BAKING QUALITY OF THE RYE FLOUR

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Abstract: The aim of the present paper was to provide information about the way in which physical, biochemical and technological properties of the rye flour influence its baking quality. We analyzed the influence of granularity, pentosans content, gelling properties of the starch and α-amylase activity on the quality of the rye bread. Four different varieties of Romanian ryes were milled through Bühler MCK-6188F laboratory aggregate using a modified technical scheme. Our results indicate that the specific volume of the bread is directly correlated with the percentage of soluble pentosans in water (r=0.973) and with the peak of amylographic viscosity (r=0.956). An indirect correlation was obtained between the elasticity of the crumb and α-amylase activity (r=0.962). The coarse fractions contain higher pentosans quantities while the fine ones have higher contents of starch.

INTRODUCTION

Baking properties of the rye flour are influenced by the functional properties of the main rye components such as starch, proteins and pentosans. The gelling properties of the starch together with the high α-amylase activity represent a critical factor for the rye baking technology.

The evaluation of the baking quality of the rye flour is usually made by studying the rheological behavior of the flour suspension in water in certain condition of dynamic regimes of temperatures. Starch gelling and the grade in which this process is influenced by the hydrolytic enzyme are reflected on the falling number and amylographic curve (Weipert, 1995, Zwingelberg *et.al.*, 2002).

Experimental studies performed in the last ten years on several variety of rye from different zones, especially from Germany (Weipert, 1995) revealed a direct correlation between the high content of pentosans, particularly the water soluble pentosans fractions, and rye baking quality.

Generally, the quality standards for rye flour refers to the ash and moisture contents, acidity, granularity and α-amylase activity. There is only one type of rye flour, 1200 – STAS 1259/87, that is produced in Romania. The quality standards of the rye flour require appropriate sensorial properties, certain granularities and minimum contents of ash, moisture and acidity.

The aim of the present study was to analyze the influence of biochemical and technological properties of four types of rye flours on its baking properties. The flours were obtained by milling the four Romanian varieties of rye using the Bühler MCK-6188F laboratory aggregate through a modified scheme.

MATERIAL AND METHODS

Materials

We tested the following varieties of rye: *Orizont*, *Gloria*, *Suceveana* (autumn varieties), *Impuls* (spring variety). The rye was milled on the Bühler, MCK-6188F laboratory aggregate using a technical scheme made up by one pre-ground passage, three break roller passages, and three reduction passages; this technical scheme implies a bran reduction also (Fig. 1) (Banu, 2004).

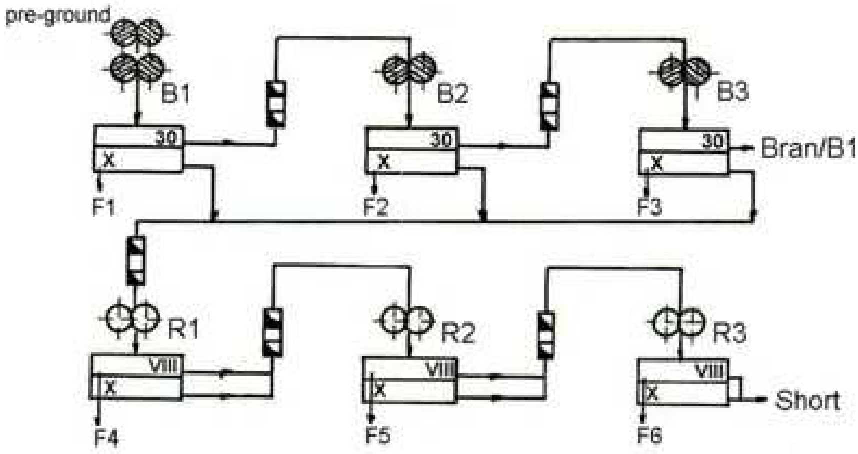

Fig. 1 Technical scheme for rye milling

Methods:

- Ash content was determined according to STAS 90/88 by calcination at 725...750ºC, in the presence of ethanol;
- Falling number was determined according to the method ICC 107/1 (1995);
- Falling number with $AgNO_3$ added (100mg/kg sample) was determined according to the method proposed by Kuracina *et al*. (1987);
- Maltose index was determined according to STAS 90/88;
- Granularity/sharpness module was determined according to the method proposed by Godon and Willm (1994);
- Total and water soluble pentosan contents were determined according to the method proposed by Hashimoto (1987) and modified by Delcour (1989);
- Amylographic curve was determined according to the method ICC 126/1 (1992);
- Baking test was done using the two phase method (leaven, dough) by adding lactic acid according to the method proposed by Szili and Kuroczi (1989);
- The bread volume and specific volume and the crumb elasticity and porosity were established according to STAS 90/88.

Each test was performed three times and the statistical analysis of the results was realized using *Statistica for Windows versiunea 4.3*.

REZULTS AND DISCUSSION

The flours obtained by milling the mentioned rye varieties had ash contents ranging between 0.74 and 0.77%.

For the same milling conditions, flours had different granulometric compositions established by evaluating the sharpness module and the pass through sieve of 90 mesh test. We obtained a sharpness module ranging between 1.76 and 2 for Orizont, Gloria and

Suceveana rye varieties, while in the case of Impuls variety the sharpness module was 2.43 (Table 1). Concerning the granularity of the flour, we could separate particles having the size smaller than 90 mesh for Orizont, Gloria and Suceveana varieties (autumn varieties), while in the case of Impuls variety (spring variety) we obtained mainly particles with sizes ranging from 125 to 90 mesh.

Table 1. Physical - chemical properties of the rye flour

Rye variety	Ash, %	Sharpness module, %	Pass through sieve of 90 mesh	Total pentosans, %	Water soluble pentosans, %
Orizont	0.77	2.00	48	2.63	1.72
Gloria	0.74	1.91	55	2.36	1.43
Suceveana	0.75	1.76	58	2.41	1.59
Impuls	0.74	2.43	31	2.85	1.50

The granulometric composition of the flours is an important factor which influences the baking technology by controlling the water binding capacity.

The results of our study showed that there is a significant indirect correlation ($p<0.05$) between output of the pass though sieve of 90 mesh (C_{90}) and total pentosan content (*PT*) described by $PT=3.4206-0.179 \cdot C_{90}$, r = -0.96. Our results agree with the observations of Bushuk (1976) who noticed that the course fractions contain higher pentosan contents, while the fine ones have a higher content of starch. In case of the starch quality degradation caused by a high α-amylase activity, the importance of the starch as participant to the crumb structure formation decreases. The role of the starch of binding water during the dough preparation step is taken over by the pentosans; they cause a slower swelling and a higher consistency of the dough.

The statistical analysis of the results was realized in terms of the correlation matrix of the quality indexes characterizing the analyzed flours which gives indications about the direct correlation between the sharpness module, total pentosan content and water absorption index (Table 2.).

Table 2. The correlation matrix of the quality indexes characterizing the analyzed flours

Quality indexes	MI	FN	FN/Ag^+	$FN\text{-}FN/Ag^+$	Vmax	SM	WAI	PT	PS
MI	1.00	-	-	-	-	-	-	-	-
FN	-0.79	1.00	-	-	-	-	-	-	-
FN/Ag^+	-0.88	0.98	1.00	-	-	-	-	-	-
$FN\text{-}FN/Ag^+$	0.52	-0.91	-0.81	1.00	-	-	-	-	-
Vmax	-0.90	0.46	0.58	-0.16	1.00	-	-	-	-
SM	0.18	-0.33	-0.19	0.56	-0.17	1.00	-	-	-
WAI	-0.21	-0.42	-0.24	0.72	0.57	0.40	1.00	-	-
PT	-0.21	-0.07	0.11	0.42	0.22	0.92	0.56	1.00	-
PS	-0.86	0.39	0.51	-0.10	1.00	-0.20	0.61	0.18	1.00

MI-maltose index, FN-falling number, FN/Ag^+-falling number with $AgNO_3$ added, Vmax-amylographic viscosity peak, SM-sharpness module, WAI-water absorption index, PT-total pentosan content, PS-water soluble pentosan

Analyzing the results presented in table 1 it can be seen that the flours obtained by milling the four rye varieties have a total pentosan content of 2.36-2.85%, from which 65.4 – 52.6% are water soluble. The statistical analysis of the experimental data depicted in table 3 indicate a direct correlation between the specific volume of the bread (*Vsp*) and water soluble pentosan content (*PS*) described by $Vsp = -0.1949+1.2723 \cdot PS$ ($p<0.05$) having a correlation coefficient of r=0.973. According to Delcour (1995) this correlation can be due to the fact that water soluble pentosans increase the stability of the liquid films which surround gas bubbles, improve the stability and resistance of the gas bubbles at pressure into the oven by preventing their association. It is believed that this stabilization can be explained also by the interactions between molecules of ferulic acid with itself or with other molecules such as pentosans and proteins.

Table 3. Quality indexes of the rye bread

Rye variety	Specific volume, cm^3/100g	Porosity, %	Elasticity, %
Orizont	2.00	47.1	72.8
Gloria	1.66	44.2	69.8
Suceveana	1.97	49.0	75.0
Impuls	1.69	45.4	72.4

Another important factor for the baking quality of the rye flour is the gelling property of starch estimated by amylographic curve plotting. The rye starch gelling starts at lower temperatures than in the case of the wheat starch. The maximum viscosity of each gel obtained from the analyzed flours varied between 180 UB (Gloria) and 375 UB (Orizont) corresponding to the gelling temperatures of 65ºC and 67.5ºC, respectively (Table 4). The α-amylase activity, most probably coupled with the high content of deteriorated starch, causes an advanced enzymatic hydrolysis of a higher starch quantity, lowering in this way the gelling temperature corresponding to the maximum viscosity.

We estimated the capacity of the flour to form low molecular weight sugars through enzymatic hydrolysis of the starch, by determining the maltose index (Table 4). According to our results, the flour obtained from Gloria variety has the highest maltose index (2.61 g maltose/100 g flour) while the lowest maltose index characterize the Orizont variety (2.09 g maltose/100 g flour).

Table 4. Technological properties of the rye flour

Rye variety	Maltose index, g maltose/100 g flour	Falling number, s	Falling number with $AgNO_3$ added, s	Amylographic viscosity peak, UB
Orizont	2.12	208	335	375
Gloria	2.61	185	311	180
Suceveana	2.09	253	359	300
Impuls	2.33	211	336	240

The α-amylase activity was estimated by determining the falling number. Gloria variety displayed the highest amylolytic activity, having a falling number of 185 s. In order to establish the contribution of the α-amylase activity to the value of the falling number determined through the standardized method, we performed the same analysis using a modified method based on enzymes inactivation with $AgNO_3$ (Kuracina, 1987). The second mentioned method gives indications about the importance of the starch structure on baking properties of the rye flour. Comparing the values of the falling numbers obtained through the two methods (Table 4) we could note that the α-amylase inactivation induced the increase of the falling number. The achieved overall value of the falling number in case of enzyme inactivation was 335±24 s.

The correlation (r=0.978) between the falling numbers obtained through the two methods was described by $FN = -259.4 + 1.4129 \cdot FN/Ag^+$, ($p<0.05$).

The gelling properties of the starch and α-amylase activity influence physical properties of the bread crumb. We could note a significant indirect correlation (r=0.962) between the crumb elasticity (*El*) and falling number (*FN*) which gives indications about the amylolytic activity ($El = 56.984 + 0.0742 \cdot FN$, $p<0.05$) and a direct correlation (r=0.956) between the specific volume of the bread (*Vsp*) and amylographic viscosity peaks (*Vmax*) ($Vsp = 1.2764 + 0.00188 \cdot Vmax$, $p<0.05$).

CONCLUSIONS

The present study revealed that granularity, pentosan content, gelling properties of the starch and α-amylase activity influence the quality of the rye bread. Our results indicate that the specific volume of the bread is directly correlated with the percentage of soluble pentosans in water (r=0.973) and with the peak of amylographic viscosity (r=0.956). A significant indirect correlation was obtained between the elasticity of the crumb and α-amylase activity (r=0.962). The coarse fractions contain higher pentosans quantities while the fine ones have higher contents of starch.

REFERENCES

1. Banu, I., 2004, Studiul proprietăților de măciniş ale unor soiuri de secară din cultura mare, Teză de doctorat, Universitatea Dunărea de Jos, Galați.
2. Bushuk, W.,1976, *Rye: Production, Chemistry and Technology*, AACC, St. Paul, Minnesota.
3. Delcour, J.A. (1995). Structure of water-and alkaliextractable rye (Secale cereale L.) araboxylans, International rye symposium: Technology and products, *VTT Symposium 161*, 103-111, Espoo, Finland.
4. Delcour, J.A., Vanhamel, S., De Geest, C., 1989, Phisico-Chemical and Functional Properties of Rye Nonstarch Polysaccharides. I. Colorimetric Analysis of Pentosans and Their Relative Monosaccharide Compositions in Fractionated (Milled) Rye Products, *Cereal chemistry*, 66 (2), 107-111.
5. Godon, B., Wilhm, C., (1994), Primary cereal processing a comprehensive soucebook, VCH, New York.
6. Kuracina, T.A., Lorenz, K., Kulp, K., 1987, Starch Functionality as Affected by Amylases from Different Sources, *Cereal chemistry*, 64 (3), 182-186.
7. Szili, M. şi Kuroczi, G., 1989, A rozsliszt sütöipari minösitéröl, *Sütöipar*, 2, 75-83.
8. Weipert, D., 1995, Processing Performance of Rye as Influenced by Sprouting Resistance and Pentosan Contents, International Rye Symposium: Technology and Products, *VTT Symposium 161*, 39-49, Espoo, Finland.
9. Zwingelberg, K., Zwingelberg, H., Kunis, Klaus K., 2002, *Technisches Jahrbuch für Getrideverarbeitung, Mischfutterstellung und Verfahrenstechnik*, 113, Jahrgang Verlag Moritz Schäfer, Detmond, 23-24, 67-80, 168-174.
10. xxx, 1988, *Colecția de standarde pentru industria de morărit panificație*, COC, Bucuresti.
11. xxx, *Method ICC*, 126/1-1992,107/1-1995.