A LABORATORY WET-MILLING PROCEDURE OF ZP MAIZE HYBRIDS

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ABSTRACT: Wet milling properties of 10 widely grown ZP maize hybrids and the amylose content of produced starch were investigated in this study. The starch yield varied from 57.3% in the hybrid ZP 633 to 69.0% in the hybrid ZP 808. Depending on the observed hybrid, the amylose content ranged from 23.3 to 26.0%, what is characteristic for normal maize starch. High starch yields and high recoveries, as well as, a low level of proteins in obtained starches (<0.4) indicate the efficiency of the applied wet milling procedure in the evaluation of the utilisable value of ZP maize hybrids.

Key words: maize, wet milling, starch, yield, recovery, amylose content

INTRODUCTION

Maize is the most important raw material for the commercial starch production. On a large scale starch is manufactured (produced) by a wet milling process. Since maize is the most important and abundant crop produced in our country, the national production of starch is entirely based on maize (Bekric, 1997). The physical and chemical properties of different starches depend on differences in molecular structure and in the morphology of the starch granule itself (Whistler et al, 1984). Amylose and amylopectin are two major components of starch. The proportions of amylose and amylopectin in starch vary with its source, but generally are in the range of 20 to 30% of amylose for normal cereal starch. Starches are widely utilised in THE industry for many purposes ranging from thickeners and adhesives in paper and textile production to a chief component of many food products.

MATERIALS AND METHODS

Ten maize hybrids of different both, genetic background and maturity groups (ZP 360, ZP 434, ZP 480, ZP 633, ZP 677, ZP 684, ZP 735, ZP 737, ZP 750, ZP 808), were studied. Methods applied in order to determine physical traits (1000-kernel weight, test weight, portion of soft and hard endosperm fraction), and chemical contents of grain (contents of starch) were described in detail in previously published papers (Radosavljevic et al., 2000, Radosavljevic et al., 2001). The wet-milling properties of the stu-

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died hybrids in starch processing were established by a modified 100-g laboratory wet-milling procedure (Eckhoff et al., 1996). By this procedure, grain was divided into its elementary constituents: starch, protein (gluten), germ/oil and fibres (bran). This technological process is an integral process of several successive operations: 48-h grain steeping in steeping water on 50˚C containing 0.2% sulphur dioxide, hand separation of germ, wet milling of degerminated grain (hull + endosperm), bran separation by filtration through the 0.5-mm sieve, separation of starch fraction from gluten fraction on the precipitation starch table, washing out and drying of starch. Starch yield, recovery and purity, then the protein content in the recovered starch, are the most important parameters for the evaluation of wet-milling properties of maize hybrid grain. Starch yield is a ratio of the amount of obtained starch to the initial amount of grain, while starch recovery is a percentage ratio of produced starch to the total amount of grain starch.

Besides, the content of amylose and amylopectin was observed in extracted maize starches. A contemporary calorimetric method (McGrance et al., 1998) was applied to determine the content, i.e. relation of amylose and amylopectin in maize starch products.

RESULTS AND DISCUSSION

Studies on quality and wet milling properties of maize grain contribute to a better valorisation of maize in the industrial processing that is almost symbolically present in our country, and especially in the production of highly valuable food and technical products. The aim is to increase economic values of this naturally renewable carbohydrate raw material that is the most important for our country.

This paper presents results on physical, chemical and technological properties of wet milling of different ZP maize hybrids. Table 1 presents results on the determination of grain starch content and physical properties of 10 ZP maize hybrids of different both, genetic background and growing season duration.

Table 1. Grain physical properties and starch content of 10 ZP maize hybrids

Hybrid	Test weight (kgm^{-3})	1000-kernel weight (g)	Portion of soft fraction (%)	Starch content (%)
ZP 360	816,4	327,6	40,9	71,7
ZP 434	841,8	351,0	39,0	72,2
ZP 480	835,7	307,3	39,4	74,3
ZP 633	860,5	311,5	33,1	70,3
ZP 677	833,1	335,2	43,4	71,8
ZP 684	841,8	336,2	42,3	72,5
ZP 735	863,3	304,3	35,5	69,5
ZP 737	844,1	298,5	39,0	73,5
ZP 750	860,7	270,8	36,6	73,2
ZP 808	825,5	309,9	45,5	73,7

The chemical composition and physical properties of the grain are the base for the analysis of the utilisable value of maize. The grain chemical composition is the most

important grain trait from aspects of its utilisation either in the industrial processing or as feed and food. The grain chemical composition, especially a starch content, widely ranged in 10 studied hybrids (from 69.5% in ZP 735 to 74.3% in ZP 480).

Beside the grain chemical composition, physical properties, such as test weight and 1000-kernel weight, portion of soft and hard endosperm fraction, are also important parameters of grain quality.

Test weight or bulk density is a weight per a volume unit, i.e. the kernel mass density. This trait as a physical criterion of quality has been very often criticised as an unreliable parameter, as it displays more the pattern of packing and arranging kernels irrespective of their size and shape. This measure is important for storage capacities of transport units, size of containers and machine capacities, and represents the oldest standard parameter of maize grain quality. According to obtained results, the test weight ranged from 816.4 kgm^{-3} (ZP 360) to 863.3 kgm^{-3} (ZP 735).

Absolute weight or 1000-kernel weight, as a physical criterion of quality, depends on the size and shape of maize kernel. Its values ranged from 270.8 g (ZP 750) to 351.0 g (ZP 434).

The portion of soft and hard endosperm fraction is one of the important parameters of kernel hardness. This trait is the most important physical property from the aspect of the industrial use and the following parameters depend on it: test weight and kernel density, some nutritive properties, susceptibility to kernel breakage and dust formation (in the processes of handling and transport), milling respopnse, possibilities of production of special maize-based products, as well as, yield of major products of dry and wet milling. According to obtained results presented in Table 1, the portion of soft endosperm fraction was the lowest in the hybrid ZP 633 (33.1%) and the highest in the hybrid ZP 808 (45.5%), which also had the best results in starch yield.

Results gained by studying physical properties and the fundamental chemical composition (starch content) of 10 widely grown ZP maize hybrids are in good accordance with previously published results (Fox et al., 1992, Radosavljević i sar., 2000, Radosavljević et al., 2002).

Yield, recovery and purity of starch, i.e. the protein content in extracted starch, are the most important parameters for evaluation of wet milling properties of maize grain. High starch recovery and yield, as well as, a low protein content in produced starch are the basic parameters of well performed process of maize wet milling. Tables 2 and 3 show results obtained by the laboratory simulation of the wet milling process of 10 selected ZP maize hybrids.

Achieved results indicate that starch yield in studied hybrids ranged from 57.3% to 69.0% in hybrids ZP 633 and ZP 808, respectively, what corresponds to starch recovery of 81.5% and 93.7%. The highest starch recovery of 94.4% was detected in the hybrid ZP 677 whose yield of starch amounted to 67.8%. The highest gluten yield was found in the hybrid ZP 633 (13.5%), while the lowest one was recorded in the hybrid ZP 808 (5.3%). Bran yield varied from 7.4% (ZP 737) to 12.1% (ZP 633). Germ yield ranged from 7.2% (ZP 808) to 10.7% (ZP 434). The protein content in extracted starches ranged from 0.14 to 0.29%, pointing out to high quality of produced starches. The highest starch yield, not accompanied with the highest starch recovery, was recorded in the hybrid ZP 808. Furthermore, gluten and germ yields were the lowest in this hybrid. The highest gluten yield and the lowest starch yield and recovery were detected in the hybrid ZP 633.

The amylose content in extracted starches ranged from 23.3 to 26.0%, what is characteristic for normal maize starch.

Table 2. Wet milling properties of maize grain of 10 ZP maize hybrids

Hybrid	Starch yield (%)	Gluten yield (%)	Germ yield (%)	Bran yield (%)
ZP 360	64,8	8,0	8,4	9,1
ZP 434	62,6	8,6	10,7	9,8
ZP 480	66,9	7,3	8,0	7,9
ZP 633	57,3	13,5	8,1	12,1
ZP 677	67,8	7,2	9,6	9,3
ZP 684	63,4	7,9	10,6	11,8
ZP 735	59,2	13,2	7,3	8,2
ZP 737	65,5	9,4	8,0	7,4
ZP 750	64,6	9,0	7,9	7,9
ZP 808	69,0	5,3	7,2	8,0

Table 3. Recovery, protein and amylose content of starch extracted from the grain of 10 ZP maize hybrids

Hybrid	Starch recovery (%)	Protein content (%)	Amylose content (%)
ZP 360	90,3	0,26	23,8
ZP 434	86,7	0,28	26,0
ZP 480	90,0	0,20	24,2
ZP 633	81,5	0,29	24,0
ZP 677	94,4	0,14	23,9
ZP 684	87,5	0,28	23,3
ZP 735	85,1	0,28	24,8
ZP 737	89,1	0,15	24,0
ZP 750	88,3	0,27	23,7
ZP 808	93,7	0,18	24,3

According to gained results it can be concluded that maize with soft, i.e. floury endosperm that is more easily and briefly seeped, which later on provides better separation of starch and gluten, is more suitable for the process of wet milling. Hybrids with a higher starch content, a greater portion of soft endosperm fraction and a lower test weight have higher starch yields and recovery in wet milling. Hybrids with a higher starch yield and recovery have lower yields of gluten and bran. The previously published results of foreign authors indicate that starch yield variability in wet milling mostly depends on the genetic background (about 70%), while the effect of environmental factors amounts to about 30% (Zehr et al., 1996, Eckhoff, 1999).

ACKNOWLEDGMENTS

The authors would like to thank the Ministry of Science and Environmental Conservation for supporting this work as a part of the Project BTN.2.1.2.0708.B.

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