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THE EVALUATION OF THE QUALITY RYE FLOURS ON THE BASIS OF THE BIOCHEMICAL AND RHEOLOGICAL INDICES

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Abstract

The starch and the amylolytic enzymes, the pentosans and their degradation enzymes influence the behaviour of the rye flour at gelatinization and accordingly the bakery quality of the rye flours. The Falling Number and the maltose index, the amylograph and swelling curves represent the methods that can be used in the estimation of the bakery quality of rye flour. The specific volume of bread correlates positively with the percentage of pentosans soluble in water from the total of pentosans.
Keywords*: rye flour, pentosans soluble in water starch gelatinization, swelling curves.*

Introduction

The baking performance of rye flour is based on the functional properties of its constituents in rye – starch, proteins and pentosans. Estimation of the quality baking is possible through used the some methods that allow the research of the behaviour of water-rye flour slurry at different conditions of temperature and time.

The interaction between the gelatinization properties of starch and the α-amylasis activity is considered an important factor for the bakery properties of rye. The Falling Number, the amylograph, the viscograph offer useful information about the starch gelatinization phenomenon and the extent to which it is influenced by the amylolytic enzymes. Beside starch it is necessary to consider the arabinoxylans and their degradation enzymes as integrant part to behaviour at rye flour gelatinization (Weipert, 1995, Zwingelberg *et.al.,* 2002).

The importance of the pentosans regarding the behaviour in the baking processes of the rye is a long time acquaintance, but the variations of this constituent with the varietals characteristics and the environment conditions, not allow the establishment some correlations between their contents and rye baking quality. The regions influence the water soluble pentosans content from rye and their percentage from total pentosans. The rye cultivation in wet region from the middle Europe contains several water soluble pentosans that the rye from the land region. This can be due the differences of the enigmatically activity because of development of the microorganisms in time of harvest, in the wet conditions from the middle Europe. Besides the climate effect in the pre-harvest period, the post- harvest treatment, especial the dry and storage conditions can influence the grains biochemistry. The studies that indicate the positive effect of the total pentosans and the water soluble pentosans was effectuated by the many researcher (ex. Delcour, 1995, Weipert, 1995, Repeckiene, *et.al*., 2001).

The researches from the last ten years on a big number of the rye variety, from the different countries, but especially from Germany, where was effectuated the systematically determinations by Weipert, admitted the importance of the direct relation between the hight content of the pentosans, particularly water soluble pentosans, and baking quality of the rye.

Experimental

Three rye samples were used. The experimental milling has been made at the Bühler laboratory aggregate (Banu, 2002). The methods used for the biochemical and rheological indices are:

- the ash content – method STAS 10668/1976,
- the protein content Kjeldahl semi-micro method,
- total pentosans measurements, water soluble, enzymatically extractable – Hashimoto method modified by Delcour (1989),
- the α-amylases activity – the colorimetrical method with acid 2,3-dinitrosalicylic, Mc. Cleary *et.al.* (2002),
- maltose index – STAS 90/88 method,
- the Falling Number – ICC 107/1 (1995) method,
- the Falling Number with $AgNO_3$ addition – method advanced by Kuracina *et. al.* (1987),
- amylograph – ICC 126/1 (1992) method,

- swelling curve – method advanced by Moraru (1983),
- viscosity of water extract of the rye flour – method advanced by Härkönen, *et. al.* (1997), viscometer Rheotest – 2,
- bread baking – method advanced by Szili and Kuroczi (1989),
- the volume and the specific volume of bread, the elasticity and the crumb porosity – STAS 90/88 method.

All experiments were duplicated and showed differences of less than 5.0%.

Results and Discussions

After milling the rye samples at the Bühler laboratory aggregate was obtained white flour whose ash contents ranges between 0.59-0.62% and proteins contents between 7 and 8.7%. The content of the total pentosans from these flours was 2.24-2.78 % and the percentage of pentosans soluble in water from the total of pentosans was 60.1 / 65.3 (table 1).

Table 1. The content of pentosans in rye four

Sample	Content of pentosans			
	total, %	water soluble, %	% of pentosans soluble in water from the total of pentosans.	enzymatically extractable, %
Flour I	2.36	1.54	65.3	1.82
Flour II	2.24	1.36	60.7	1.72
Flour III	2.78	1.67	60.1	1.88

The specific volume of bread (table 2) correlates positively with the percentage of pentosans soluble in water from the total of pentosans, $r = 0.997$ ($p = 0.046$).

Table 2. Quality indices of rye bread

Sample	Quality indices		
	the specific volume, $cm^3/100g$	the elasticity, %	the crumb porosity, %
Flour I	185	76.0	49.4
Flour II	158	71.0	45.4
Flour III	159	75.8	45.1

This correlation is explained by the fact that the pentosans that are soluble in water increase the stability of the liquid coat that surround the gas bubbles, increase the stability and resistance at pressure of the gas bubbles in the oven preventing them from. It is generally thought that the relationships among the ferulic acid and the ferulic acid and other molecules of pentosans or proteins are to be appreciated in this stabilization (Delcour, 1995).

Was obtained a significant correlation between the elasticity of the crumb and viscosity of the pentosans soluble in water (table 3), r = 0.998 (p = 0.041).

The evolution of the starch gelatinization under the action of amylolytic enzymes is pointing through amylograph curve (table 3). The Falling Number can be used, too. The values obtained for the Falling Number ranged 200 – 274 s, the smallest one being recorded for Flour II and the highest for the Flour I (table 4).

Table 3. Viscometric characteristics of rye flour

Indices	sample		
	Flour I	Flour II	Flour III
The viscographs characteristics - peak viscosity, UB - peak temperature, ˚C	 575 71	 360 67	 480 69.5
Swelling curves - viscosity at 42˚C, UB - viscosity after 30min/42˚C, UB	 140 120	 110 80	 120 105
Viscosity of water soluble pentosans, mPa · s	1.190	0.914	1.233

Table 4. Biochemical and technological indices of rye flour

Sample	Bichemical and technological indices			
	The maltose index, g maltose/ g flour	α-amylases activity, g maltose/100g starch, 1ml enzymatic extract, 3min/37ºC	Falling Number, s	Falling Number with $AgNO_3$, s
Flour I	1.94	21.3	274	372
Flour II	2.49	22.3	200	321
Flour III	2.19	26.0	240	350

In order to evaluate the way in which the alpha-amylases activity contributes to the Falling Number, and consequently, the importance of the starch structure, was realized determinations with adding of $AgNO_3$. From table 4 can notice that by non-activating the alpha-amylases, the Falling Number rises, reaching 347 ± 26s. The biggest differences between the Falling Number and the Falling Number with adding of $AgNO_3$ have been noticed for the flour with high alpha-amylases activity, flour II (+121) s, while for Flour I and Flour III, the differences equaled (+98) s and (+110) s. Between the Falling Number and the Falling Number with adding of $AgNO_3$, I got a significant correlation, $r = 0.99$ ($p = 0.02$). The significant correlation was obtained between the maximum amylographical viscosity and the Falling Number with adding of $AgNO_3$.

The ability of flour to form glucides through the hydrolysis of starch under the influence of amylolitical enzymes is rendered on the basis of maltose index (table 4). The data obtained for the maltose index of the flour obtained from the varieties of rye analyzed, ranged between 1.94 – 2.49g maltose/100g flour.

Besides the starch, it is necessary to consider the contents of pentosans and of the enzymes that degrade them as component part of the behaviour of rye flour in the gelatinization. The actions of enzymes present in the rye, which degrade pentosans, diminish their capacity of swelling. It is pointed out by the swelling curve traced by heating a suspension of rye flour in sodium phosphate buffer solution (*p*H = 5.3) at 42ºC followed by the maintenance for 30 minutes at this temperature (table 3).

The high value of the initial viscosity is due to the capacity of swelling of the flour constituents immediately after the formation of the suspension. In the first minutes of the mixture, the viscosity rises, and afterwards it falls. The speed, at which the viscosity diminishes, can be considered an indicator of the degradation of soluble pentosans. The viscosity after maintenance at 42ºC depends on the quantity of substance that swollen, on the swelling or hydrating properties of these substances, on their degree of enzymatic degradation during the determination.

The adding of a mixture of enzymes that degrade the cellular walls produce a significant reduction of the initial viscosity as well as of the viscosity after maintenance at 42ºC (it takes place the fragmentation of the cellular walls and the redistribution of water in the dough (Bushuk, 1995).

The highest viscosity difference between the viscosity measured at 42ºC and the one obtained after maintenance for 30 minutes at this temperature has been obtained for the samples that have higher contents of pentosans that are enzymatically extractable and soluble in water (table 3).

Between the specific volume (V_{sp}), the viscosity at 42ºC (V_{42}) and the peak viscosity (at Amylograph) was obtained the following correlation, r = 0.995, variance explained 99.167 %:

$$V_{sp} = -\ 0.0015 \cdot V_{max} + 0.0195 \cdot V_{42}$$

An overall look on the enzymatical activity and the behaviour of the rye flour suspension in water, under certain conditions of temperature and time, is given by the radar chart (figure 1, the radar chart has been represented for the flours with alpha-amylases activity min. and max.). In the radar charts, seven indices have been represented. For three of these indices – the difference between the Falling Number with and without adding of $AgNO_3$, the alpha-amylases activity, the maltose index, high values are correlated with a high amylases activity. For the Falling Number, the peak viscosity (at Amylograph) and the temperature at which we get this viscosity, high values are correlated with a reduced amylases activity, while for the viscosity established after maintaining a suspension at 42ºC for 30 minutes, high values indicate a high amylases and pentosanasic activity. Under the circumstances, the moving of the heptagon to the right is correlated with a high alpha-amylases activity.

Conclusions

The starch and the amylolytic enzymes, the pentosans and their degradation enzymes influence the behaviour of the rye flour at gelatinization and accordingly the bakery quality of the rye flours. The Falling Number and the maltose index, the amylograph and swelling curves represent the methods that can be used in the estimation of the bakery quality of rye flour. The specific volume of bread correlates positively with the percentage of pentosans soluble in water from the total of pentosans (r = 0.997, p = 0.046).

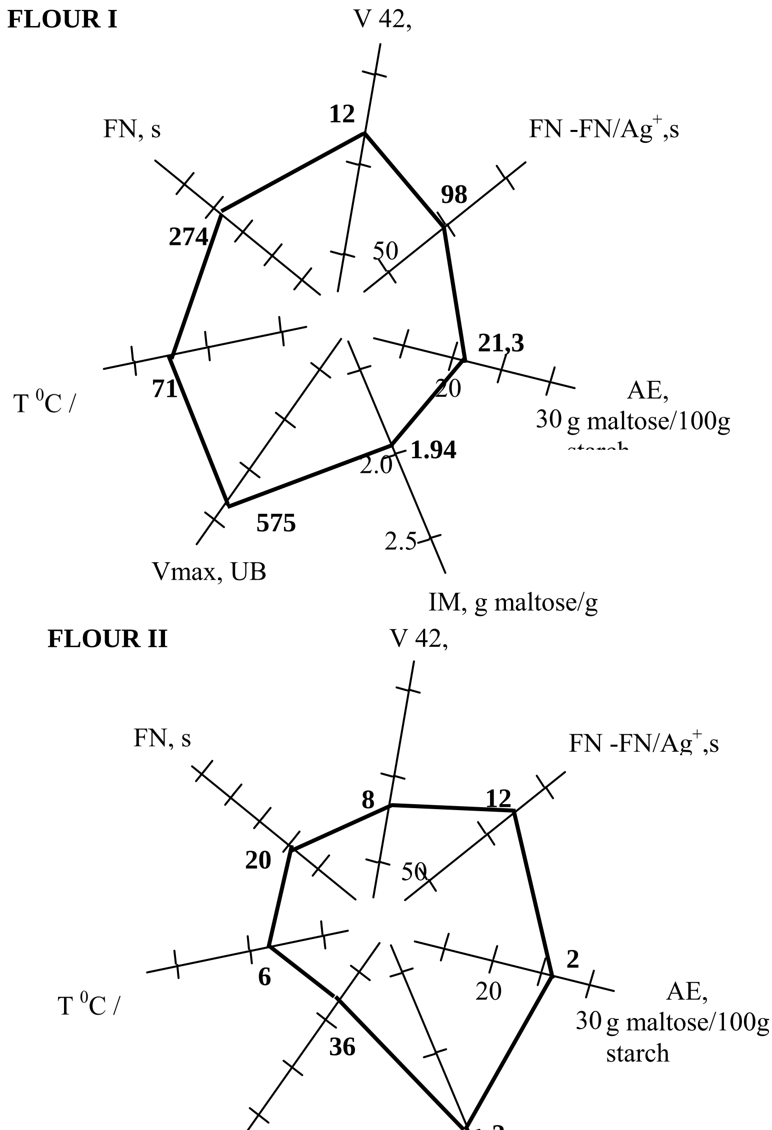

Fig. 1. Radar chart appreciating the enzymatic activity and the behaviour of the rye flour suspension under certain circumstances of time and temperature

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