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Vegetable raw materials as a way to improve the quality of bakery products

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Abstract. The development of the food industry is aimed at developing products with new consumer properties: low in sugar and fat, with an increase in the amount of dietary fiber, vitamins and minerals. As one of such an approach, the use of non-traditional vegetable raw ingredients (whole grain flour from sprouted grain (WG) and pectin) can be proposed, which will allow the formation of high-quality food products of a functional orientation. The conducted studies have shown that the above components have an effect on the dough rheological properties: the extensibility of the dough decreases with the introduction of pectin by more than 2 times, the values of the farinograph quality index increase, and the best result is characteristic with the introduction of 2% pectin. The use of WG slightly increases the time of dough formation, while the dough resistance to kneading and the farinograph quality index increase by an average of 54 – 240% from the amount of replacement. Control and experimental bread samples have fairly high total values of organoleptic evaluation. The specific volume of bread increased by 12% when adding WG, and by 8% when adding pectin.

1 Introduction

The modern development of the food industry is aimed at creating products with new consumer properties: a decrease in the formulation of fats, with an increase in dietary fiber, vitamins and minerals. At the same time, a prerequisite for the successful finding of a product on the market is its high organoleptic properties with a fairly low price policy. Therefore, the search for ways to improve the formulation, improve the quality and nutritional value of this product segment is relevant. Bread remains one of the most important foods in the human diet and the main defining criterion of the cultural identity of communities around the world. In the Russian Federation this value is approximately 90.3 kg per year, while 29% [1, 2, 3] in the consumption structure falls on traditional wheat flour products.

As one of such an approach, the use of non-traditional plant raw materials (WG [4] and pectin) can be proposed, which will allow the formation of high-quality food products. The introduction of sprouted wheat grain into the formulation under controlled conditions makes it possible to enrich the final products with antioxidants (flavonoids, polyphenols, etc.), dietary fibers, vitamins and minerals [4].

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A number of researchers [5, 6] have found that the quality of bread increases due to the addition of hydrocolloids. Pectin is a complex polysaccharide hydrocolloid [6, 7], is a source of high-quality soluble dietary fiber and is beneficial to human health [8, 9, 10]. Studies presented in the open press prove that the addition of pectin at a concentration of 1.5 – 4% increases the gas-retaining capacity of the dough, improves rheological characteristics and interaction with proteins and starch, thereby increasing their digestibility [11, 12, 13]. The introduction of pectin in small amounts (1-5%) contributes to the aggregation and strengthening of the gluten network. Thus, the study of the possibility of improving bread quality by adding WG and pectin is relevant.

The purpose of the study was to evaluate the possibility of using non-traditional vegetable raw materials (WG and pectin) in bread technology as a way to improve their rheological properties and quality.

2 Materials and Methods

2.1 Raw material

The following raw materials were used to produce dough and bread:

– wheat flour (WF), produced by JSC Petersburg Mill Plant, purchased in St. Petersburg (Russia): humidity (13.3±0.5) %; amount of gluten – (25.8±0.6) %, gluten quality – (67±4) FDM units, falling number – (302± 10) seconds; ash content – (0.75±0.3) %.

– whole-ground flour from sprouted wheat grain (WG), obtained using technology developed on the basis of the Department of Food and Biotechnology of the Federal State Autonomous Educational Institution of Higher Education "South Ural State University (NRU)", described earlier in the article [4];

– pressed yeast, produced by "Saf-Neva", St. Petersburg (Russia);

– food salt, produced by LLC "Salt of Petersburg", St. Petersburg (Russia);

– sugar, produced by St. Petersburg Sugar Factory, St. Petersburg (Russia);

– table margarine with fat mass fraction of 75%, produced by METRO Cash and Carry LLC, St. Petersburg (Russia);

– pectin (Genu Pectin Type YM-115-H), manufactured by CP Kelco ApS (Lille Skensved, Denmark), purchased in St. Petersburg.

2.2 Preparation of the dough

To study the rheological properties of the dough, model mixtures were used in these ratios:

Control – WF;
1 – WF:WG in a ratio of 90:10;
2 – WF:WG in the ratio of 85:15;
3 – WF:WG in a ratio of 80:20;
4 – WF:pectin in a ratio of 100:3.5;
5 – WF:pectin in a ratio of 100:5.0;
6 – WF:pectin in a ratio of 100:6.5;

2.3 Making bread

Laboratory test samples for bread technology were prepared using a non-stick technology (kneading was performed once, flour was pre-sieved for air enrichment, yeast and salt were dissolved in water. To obtain the batch, a Diosna SP 200 kneading machine was used (manufacturer DIOSNA Dierks & Söhne GmbH, Germany). The temperature of the raw

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material in the batch was 30°C ± 2°C. The total duration of dough fermentation was 170 minutes. When preparing the dough, a double breakdown was used (after 60 and 120 minutes of fermentation). To obtain bread, the recipe presented in Table 1 was used.

Table 1. Recipe of bread samples.

Name of raw material	Quantity of raw material, g / bread sample number						
	Control	1	2	3	4	5	6
WF	1000	90	85	80	100	100	100
WG		10	15	20	–	–	–
Pressed yeast	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Edible salt	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Sugar	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Margarine	3.8	3.3	3.3	3.3	3.3	3.3	3.3
Pectin	–	–	–	–	3,5	5,0	6,5
Water	calculation						

The resulting dough was cut into pieces of 400 g, placed in special containers and proofed for 20 minutes (temperature 30 ± 1°C, relative humidity 85%). Laboratory test baking of bread weighing 400 g was carried out at a temperature of 220°C [3].

The baking process was carried out in a baking heath rack MIWE CONDO CO 3.1208 (manufacturer MIWE, Germany). The finished product was cooled to a temperature of 22 ± 1°C and packed in Zip-lock packages. The samples were stored at a temperature of 22 ± 3°C. The tests were carried out 24 and 72 hours after baking.

2.4 Research methods

Rheological characteristics of the dough were determined by the farinograph parameters, according to GOST ISO 5530-1-2013 using the Brabender farinograph (manufacturer Brabender GmbH & Co, Germany) and the Farinograph-TS 2.2.0 software.

The organoleptic indicators of bread quality were evaluated using a 20-point scale.

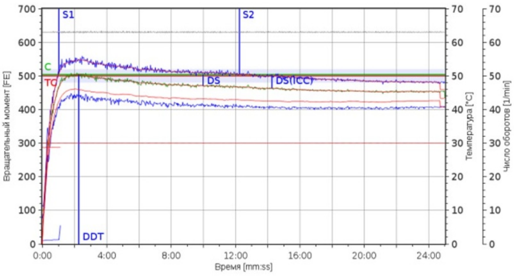
The specific volume of bread was determined by a device for determining the bread volume OHL-2 (manufacturer LLC "Zernotekhnika", Moscow, Russia).

The moisture content of the bread crumb was determined by drying in infrared radiation using a gaged instrument Sartorius M 150 (concern Sartorius AG, Germany).

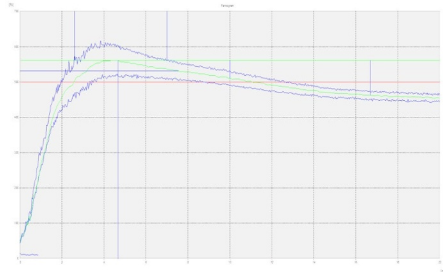
All the research results were carried out in 3-fold repetition and processed on the basis of mathematical statistics methods using Microsoft Excel. The data obtained are presented with a confidence coefficient of 0.95.

3 Results and Discussion

The introduction of non-traditional raw materials into the wheat flour dough system can greatly affect both its rheological properties and the quality of finished products. Therefore, at the initial stage of the research, the rheological properties of the control and experimental dough samples were evaluated. A characteristic view of the farinograms of the control and experimental dough samples obtained using the Brabender farinograph is shown in Figure 1.



Control



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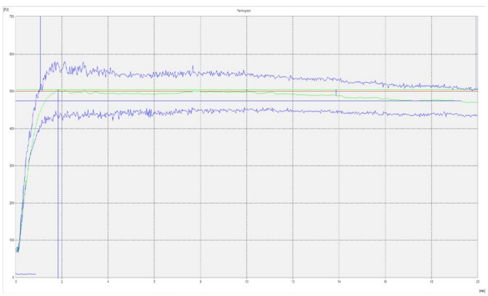

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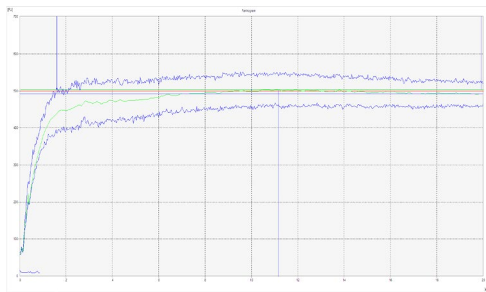

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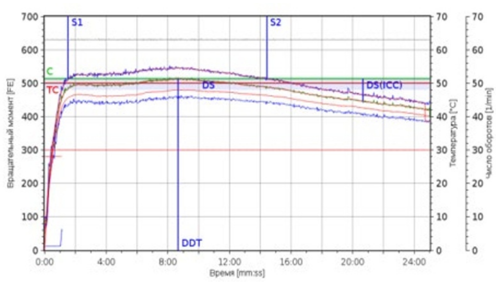

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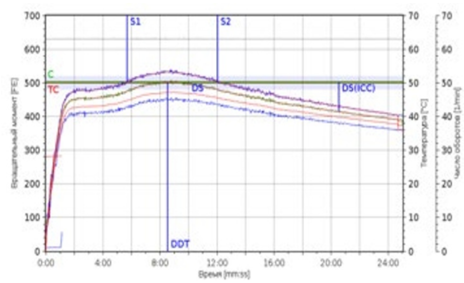

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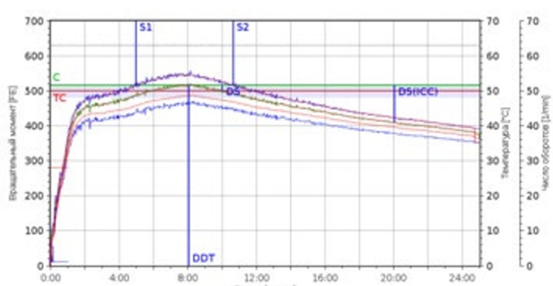

Sample 6

Fig. 1. A characteristic view of the farinograms of dough samples obtained using the Brabender farinograph.

Table 2. The results of determining the dough rheological parameters obtained on the farinograph.

Sample number	Dough resistance to kneading, min	Degree of dough dilution 10 minutes after the start, EF	Degree of dough dilution 12 minutes after the start (ICC), EF	Farinograph quality indicator, mm	Water absorption, %	Dough formation time, min
Control	11.12	34	41	75	57.5 ± 0.7	2.16 ± 0.30[c]
1	11.28	32	31	116	56.0 ± 0.9	2.30 ± 0.30
2	12.86	28	25	136	54.6 ± 0.4	2.70 ± 0.05
3	13.44	25	22	180	53.6 ± 0.6	3.30 ± 0.30[c]
4	12.54	5	68	153	64.0 ± 0.6	8.40 ± 0.46
5	6.20	7	89	126	68.5 ± 0.3	8.32 ± 0.40
6	8.03	7	107	111	72.1 ± 0.5	8.03 ± 0.22

The use of WG slightly increases the dough formation time (statistically significant differences were found for sample 3), which is probably due to the presence of large shell particles and longer wetting of the particles. The water absorption capacity decreases in the minimum range, which is due to the larger granulometric composition of WG described earlier [4], the dough resistance to kneading and the farinograph quality index increase by an average of 54% (sample 1) to 240% (sample 3).

The addition of pectin to the dough formulation made it possible to increase the values of the farinograph quality indicator, and the best result is typical when applying pectin in an amount of 2%. At the same time, the maximum stability of the dough to kneading and the minimum values of dough dilution degree are observed. Nevertheless, when pectin is added in larger quantities (3.4%), the quality indicator of the farinograph decreases and the dough is liquefied during the kneading process, which may be due to changes in the protein structure and faster swelling of pectin during the kneading process [14, 15, 16, 17]. This assumption is confirmed by the time of experimental dough samples formation with pectin (sample 4, 5 and 6), they have values several times higher than the control for this indicator.

The results of the organoleptic evaluation of bread allow to say that the control and experimental samples had the correct shape, smooth surface, uniform porosity, and sufficient elasticity of the crumb. The crumb elasticity of the control samples had the lowest values, the tasters noted an increased density and a lumpy crumb, which was most felt at the end of storage. At the beginning of storage, the highest total score was typical for samples 2 and 3 (Fig. 3).

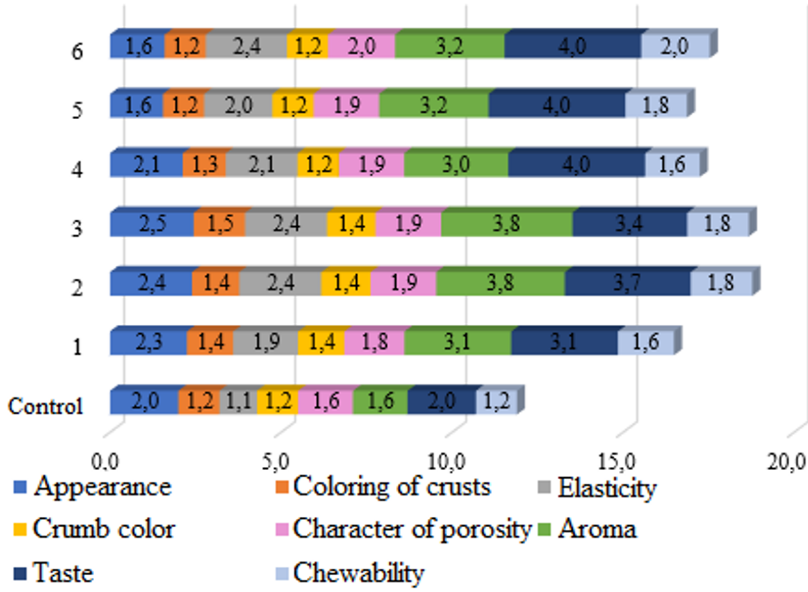

Fig. 3. Results of organoleptic evaluation of bread samples after 24-hour storage.

The samples obtained with the addition of pectin had good crumb properties: soft, elastic, well chewed and creating a pleasant feeling in the mouth with a pleasant taste and aroma, nevertheless, their total score was slightly lower than the bread samples with WG. It should be noted that in the formulation of bread prototypes, the volume of margarine introduced was reduced by 5%, which could negatively affect their organoleptic properties, nevertheless, both at the beginning and at the end of storage, with a total score, they had high values in terms of taste, aroma, crumb elasticity and porosity, relative to control (fig. 4).

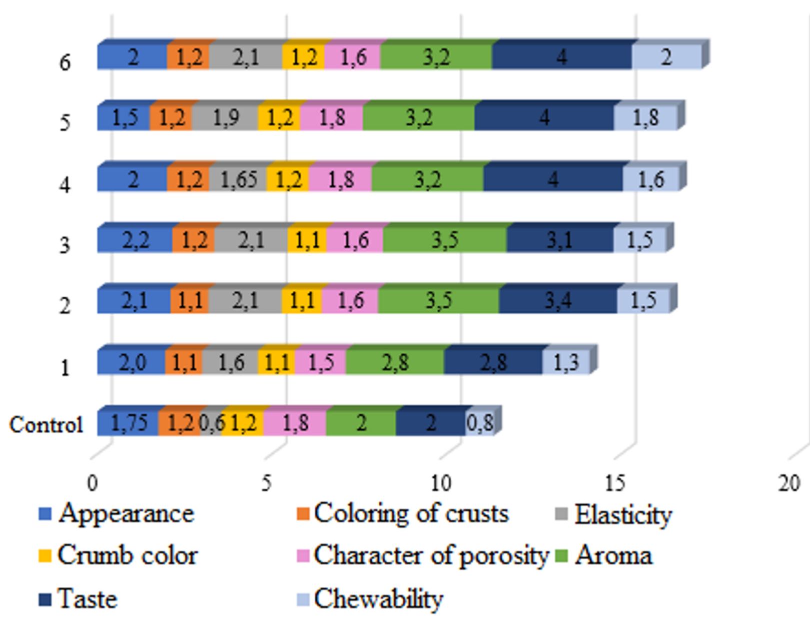

Fig. 4. Results of organoleptic evaluation of bread samples after 72-hour storage.

After 72 hours of storage, bread samples with the addition of 4% pectin (sample 6) had the highest total score among the prototypes with this raw ingredient. Bread samples with WG (samples 2 and 3) in the dynamics of storage retained a high total score, had a more elastic crumb, pleasant taste and aroma. The color of crusts, the color of the crumb and the moisture content of the crumb were affected by the introduction of non-traditional raw materials, while the specific volume of finished products had a significant range of variation (Fig. 5).

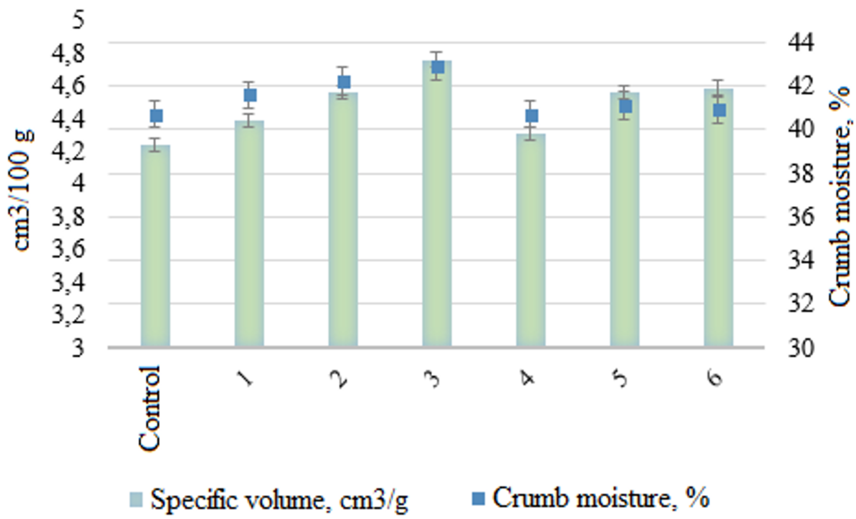

Fig. 5. The results of determining the specific volume and moisture content of the crumb of bread samples.

The specific volume of bread prototypes varied depending on the application of non-traditional raw materials. Thus, the introduction of WG in the amount of 20% (Sample 3) allowed to increase the value of this indicator by an average of 12%, and the introduction of pectin in the amount of 4% (Sample 6) by 8%, respectively.

4 Conclusion

The results obtained allow to say that the use of non-traditional raw materials in bread technology makes it possible to obtain products with high consumer characteristics while reducing the fat content in the formulation of experimental samples. The use of pectin in the formulation leads to a decrease in dough extensibility by more than 2 times, an increase in the values of the farinograph quality indicator, and the best result is typical when applying pectin in an amount of 2%, maximum dough resistance to kneading and minimum values of dough dilution degree are observed. During the research, it was found that the introduction of pectin in large quantities makes the dough elastic and less elastic, which can negatively affect the quality of finished products. This fact allows to recommend adding pectin and WG to the formulation, which requires further research in the chosen direction.

Acknowledgements

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References

1. AHFES (Atlantic Area Healthy Food Eco-System) Bakery: European market, consumer trends, and innovation [Electronic resource]. URL: https://www.ahfesproject.com/research/bakery-european-market-consumer-trends-and-innovation (accessed 29.01.2024)
2. In 2022, the consumption of bread products in the Russian Federation amounted to 90.3 kg per year [Electronic resource]. URL: https://agrarnayanauka.ru/v-2022-godu-potreblenie-hlebnyh-produktov-v-rf-sostavilo-903-kg-v-god (accessed 02/01/2024)
3. L. Nilova, N. Naumenko, I. Kalinina, Agronomy Research, **15(S2),** 1386-1398 (2017).
4. N. Naumenko, I. Potoroko, I. Kalinina, Ultrasonics Sonochemistry, **86,** 106000 (2022). 10.1016/j.ultsonch.2022.106000
5. S. Christiaens, S. Van Buggenhout, K. Houben, Z.J. Kermani, K.R.N. Moelants, E.D. Ngouémazong, et al. Critical Reviews in Food Science and Nutrition, **56,** 1021-1042 (2015). 10.1080/10408398.2012.753029
6. T. Matsunaga, T. Ishii, S. Matsumoto, M. Higuchi, A. Darvill, P. Albersheim, et al. Plant Physiology, **134** (1), 339-351 (2004). 10.1104/pp.103.030072
7. J.F. Chen, Y.L. Cui, Y.X. Ma, S.G. Zhang, Carbohydrate Polymers, **277,** 118849 (2022) 10.1016/j.carbpol.2021.118849
8. F. Naqash, F.A. Masoodi, S.A. Rather, S.M. Wani, A. Gani, Carbohydrate Polymers, **168,** 227-239 (2017). 10.1016/j.carbpol.2017.03.058
9. H. Yang, Y.R. Sun, R. Cai, Y. Chen, B. Gu, Microbial Pathogenesis, **140(3),** 1-18 (2020) 10.1016/j.micpath.2019.103931
10. L.R. Adetunji, A. Adekunle, V. Orsat, V. Raghavan, Food Hydrocolloids, **62,** 239-250 (2017). 10.1016/j.foodhyd.2016.08.015
11. C.F. Li, G.J. Chen, C.X. Ran, L.J. Liu, S.S. Wang, Y. Xu, et al. Food Chemistry, **289,** 121-129 (2019) 10.1016/j.foodchem.2019.03.030
12. B.O. Ajibade, O.A. Ijabadeniyi, Journal of Food Science and Technology, **56,** 83-92 (2019). 10.1007/s13197-018-3457-7
13. X. Zhang, J.H. Li, J.Y. Zhao, M.Y. Mu, F. Jia, Q. Wang, et al. Journal of Cereal Science, **100,** 103247 (2021). 10.1016/j.jcs.2021.103247
14. P. Chareonthaikij, T. Uan-On, W. Prinyawiwatkul, International Journal of Food Science and Technology, **51(5),** 1120-1129 (2016). 10.1111/ijfs.13072
15. B.S. Khatkar, S. Barak, D. Mudgil, International Journal of Biological Macromolecules, **53,** 38-41 (2013). 10.1016/j.ijbiomac.2012.11.002
16. X.H. Hu, L. Cheng, Y. Hong, Z.F. Li, C.M. Li, Z.B. Gu, International Journal of Biological Macromolecules, **206,** 534-542 (2022). 10.1016/j.ijbiomac.2022.02.150
17. G.J. Chen, L. Ehmke, R. Miller, P. Faa, G. Smith, Y.H. Li, Journal of Agricultural and Food Chemistry, **66(26),** 6840-6850 (2018). 10.1021/acs.jafc.8b01197