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## STUDIES ON THE SUITABILITY OF TRITICALE FOR STARCH PRODUCTION

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Key words: triticale, chemical composition of grain, physico-chemical characteristics of starch, suitability for starch-manufacturing industry.

53 varieties of triticale were examined in respect of the chemical composition of grain and the selected physico-chemical properties of starch. The results made it possible to select 20 varieties featuring the best technological qualities for use in the starch-manufacturing industry. Attention was paid to the high viscosity of starch pastes of triticale.

### INTRODUCTION

For many years, cultivation work has been conducted in Poland with the aim to obtain own varieties of triticale, characterized by good functional qualities [5, 6, 14, 16, 17, 19, 21, 22, 23]. The results achieved so far make it possible, to expect that triticale will be widely grown in our country due to proper climate and soil conditions.

Triticale has been utilized so far mainly for feeding purposes, e.g. as a component of concentrates, due to the high level of protein (11.8-22.5%) [7], and to a lower degree, as a component of flour mixtures for baking purposes [7]. Tests were also made to use triticale for industrial purposes e.g. for the production of beer [4, 12, 18]. There are no information concerning the use of this cereal in the starch-manufacturing industry.

Literature provides little information on the starch of triticale. Haber [7] reports that starch content in the grains of triticale ranges within 49-57%. Other authors found 73-82% of starch in triticale flour [1, 9]. The same authors report that triticale starch contains about 23% amylose.

Besides, triticale starch contains the following accompanying non-car-

bohydrate components: 0.39% ash [1] including total P — 0.042% [2, 18]; 0.78% fat [2, 18] and total N — 0.04% [2, 18].

In terms of physical properties of starches from triticale, studied were: the size and shape of grains [9], pasting temperature [11] and viscosity of water pastes [1].

In terms of grain size, starch of triticale occupies an intermediate position between rye and wheat [9]. The shape of triticale grains is similar to that of rye starch grains [9].

The range of the pasting temperature, defined by Lii and Lineback [11] was 53.0-61.5°C. Berry and d'Appolonia [1], when examining the consistency of 4.44% starch dispersions in Brabender viscosimeter, obtained the result of 55°C for the pasting temperature of triticale starch. In these experiments, triticale starch, the two authors obtained the following results triticale starch: viscosity maximum — 800 B.U. whereas viscosity at 50°C was 695 B.U.

The few data found in literature on triticale starch all come from foreign authors who studied varieties of this cereal, grown in their respective countries. The purpose of the present work was to study the Polish varieties of triticale in respect of the physico-chemical properties of their starch, and the suitability of triticale grains for the production of starch.

## MATERIALS

The material for the experiment was composed of grains and starches isolated from 48 winter and 5 spring varieties of triticale (Table 1), cultivated in Poland by the following institutions:

1. Institute for Plant Breeding and Seed Production of the Academy of Agriculture in Lublin, varieties marked with CR symbol;
2. Station of Plant Breeding in Laski — LT symbol;
3. Experimental Station of Plant Breeding and Acclimatization in Grodkowice — B and BF symbols;
4. Station of Plant Breeding in Choryń — CT symbol;
5. Experimental Station for Plant Breeding and Acclimatization in Małyszyn — varieties marked with MT symbol and 5 spring varieties.

All the above mentioned winter varieties and the "Grana" variety of wheat treated as standard, were seeded in the years 1978 and 1979 during a field collective experiment conducted in the Experimental Station for Plant Breeding and Acclimatization in Małyszyn. Samples for the examination were taken in a state of hard ripeness.

Table 1. Presentation of the examined varieties of triticale

Symbol of variety	Year of cultivation	Genetic origin
CR-130	1978	Sub-lines of hybrides: triticale Muntzinga 8 × (Sweden) × triticale Nakajima 6 × (Japan) × triticale Kissa 6 × (Hungary)
CR-131	1978	
CR-131	1979	
CR-146	1978	
CR-146	1979	
CR-141	1979	
CR-64	1979	
CR-10	1978	triticale Nakajima 6 × triticale Kissa 6 ×
CR-11	1978	
CR-294	1978	
CR-384	1978	
CR-384	1979	
CR-440	1979	
CR-516	1979	
LT-363/75	1978	triticale USA 6TA131 × triticale Hungary T57 × triticale USA 6TA 206
LT-363/75	1979	
LT-176/73	1978	Hungarian triticale T57 × Winter wheat C 1218/67 × triticale USA 6 TA206
LT-176/73	1979	
LT-404/76	1979	
LT-349/74	1979	
LT-695/75	1978	
LT-173/73	1968	
LT-259/72	1978	
LT-142/75	1978	Hungarian triticale T64 × Winter wheat C 1218/67 Hungarian triti- cale T64 × Winter wheat "Grana"
LT-59/76	1979	
LT-17/76	1979	
LT-850/74	1978	Hungarian triticale T64 × Rye Car- sten Rogen × triticale USA 6 TA 131
B-866/GR	1978	reselection from hexaploidal tri- ticale deriving from USA
BF-866	1979	
B-426/1/GR	1978	
BF-426/1	1979	
B-277/GR	1978	hexaploidal triticale × Triticale villax × hexaploidal triticale
B-951	1979	Hexaploidal triticale × Triticale aestivum
B-2061/GR	1978	

Symbol of variety	Year of cultivation	Genetic origin
CT-113/76	1979	selection in Mexico population M <sub>2</sub> A — 274/320
CT-93/76	1979	
CT-252/76	1979	triticale from Canada 6A298 × × Winter wheat Choryń C954/72 × triticale from Laski LT310/72*)
MT-29-515	1978	materials deriving from Hungary
MT-29-515	1979	
MT-35-501	1978	
MT-24-501	1978	
MT-24-501	1979	
MT-20-520	1978	
MT-3-519	1978	
MT-15-502	1978	
MT-3-128	1979	
MT-117/58	1979	
MT-115/50	1979	Hybrides obtained in Małyszyn from Hungarian materials
6036-500	1979	Spring triticale — materials deriv- ing from Mexico
6TA-204	1979	
5977-500	1979	
6022-500	1979	
6000-500	1979	
Standards:		
winter wheat	1978	"Grana"
winter wheat 8	1979	"Grana"

\*) Hungariana T57 × Dańkowskie Złote rye

## METHODS OF THE EXPERIMENT

### ANALYSIS OF THE GRAIN

Analysis of the grain covered the determination of fat, protein, starch and cellulose content in an analyser produced by Neotec company \*).

Starches were isolated by a laboratory method from the parallel mean samples of all varieties of triticale [13] and arially dried samples were subjected to analysis.

\*) Analysis conducted at the Institute of Plant Breeding and Acclimatization in Cracow.

## ANALYSIS OF STARCH

The analysis of starch covered the following determinations:

1) dry matter content by drying of about 0.5 g starch at 130°C [8] for 1 hour;

2) protein content by Kjeldahl method [13];

3) fat content by the extraction method according to Soxhlet [13];

4) ash content by the dry combustion method [13];

5) sum of carbohydrate content by the modified anthrone method of Samotus and Kujawski [15]. A weighed portion (0.05 g in terms of dry matter) was transferred with 0.1 n H<sub>2</sub>SO<sub>4</sub> to a 50-ml measuring flask and heated on boiling water bath for 40 minutes. After cooling, 0.1 n H<sub>2</sub>SO<sub>4</sub> was supplemented to the mark and centrifuged in centrifuge type 310 for 5 minutes at 15 000 r.p.m. The obtained solution was used for colorimetric determinations. The results of this analysis are a measure of purity of starch preparations;

6) mean molecular weight by the potentiometric titration method acc. to Čeh [3];

7) granularity of starch on a sedimentation "Sartorius" balance, using anhydrous ethyl alcohol as a liquid phase. The density of suspension of triticale starch in anhydrous ethyl alcohol, determined by the pycnometric method for 12 samples of this starch, was 1.6268 g/cm<sup>3</sup>. Irrespectively of the analysis of graininess performed by the sedimentation method, the determination of the range of grains' size was conducted using a projection microscope;

8) pasting characteristics of 7.4% water dispersions of starch in rotatory viscosimeter Rheotest 2. The viscosimeter used for determinations, was modified according to the suggestion of Koubek [10] by adding an stirrer in order to mix the starch suspensions. The determination of pasting characteristics was performed on the basis of Winkler method [20] but the change of stirrer into a measuring cylindrical (S2) was done when  $\alpha = 1$  (one on the scale of the device). The readout of temperature at this moment was considered to be the pasting temperature. During the heating of the suspension, the temperature was increased from 50 to 96°C, averagely 1°C/min. Then the pastes were held at 96°C for 20 minutes and after this period, they cooled to 50°C (averagely by 3°C/min);

9) degree of water binding and solubility at 60°C on the basis of F. Schierbaum method [13].

## DISCUSSION OF THE RESULTS

Characteristics of the properties of triticale grains are given in Table 2. The obtained results demonstrate the significant differentiation of the

Table 2. Characteristics of triticale grain

Examined property	Mean value	Range of variation	Standard "Grana" wheat	
			I(1978)	II(1979)
Fat content, %	1.30	0.79-1.63	2.01	2.04
Protein content, %	12.25	9.90-15.14	8.88	9.62
Starch content, %	82.13	78.34-84.55	81.15	82.15
Cellulose content, %	2.94	2.38-3.81	4.08	4.32
Crop of grain at 15% water content (t/ha)	in 1978	4.18	3.07-5.67	5.56
	in 1979	6.90	5.84-8.00	—
Crop of starch (t/ha)	in 1978	3.41	2.55-4.72	4.51
	in 1979	5.73	4.79-6.66	—

examined properties in all the analysed varieties. Mention is due to the high level of starch in the studies samples of triticale.

Considerable differentiation in the size of starch crop from an area unit has been observed both for 1978 and 1979. In 1978, the starch crop in most triticale samples was lower in comparison to the standard while in 1979, 70% samples revealed higher crops than that the standard.

The crops obtained in the field experiments for the examined samples from 1978 and 1979 comply with data found in literature [5, 6, 16, 17, 23].

The characteristics of chemical and physical properties of the examined starches of triticale are presented in Table 3. The obtained results show a high differentiation of the studied properties in all analysed varieties. Only the graininess of starch reveals small differentiation. A comparatively high content of grains with diameter size  $\geq 13.8 \mu\text{m}$  (72-88%) is an important property of triticale starch.

Chemical properties of starch show that the obtained preparations feature a relatively high purity: the average level of carbohydrates sum is 98.5% d.s., the content of examined non-carbohydrate components of starch (protein, fat, ash) does not exceed values given by literature [1, 2, 9, 11, 18] and in the case of ash level, it lies below the reported literature data.

Physical properties are more differentiated. The highest range of variation is observed for mean molecular weight.

Table 3. Characteristics of triticale starch

Examined property	Triticale starch		"Grana"/standard wheat		Standard deviation	Error of the method (%)
	mean value	range of variation	I	II		
Fat content (%)	0.37	0.20-0.56	0.22	0.33	0.015	4.27
Protein content (%)	0.24	0.18-0.30	0.25	0.25	0.006	2.75
Ash content (%)	0.07	0.04-0.13	0.09	0.05	0.003	4.28
Sum of carbohydrates content (%)	98.49	94.72-103.01	102.32	97.7	1.57	1.59
Mean molecular weight	52.400	17.900-139.800	102.100	64.000	2.276	4.3
% of grains with $\varnothing$ 13.8 $\mu$ m	79	72-88	79	89	4	5
Range if grains size ( $\mu$ m)		2-46	2-38	2-42		
Pasting characteristics						
— pasting temperature ( $^{\circ}$ C)	87	80.5-92	89	87	0.37	0.4
— viscosity maximum (mPa · s)	267	11*)-474	254	223	12.5	4.6
— temperature at viscosity maximum ( $^{\circ}$ C)	92	90.5-94	93.5	92.5	0.34	0.4
— viscosity at 96 $^{\circ}$ C (mPa · s)	99	11*)-230	169	175	9.7	9.5
— viscosity after 20 min at 96 $^{\circ}$ C (mPa · s)	153	11*)-338	284	169	11.8	7.7
— viscosity at 50 $^{\circ}$ C (mPa · s)	530	11*)-930	477	404	33.8	6.3
Degree of water binding at 60 $^{\circ}$ C (g/1 g starch)	5.71	4.99-6.75	5.90	5.44	0.14	2.5
Solubility at 60 $^{\circ}$ C (in %)	5.16	2.24-16.44	2.51	3.97	0.26	5.04

\*) Values are below the measuring capacity of the device.

Big differences occur in the indices of pasting characteristics of interest. For industrial applications are starches which give pastes more viscous than pastes made of starch from "Grana" wheat.

Interesting from the theoretical viewpoint are starches which revealed minimal viscosities of the order of 11 mPa·s; c.g. those which lie in the low limit of the measuring device sensitivity. Considerable differences were also noted in respect of pasting temperature.

Generally speaking, the examined properties of triticale starch are on the level of the "Grana" wheat standard. Higher values for the majority of samples of triticale starch were observed only for the maximum of viscosity and for viscosity after cooling to 50°C as well as for solubility at 60°C.

Values obtained for pasting characteristics cannot be compared with the literature data because of the different measuring methods used. Our data confirm the information [1] that triticale starch gives more viscous pastes than wheat starch.

On the basis of the obtained results, varieties with the most favourable technological properties for the starch industry may be selected. A high crop of starch from 1 ha ( $\geq 4.00$  t in 1978 and  $\geq 6.00$  t in 1979) and the highest graininess of starch ( $\geq 80\%$  grains having a diameter  $\geq 13.8$   $\mu\text{m}$ ) and high viscosity at 50°C  $\geq 700$  mPa·s was reported in the following cases: LT-695/75 and LT-850/74 in 1978 and LT-176/73-LT-59/76 and CT-252/76 in 1979.

High crop from 1 ha and slightly inferior graininess ( $\geq 72\%$  grains with diameter  $\geq 13.8$   $\mu\text{m}$ ) and lower viscosity (but remaining above the viscosity of the standard) was found for: LT-176/73 and B-866/GR in 1978 and LT-363/75, LT-404/76, LT-349/74 and CT-93/76 in 1979.

Slightly lower crops of starch from 1 ha (3.50-3.90 t in 1978 and 5.50-5.90 t in 1979) and favourable graininess and viscosity were observed in case of the following varieties: CR-130 and LT-363/75 in 1978 and CR-146, CR-384, CR-440, B-951, CT-113/76, MT-29-515 and MT-3-128 in 1979.

## CONCLUSIONS

1. In respect of the examined chemical and physical properties, starches of triticale varieties grown in Poland, do not differ essentially from the starch of Grana wheat adopted as a standard. Only in case of few varieties, viscosity of starch pastes revealed lower values than those of standard.

2. From the examined 53 varieties of triticale, 20 varieties were selected which due to their technological properties could be processed in to starch.



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## BADANIA NAD PRZYDATNOŚCIĄ PSZENŻYTA DO PRODUKCJI KROCHMALU

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## Streszczenie

W poszukiwaniu nowych źródeł surowcowych dla przemysłu krochmalniczego zwrócono uwagę na pszenżyto (triticale). Przewidując, że zboże to wejdzie w niedalekiej przyszłości w Polsce na szeroką skalę przebadano 53 rody pszenżyta znajdujące

się w badaniach hodowlanych (tab. 1). Badania te obejmowały analizę ziarna zboża na zawartość skrobi, białka, tłuszczu i błonnika (tab. 2) oraz analizę skrobi wyosobnionej z ziarna metodą laboratoryjną. W skrobi oznaczono zawartość białka, tłuszczu i popiołu oraz dokonano analizy ziarnistości, średniej masy cząsteczkowej, stopnia wiązania wody i rozpuszczalności w wodzie oraz charakterystyki kleikowania (tab. 3). W celu porównania wszystkie analizy przeprowadzono również na pszenicy "Grana" uprawianej w latach 1978 i 1979 w tych samych warunkach co badane rody pszenżyta.

Ziarniaki przebadanych rodów pszenżyta odznaczały się wysoką zawartością skrobi (73-85<sup>0</sup>/<sub>0</sub> s.s.) oraz białka (10-18<sup>0</sup>/<sub>0</sub>). Pod względem właściwości fizykochemicznych skrobia pszenżyta nie wykazywała zasadniczych różnic "in minus" w stosunku do skrobi pszenicznej. W związku z tym wytypowano wiele rodów tego zboża, które ze względu na ich wysoki plon ziarna z ha oraz właściwości skrobi nadawałyby się jako surowiec do produkcji krochmalu.

I tak najwyższym plonem skrobi z hektara i korzystną ziarnistością oraz wysoką lepkością odznaczają się rody: LT-695/75 i LT-850/74 w 1978 r. oraz LT-176/73, LT-59/76 i CT-252/76 w 1979 r.

Najwyższym plonem z hektara, przy nieco gorszej ziarnistości i niższej lepkości, charakteryzują się rody: LT-176/73 i B-866/GR w 1978 r. oraz LT-363/75, LT-404/76, LT-349/74 i CT-93/76 w 1979 r. Nieco niższe plony skrobi z hektara, ale korzystną ziarnistość i wysoką lepkość wykazywały: CR-130, LT-363/75 w 1978 r. oraz CR-146, CR-384, CR-440, B-951, CT-118/76, MT-29-515 i MT-3-128 w 1979 r.