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Flour and Bread Quality of Spring Spelt

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***Abstract*—**The article contains results of the flour and bread quality assessment from the grains of spring spelt, also called as an ancient wheat. Spelt was cultivated on heavy and medium soils observing principles of organic farming. Based on flour and bread laboratory studies, as well as laboratory baking, the technological usefulness of studied flour has been determined. These results were referred to the standard derived from common wheat cultivated in the same conditions. Grain of spring spelt is a good raw material for manufacturing bread flour, from which to get high-quality bakery products, but this is strictly dependent on the variety of ancient wheat.

***Keywords*—**Bread, dark flour, wholemeal, flour quality, spelt

I. Introduction

SPELT is one of the oldest species of wheat. Ancient wheat (*Triticum aestivum ssp. spelta*) has been already known about 7,000 BC, and widely cultivated in ancient and medieval Europe [1;2]. It belonged to the most important cereals cultivated in Europe until the twentieth century, mainly in German-speaking Alpine countries, like Switzerland, Austria, and Germany. In the south of Germany still in the early twentieth century spelt was grown more than ordinary wheat [3;4].

Today in Europe spelt of winter varieties is grown on a large area (Belgium, Italy, Spain, Hungary, Poland, Slovakia) [5;6]. On the contrary, spring crops, by nature characterized by very good technological parameters, are not known in practice.

Needs of farming and processing practices were the direct reason for starting research in this area. Until now, a lot of data has been obtained on the rules of winter spelt crops cultivation, with particular emphasis on selection of varieties, as well as determining technological parameters and nutritional values [7-9]. Still, very little is known yet about the spring spelt.

In Poland, sowing of spelt was abandoned even in the Middle Ages, and the rebirth of its crops at the beginning of 80s last century is mostly associated with movement of organic farming [10;11]. With the increase of areas under cultivation, demand for information about varieties, cultivation practices, as well as technological and nutritional qualities is increasing.

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In the research project (Grant of the Ministry of Agriculture and Country Development, Nr RR-re-029-16-2784/10: *Organic cultivation of spelt and its technological value assessment*), aimed at improvement of agricultural technology rules of spring spelt grown in organic farming and to determine its health and productive potential in relation to common wheat, the qualities of flour and bread from the spring spelt were taken to assess [12].

II. Material And Methods

A. Field experience. Material

Field experiments were carried out on medium and heavy soil on certified organic farms (AgroBioTest No: Pl - 07-90013/09; AgroBioTest No: Pl - 07-93011/09). The following three families of spring spelt have been practiced: UWM 10, UWM 12, UWM 13. The Bombona ordinary wheat was used as a reference, characterized by high health, good yielding in organic farming, as well as high-quality grain and flour.

B. Laboratory Studies of Flour

Both spelt and wheat grains were cleaned, followed by milling to yield two types of flour: a dark flour and a wholemeal [13]. The following parameters were determined in both spelt and wheat samples: moisture [%] [14], acidity [as its degree] [15], total ash content [%] [16], starch [%] according to Lintner, falling number [s] [17], Total nitrogen per proteins [%] using Kjeldahl method [18], water absorption [%] according to Sadkiewicz [19], quantity [g] and quality of wet gluten: flexibility [degrees] and deliquescence [mm], fermenting properties: CO_2 volume retained in dough [cm^3], total CO_2 volume [cm^3], total fermentation time [mins] [20].

C. Laboratory Studies of Bread

Two loaves of bread were baked from each of flour samples. Test baking was performed using the direct method of the Bakery Institute in Berlin. After 24-hours cooling at ambient temperature, organoleptic, physicochemical and bread scoring analyses were evaluated. The following parameters were identified: moisture [%], bread acidity [deg acidity], volume [cm3/100g], dough yield [%], bread yield [%], stove loss [%], total stove loss [%]. Also a bread point evaluation was made after 24 hours (assessment of appearance, crust, crumb, taste and smell) [22].

D. Statistical Analysis of Data

Data were analysed using one-way ANOVA analysis of variance, which classifying of $P < 0.05$ as statistically significant.

III. Results and Discussions

A. Spelt Flour Baking Values

1. Physical and chemical properties of flour

Table I presents physical and chemical properties of flour. Moisture of the spelt flour did not depend on its family and its type, as did not differ from the results obtained for wheat flour. Spelt flour had, however, higher acidity (5.0 ÷ 7.4) compared to flour obtained from wheat (3.9 ÷ 4.9). Acidity of wholemeal flour was higher than dark flour. In all cases, the acidity is consistent with the standard and did not exceed 8 degrees (Table I).

Contents of mineral compounds as total ash in the test flours varied depending on the type of flour and wheat varieties. The values obtained testified that these were the dark flours, corresponding to type 1400 and 2000 [13]. There were no differences in total ash content between cultured families. In most cases, spelt flours were characterized by a higher compactness of total ash 1,3-2,4%, compared to wheat flour. Ruibal-Mendieta et al [23], by comparing the nutritional value of flours derived from spelt and winter wheat and their products, gained as much as 30-60% higher concentrations of minerals in the spelt products.

Physicochemical parameters of surveyed flours, such as moisture, acidity and ashing were not dependent on type of soil.

TABLE I
PHYSICAL AND CHEMICAL PROPERTIES OF FLOUR

Features	Variety of wheat	Soil medium		Soil heavy	
		Flour dark	Flour wholemeal	Flour dark	Flour wholemeal
Humidity [%]	UWM - 10	12.4 ± 0.12^{a}	11.4 ± 0.11^{a}	11.8 ± 0.11^{a}	12.0 ± 0.09^{ab}
	UWM - 12	11.1 ± 0.11^{b}	11.3 ± 0.10^{a}	11.7 ± 0.10^{a}	12.5 ± 0.08^{a}
	UWM - 13	13.4 ± 0.12^{c}	12.7 ± 0.09^{b}	11.3 ± 0.11^{b}	11.9 ± 0.12^{b}
	Bombona	12.4 ± 0.09^{a}	13.1 ± 0.08^{c}	11.9 ± 0.12^{a}	12.1 ± 0.11^{a}
Acidity [degrees of acidity]	UWM - 10	5.5 ± 0.06^{a}	6.8 ± 0.12^{a}	6.3 ± 0.06^{a}	7.4 ± 0.08^{a}
	UWM - 12	5.0 ± 0.08^{b}	5.3 ± 0.07^{b}	5.2 ± 0.08^{bA}	5.7 ± 0.07^{b}
	UWM - 13	5.4 ± 0.07^{a}	6.4 ± 0.08^{c}	5.2 ± 0.08^{cA}	6.2 ± 0.06^{c}
	Bombona	4.4 ± 0.04^{c}	4.9 ± 0.07^{d}	3.9 ± 0.07^{d}	4.1 ± 0.09^{d}
Total ash content [%]	UWM - 10	1.3 ± 0.03^{a}	$2,4 \pm 0.05^{a}$	1.5 ± 0.07^{a}	2.3 ± 0.05^{a}
	UWM - 12	1.3 ± 0.06^{aA}	$2,3 \pm 0.07^{b}$	1.5 ± 0.08^{a}	2.3 ± 0.04^{a}
	UWM - 13	1.5 ± 0.08^{b}	$2,4 \pm 0.06^{a}$	1.5 ± 0.06^{a}	2.3 ± 0.05^{a}
	Bombona	1.3 ± 0.06^{cA}	$2,1 \pm 0.06^{c}$	1.4 ± 0.05^{b}	1.9 ± 0.07^{b}

Results are expressed as mean ± standard error (n = 6). Data were analysed by means of one-way ANOVA. Mean values in the same row for a particular medium with the same lowercase superscripts are not significantly different (P > 0.05). UWM-10, UWM-12, UWM-13: farm families winter spelt. Bombona: spring wheat habits.

2. Selected Properties of Flour Starch

Table II shows the total starch content in the tested spelt flours, which varied depending on the family, soil type and the type of flour. In most cases, dark flour contained a higher total amount of starch than wholemeal flour. The highest starch content was determined in the flour originating in UWM 13. Flour obtained from grain grown on the medium soil contained more starch (49,6-69,2%) than the flour from grains cultivated on heavy soil (41,6-47,6%).

Falling number is a parameter that indicates activity of amylolytic enzymes in flour and indirectly refers to its suitability for baking. The correct level of value of this parameter in the range of 200-400 s. Wheat flour falling numbers above 300 are characterized by low activity of α-amylase, and as result should be used to develop blends. Falling number of all tested spelt flours exceeded this value, and in most cases was over 400 s. The UWM 12 flour acquired the lowest and most advantageous falling number from the technological point of view, indicating the average amylolytic activity (Table 2).

Falling number values depended on soil type, and were lower in the case of flour derived from the grain grown on the medium soil. Spelt flour falling number was significantly higher compared to wheat flour. Similarly, high values of this parameter were also obtained by Bojňanská and Frančáková [24], Capouchová [25] and Marconi et al [26] in their investigations.

3. Quantity and Quality of Flour Protein

Total protein content and yield of wet gluten are important indicators of the value of baking flour [24]. Total protein contents in the tested flours ranged 11-13,2% and depended on the family and the type of flour, but did not depend on the type of soil (Table 3). Spelt flour contained more total protein than flour of wheat. The greatest amount of protein was determined in the flour from the grains of UWM 10. The dark flour contained more protein than the wholemeal flour. These findings follow in accordance with the research of many authors who also demonstrate higher content of total protein in spelt as compared to common wheat [25, 26].

The quantity and quality of wet gluten is an indicator of the value associated with baking. Wet gluten plays a crucial role in creating of dough and baking bread. It affects the stability of the dough and bread volume, forming the skeleton of wheat dough that combines the remaining ingredients and additives to the dough. With the rise of flour ashing, the gluten content is also increased. In the case of dark flour, gluten content ranged from 24.1 to 42.8% and did not depend on the family and the type of soil. The spelt gluten was characterized by good quality, comparing with wheat flour gluten that achieved a good and sufficient quality. The high content of gluten (so

called, strong flour) requires larger, colder water refills and much longer kneading the dough.

Water absorption of flour, shaping the dough properties and baking performance, should be within the range from 50 to 60%. The samples of spelt flour were characterized by higher water absorption ranging from 61.2 to 67.7%. The highest value of this parameter was determined for the flour type UWM 13. Spelt flour had higher water absorption compared with wheat flour, with the dark flour showing a lower water absorption compared to wholemeal flour. Soil type had no effect on the size of this parameter.

TABLE II
AMOUND AND QUALITY OF STARCH FLOUR

Features	Variety of wheat	Soil medium		Soil heavy	
		Flour dark	Flour wholemeal	Flour dark	Flour wholemeal
Starch content [%]	UWM - 10	51.6 ± 2.16 [a]	49.6 ± 0.91 [a]	41.6 ± 1.16 [a]	43.6 ± 2.14 [a]
	UWM - 12	57.6 ± 1.15 [b]	55.6 ± 1.15 [b]	46.4 ± 2.13 [b]	37.6 ± 1.16 [b]
	UWM - 13	69.2 ± 2.12 [c]	55.6 ± 0.87 [b]	47.6 ± 0.90 [b]	43.6 ± 0.15 [a]
	Bombona	47.6 ± 0.19 [a]	51.6 ± 1.17 [a]	60.4 ± 0.18 [c]	52.4 ± 1.15 [b]
Falling number [s]	UWM - 10	408.5 ± 5.75 [a]	401.5 ± 6.33 [a]	446.0 ± 2.12 [a]	530.5 ± 2.51 [a]
	UWM - 12	379.0 ± 3.14 [a]	380.0 ± 4.10 [a]	418.0 ± 4.19 [b]	398.0 ± 5.43 [b]
	UWM - 13	413.5 ± 6.2 [a]	427.0 ± 3.67 [a]	432.0 ± 1.49 [c]	425.0 ± 6.89 [c]
	Bombona	274.0 ± 7.12 [b]	260.0 ± 4.51 [b]	421.5 ± 9.76 [d]	369.0 ± 7.13 [c]

Results are expressed as mean ± standard error (n = 6). Data were analysed by means of one-way ANOVA. Mean values in the same row for a particular medium with the same lowercase superscripts are not significantly different (P > 0.05). UWM-10, UWM-12, UWM-13: farm families winter spelt. Bombona: spring wheat habits.

TABLE III
CHARACTERISTIC AMOUND AND QUALITY OF FLOUR PROTEIN

Features	Variety of wheat	Soil medium		Soil heavy	
		Flour dark	Flour wholemeal	Flour dark	Flour wholemeal
Total protein content [%]	UWM - 10	13.2 ± 0.98 [a]	12.5 ± 0.17 [a]	13.2 ± 1.05 [a]	11.8 ± 0.70 [a]
	UWM - 12	11.3 ± 0.74 [b]	11.5 ± 1.24 [a]	12.3 ± 0,16 [a]	10.8 ± 1.53 [b]
	UWM - 13	12.1 ± 0.18 [a]	11.4 ± 0.16 [a]	13.1 ± 0.84 [a]	11.0 ± 1.01 [b]
	Bombona	11.8 ± 0.80 [b]	10.6 ± 1.08 [b]	11.1 ± 0.79 [b]	10.3 ± 0.82 [b]
Gluten content [g]	UWM - 10	24.1 ± 0.72 [a]	-	37.2 ± 0.56 [a]	-
	UWM - 12	39.8 ± 0.14 [b]	-	42.8 ± 0.92 [b]	-
	UWM - 13	39.2 ± 0.65 [c]	-	35.5 ± 0.87 [a]	-
	Bombona	39.2 ± 0.93 [b]	-	22.7 ± 1.12 [c]	-
Gluten quality - flexbility [degrees]	UWM - 10	2.0 ± 0.08	-	2.0 ± 0.07	-
	UWM - 12	2.0 ± 0.02	-	2.0 ± 0.04	-
	UWM - 13	2.0 ± 0.06	-	2.0 ± 0.08	-
	Bombona	2.0 ±0.02	-	3.0 ± 0.05	-
Gluten quality – deliquescence [mm]	UWM - 10	5.0 ± 0.07	-	3 .0 ± 0.02	-
	UWM - 12	3.0 ± 0.08	-	3.0 ± 0.06	-
	UWM - 13	8.0 ± 0.05	-	2.0 ± 0.07	-
	Bombona	8.0 ±0.10	-	1.0 ± 0.05	-
Water absorption [%]	UWM - 10	61.3 ± 2.14 [a]	64.6 ± 0.75 [a]	64.8 ± 0.12 [a]	64.7 ± 1.10 [a]
	UWM - 12	61.8 ± 0.19 [a]	64.0 ± 0.48 [a]	62.6 ± 0.19 [b]	63.7 ± 1.07 [a]
	UWM - 13	64.9 ± 0.47 [b]	67.7 ± 0.69 [b]	64.7 ± 0.35 [a]	67.6 ± 1.13 [b]
	Bombona	60.6 ± 0.69 [a]	60.9 ± 0.16 [c]	63.3 ± 0.42 [b]	62.7 ± 0.39 [a]

Results are expressed as mean ± standard error (n = 6). Data were analysed by means of one-way ANOVA. Mean values in the same row for a particular medium with the same lowercase superscripts are not significantly different (P > 0.05). UWM-10, UWM-12, UWM-13: farm families winter spelt. Bombona: spring wheat habits. Not determined gluten content and gluten quality in flour wholemeal (not standardized). In the wholegrain flours surveyed determining the amount and quality of gluten abandoned, due to the difficulty in washing gluten, associated with the presence of significant quantities of seed coat.

4. Fermentation Capacity of Flour

Figure 1 presents the summary of test results of fermentograph. The amount of gas retained in dough determines the optimal leavening of dough while ensuring an appropriate amount of evolved CO_2. Studies show that wholemeal flour obtained from the grain cultivated on the medium soil revealed a greater ability to CO_2 retention then dark flour received from the grain cultivated on the heavy soil.

B. Laboratory Baking Test and Point Evaluation

1. Physical and Chemical Properties of Bread

Table 4 shows physical and chemical properties of bread. Spelt bread moisture content amounted from 43,17 to 44,50% and did not depend on variety and family of the wheat but depended on the flour type. The bread made of the wholemeal flour had higher moisture content then from the dark flour and the highest moisture content was determined in the wholemeal bread baked from grains harvested on the medium soil field.

Also the spelt bread acidity depended on type of flour and type of soil. The wholemeal bread and that baked of grain from the heavy soil had higher acidity than the others. In most cases the spelt bread had higher acidity (2,6–3,8°) than that baked of the common wheat flour (2,3–3,2°).

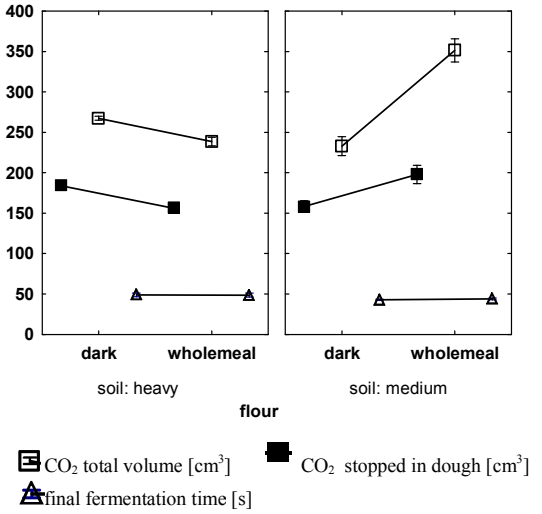

Fig. 1 Summary of test results of fermentograph: CO_2 stopped in dough [cm^3], CO_2 total volume [cm^3] and final fermentation time [s]. Results are expressed as mean ± standard error (n = 9).

TABLE IV
PHYSICAL AND CHEMICAL PROPERTIES OF BREAD

Features	Variety of wheat	Soil medium		Soil heavy	
		Flour dark	Flour wholemeal	Flour dark	Flour wholemeal
Humidity [%]	UWM - 10	43.37 ± 1.01 [a]	44.12 ± 0.85 [a]	43.35 ± 1.48 [a]	43.79 ± 2.59 [a]
	UWM - 12	43.70 ± 0.98 [a]	44.50 ± 1.36 [a]	43.82 ± 2.74 [a]	43.90 ± 1.65 [a]
	UWM - 13	43.36 ± 2.54 [a]	44.10 ± 2.51 [a]	43.17 ± 0.88 [a]	43.67 ± 0.95 [a]
	Bombona	43.79 ± 1.75 [a]	44.78 ± 1.72 [a]	43.10 ± 2.21 [a]	43.78 ± 1.75 [a]
Acidity [degrees of acidity]	UWM - 10	2.6 ± 0.02 [a]	3.4 ± 0.07 [a]	3.2 ± 0.08 [a]	3.8 ± 0.04 [a]
	UWM - 12	2.6 ± 0.06 [a]	2.5 ± 0.05 [b]	2.7 ± 0.05 [b]	3.2 ± 0.07 [b]
	UWM - 13	2.7 ± 0.09 [a]	3.3 ± 0.02 [a]	2.7 ± 0.04 [b]	3.1 ± 0.06 [b]
	Bombona	2.3 ± 0.07 [c]	2.6 ± 0.09 [b]	2.3 ± 0.06 [c]	3.2 ± 0.0 [b]
Bread volume [cm^3/100 g]	UWM - 10	230.1 ± 2.08 [a]	260.2 ± 1.71 [a]	309.4 ± 3.74 [a]	259.5 ± 0.99 [a]
	UWM - 12	261.6 ± 1.87 [b]	227.2 ± 3.52 [b]	324.2 ± 1.56 [a]	359.2 ± 2.34 [b]
	UWM - 13	268.1 ± 1.07 [b]	237.1 ± 1.02 [b]	237.7 ± 3.04 [b]	202.8 ± 3.87 [c]
	Bombona	267.0 ± 0.95 [b]	199.6 ± 2.08 [c]	237.1 ± 1.75 [b]	322.4 ± 1.77 [b]

Results are expressed as mean ± standard error (n = 6). Data were analysed by means of one-way ANOVA. Mean values in the same row for a particular medium with the same lowercase superscripts are not significantly different (P > 0.05). UWM-10, UWM-12, UWM-13: farm families winter spelt. Bombona: spring wheat habits.

The assumed dough yield amounted to 165%, and the real one was lower (in the range of 159 to 161%); the yield of the bread was in the range of 134 to 147%.

2. Laboratory Baking Test

Figure 2 presents results of test baking.

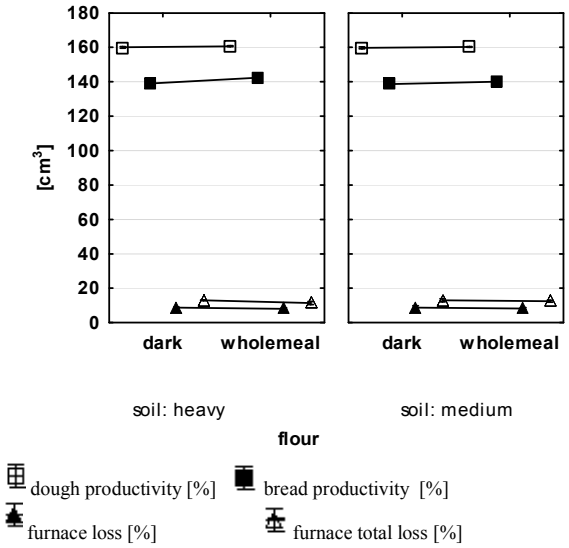

Fig. 2 Results of test baking: dough productivity [%], bread productivity [%], furnace loss [%] and furnace total loss [%]
Results are expressed as mean ± standard error (n = 9)

Variety and family of the cereal, and also the soil type did not influenced dough and bread yield. Volume of the bread amounted from 203 to 309 cm^3/100 g and did not differ to the common wheat bread volume (Table 4). Bojňanská and Frančáková [24] fund significantly lower volume of spelt bread than of common wheat.

The oven loss of spelt bread was determined in the range from 6,80 to11,22%, and the total oven loss – from 8,68 to 15,54% (Figure 2). Both parameters did not differ to the parameters values found for bread baked of common wheat; they did not depend on the soil type and type of flour.

3. Point Evaluation of Bread

Spelt bread gained from 23 to 37 points (Table 5). Bread baked of UWM 10 cultivated on heavy soil gained the highest results (37) and these were lower than those found for common wheat bread cultivated on the same type of the soil (38 – 39). Also, the bread baked of UWM 12 cultivated on medium soil gained high note (36). For bread made of UWM 13 cultivated on both types of soil and of UWM 12 from heavy soil considerable divergence of point assessment has been noted in dependence on the type of the flour.

TABLE V
EVALUATION POINT OF BREAD

Features	Variety of wheat	Soil medium		Soil heavy	
		Flour dark	Flour wholemeal	Flour dark	Flour wholemeal
Piont evaluation	UWM - 10	34 ± 1.13 [a]	34 ± 0.85 [a]	37 ± 0.75 [a]	37 ± 1.29 [a]
	UWM - 12	36 ± .0.98 [b]	36 ± 2.47 [b]	34 ± 1.71 [b]	23 ± 3.62 [b]
	UWM - 13	33 ± 2.62 [a]	37 ± 3.21 [b]	26 ± 3.87 [c]	29 ± 0.69 [c]
	Bombona	37 ± 1.72 [b]	28 ± 2.40 [c]	39 ± 1.19 [a]	38 ± 2.65 [a]
Bread class	UWM - 10	II	II	I	I
	UWM - 12	I	I	II	II
	UWM - 13	II	I	III	III
	Bombona	I	III	I	I

Results are expressed as mean ± standard error (n = 6). Data were analysed by means of one-way ANOVA. Mean values in the same row for a particular medium with the same lowercase superscripts are not significantly different (P > 0.05). UWM-10, UWM-12, UWM-13: farm families winter spelt. Bombona: spring wheat habits.

4. Class of Bread

Spelt bread has been classified to I, II and III class (Table 5) according to to cereal family and soil type. Only bread made of wholemeal flour prepared from cereals cultivated on medium soil was classified better than that made of common wheat; all other kinds of breads were classified with the same or lower class than bread made of Bombona.

IV. Conclusion

Grain of the spring spelt has been proved to be a good material for bread flour, with variations according to the variety. Type of soil has no influence on the following physic-chemical properties of spelt flour, as moisture, acidity, ash content, total protein, gluten, and such parameters of bread baking process, as dough and bread yield. The flour made of spelt of UWM 10, UWM 12 and UWM 13**,** contained more ash, total protein, had higher water-absorption acidity and gluten of good quality, in comparison with common wheat flour.Bread of the quality similar or even better to that baked of the common wheat flour can be produced from flour made of grain of spring spelt wheat. Bread baked of UWM 10 spelt wheat cultivated on heavy soil and of UWM 12 from medium soil have both been classified as the 1st class. Bread made of UWM 10 cultivated on heavy soil gained the best opinion by the point assessment.

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