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**ODESSA NATIONAL ACADEMY OF
FOOD TECHNOLOGIES**

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**BLACK SEA
SCIENCE 2020**
PROCEEDINGS



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Odessa National Academy of Food Technologies

International Competition of Student Scientific Works

BLACK SEA SCIENCE 2020

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1. FOOD SCIENCE AND TECHNOLOGIES

SUBSTANTIATION OF WHOLE-GRAIN FLOUR PRODUCTION TECHNOLOGY

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Abstract. *Current work is devoted to the research of wheat and spelta grain technological properties, development of grain processing scheme for obtaining whole-grain flour (WGF) and determining its quality. The technological and baking properties of WGF are substantiated.*

Keywords: *WGF, wheat flour, spelta flour, baking properties, ash content, gluten, grain size, flour quality, rheological properties.*

I. Introduction

Grain processing is one of the leading branches of the food industry. It provides the population with flour and cereals; its waste is used for the feed industry. Technological processes of grain processing into flour result with complex structural and mechanical, physical and biochemical changes in grain and also in finished products. Thus, knowing of these changes regularities is not only the essence of studying the flour milling technology, but also is the source for further technological improvement of grain processing into flour.

Compliance violation of rational nutrition principles nowadays is the main reason for rapid non-contagious diseases development. The most common consequences of unbalanced diet in Ukraine is different metabolic disorders. Being overweight and fattiness is the fifth largest risk factor for death in the world, as it is the leading cause of diseases such as diabetes, cardiovascular disease, musculoskeletal disorders, and some cancers. The main treatment and prevention of metabolic diseases is diet therapy with the inclusion in the diet of high-fiber products, vitamins and minerals. Under these conditions, it is urgent to manufacture bakery products with healthy and preventive purposes with reduced energy and increased nutritional value [1].

II. Analytical literature overview

The traditional cereal grinding is based on the gradual grain milling and the mechanical distribution of its three main parts (endosperm, embryo and shells), which are significantly different in their physical and mechanical properties and chemical composition.

This is achieved while using of a large number of crushing systems, which leads to high energy costs for the high-quality flour production [1]. Separating from the endosperm shells, aleurone layer and embryo results in removing most of the vitamins, proteins and minerals (table 1). This reduces the biological value of flour comparing to grain reduces the nutritional value of bread.

Compared to wheat flour of the highest grade, WGF contains 12.5 times more fiber, 2.1 times more calcium, 5.8 times magnesium, 3.9 times - phosphorus, 3.4 times - iron, 3.7 times - vitamin PP, 2.3 times - vitamin B1, B2. In addition, WGF contains vitamin E, which is completely absent in premium flour. [2].

Table 1. Some nutritional values of wheat flour

Indicator	High-grade wheat flour	Wheat WGF
Fiber content, %	0,15	1,90
Mineral content, mg/100g		
Ca	18	39
Mg	16	94
P	86	336
Fe	1,2	4,1
Vitamin content, mg/100g		
B ₁	0,41	0,98
B ₂	0,08	0,19
PP	1,2	4,5
E	0,0	5,7

There is high interest to spelta grain nowadays. However, the cultivation and use of spelta is hampered by hard threshing of the grain due to the tight coverage of the flower scales of the grain. This requires equipment and additional energy costs to manufacture grain without films [3].

The content of the anatomical parts varies significantly depending on the variety. According to Egorov and Kazakov [4], the shells content in wheat grain floats from 5.6 to 11.2%, aleurone layer - from 5.2 to 8.8, embryo - from 1, 4 to 4.2, endosperm - from 78.7 to 84.3%.

Increasing the Protein content increasing of spelta grains adversely affects the baking quality of the flour. This is due to the fact that with increasing protein content increases the proportion of gluten-forming proteins (gliadin and glutenin), and the proportion of albumins and globulins decreases. For wheat spelta, carbohydrates are a major component (50-70%) of grain, and sugar content is 2-3%. The dietary fiber content of spelta wheat varies from 10.5 to 14.9%. The rich vitamin and mineral composition of spelta wheat can be explained by its specific ability — to absorb nutrients from the soil better than bare wheat.

More proteins and lipids content in spelta wheat, along with the reduced carbohydrate content, makes the bread-baking properties of these crops different. It is indicated (in Table 2) that spelta wheat has a lower sugar content than wheat, since it contains less starch than wheat, whose grains are smaller but better protein-bound [5].

Table 2. Quality indicators of wheat and spelta WGF

Indicator	WGF	
	Wheat	Spelta
Gluten content, %	24	32
Gluten extensibility, cm	14	18
Elasticity, IDG units	74	90
Hydration capability, %	174	151
Flour acidity, Degrees	4,8	5,2
Water absorption capability, %	65	61

As a result, the spelta flour dough ferments less intensively, which is confirmed by a 21% lesser release of carbon dioxide during its fermentation. Acidity of spelled

flour is higher by 0.4 deg. It was found that spelta flour releases gluten by 8% more than wheat flour. Spelta flour gluten is less plastic, more elastic, has less than 15% hydration capacity and 28% - elasticity.

There are several technologies for processing grain into WGF. Rolling mills, crushers or millstones can be used as crushing equipment (Fig. 1).

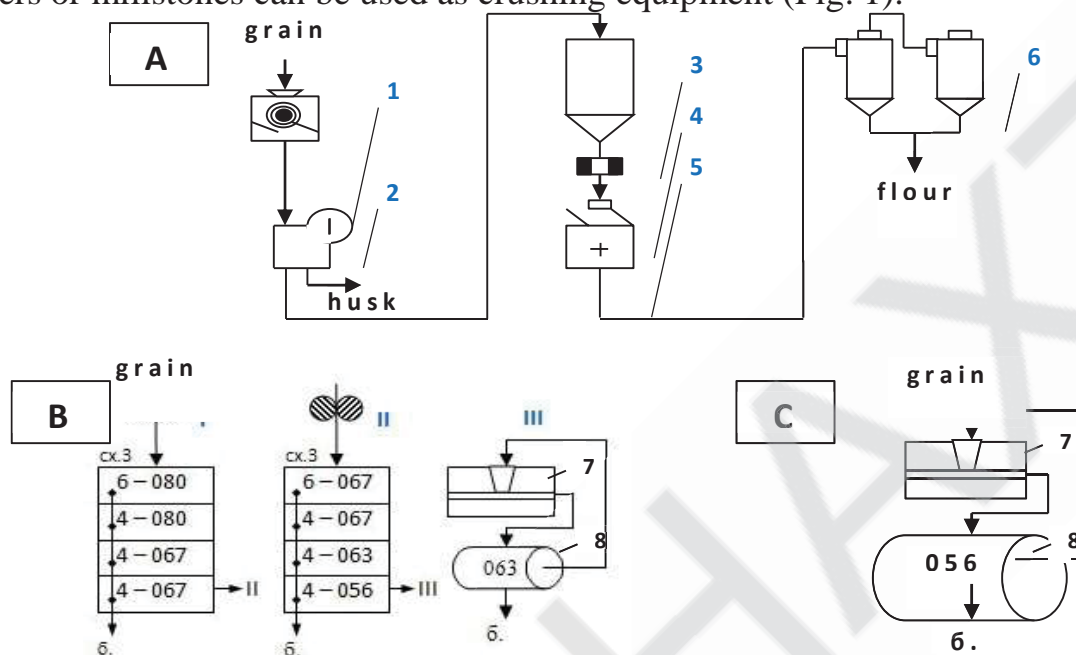


Fig. 1. Structural scheme of wheat grain processing in WGF: A — with crusher using; B — with roller mills and millstones using; C — with millstones using: 1 – the peeler; 2 – aspiration column; 3 – operational bunker; 4 – magnetic separator; 5 – hammer crusher; 6 – cyclone; 7 – millstone; 8 – burate

There is also the practice of using flow charts, where roller machines are used as the main grinding equipment, and millstones or crushers are installed on the latter grinding systems [2].

WGF obtained by different manufacture technology, differs significantly in quality.

In the most world countries, the moisture content of the flour should not exceed 14.5-15.0% (except France, where moisture content is limited to be not more than 16.0%). In some countries, cereal flour standards have upper and lower ash limits, such as the United States (1.6 - 1.8%), the United Kingdom (1.6-2.2%) and Canada (1.07-1.94%). In Germany, the production of three types of flour with a high content of ballast substances with an ash content of 1.60 to 1.85% is allowed.

The highest ash content of flour is regulated in:

- Bulgaria (flour of coarse flour with an ash content of not more than 1.85%);
- Poland ('Graham' flour with an ash content of not more than 1.85%);
- UK (WGF with an ash content of 1.60 — 2.20%);
- Canada (coarse flour with an ash content of 1.07 - 1.94%).

The standards of some countries regulate gluten content in wheat WGF:

- Bulgaria - at least 26.5% of coarse flour;

- Poland - at least 24.0% of flour;
- Czech Republic - at least 23.0% of flour, in flour of coarse grinding not less than 22,0%;
- the USA - in flour of whole grain grain not less than 14,0%.

Ukraine's standards for WGF are absent today. GSTC 46.004-99 «Wheat flour. Specifications» apply only to high-quality flour and upholstery. The production of WGF from cereals and legumes, on the contrary, allows to preserve all the natural nutritional value of the grain. Therefore, the purpose of the study was to examine the quality indicators of WGF.

III. Object, subject and methods of research

Literature analysis allowed to formulate the purpose and tasks of research.

The purpose of the work is to substantiate technological scheme and optimal modes of wheat WGF production.

Objectives are:

- To carry out the analysis of technologies and quality indicators of ukrainian and foreign WGF;
- Investigate technological and baking indicators of quality for WGF obtained by different technological schemes;
- To substantiate the technological scheme of WGF production;
- To justify the requirements for WGF quality indicators.

Object of study: Wheat WGF production technology.

Subject of study: Wheat and spelta WGF obtained in manufacture conditions and in the laboratory under various technological schemes.

In the first stage of the study, organoleptic parameters of flour quality, moisture, whiteness, size, gluten quantity and quality were determined.

The main indicators of quality in flour were determined by standard methods:

- GSTC 27558-87. Flour and bran. Methods for determining color, odor, taste and crunch;
- GSTC 9404-88. Flour and bran. Method of determination of humidity;
- GSTC 26361-84. Flour. Method of determining whiteness;
- GSTC 27560-87. Flour and bran. Size determination method;
- GSTC 27839-88. Wheat flour. Methods for determining the quantity and quality of gluten.

The study of the baking properties of flour was carried out using the direct method: the evaluation of the quality of flour by trial baking.

The standard for the method of trial laboratory baking of bread [6] provides a clear method of preparation of dough from flour, water, baker's yeast and salt. Bread quality assessment was carried out according to physic-chemical parameters according to GSTC 27669-88 “Wheat flour bakery. Method of trial laboratory baking of bread.”

Sensor evaluation of bread was performed by the method of describing and evaluating flavors.

Descriptors were developed for the objective evaluation of bread, showing its main characteristics. Each indicator was evaluated according to a number of descriptors, indicating its intensity on a 5-point scale. The following scale was used to

evaluate the intensity of the characteristics:

Intensity scale
 Weak intensity → Strong intensity
0 1 2 3 4 5

The following evaluation sequence was selected. First, the descriptors that characterize the appearance (the appearance of the crust, the appearance of the crumb, the color of the crumb) were evaluated to determine the sensory profile of the bread.

Wheat grain was used for laboratory grinding, which, according to the quality indicators, belongs to class 4 (group B) and spelta grain (Table 3).

Table 3. Wheat grain quality indicators.

Quality indicator		Sample 1 wheat grain	Sample 2 spelta grain
Bulk density, g/L		780	668
Vitreous, %		53	79
Test weight, g		43	42
Moisture, %		13,2	12,9
Protein, %		10,4	-
Gluten	content, %	16,3	44
	quality, units	82	105,0

The experimental base of the Department of Grain Processing Technology and the base of the ONAFT Sensor Analysis Laboratory were used for the research.

To implement the scheme of laboratory grinding of grain into WGF, “Nagema” laboratory mill and “KoMo Fidibus XL” mill were used.

IV. Results

The ukrainian market offers to the consumer various types of flour (Table 4): milled wheat WGF, varietal wheat flour, milled spelta WGF, varietal spelta flour, coarse grinded wheat flour.

Table 4. Product packing and marking

N	Product name	Storage period	Normative document	Weight, g
1	milled wheat WGF	10 months	GSTU 46.004-99	1000 ±2%
2	wheat flour “whole-grain”	12 months	GSTU 46.004-99	2000 ±2%
3	milled spelta WGF	10 months	GSTU 46.004-99	1000r±2%
4	milled spelta WGF	10 months	GSTU 46.004-99	1000 ±1%
5	coarse-grinded wheat flour “organic”	12 months	GSTU 46.004-99	1000 ±15r
6	wheat WGF	12 months	TCU15.6-36594696-001:2009	1000 ±1%
7	coarse-grinded wheat flour “special”	12 months	TCU10.6-36580577-001:2012	1000 ±1%
8	milled wheat WGF	12 months	TCU15.6-24582550-002:2004	1000 ±1%
9	wheat WGF	8 months	TCU 15.6-00952737-006:2002	1000 ±15r

Analysis of the package and labeling of the product (according to the manufacturer) showed that the flour samples No. 1-5 were manufactured according to GSTU 46.004-99, the quality of the flour samples No. 6-9 is controlled by the manufacturer's own specifications. There are no Ukrainian standards for wheat WGF.

Flour quality studies usually begin with the determination of organoleptic characteristics, moisture, whiteness, size, quantity and quality of gluten (table. 5).

The moisture of all samples of WGF did not exceed 15.0%.

Ash content of WGF of domestic production ranges from 1.12-1.26% (for samples No. 6-9) to 1.37-1.58% (for samples No. 1-5).

The size of coarse flour (padded wheat flour) according to the standards is controlled by two sieves: residue on sieve No. 067 and passage of sieve No. 38. The size of the studied flour samples differed greatly, so for samples No. 1, 3 the residue on sieve No. 067 was within 3-6%, samples No. 2, 4, 5, 6, 7, 9 - 0,4-1,0%, sample No. 8 - 16%. The highest content of fine fraction of flour (passage of sieve No. 38) in the range of 50-60% was observed in samples No. 1, 2, 3, 6, 7 and 9. In samples No. 5, 8, the content of the corresponding fraction of flour is 30%, which is less, than recommended by GSTU 46.004-99.

Table 5. Quality indicators of flour samples.

Sample No.	Product name	Moisture, %	Ash, %	Whiteness, convent. units	Size, %	
					Sieve N067 residue	Sieve N38 pass
1	milled wheat WGF	12,0	1,58	-29,0	6,0	60
2	wheat flour "whole-grain"	10,6	1,37	-9,5	0,2	49
3	milled spelta WGF	10,8	1,46	-2,7	3,0	56
4	milled spelta WGF	11,4	1,41	-0,5	1,0	50
5	coarse-grinded wheat flour "organic"	11,3	1,39	-0,5	--	30
6	wheat WGF	12,2	1,12	30,4	0,4	51
7	coarse-grinded wheat flour "special"	12,3	1,15	6,1	--	50
8	milled wheat WGF	10,9	1,26	-15,9	16	30
9	wheat WGF	12,8	1,13	19,7	0,6	62
GSTU 46.004-99 requirements for quality indicators of upholstery flour		< 15,0	< 2,0	Not limited	< 2,0	> 35

Judging from the ash and grain size indicators, several manufacturers in their production adhere to the principle of almost 100% of all anatomical components of the grain getting into WGF, but the grain size may be at or equal to the size of the size of the upholstered flour.

One of the main indicators characterizing the baking properties of flour is the amount and quality of crude gluten. The amount of gluten, as well as its quality depends on both the varietal characteristics of the grain, the conditions of its growth, and the size of the flour. In terms of grain quality, the approach to the selection of raw materials

from different suppliers is also heterogeneous. Some manufacturers get whole wheat flour from high quality wheat, which results in higher baking properties and the higher cost of such flour, while others follow the approach of using cheaper but weaker wheat. In addition to wheat, some manufacturers use expensive spelta wheat, which increases the nutritional value of bread and also affects the baking properties of flour.

According to the requirements of GSTU 46.004-99, the gluten content is limited to at least 18% (Fig. 2).

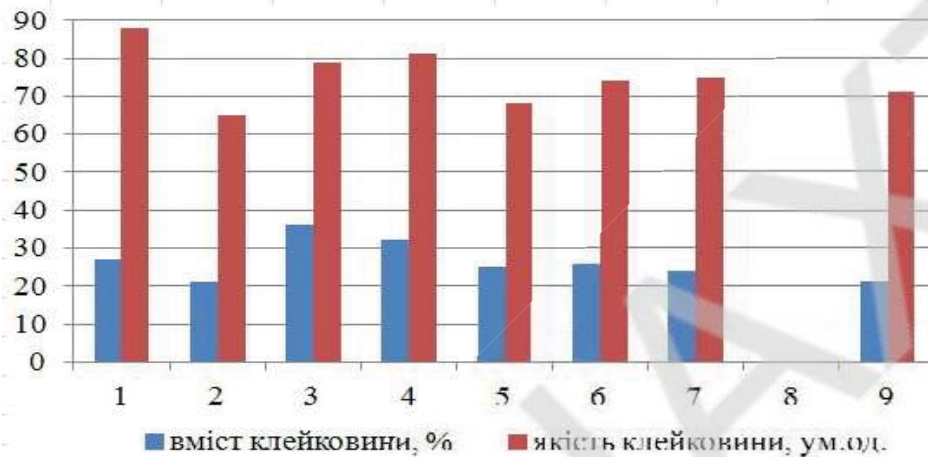


Fig. 2. Content and quality of raw gluten in studied flour samples.

The highest gluten content was observed in samples No. 3, 4 (spelta flour) – 32 and 34% respectively, in samples No. 1, 5, 6, 7 gluten content was 25-27%, the lowest crude gluten content was observed in samples No. 2 and 9 - 21%. In sample No. 8, gluten is not washed out.

The standard for the laboratory test baking method of bread (GSTU 27669-88) provides a non-hazardous way of preparing dough from flour, water, yeast and salt. The quality analysis of the finished products was performed according to organoleptic and physic-chemical indicators of quality. The results of the trial baking of bread from the samples of flour are shown in table 6.

Table 6. Physic-chemical indicators of bread from WGF

No.	Product name	Bread vol., cm ³	Porosity, %	Specific vol., cm ³ /g
1	milled wheat WGF	375	64	1,7
2	Wheat flour “whole-grain”	434	66	2,0
3	milled spelta WGF	500	69	2,2
4	milled spelta WGF	520	70	2,4
5	coarse-grinded wheat flour “organic”	455	70	2,1
6	Wheat WGF	590	75	2,8
7	coarse-grinded wheat flour “special”	475	70	2,1
8	milled wheat WGF	255	47	1,2
9	wheat WGF	430	68	2,0

The baked bread had a developed, uniform porosity, smooth, with no lateral detonations on the crust surface, had a pleasant taste and aroma. The largest volume of bread is observed in flour samples No. 3, 4, 6, 7. This is due primarily to the high content and quality of gluten (more than 24%) and the size of flour of the specified samples (passage of sieve No. 38 is 50-56%) . Bread porosity is in the range of 66-75%.

Sample flour No. 8 has the lowest volume of bread among the samples tested because it has the weakest protein complex that does not form a gluten framework. This bread has a low porosity of 47%.

WGF was obtained from two variants of technological schemes with different modes of grinding systems. The technological scheme according to option No. 1 (grinding No. 1.1-1.4) included four break grinding systems (B1, B2, B3, B4) on roller machines and one grinding system (St1) on a millstone. The technological scheme according to option No. 2 (grinding No. 2.1-2.3) included three break grinding systems (B1, B2, B3) on roller machines (whereby I and II break grinding systems were carried out without intermediate sieving) and two grinding systems (St1, St2) on a millstone.

According to the scheme option No. 1 at each of technological system the WGF was obtained by the using of sieves No. 1,0; 090; 080; 067; 063; 056. The overtail products, after the sieving of the flour, were directed for further grinding at subsequent systems. The final grinding of the brans obtained at the last roller mill system (B4) took place on a millstone (St1). Tables 7-10 show the balances of wheat WGF laboratory grindings according to scheme option No. 1.

In laboratory grinding No. 1.1 the following operative system modes (sieve release) were maintained: $SR_I = 34\%$, $SR_{II} = 58\%$, $SR_{III} = 57\%$. At the final grinding system the maximum amount of flour was selected. During the laboratory grinding No. 1.2 the operative modes at B3 and B4 were slightly higher than at the previous grinding: $SR_{III} = 41\%$, $SR_{IV} = 21\%$. The load on millstone system (St1) at grinding No. 1.2 was 13.8 %.

During laboratory grinding No. 1.3 low operating modes of the systems were maintained: $SR_I = 36\%$, $SR_{II} = 76\%$, $SR_{III} = 74\%$, $SR_{IV} = 86\%$. The load at St1 at this grinding was the lowest and equal 0.6 %. Laboratory grinding No. 1.4 is characterized by the following operation modes of the grinding systems: $SR_I = 26\%$, $SR_{II} = 53\%$, $SR_{III} = 36\%$, $SR_{IV} = 23\%$. In this grinding operation mode of B1 was the highest comparing to other grindings. The load on St1 at grinding No. 1.4 was the highest comparing to other similar laboratory grindings and equal 17,3 %.

Table 7 – Balance of laboratory grinding No. 1.1, %

System	System load, %	B2	B3	B4	St1	WGF
B1	100,0	66,0				34,0
B2	66,0		28,0			38,0
B3	28,0			12,0		16,0
B4	12,0				3,0	9,1
St1	3,0					3,0
Total		66,0	28,0	12,0	3,0	100

Table 8 – Balance of laboratory grinding No. 1.2, %

System	System load, %	B2	B3	B4	St1	WGF
B1	100,0	67,9				32,1
B2	67,9		29,8			38,1
B3	29,8			17,5		12,4
B4	17,5				13,8	3,7
St1	13,8					13,8
Total		67,9	29,8	17,5	13,8	100

Table 9 – Balance of laboratory grinding No. 1.3, %

System	System load, %	B2	B3	B4	St1	WGF
B1	100,0	63,6				36,4
B2	63,6		15,5			48,2
B3	15,5			4,0		11,5
B4	4,0				0,6	3,5
St1	0,6					0,6
Total		63,6	15,5	4,0	0,6	100

Table 10 – Balance of laboratory grinding No. 1.4, %

System	System load, %	B2	B3	B4	St1	WGF
B1	100,0	74,1				25,9
B2	74,1		34,8			39,4
B3	34,8			22,4		12,4
B4	22,4				17,3	5,2
St1	17,3					17,3
Total		74,1	34,8	22,4	17,3	100

In the next stage, the laboratory grinding of common wheat and spelta wheat grains into WGF according to the scheme option No. 2. It consisted of three roller mill grinding systems and two millstone grinding systems, and based on gradual-parallel grain grinding. On the roller mill grinding systems, WGF was selected by passage of flour sieves No. 38, which provided separation of pure flour. Larger fraction with brans in its composition was sent for further grinding. Balances of laboratory grinding of common wheat grain are given in Table 11-12, and for spelta wheat grain – in Table 13.

For laboratory grindings the sieve release on the first two systems SRI+II was gradually reduced: 54.6%, 48.8%, and 39.8% for grindings No. 2.1, 2.2, 2.3, respectively. As a result, the load on the millstone systems increased and the amount of flour obtained from the abrasion deformation also increased.

Table 11 – Balance of laboratory grinding No. 2.1, %

System	System load, %	B3	St1	St2	WGF
B1+B2	100	45,4		13,4	41,2
B3	45,4		10,1	2,7	32,6
St1	10,1			10,1	
St2	26,2				26,2
Total		45,4	10,1	26,2	100

Table 12 – Balance of laboratory grinding No. 2.2, %

System	System load, %	B3	St1	St2	WGF
B1+B2	100	51,2		13,4	35,4
B3	51,2		10,8	7,8	32,6
St1	10,8			10,8	
St2	32,0				32,0
Total		51,2	10,8	32,0	100

Table 13 – Balance of laboratory grinding No. 2.3, %

System	System load, %	B3	St1	St2	WGF
B1+B2	100	60,2		12,4	27,4
B3	60,2		16,6	10,5	33,1
St1	16,6			16,6	-
St2	39,5			-	39,5
Total		60,2	28,6	39,5	100

There were no significant difference in moisture content, ash content and gluten content between the obtained WGF samples (Table 14). Analyzing the obtained data it can be noted that the best sample for quality indicators and baking properties in the grinding scheme option No. 1 was a sample of whole grain flour from laboratory grinding No. 1.3. This is connected directly to the particle size of the flour: passage through the sieve No. 38 was 55 %, and the top of sieve No. 067 – 1.5 %, which indicates a more balanced particle size distribution. Bread volume for samples No. 1.1-1.4 fluctuated within 330-360 cm³, the porosity of the studied bread samples varied within 76-77 %. The worst quality had the sample of flour obtained as a result of laboratory grinding No 1.4, which is also related to its particle size.

Table 14 – Quality indicators of WGF

No. grindings	Moisture, W %	Ash content, Z %	Crude gluten		Granulatory, %		Physiochemical indicators of bread		
			content, %	gluten deformation index, units	top on sieve No. 067, %	passage through sieve No. 38, %	bread volume, cm ³	porosity, %	specific bread volume, cm ³ /g
1.1	12,9	1,68	17,1	71	4,3	44,3	350	75	1,5
1.2	12,5	1,68	17,0	70	4,9	40,8	350	75	1,5
1.3	12,8	1,67	17,1	71	1,5	55,0	360	77	1,6
1.4	13,0	1,68	17,2	72	11,0	36,0	330	75	1,4
2.1	12,8	1,68	17,4	70	1,3	64,3	430	79	2,0
2.2	12,6	1,68	17,2	68	3,4	60,1	400	79	1,9
2.3	11,3	1,81	39,6	106	1,6	50,3	380	67	1,8

The quality indicators of the common wheat whole grain flour obtained according to the scheme option No. 2 (grinding No. 2.1 and No. 2.2) differed with a smaller particle size of the flour: the top on sieve No. 067 was 1.3 and 3.4 %, respectively. The passage through sieve No. 38 had 64.3 % and 60.1 %, respectively. The obtained bread from these samples was characterized by good baking properties, a larger bread volume of 430 and 400 cm³, and a high porosity that corresponds with similar indicator from bread made of high-grade flours.

Particle size of spelta WGF was characterized by top on sieve No. 067 – 1.56 % and sieve No. 38 passage – 50.3 %. The content of crude gluten in the sample was 39.6 %, gluten deformation index (GDI) = 106 units. The high value of GDI resulted in worse baking properties compared to wheat flour obtained in the same scheme.

In the next phase of research, we investigated the rheological properties of WGF.

The set of obtained indicators allows to create a specific graphical profile for a particular flour or grain sample and describe its rheological characteristics in the way of consecutive 6 product quality indicators for easy comparison and use.

Flour samples selected for the study of rheological properties are presented in Table 15 and Figure. 3.

Mixolab profilers for industrial-grade flours and laboratory-grade flour indicate that the WAC index (1) varies over a wide range, from 1 to 8, due to fluctuations in the protein content of the grain, the number of damaged starch grains, and the number of shell particles. The degree of hydration influences all technological processes,

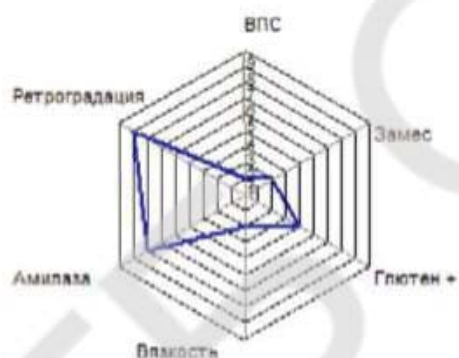
especially the mechanical mixing, the weight yield of dough and bread, the quality of the final product.

Table 15. Samples of flour that were examined on Mixolab

Sample No.	Product name	Trademark
1	Milled spelta WGF (upholstery)	Green Mill (TM)
2	Milled spelta WGF	Traditions bench (TM)
3	Coarse-grinded wheat flour organic	Eco-family (TM)
4	Wheat WGF	Alta-Vista (TM)
5	Coarse-grinded wheat WGF	Health formula (TM)
6	Wheat WGF	Laboratory grinding (No.1)
7	Wheat WGF	Laboratory grinding (No.3)
8	Wheat WGF	Laboratory grinding (No.4)
9	Wheat WGF	Laboratory grinding (No.5)
10	Spelta WGF	Laboratory grinding (No.7)

The highest value of the index 2 was noted in samples № 5, № 7-8. Interpreting the results of the analysis of the sample of flour on the mixolab chart, we can assume that the higher the water absorption index, the better the technological value of the sample. The kneading index (2) depends on the kneading behavior of the dough, especially the stability. The higher the index, the more stable the dough is during kneading. For baked bread, it is preferable to use flour with an index of 4-6. The smallest batch index 2 in samples № 1 and № 3.

Sample №1



Profile 1-24-278
Sample №3

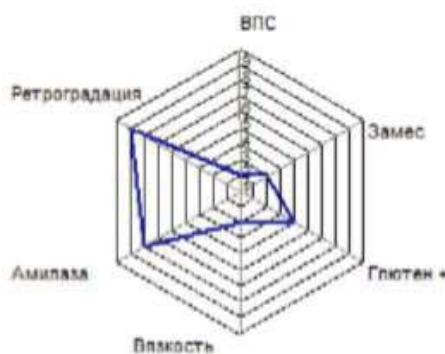


Profile 2-67-596

Sample №2

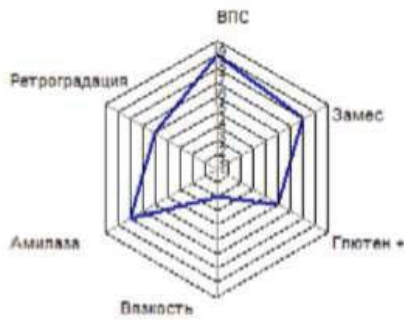


Profile 7-62-488
Sample №4

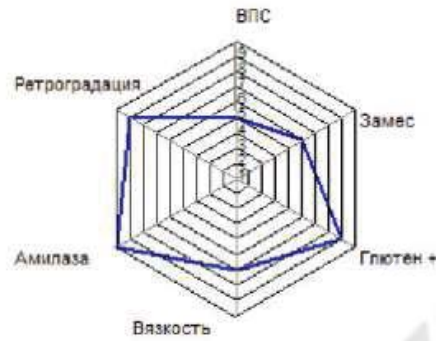


Profile 1-58-898

Sample № 5



Sample № 6



Profile 8-75-275

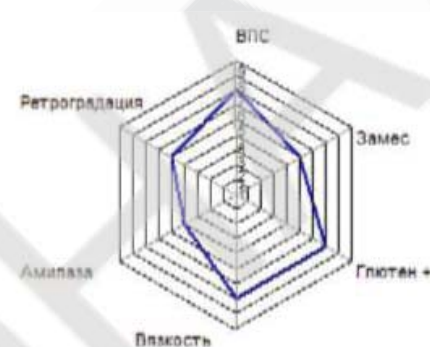
Profile 4-58-698

Fig. 3. Mixolab profiles of samples

Sample № 7



Sample № 8



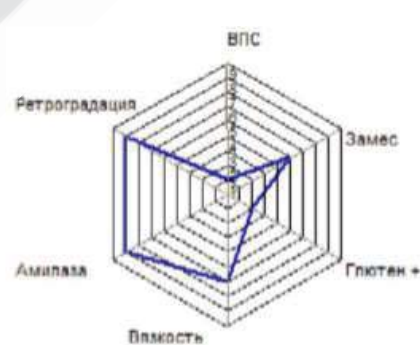
Profile 7-58-788

Profile 7-57-745

Sample № 9



Sample № 10



Profile 6-57-645

Profile 1-52-688

Fig. 3. Mixolab profiles of samples

The Gluten + index (№) depends on the links between the gluten molecules and has a significant impact on the volume of the final product. The higher the index on the initial phase of gluten + heating, the more stable the dough behaves when it is initially heated. The gluten + index in most samples was 7-8, exceptions are samples № 1, № 2 and № 10.

The viscosity index (4) depends on the structure and degree of damage to the starch. The lower the index, the higher the resistance of the test against attack by amylases. The low viscosity index of the dough is caused not by the high amylase

activity but by the features of the starch structure. In the above samples, the index ranges from 2 to 8.

The amylase index (5) mainly depends on the amount of α and β amylase. This index is based on the same interpretation as the traditional method for the analysis of amylolytic activity, the number of falls, namely: a high index of amylolytic activity of Mixolab will correspond to a high value of the number of falls, therefore, a weak activity of alpha-amylase (hypodiasis) and vice versa (hyper). Samples № 8 and № 9 have an index value above 4, other index values for other samples range from 7 to 8, and the samples have low amylase activity.

The Retrogradation Index (6) indicates how fast the bread stems, the hardness of the bread crumb, and the softness of the crust. Samples №№. 5, 8, 9 have index values of 5, which indicates a longer shelf life and freshness of whole grain bread.

V. Conclusions

Wheat and spelta WGF is popular among the population of many countries in the world. Ukrainian state standards for wheat WGF are absent for this moment. DSTU 46.004-99 «Wheat flour. Specifications» apply only to high-grade flour and dark flour. The research of technological, baking quality indicators of wheat and spelta WGF and the indicators of baked bread showed completely different end-results, due to different technological approaches for its production and lack of general normative documentation.

For the production of WGF, it is most appropriate to use combined technological schemes with the usage of roller machines as grinding equipment on the main systems of the technological process and millstones at the ending systems for the final grinding of intermediate products.

Based on the conducted researches it is advisable to use the scheme, which consists of 3-4 roller mill grinding systems and 1-2 millstone grinding systems with sequentially grinding. The following operative modes of systems (passage through sieve No. 067) are recommended: $SR_{II} = 30-40 \%$, $SR_{III} = 60-70 \%$. The operation mode of other systems must be such as to ensure maximum extraction of WGF.

It was found that the particle size of wheat WGF, which is controlled by the top on sieve No. 067, must be not more than 2.0 %, while the passage through sieve No. 38 must be not less than 50 %.

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