović, Igor Đurović, Nemanja Miletić, Jovana Radovanović (2020), Chemical, antioxidative, and sensory characteristics of wheat bread partially substituted with black chokeberry (Aronia

melanocarpa L.) powder, Journal of Food Processing and Preservation, Volume 45,2020-Issue1.

[22] Sensory analysis – Methodology – General guidance for establishing a sensory profile (ISO 13299 :2003).

[23] Sidor A., A. Gramza-Michałowska (2019), Black Chokeberry Aronia Melanocarpa L.—A Qualitative Composition, Phenolic Profile and Antioxidant Potential, Department of Gastronomy Sciences and Functional Foods, Faculty of Food Science and Nutrition, Pozna´n , Poland, 2019.

[24] Sim Sol, Yeong-Ju Park, Jin-Ho Lee, So-Yeon Jeong, Ju-Jin Lim, Ga-Hyun Yu, Eun-Gyeom Kim, Hee-Jae Suh (2019), Quality Characteristics and Antioxidant Activities of Morning Bread-Containing Aronia Sourdough Starter, Journal of Food Hygiene and Safety, Vol. 34, No. 5, p. 463~472 (2019).

[25] Şahin A., Ü. Erdoğan, Aronia (Aronia melanocarpa Michx Elliot) Production and Evaluation Methods in the World and Turkey, Department of Food Engineering, Faculty of Engineering, Bayburt University, Bayburt, Turkey.

[26] Vinogradova Y., O. Vergun, O. Grygorieva, E. Ivanišová, J. Brindza (2020), Comparative analysis of antioxidant activity and phenolic compounds in the fruits of aronia spp., Potravinarstvo Slovak Journal of Food Sciences.

[27] Yoon H., J. Kim, S. Kim, Y. Kim, H. Eom, Quality Characteristics of Bread added with Aronia Powder (Aronia melanocarpa), Chungcheongbukdo Agricultural Research and Extension Services, Chungbuk 363-883, Korea.

[28] Catana, M., Catana, L., Iorga, E., Asanica, AC, Belc, N. (2018). Bakery products fortified with dried fruits of Aronia melanocarpa. Scientific Papers-Series B-Horticulture, 62: p.693-701.

[29] L: Huang, X Zhang, H Zhang, J Wang Interactions between dietary fiber and ferulic acid changed the aggregation of gluten in a whole wheat model system - Lwt, 2018 – Elsevier.

[30] Macari E., Cojocari A., Balan D., Popa G., Turculet S., Ghendov-Moşano N., Sturza A. (2022). Antimicrobial properties of sea buckthorn grown in the Republic of Moldova. In: Journal of Engineering Sciences. Journal of Engineering Sciences. 2022, nr. 1, pp. 164-175. ISSN 2587-3474. DOI: 10.52326/jes.utm.2022.29(1).15.p. 164-175.

[31] Han, HM, & Koh, BK (2011). Effect of phenolic acids on the rheological properties and proteins of hard wheat flour dough and bread. Journal of the Science of Food and Agriculture, 91(13),p. 2495–2499.

[32] Korenets Yurii, Iuliia Goriainova, Radion Nykyforov, Iryna Nazarenko, Olga Simakova (2017), The study of influence of aronia additives on functional-technological properties of whet flour, Department of technology in a restaurant economy and hotel and restaurant business Donetsk National University of Economics and Trade named after Mykhailo Tugan-Baranovsky, Ukraine.