Int. Agrophysics, 1994, 8, 377-380

HIGH RELATIVE HUMIDITY AS A CAUSE OF INNER DAMAGE OF WHEAT GRAIN

W. Woźniak[1], *W. Styk*[2], *M. Geodecki*[1]

[1]Intitute of Agrophysics, Polish Academy of Sciences, Doświadczalna 4, 20-236 Lublin, Poland
[2]University of Agriculture, Doświadczalna 44, 20-236 Lublin, Poland

A b s t r a c t. Inner damage of grain influences technological quality and reproductive ability of wheat. The study conducted so far points out to the fact that the primary reason for inner damage is, most often, high moisture gradient which may be present in the process of steeping.

The analysis concerned mechanical damage resulting from intensive wetting of dry wheat grain at high relative humidity. Roentgenographic detection method was applied in order to determine the location and the number of cracks. The experiments conducted have proved the extend of endosperm destruction to be influenced by both its moisture content humidity and its texture type as well as kernel size.

K e y w o r d s: wheat grain, inner damage, moisture gradient

INTRODUCTION

Inner cracks of wheat grain result from the following factors: type-specific features, ripening conditions, harvesting and post-harvesting processing. Such damage may appear already before harvesting, being influenced by a high humidity gradient, or may result from working elements of machines during harvesting and transport as well as from intensive heat and mass transfer during post-harvesting processing.

Considering practical aspects of quality evaluation of wheat grain, an attempt was made at a description of dry grain susceptibility to mechanical damage during steeping at high relative humidity.

MATERIAL AND METHOD

Endosperm damage of Henika spring wheat grain appearing during dry grain steeping at 15 °C and relative humidity 96 % was analysed. Intact grain 2.2 mm and 2.9 mm thick, having two entirely different endosperm types - vitreous and mealy, were selected for the experiments. Each experimental combination was repeated four times, 100 kernels being used in each test. Grain with initial moisture content of 10 % was steeped to 26 % and, subsequently, air-dried back to the initial state. Grain inner damage, which considered as characteristic cross-cracks of the endosperm, were detected by X-ray method [3] for the subsequent levels 13,15,18,21 and 26 % of grain moisture content.

An X-ray picture of a single grain was divided into three horizontal layers (bottom - germ segment, middle and top), the number of cracks was calculated for each layer separately [1,2], and the evaluated damage index (SI) was determined.

RESULTS AND DISCUSSION

The qualitative analysis of the results obtained proved the fact that the process of steeping of dry grain at high relative humidity led to endosperm destruction visible on roentgenograms as cross-cracks. In all experimental combinations the percentage of damaged grain was initially increasing with the growing moisture content (10-15 %) and later dropping (18-26 %), to increase again after drying (Table 1). In the vitreous type endosperm grain sample the damaged

grain content was much higher (mean value -70 %) than in the mealy-type 55 %. The thickness classes taken into consideration, the differentiation was lesser. The damaged grain content in 2.9 mm and 2.2 mm classes was 69 and 56 %, respectively. Such results point out to the fact that the endosperm structure exerts greater influence on the susceptibility to inner cracking than the size of grain does.

The quantitative analysis allowed the extent of the endosperm damage to be expressed by means of a summary index SI (Table 2). Regardless of both the thickness and the endosperm type, the number of cracks was highest at the 15 % moisture content (SI=2.6). Further steeping caused a monotonic decrease of the number of cracks to SI=0.5 at 26 %. This seems to imply that steeping of starch cells increasing their size causes the previously detected cracks to close so that they can no longer be detected using the X-ray method. Vitreous grain were damaged to a greater extent than mealy ones (SI=1.7, SI=1.5, respectively) and the same applies to larger 2.9 mm (SI=1.8) as opposed to smaller grain 2.2 mm (SI=1.4). In general, after drying the number of the reappearing cracks was approximately equal to

Table 1. Percentage of damaged grain

Grain size (mm)	Endosperm structure	Protein content (%)	Moisture content (%)							Average
			10*	13	15	18	21	26	10	
2.2	vitreous	10.9	0	60	88	78	66	10	93	66
	mealy	8.1	0	61	71	37	22	14	72	46
	average		0	61	80	58	44	12	83	56
2.9	vitreous	11.4	0	42	87	92	83	43	94	74
	mealy	8.4	0	65	90	72	61	40	53	64
	average		0	54	89	82	72	42	74	69
average for vitreous			0	51	88	85	75	27	94	70
average for mealy			0	63	81	55	42	27	63	55
average			0	57	85	70	58	27	79	63

10* - initial moisture content not taken for average; $LSD_{0.05}$ - for moisture content = 11; $LSD_{0.05}$ - for endosperm structure = 15; $LSD_{0.05}$ - for grain size = 15.

Table 2. Mean values of summary damage index (SI)

Grain size (mm)	Endosperm structure	Protein content (%)	Moisture content (%)							Average
			10*	13	15	18	21	26	10	
2.2	vitreous	10.9	0	1.2	2.5	1.9	1.3	0.1	3.1	1.7
	mealy	8.1	0	1.2	2.0	0.7	0.4	0.2	2.0	1.1
	average		0	1.2	2.3	1.3	0.8	0.2	2.5	1.4
2.9	vitreous	11.4	0	0.6	2.2	2.3	1.8	0.7	2.9	1.8
	mealy	8.4	0	1.7	3.5	2.1	1.6	0.8	1.4	1.9
	average		0	1.2	2.9	2.2	1.7	0.8	2.2	1.8
average for vitreous			0	09	2.4	2.1	1.6	0.4	3.0	1.7
average for mealy			0	1.5	2.7	1.4	1.0	0.6	1.7	1.5
average			0	1.2	2.6	1.8	1.3	0.5	2.4	1.6

10* - initial moisture content not taken for average; $LSD_{0.05}$ - for moisture content = 0.39, $LSD_{0.05}$ - for endosperm structure = 0.54; $LSD_{0.05}$ - for grain size = 0.54.

that observed at 15 %, where the extent of the damage reached its peak.

Figure 1 shows the values of the evaluated damage index SI as a function of moisture content for the three examined zones of grain. In the initial phase of moisture absorption, mainly the bottom, germ zone, was damaged. With further steeping - to 15 % - the most intensive damage was present in the middle segment, the phenomenon much more visible in vitreous than in mealy grain. The smallest number of cracks appeared in the top segment regardless of the moisture content, endosperm type or grain size. Hence, it is clear that the middle segment of a grain is the most susceptible to inner damage.

Rapidly appearing cracks in the bottom zone in the initial stage of steeping and a subsequent, equally rapid, increase of their number in the middle zone during further steeping points out to the fact that water enters a grain from its germ zone most rapidly. Moreover, it was observed that in the mealy samples, with the moisture content exceeding 18 %, the number of previously detected cracks was rapidly decreasing, i.e., they were disappearing. In vitreous grain this phenomenon was less visible and the decrease of the

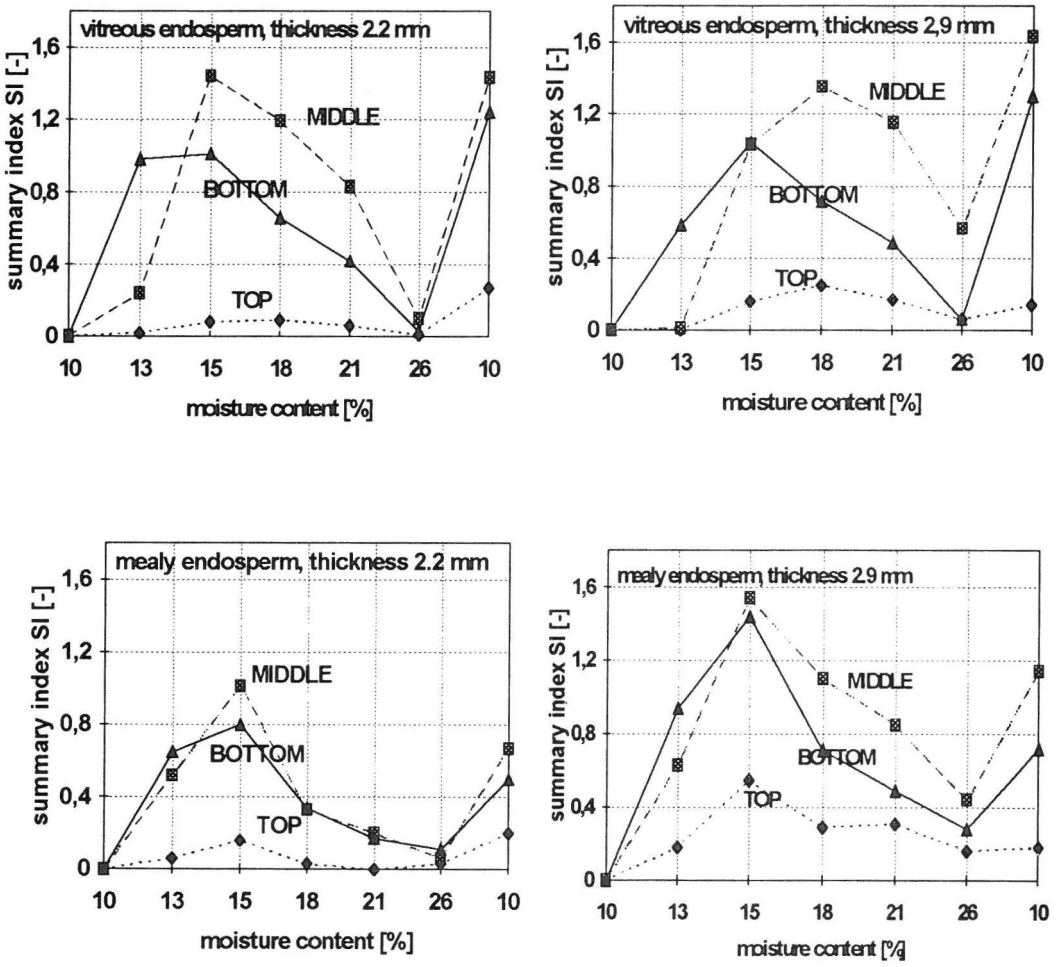

Fig. 1. Summary damage index as influenced by moisture content for the three zones of grain (top, middle and bottom), two endosperm structure (vitreous and mealy) and two grain size (thickness 2.2 and 2.9 mm).

number of the previously recorded cracks started at a higher moisture content, the fact resulting most probably from the endosperm structure and the higher protein content in vitreous grains (Table 2). The solid protein has to be hydrated first, in the process of water penetration and only after that the water enter starch granules causing their swelling which make the previously occurring cracks disappear. Mealy grains absorb water and swell faster because of their looser endosperm structure and smaller protein content, which may be the cause of the increase of crack disappearing rate in them.

CONCLUSION

Summing up it may be stated that an intensive steeping of dry wheat grain at high relative humidity is accompanied by endosperm damage considered characteristic cross-cracks which disappear at later stages of this process. The grain having been air-dried, the previously detected inner cracks reappear. The extent of the endosperm damage was most heavily influenced by the water content in the grain. The influence of the endosperm type was considerably lesser and that of the grain size the least important.

REFERENCES

1. **Niewczas J.**: The method of determination of the index of mechanical damage of single kernel by means of X-ray detection. Zesz. Probl. Post. Nauk Roln., 389, 89-95, 1991.
2. **Niewczas J., Woźniak W.**: Application of the discretization of an X-ray picture of wheat grain for the evaluation of endosperm cracks. Zesz. Probl. Post. Nauk Roln., 397, 45-51, 1991.
3. **Styk B., Grundas S., Savin N., Vielikanov L.**: Ocenka mekhanicheskikh povrezhdenij zerna jarovoj pshenicy kolorimetricheskim i rentgenograficheskim metodami. Mezhdunarodnyj Agropromyshlennyj Zhurnal, 1, 85-89, 1989.