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TRITICALE IN MALTING

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Grain and malts from winter and spring triticale varieties were subjected to standardized investigation. A particularly interesting feature of the considered malts was high amylolytic activity, much greater (1.5-2.4-fold) than in standard malt. The inferiour qualities of these malts included excessive protein content, too low germination energy and susceptibility to mould growth during malting.

Triticale, a "new" cereal, is attracting increasing attention on the part of breeders, and is being used as both fodder and food. Studies of animal [16, 18, 20-22, 25] and human nutrition [12, 13] demonstrate that triticale may be as valuable as its parent forms. Numerous research programs were devised with this fact in mind, also in Poland [27]. The main center coordinating triticale research is the Mexican CIMMYT headed by Borlaug and Żilinsky [27].

The available literature indicates that triticale may be used with good results in food industry as raw material in the production of bread and buns, cakes (triticakes), wafers, and pasta [2-4, 6, 9, 16], and in fodder industry in the production of nutritive fodder mixtures and even of silage [23]. The qualitative properties of triticale strictly define its applicability and more efforts must be made to genetically stabilize this cereal.

The fairly wide range of applicability of triticale is reflected in studies of its usefulness in malting. These studies were prompted by the observed high susceptibility of triticale grain to germination and the brief period of post-harvest rest (or its absence), both features being indicative of increased alpha amylase activity. Malting of triticale grain was first attempted by Pomeranz [18] and Charalambous and Bruckner [7]. Our own studies were based on the currently (1983) best local varieties of spring and winter triticale, examined against barley, wheat and rye. The obtained results cast light on the qualities of triticale from the point of view of malting.

MATERIAL AND METHODS

The experiments were performed with the best varieties of the basic cereals: Trumpf barley (B) which was taken as the standard, Grana wheat (W), Dańkowskie Złote rye (R), six winter triticale lines (Wt) — BR-2061, BR-426, BR-227, BR-866, BF-951, LT-176 73 — and five spring lines (St) — 6036-500, 6022-500, 5877-500, 6TA-207, 6000-500. The winter lines BR-2061 and LT-17 73 and the sprin line 6TA-207 are regarded by breeders as deserving of the rank of variety. The material for experiments was obtained from the Department of Cereal Plants of the Institute of Plant Breeding and Acclimatization in Cracov and from the Experimental Station of this Insctitute in Małyszyn.

Malting was preceded by eight weeks of post-harvest storage. 500-g samples of healthy grain were taken for malting. Grain was steeped in tap water (14°C) for various periods during three days until humidity rose to 45%.

Disinfecants commonly applied in malting technology, 40% commercial formalin, 18% sodium hypochlorite, potassium permanganate and H_2O_2, were used to inhibit mould growth according to Chełkowski [8]. Germination was performed for 5 days at 14°C at relative air humidity of 96%. Malt was dried for 24 h in an automatically controlled Seeger drier in constant air flow. The obtained malt of 4-5% humidity after germination was stored for at least 6 weeks in air-tight jars and then subjected to assessment. The qualitative characteristic of grain and malts was performed according to normative regulations and requirements applying to raw materials and malts of the Pilsen type [20, 21]. Protein content was determined by Kjeldahl's method [19] and starch content according to Clendening [10]. The quantitative and qualitative determinations of funguous microflora were based on Janicki's methodological recommendations [11].

RESULTS AND DISCUSSION

The physical properties of grain are strictly correlated with the degree of endosperm filling with starch. Although in the case of triticale this characteristic still depends on the considerable genetical lability of the cereal, the determined weight indices of its grain suggested a correct course of malting.

The weight of 1000 grains, equalization and bulk density (Table 1) indicate fine quality of grain of all the studied cereals, including the ten triticale forms (the only exception was sample Wt-9). The winter triticale lines were supjeriour in the mentioned respects to the remaining samples. All this justified expections of uniform steeping and germination of the grain.

Table 1. Characteristic of grain used in malting

Grain kind	Moisture (%)	1000 grains weighth (g)	Equalization (%)	Bulk density kg/hl	Total protein (%)	Starch (%)	Germination energy (%)
B1 Barley (Trumpf)	13.6	43	90	69.4	12.1	61.2	96
W2 Wheat (Grana)	13.3	39	94	75.4	10.5	66.2	98
R3 Rye (Dańkowskie Złote)	13.2	42	89	72.4	10.6	60.6	96
Winter triticale							
Wt 4 (BR-2061)	12.6	49	97	67.4	15.7	57.4	82
Wt 5 (BR-426)	12.3	47	95	66.6	16.4	60.3	93
Wt 6 (BR-227)	12.7	43	95	66.8	15.9	60.3	90
Wt 7 (BR-866)	12.6	51	96	66.8	14.9	64.8	87
Wt 8 (BF-951)	12.6	51	98	67.8	16.2	63.4	85
Wt 9 (LT-176/73)	12.7	40	85	76.0	16.4	58.6	69
Spring triticale							
St 10 (6036-500)	12.7	40	89	68	15.5	57.2	84
St 11 (6022-500)	12.0	42	95	65	15.2	57.6	91
St 12 (5977-500)	12.4	41	95	69	17.6	59.6	71
St 13 (6TA-207)	12.9	42	95	65	17.7	59.0	98
St 14 (6000-500)	12.3	41	92	69	13.5	59.2	97

Unfortunately, the germination energy of most triticale forms was low. The genetically stable cereals — barley, wheat and rye — all displayed high values of this energy (Table 1). The results for the investigated triticale lines were lower and more differentiated, and samples Wt-9, St-10 and St-12 even failed to meet the normative requirements.

A negative property of triticale, namely a tendency to mould growth, emerged during malting. The main source of infection were poorly developed (creased) and dead grains, the presence of which in the grain mass was responsible for the low germination energy (Table 1); their effect on malting yield was less pronounced (Table 2). The winter lines were much more susceptible to mould growth than the spring lines. Conidia of the following fungus genera were found on the grains: *Aspergillus*, *Fusarium*, *Penicillium*, *Alternarium*, *Rhizopus* and *Mucor*. The triticale grains are not specifically different in this respect Inded, the number of mould conidia on them (Fig.) is greater than on grains of other cereals. However, the difference is not big enough to completely account for the more intense mould growth on triticale. The small resistance of this cereal to mould growth is probably due to its genetical instability.

The disinfection during steeping slightly reduced the number of spores (by about 20% with NaClO). The effectiveness of the various disinfecants is hard to asses since it was only the total effect of grain

Table 2. Physico-chemical characteristics of brewers malts

Grain kind	Moisture (%)	Yield of malting process (%)	Total protein (%)	Diastatic power (u.W-K)	Extractivity (% d.s.)	Difference extracts powder/grist (%)
B1	4.3	83.0	11.7	320	79.6	2.7
W2	4.2	79.6	10.0	430	91.0	3.2
R3	4.3	82.1	10.1	320	83.5	2.4
Wt 4	4.3	77.8	15.4	590	84.7	2.0
Wt 5	4.2	79.6	16.1	720	81.3	2.1
Wt 6	4.3	78.6	15.5	630	82.7	1.8
Wt 7	4.5	78.8	14.6	510	81.3	1.9
Wt 8	4.4	77.7	15.7	600	81.0	1.9
Wt 9	4.3	70.8	16.0	480	83.5	1.9
St 10	4.4	81.3	15.0	510	78.9	1.9
St 11	4.4	81.0	14.8	650	80.1	2.0
St 12	4.1	82.2	17.3	680	77.6	1.9
St 13	4.4	81.3	17.4	750	75.7	2.0
St 14	4.0	81.4	13.1	550	74.4	2.3

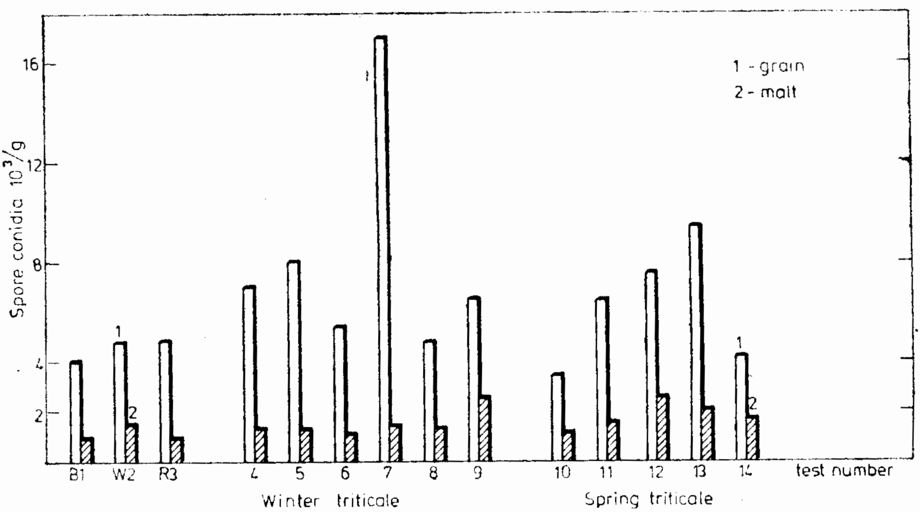

Fig. Fungous microflora on grains and in brewers' malts

disinfection and malt drying that led to a 3-15-fold reduction of spore number (Fig.). The susceptibility to mould growth is a highly disadvantageous property, creating conditions for the production of inferiour-quality malt and hence of low-quality and unhealthy final products. Our observations indicate that this is one of the main factors potentially limiting the use of triticale in malting. It is to be expected, however, that suitably immune forms of triticale and the elaboration of an effective disinfection method will help overcome this drawback.

Protein and starch contents are regarded as the fundamental criteria in evaluating the usefulness of the given grain in brewers' malt production (Table 1). The two components are the basic source of extract in the production of malt mash. The main role in distilling is played by enzymatic protein which is a part of total protein. According to Petersen [17] in cereal grain it amounts to 20-23% of total protein. Starch, on the other hand, augments the carbohydrates balance of fermenting components.

A good raw material for the production of brewers' malt ought to contain no more than 12% protein. Among the investigated samples only barley, wheat and rye met this requirement. All the triticale lines had a much higher protein content (13.5-17.75%). The excessive protein level may lead to technological difficulties. On the other hand, such a malt enables composition with large quantities of high-starch unmalted raw material with a low protein content, such as rice (the studies on this are reported in part II of this paper). The excessive protein content may be satisfactorily corrected by a mechanical separation of the smallest grains with the highest protein content, by a suitable proportion of raw materials during mashing, and by colloidal stabilization of the beer. However, the most effective solutions are to be expected from further progress in breeding of this cereal. The differentiated protein content in the initial raw material (grain) cbecked once more during malt assessment reveals a property characteristic for various cereals, namely similar losses of this component (about 0.5%) during malting (Table 2). The high protein content characteristic for triticale malts is doubtless the reason for their high enzymatic potential. They are marked by an exceptionally high diastatic force. Compared with the standard barley malt which must be regarded as excellent (320 u. W-K), the winter triticale lines had 1.5-2.2 times higher and the spring lines 1.6-2.4 times higher W-K values (Table 2). The availability of malts with such enzymatic parameters makes it possible to use large quantities of unmalted raw material in the mash without having to introduce additional sources of amylolytic enzymes, e.g. of microbiological origin.

Starch as the principal component of cereal grain in the malt raw material is the main extract-producing component. According to Schur [24] the mean starch contents in the typical four cereals of our climate range from 44-7% in the case of oats to 63.8% in the case of wheat and rye; barley occupies an intermediate position with 62%. Numerous publications [1, 4, 6, 15, 26] indicate a considerable differentiation of this content in triticale. Despite the lower starch content in triticale grains that in the control barley (Table 1) the extractivity of triticale malts (Table 2) is very good for the winter lines and satisfactory for the spring lines. Malt extractivity is correlated with bulk density and diastatic power. As already suggested, the high diastatic power of these malts makes possible additions of unmalted starch raw material, thereby improving brewery output.

CONCLUSIONS

1. The investigated triticale forms, compared as brewers' malt raw material with the barley standard, displayed considerable variability as to qualities specified by production norms.

2. A particularly valuable property of the obtained malts was their high amylolytic activity, exceeding 1.5-2.4-fold that of the standard barley malt.

3. The factors limiting the applicability of the studied triticale lines in brewers' malt production are: the frequent inadequate germination energy, excessive protein content, susceptibility to mould growth higher than in other cereals.

4. The investigated cereals subjected to the standard malting process display similar properties: a systematically similar fungous microflora infecting the germinating grains, and similar protein losses during germination (0.5%).

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S t r e s z c z e n i e

Pszenżyto, jako „nowe" zboże coraz powszechniej zyskuje sobie opinię zboża uniwersalnego. Z coraz szerszą aprobatą przyjmuje je agrotechnika, żywieniowcy i paszoznawcy. Skłonność do porastania, jak również krótki okres spoczynku pożniwnego lub zupełny jego brak u większości form pszenżyta świadczą o podwyższonej zawartości α-amylazy. Właściwość ta, jako niekorzystna w agrotechnice, stanowi cenny walor z punktu widzenia przydatności słodowniczej.

Pod tym kątem przebadano aktualnie najlepsze polskie formy przenżyta ozimego (6 form) i jarego (5 form) na tle jęczmienia (Trumpf), pszenicy (Grana) i żyta (Dańkowskie Złote). Badania przeprowadzono na podstawie przepisów normatywnych opracowanych dla słodu browarowego typu pilzneńskiego. Uzyskane wyniki ujawniły zarówno wady, jak i zalety pszenżyta. Do właściwości pozytywnych należy zaliczyć poprawne wskaźniki cech fizycznych ziarna i słodu. Walorem szczególnie wartościowym badanych słodów jest bardzo wysoka aktywność amylolityczna przewyższająca wzorcowy słód jęczmienny 1,5-2,4-krotnie. Czynnikami ograniczającymi są przede wszystkim zbyt niska energia kiełkowania oraz wyższa niż u pozostałych zbóż skłonność do pleśnienia i za wysoka zawartość białka. Mikroflora bytująca na kiełkującym ziarnie pszenżyta nie wykazuje odrębności systematycznej w odniesieniu do pozostałych zbóż.

Proces słodowania ujawnił również, że zbliżone ilościowo (0,5%) straty białka w procesie kiełkowania to charakterystyczna właściwość nie tylko dla jęczmienia, ale dla wszystkich badanych zbóż poddanych jednakowej obróbce technologicznej.