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Changes in water absorption of gluten as a result of sprouting of wheat grain

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A b s t r a c t. The laboratory test for sprouting of wheat grain (cv. Igna and Roma) was used to evaluate the influence of the degree of sprouting on changes in sorption and rheological properties of gluten freshly washed out by means of the Glutomatic device. Lower water additions used for sprouting did not change the water absorption of gluten and the gluten index. A further increase in the water addition caused significant changes in the gluten properties in relation to the untreated grain (control). Gluten index values decreased from about 57 to 35% for cv. Roma and from 94 to 38% for cv. Igna, and contents of the non-absorbed water contents in gluten freshly washed out increased from 4.1 to 13.9% and from 1.2 to 9.6%, respectively. Simultaneously there took place decreases in the absorbed water contents in the gluten from 63.3 to 55.1% for cv. Roma and from 65.8 to 59.0% for cv. Igna.

K e y w o r d s: wheat grain, sprouting, wet gluten, water absorption, gluten index

INTRODUCTION

High water absorption of gluten in view of its bakery applications is a very useful feature that positively influences the dough and bread yield [2].

The sorption properties may be evaluated simplest by testing gluten freshly washed out from a studied wheat flour sample. In the automatised process of the washing out and at its fixed conditions, the gluten absorbs a different amount of water dependent on its sorption properties. Miœ [10] has pro- posed a way for determining the amount of water stored by gluten during its washing out with use of a Glutomatic device. It consists in measuring the water content in gluten firstly after its washing out and secondly after its centrifugation. On this basis the content of non-absorbed water that is lost by the centrifugation is determined and the content of absorbed water that remains in gluten after its centrifugation. The usefulness of such determined sorption properties of gluten was confirmed by the results of studies so far [10–13]. They showed that the non-absorbed water content differs considerably in relation to a wheat cultivar and a grain ripe stage at which wheat harvest is made as well as to a technological treatment used, e.g., drying grain or moistening it before milling. Additionally, this kind of water strongly affects the rheological properties of gluten.

Going on this subject the present studies were undertaken on modifications of these sorption properties of gluten as a result of sprouting of wheat grain. Results of numerous studies [6–8,15–17] have indicated that the yield of gluten washed out from the sprouted grain decreases and its quality worsens. But there are unavailable data on changes in absorption of water by the freshly washed out gluten from wheat grain with a differentiated sprouting degree.

So the main aim of the present studies was to determine the influence of the sprouting degree of wheat grain on changes in the contents of the water absorbed and non-absorbed in gluten freshly washed out as well as the quantity of isolated gluten and its rheological properties measured as the gluten index. For modelling the sprouting degree, a simply laboratory test was used, which has been described in detail in a previous paper [14].

Characteristics of these features of gluten modified in a result of sprouting are presented in this paper.

MATERIAL AND METHODS

Wheat grain and its preparation

For the studies, wheat grain (cv. Igna and Roma) samples, the test for sprouting and the manner for differentiating

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the degree of sprouting of the grain were the same as those described in the above cited paper [14]. One should add only that studied wheat cultivars clearly differed in quality of wet gluten. Roma, a winter wheat, had weak gluten, while Igna, a spring one, was distinguished by very strong gluten.

Methods used for determining quantity and properties of gluten

Determination of quantity and physical properties of gluten were made on grain samples previously stored by about 3 months after sprouting and with moisture content equilibrated on level 11.5 0.5%. The grain samples directly before the determinations were grounded by means of a Laboratory Falling Number Mill 3100, (AB, Huddinge, Sweden).

The process of washing out gluten from whole meals and determinations of gluten index were performed on a Glutomatic 2200 system (Perten Instruments AB, Huddinge, Sweden), according to ICC Standard No. 155 [5]. One modification was introduced at determining the gluten index. At centrifugation the constant weighed amounts of the wet gluten equal to 2.1±0.05 g were used. In that way, differences in centrifugal force that affects the rate of forcing gluten through the sieve openings were eliminated [9]. Gluten centrifuged in which the absorbed water remains only is called the wet gluten. By drying the centrifuged gluten, the dry gluten not containing any water is obtained. Values of the quantity of wet and dry gluten, were reported on a 14% grain moisture basis.

Measurements of contents of the non-absorbed and absorbed water in gluten freshly washed were based on an evaluation of the weight of water accumulated by the gluten in the course of its standard washing out [5]. Using a Centrifuge 2015, the content of non-absorbed water was calculated by measuring a loss in weight of a freshly washed out gluten sample (2.1±0.05 g) by the 1 min centrifugation (~2000 *g*). Thus using a Glutork 2020, the absorbed water content was calculated by determining a loss in weight of the centrifuged gluten sample by drying (150°C for 4 min).

All measurements were made in 4 repetitions. Based on the 95% confidential intervals for means (LSD), the allowable amounts of the water addition used in the sprouting test or the resultant grain moisture contents, which did not yet cause worsening studied gluten properties, were determined. In this case, changes in values of the gluten features in relation to those for the grain not subjected to sprouting (the control) did not exceed the LSD intervals.

RESULTS

Changes in quantity of wet and dry gluten

The influence of the sprouting degree induced by the amount of water addition used in the test on changes in the quantity of wet gluten is presented in Fig. 1a. At lower water additions, with an increase of them, the quantity of wet gluten firstly decreased gently and then increased. Referring these changes to the control, the decrease ranged from 0.6 for cv. Roma to 0.8% for cv. Igna, and the increase – from 0.2 to 0.7%, respectively.

A further increase in the water addition over the allowable values (Table 1) caused already a gradual decreasing of the yield of washed out gluten. The quantity of wet gluten decreased by 7.3% for cv. Roma and by 4.2% for cv. Igna as the water addition increased to 80 g (Fig. 1a).

A course of changes in the dry gluten quantity (Fig. 1b) had a similar character as that for the wet gluten . Only there were noted considerably higher allowable water additions (Table 1), which were 60 and 70 g for cv. Roma and Igna, respectively. This means that gluten proteins in wheat grain during sprouting are much more resistant to the quantitative changes than the qualitative ones.

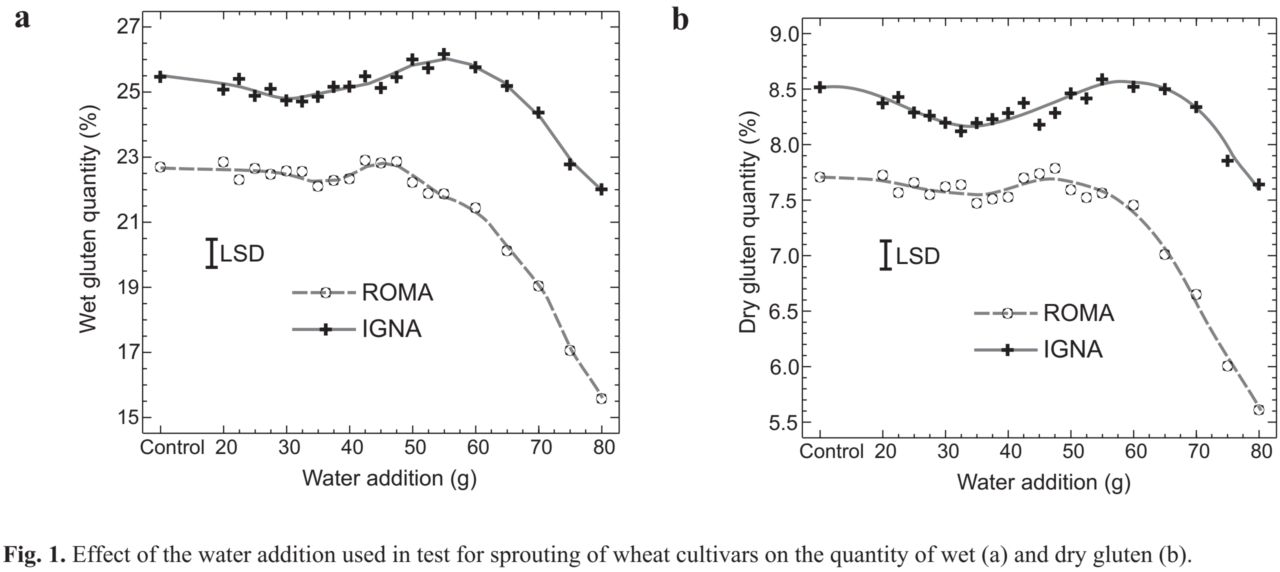

Fig. 1. Effect of the water addition used in test for sprouting of wheat cultivars on the quantity of wet (a) and dry gluten (b).

T a b l e 1. Allowable values of the water addition and the grain moisture contents, in relation to a gluten feature and a wheat cultivar

Gluten features	Water addition (g)		Moisture content (%)	
	Roma	Igna	Roma	Igna
Wet gluten quantity	50.0	65.0	31.2	36.0
Dry gluten quantity	60.0	70.0	34.5	37.5
Non-absorbed water content	42.5	55.0	28.4	33.0
Absorbed water content	42.5	60.0	28.4	34.7
Gluten index	42.5	52.5	28.4	32.4

Changes in contents of the non-absorbed and absorbed water

The changes in the non-absorbed water contents in the freshly washed out gluten as a result of sprouting influenced by the amount of water added are presented in Fig. 2a. In a wide range of the water additions, contents of the non-absorbed water remained at unchanged levels, which amounted for 4.1 and 1.2%, for cv. Roma and Igna, respectively. The allowable values of the water addition were 42.5 and 55.0 g, for cv. Roma and Igna, respectively (Table 1). The further increasing of the water addition caused a gradual increase in the content of non-absorbed water in the washed out gluten. At the maximum water addition, contents of non-absorbed water increased several times in relation to the control, reaching 13.9 and 9.6%, for cv. Roma and Igna, respectively.

The course of dependence of the absorbed water content in the washed out gluten on the water addition used for sprouting wheat grain (Fig. 2b) had a different character than that for the non-absorbed water content. With an increase in the water addition, the absorbed water content in gluten, dependent on a wheat cultivar, first did not change (cv. Roma), or gently increased (cv. Igna), by about 1%. Then, as a result of a further increasing of the water addition, there took place the gradual worsening of sorption properties of gluten. Significant decreases in the absorbed water contents, referred to the control, appeared as the water addition values were higher than 42.5 and 60.0 g, for cv. Roma and Igna, respectively (Table 1). Contents of the absorbed water in the gluten decreased from 63.3 to 55.1%, for cv. Roma, and from 65.8 to 59.0%, for cv. Igna.

The data presented in Figs 2a and 2b indicate that the total water content in the freshly washed out gluten, i.e., a sum of contents of the non-absorbed and absorbed water, showed a tendency to increase as the sprouting degree increased. At the maximum degree, the total content of water in gluten increased for both cultivars by about 1.6% in relation to the control.

Changes in rheological properties of wet gluten

The dependence of rheological properties of the freshly washed out gluten determined as the gluten index on the amount of water addition used in test for sprouting is presented in Fig. 3. At lower water additions, similarly as for previously described gluten features, values of the gluten

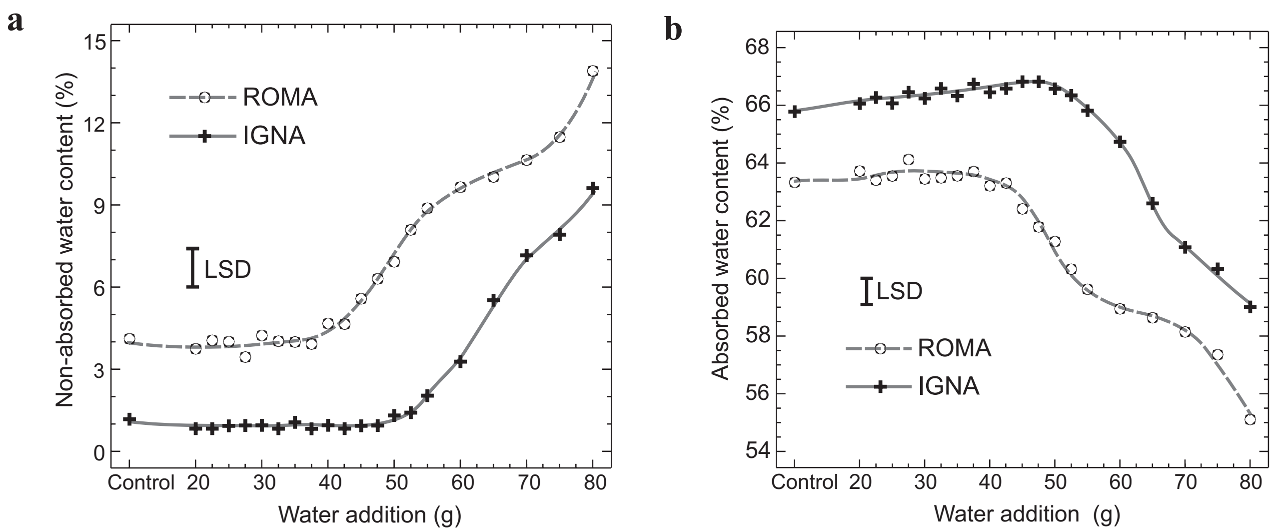

Fig. 2. Effect of the water addition used in test for sprouting of wheat cultivars on the content of non-absorbed (a) and absorbed water (b) in gluten freshly washed out.

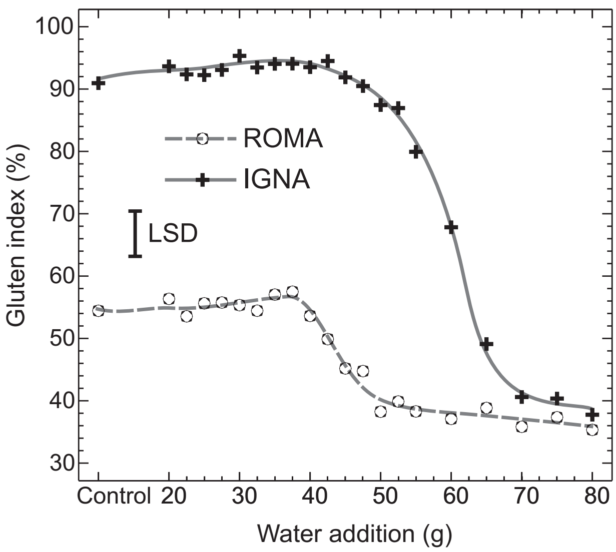

Fig. 3. Effect of the water addition used in test for sprouting of wheat cultivars on the gluten index.

index ranged almost on the same level as for the control. In a result of further increasing of the sprouting degree when the water additions were higher than 42.5 for cv. Roma and 52.5 g for cv. Igna, significant decreases in the gluten index took place (Table 1). Distinctly lesser decreases were noted for cv. Roma, and values of the gluten index decreased from about 54% (the control) to 35% (the maximum water addition). Whereas for cv. Igna index values decreased from a considerably higher level (94%) to a level almost the same as for cv. Roma (Fig. 3). The results clearly show a gradual weakening of wet gluten in its mechanical strength under the influence of sprouting wheat grain.

The course of this dependence was of a similar character to those noted for quantities of the wet and dry gluten and the absorbed water contents, thus in contrast to that noted for the contents of the non-absorbed water. It means that under the influence of sprouting wheat grain, it follows simultaneously lowering the gluten index, the content of absorbed water and the quantity of wet and dry gluten, and increasing the content of non-absorbed water. However, changes in these features were initiated at a different degree of sprouting. Based on the allowable values of the water addition (Table 1), it may be indicated that a beginning of the weakening of the mechanical strength of gluten (gluten index) was not related to changes in the quantity of wet gluten, which took place at a considerably higher sprouting degree. But it was reflected strongest by changes in contents of the non-absorbed water. This shows an important role of this kind of water in freshly washed gluten to creating its rheological properties.

DISCUSSION

The sprouting process is characterised by an increase in activities of proteolytic and amylolytic enzymes that modify quality features of wheat grain, e.g., weakening its hardness as it has been reported in accompanying paper [14].

For changes in gluten properties, there are responsible mainly endoproteases, a group of enzymes synthesised in the aleurone layer and scutellum and secreted to starchy endosperm [3,17]. As the sprouting degree increases, the progressive degradation of gluten proteins stored in the grain endosperm by the proteases causes a worsening quality of gluten as well as decreasing its quantity [7,8,15,16].

For practice it is important to know the sprouting effects on these gluten features on the basis of which the baking potential of wheat grain is predicted. One such gluten feature is water absorption of gluten.

The present investigations indicated that effects of enzymatic hydrolysis of gluten proteins with an increase in the sprouting degree initially appear in lifting the sorption abilities of gluten. The maximum for the absorbed water content was noted for cv. Igna at the water addition from 45.0 to 47.5 g. This agrees with the results of investigations of Bombara *et al*. [1], who studied the sorption properties of wheat flour proteins in dependence on the degree of hydrolysis (DH) by added proteases. They observed a maximum for water absorption at a moderate degree of hydrolysis (3.8% DH), where the water absorption determined by farinograph and Baumann methods increased by 30%.

When the hydrolysis of gluten proteins reach a certain degree, the sorption abilities are reduced, and the content of absorbed water in gluten begins to decrease. Simultaneously the gluten stores more and more higher contents of the non-absorbed water, and its mechanical strength weakens.

The described decrease in the absorbed water content in wet gluten caused by sprouting wheat grain is consistent with results obtained using other methods. Investigations of Morad and Rubenthaler [15], Lukow and Bushuk [8], Leelavathi *et al*. [6], and Singh *et al*. [18] have shown that the water absorption gradually decreased during lengthening of a period of sprouting.

The microscopic studies conducted by Freeman *et al*. [4] have found that gluten freshly washed out is the reticulate material containing water in a form of pools. One should suppose that the proposed measurement of water losses by centrifugation of the washed out gluten, known as the non-absorbed water content, directly depends on the amount of water contained in these pools and distribution of them in the gluten material.

The present studies clearly showed a strong and negative influence of the non-absorbed water in freshly washed out gluten on its mechanical strength. The existence of such a relationship was also found in previously conducted studies [11,13]. They showed that at drying of moistened wheat grain, with an increase in its moisture, contents of the non-absorbed water in gluten increased and simultaneously gluten index values decreased considerably. With the increasing temperature of drying, contents of the non-absorbed water decreased clearly, and gluten index values increased quickly. Thus the treatment of grain moistening similar to that one used at tempering of wheat grain, influenced decreasing the content of non-absorbed water in gluten, and the effect of that the improvement of gluten strength (the gluten index) took place.

The present studies show that cv. Igna, having gluten of a distinctly higher gluten index in relation to cv. Roma, was characterised by significantly higher contents of the absorbed water in gluten and simultaneously significantly lower contents of the non-absorbed water. Besides that cv. Igna within all studied features distinguished considerably higher allowable values of the water addition. It means that gluten of a better quality, i.e., binding more waters and mechanically stronger (cv. Igna), simultaneously is more resistant to the effects of sprouting of wheat grain. These observations find also the confirmation in results of investigations of Toma and Moraru [19], who connected the greater resistance to sprouting effects of wheat cultivars of better quality with slower degradations of a glutenin fraction of gluten protein during sprouting.

Making the comparison of results of the present studies with those describing changes in activity α-amylase in wheat grain (the falling number), and which have been discussed in the previous paper [14], information useful for practice can be drawn. In a water addition interval from 30 to 50 g, a quick tempo of decrease in the falling number, up to the end of the measuring scale (62 s) was observed. Whereas no symptoms of worsening quality of washed out gluten were found. In this range of α-amylase activity, cv. Igna distinguished maximum values of the absorbed water content in gluten and of its yield. This observation can indicate new possibilities for the utilisation of the sprouted wheat grain of the falling number value below 150 s, which is useless for bakery, but it could be useful, e.g., for the vital gluten production. This could refer in particular to wheat cultivars of the high yield and quality of gluten.

CONCLUSIONS

The conducted studies with use of a worked out test for the sprouting of wheat grain allowed to one draw the following conclusions:

1. In an initial range, the water addition used for sprouting did not cause significant changes in the content of non-absorbed water in gluten and in the gluten index. While for a wheat cultivar of better quality (cv. Igna), it influenced a gentle increase in the content of absorbed water and a decrease and then an increase in the quantity of wet and dry gluten.

2. Further increasing of the water addition over the allowable values, which were dependent on a gluten feature and a wheat cultivar, caused unprofitable changes in gluten properties. The initiation of these changes was observed earliest in the gluten index and the non-absorbed and absorbed water content, and later in gluten quantity. The cultivar of better quality (cv. Igna), in comparison with that one of worse quality (cv. Roma), had gluten more resistant to the effects of sprouting.

3. The unprofitable effects of the sprouting on gluten quality appeared in a gradual weakening of both the sorption ability of gluten and its mechanical strength, expressed as the decrease in the absorbed water contents and gluten index values. Simultaneously contents of the non-absorbed water in the freshly washed out gluten increased causing looseness of its structure. The process of sprouting also influenced the yield of wet gluten. As a consequence, the wet gluten quantity decreased considerably.

4. However, the conducted studies have recovered the positive effect of lower sprouting degrees on the water absorption of gluten and simultaneously not worsened rheological properties of it. This may indicate that the wheat grain sprouted in lesser degree could be successfully used for the production of the vital gluten.

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