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PREDICTING THE FARINOGRAPH AND ALVEOGRAPH PROPERTIES OF FLOUR BASED ON THE RESULTS OF MIXOLAB PARAMETERS

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Abstract. Protein and gluten content, Zeleny Index, farinograph and alveograph properties are widely used to determine the protein quantity and the quality of flour. Mixolab can be used to measure dough characteristics such as protein quality, enzymatic activity and starch retrogradation in a single test. The objective of this study was to determine the variability of and the relationship among the farinograph and alveograph properties and mixolab parameters which characterise the protein complex. Tests were performed on 76 samples of wheat flour type 550 and type 750 produced in Poland. Wheat flour type 750 was characterised by significantly higher protein content, farinograph water absorption, dough development and stability time. Rheological properties of dough tested by mixolab differed with regard to the type of flour. Wheat flour type 750 was characterised by higher water absorption and time T1 and lower torque in points C2, C_{12min}, C_{14min}, C_{16min} than wheat flour type 550. Higher correlation coefficients were obtained between farinograph parameters (stability and softening) and mixolab torque in points C_{8min}, C_{10min}, C_{12min}, C_{14min} than in point C2 which is a mixolab parameter commonly used to determine protein weakening. Mixolab values can be used to elaborate predictive models for estimating values of farinograph water absorption, dough stability, dough softening, alveograph baking strength (W) and P/L index.

Keywords: alveograph, farinograph, mixolab, protein quality, wheat flour

INTRODUCTION

Baking test is one of the best methods for the prediction of the suitability of flour for production of high quality bread. However, the baking test is time-consuming, labour intensive, requires experienced staff and costly infrastructure (Koksel *et al.* 2009, Caffe-Treml *et al.* 2010). Therefore, several quality prediction methods based on dough rheological properties of wheat flour dough are used in milling and baking industry. The farinograph test provides information on the behaviour of dough during the mixing stage. The extensograph and the alveograph describe dough resistance to extension simulating the uni- or biaxial deformation of dough occurring during fermentation and oven rise (Codina *et al.* 2012). The amylograph test is a method commonly used to estimate alpha-amylase activity of flour (Dapcevic *et al.* 2009, Szafrańska 2014).

Mixolab determines the rheological properties of dough, recorded on a graph. Measuring the consistency of dough over time, with a gradual increase in the applied temperature, enables the user to determine the quality of flour and provides, in a single test, the information on water absorption, protein strength (dough development time, kneading stability, gluten quality, protein breakdown) and starch characteristics (gelatinisation, retrogradation, enzymatic activity) and on the interactions among these features (Dubat 2010).

The use of results obtained by mixolab requires much research, comparison with the results of production and traditionally used quality parameters (Codina *et al.* 2010). Mixolab values are generally in agreement with farinograph values. The results obtained by Le Brun *et al.* (2008) and Dapčević *et al.* (2009) show a significant high correlation between farinograph and mixolab water absorption. The correlation between farinograph stability and mixolab stability and C2 was considerably high, as well as between farinograph dough development time and mixolab time T1 (Dapčević *et al.* 2009, Koksel *et al.* 2009). Negative correlation was found between farinograph softening and mixolab stability and torque in point C2. Codina *et al.* (2010) evaluated the relationship between the alveograph and mixolab values of wheat flour with ash content in the range of 0.63 to 0.67%. There were significant correlations between mixolab stability and protein weakening (C2) and the alveograph parameters: tenacity (P) and baking strength (W). Koksel *et al.* (2009) found significant correlations between stability and C2 and baking strength (W), whereas Banu *et al.* (2011) obtained a negative correlation coefficient between mixolab stability and baking strength (W) ($r = -0.95$).

The growing interest in mixolab on the part of the milling and baking industries requires the adaptation of the interpretation of its results for Polish wheat flours. For this purpose, two types of wheat flour produced in Polish milling companies were analysed using starch damage, falling number and amylograph properties (Szafrańska 2014). The predictive models for evaluating the falling number and amylograph parameters as a function of mixolab values were established.

The aim of this study was to characterise the protein quality of wheat flour by traditional and modern techniques. The relationships between mixolab parameters and parameters obtained by farinograph and alveograph among wheat flour samples of different technological quality were determined.

MATERIALS AND METHODS

Thirty eight samples of commercial wheat flour type 550 and thirty eight samples of wheat flour type 750 were acquired from nineteen milling companies located in Poland. The ash content varied between 0.45÷0.63% for tested wheat flour type 550 and between 0.58÷0.85% for wheat flour type 750. Alpha-amylase activity of tested wheat flour was characterised in the previous article (Szafrańska 2014).

For each wheat flour sample, the following specific qualities were determined: protein content (PN-EN ISO 20483), gluten content and gluten index (PN-A-74042), Zeleny test (PN-ISO 5529). The farinograph and alveograph properties of the flours were determined by Brabender farinograph (PN-ISO 5530-1) and Chopin alveograph (PN-EN ISO 27971), respectively. The rheological properties of dough were studied using Chopin mixolab (Dubat 2010). The protocol has the following settings: mixing speed 80 rpm, total analysis time 45 min, dough weight 75.0 g, tank temperature 30°C, hydratation water temperature 30°C. Flour and water were added accordingly to obtain 75 g of dough with a maximum consistency of 1.10 Nm (±0.05) during the first test phase. The mixolab test was performed using the standard protocol: 8 min at 30°C, heating at the rate of 4°C min^{-1} for 15 min, holding at 90°C for 7 min, cooling to 50°C at the rate of 4°C min^{-1} for 10 min and holding at 50°C for 5 min. A typical mixolab curve (Fig. 1) is divided into five different phases: phase 1, initial kneading; phase 2, protein weakening, phase 3, starch gelatinisation; phase 4, cooking stability; phase 5, starch gelling (Rosell *et al.* 2007).

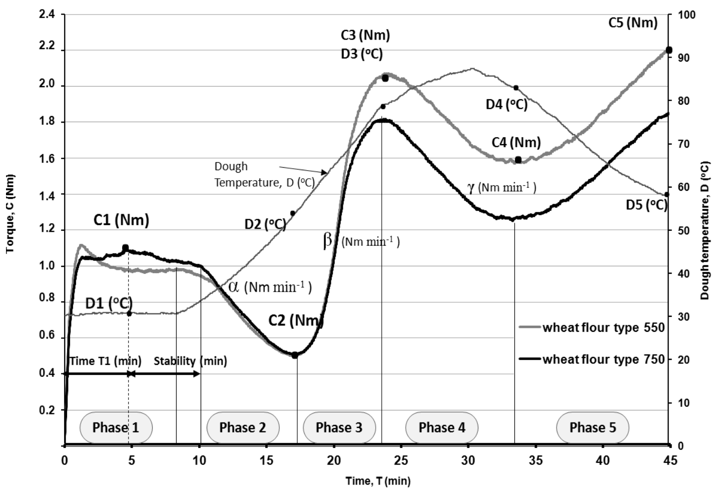

Fig. 1. Typical mixolab curves of wheat flour type 550 and type 750

The parameters which inform about protein characteristics that are read from the mixolab curve are water absorption (%), dough development time (time T1, min), dough stability (C1-0.11C1) (min), protein weakening (C2, N m), slope between C1 and C2 (slope α, N m min^{-1}) (Rosell *et al.* 2007).

For this study, also the torque in the 8^{th}, 10^{th}, 12^{th}, 14^{th}, 16^{th} minute of mixolab analyses was checked from the curve (abbreviated C_{8min}, C_{10min}, C_{12min}, C_{14min}, C_{16min}, respectively), as well as the differences between these points and C2 (abbreviated i.e. C_{8min}-C2) which also indicate the gluten strength.

Statistical analysis

The results were statistically evaluated by the one-way analysis of variance (ANOVA) with subsequent Tukey's HSD test, using Statgraphics Centurion XVI.I. Correlations between the mixolab, farinograph and alveograph characteristics were determined with the statistical significance expression on the level of $p = 0.05$ and $p = 0.01$.

The multiple regression analysis was used to determine whether the farinograph and alveograph characteristics were functionally related to the mixolab parameters values. By this method the best subgroup of tested variables with the highest multiple coefficients of determination $R^2_{adjusted}$ of the 95% confidence interval was determined. The dependent variables are: farinograph water absorption, dough development time, dough stability, softening, alveograph baking strength (W) and tenacity to extensibility ratio (P/L index). The regression model between the dependent variable (Y) and independent variables (x_1 to x_n) is:

$$Y = b_0 + b_1x_1 + b_2x_2 + \cdots + b_nx_x \quad (1)$$

where b_0 is a constant value and b_i, i = 1,…,n are the regression coefficients of the predictive model (Tab. 5). The predictive models were well correlated with the measured data and were significant at $p < 0.05$. Student's t-test was used to determine the significance of each coefficient in the regression model.

RESULTS AND DISCUSSION

Protein content in tested wheat flour was in the range of 10.4 to 14.8%, which indicates that it can be used to production of many types of bread, cookies, cakes and pastries (Słowik 2006). Wheat flour type 750 was characterised by a higher protein content than wheat flour type 550 (Tab. 1) because the greatest share of protein is contained in parts of endosperm situated near to the aleurone layer. These results agree with the observation of Rothkaehl (2004) and Achremowicz *et al.* (2010). Very good baking quality characterises flour with sedimentation value above 40 cm^3, good 30-40 cm^3, satisfactory 20-29 cm^3 and insufficient below 20 cm^3 (Słowik 2006). According to this criterion, most of tested flours were characterised by good and very good quality of protein (Tab. 1).

Table 1. Protein characteristics of tested wheat flours

Parameters	Wheat flour type 550			Wheat flour type 750		
	Mean	Range		Mean	Range	
		min	max		min	max
Protein content (%)	11.8^{a**}	10.4	13.0	12.8^{b**}	11.2	14.8
Wet gluten content (%)	28.4^{a*}	24.3	31.7	29.6^{b*}	24.8	36.3
Dry gluten content (%)	9.9^{a*}	8.4	11.0	10.3^{b*}	9.1	12.4
Gluten index	93^{a}	77	98	93^{a}	74	99
Zeleny index (cm^3)	38^{b*}	27	46	36^{a*}	28	44
Farinograph water absorption (%)	57.4^{a**}	55.3	59.4	59.0^{b**}	55.9	63.6
Dough development time (min)	2.1^{a**}	1.7	3.0	3.0^{b**}	1.7	6.9
Dough stability (min)	2.1^{a**}	1.4	9.8	6.1^{b**}	1.8	10.7
Degree of softening (FU)	64^{a}	30	100	66^{a}	40	86
Quality number	61^{a**}	28	113	79^{b**}	33	131
Baking strength – W (10^{-4}J)	239^{a}	165	332	235^{a}	156	320
Tenacity – P (mm)	84^{a}	62	115	87^{a}	59	120
Extensibility – L (mm)	86^{a}	55	127	87^{a}	62	128
P/L	1.05^{a}	0.58	1.98	1.06^{a}	0.53	1.76

a, b – mean values marked by different letters differ significantly at $p < 0.05$ (*) and $p < 0.01$ (**), respectively

Farinograph water absorption of tested flours was in the range of 55.3-63.6% (Tab. 1) which, according to Rothkaehl (2004), characterises good and very good suitability for baking (in the range of 50-57% and 58-60%, respectively). Wheat flour type 750 was characterised by greater dough development time and dough stability time than flour type 550. These results agree with the observation of Rothkaehl (2004), while Karolini-Skaradzińska *et al.* (2010) did not find differences between tested wheat flours.

Tested wheat flours were characterised by alveograph baking strength (W) in the range of 156-332·10^{-4}J (Tab. 1) which, according to Abramczyk and Stępniewska (2009), indicates its wide technological suitability. Most of the tested flour samples (86% flour type 550 and 57% type 750) were suitable for the production of traditional wheat bread, toast bread and crescent (W in the range of 200-300·10^{-4}J). 11% of wheat flour samples of type 550 and 36% of type 750 were proper for baking cookies, biscuits, baguettes and for household use (W in the range of 100-200$\cdot 10^{-4}$J). 61% of flour samples of type 550 and 36% of type 750 were characterised by P/L index in the range of 0.5-1.0 which is proper for cookies. Dough obtained from the rest of the wheat flour samples was characterised by small extensibility and high tenacity (P/L index above 1.0).

Water absorption tested by mixolab was lower by about 0.5% than water absorption obtained by farinograph (Tab. 2). Wheat flour type 750 was characterised by higher water absorption than flour type 550. These results agree with observations of Codina (2008) in which higher water absorption was found in flour with higher content of parts of bran. Tested samples of wheat flour type 750 were characterised by two times greater Time T1 than flour type 550. These results agree with observations of Dapčević *et al.* (2009) and Caffe-Treml *et al.* (2010) who proved that wheat flour with higher gluten content is characterised by a higher value of time T1.

Table 2. Mixolab characteristics of tested wheat flours

Parameters	Wheat flour type 550			Wheat flour type 750		
	Mean	Range		Mean	Range	
		min	max		min	max
Water absorption (%)	56.9^{a**}	54.3	59.0	58.4^{b**}	55.5	62.5
C2 (N m)	0.52^{b**}	0.46	0.59	0.50^{a**}	0.43	0.57
C1 – C2 (N m)	0.58^{a**}	0.50	0.66	0.60^{b**}	0.50	0.66
Slope α (N m min^{-1})	-0.075^{a}	–0.120	–0.004	-0.087^{a}	–0.140	–0.018
Time T1 (min)	1.6^{a**}	1.1	3.5	3.4^{b**}	1.2	7.3
Stability (min)	10.2^{a}	8.8	11.1	10.2^{a}	8.6	11.7
Time T1 + Stability (min)	11.8^{a**}	10.0	14.0	13.6^{b**}	10.1	19.0
$C_{8\,min}$ (N m)	1.02^{a**}	0.94	1.1	1.04^{b**}	0.96	1.09
C_{10min} (N m)	0.98^{a*}	0.91	1.06	1.00^{b*}	0.95	1.05
C_{12min} (N m)	0.87^{a}	0.78	0.98	0.88^{a}	0.98	0.21
C_{14min} (N m)	0.69^{a}	0.62	0.79	0.69^{a}	0.61	0.78
C_{16min} (N m)	0.55^{a}	0.49	0.62	0.54^{a}	0.47	0.61
C_{8min} -C2 (N m)	0.50^{a**}	0.43	0.56	0.54^{b**}	0.46	0.59
C_{10min} -C2 (N m)	0.46^{a**}	0.40	0.52	0.50^{b**}	0.44	0.55
C_{12min} -C2 (N m)	0.35^{a**}	0.27	0.41	0.38^{b**}	0.33	0.48
C_{14min} -C2 (N m)	0.17^{a**}	0.13	0.21	0.19^{b**}	0.15	0.26
C_{16min} -C2 (N m)	0.03^{a**}	0.02	0.06	0.04^{b**}	0.02	0.08

a, b – mean values marked by different letters differ significantly at $p < 0.05$ (*) and $p < 0.01$ (**), respectively

During mixolab test the dough and the mixer are kept at 30°C for 8 min. After this time there is a gradual temperature rise with a gradient of 4°C min^{-1}. As the temperature increases the consistency of the dough decreases with excessive mixing, which is an indication of protein weakening (Dubat 2010). The greater the decrease in consistency, the lower the protein quality. According to Dhaka *et al.* (2012) there is a significant positive correlation between C2 and loaf volume. Usually the mixolab stability, torque in point C2, difference between C1 and C2 values and slope α are measured (Koksel *et al.* 2009) as it is related to gluten quality. For this study, also the torque in the 8th, 10th, 12th, 14th, 16th minute of mixolab analyses was checked from the curve (abbreviated, i.e. C_{8min}), as well as the differences between these points and C2 (abbreviated, i.e. C_{8min}-C2) which also indicate protein weakening. Tested wheat flour type 550 was characterised by significantly higher C2 and lower C_{8min}, C_{10min}, C_{8min}-C2, C_{10min}-C2, C_{12min}-C2, C_{14min}-C2, C_{16min}-C2 than flour type 750 (Tab. 2).

Mixolab water absorption, time T1 and stability obtained from mixolab curve were correlated with the corresponding farinograph characteristics (Tabs 3 and 4). These results agree with the observations of Le Brun *et al.* (2008) and Dapčević *et al.* (2009).

Table 3. Coefficients of correlation between parameters measured by farinograph, alveograph and mixolab of tested wheat flour type 550, significant at $p < 0.05$ and $p < 0.01$*, respectively

	FWA	FDDT	FDS	FS	W	P	L	P/L
MWA	0.900*					0.770*	-0.537*	0.635*
Time T1							0.352	
Stability		0.385	0.691*	–0.767*	0.462*		0.585*	–0.495*
T1+stability		0.640*	0.668*	–0.592*		0.596*	–0.506*	
C2			0.526*	–0.631*	0.369			
C1-C2			–0.331	0.515*				
C_{8min}	–0.342	0.549*	0.793*	–0.617*	0.321	–0.397	0.645*	–0.579*
C_{10min}		0.521*	0.809*	–0.722*	0.930*	–0.335	0.626*	–0.561*
C_{12min}			0.707*	–0.818*	0.622*		0.619*	–0.460*
C_{14min}			0.700*	–0.778*	0.538*		0.588*	–0.460*
C_{16min}			0.627*	–0.726*	0.418		0.441*	–0.362
C_{8min} -C2		0.450*	0.336			–0.397	0.417	–0.401
C_{10min} -C2		0.477*	0.372			–0.383	0.442*	–0.427*
C_{12min} -C2		0.365	0.574*	–0.639*	0.608*		0.715*	–0.518*
C_{14min} -C2	–0.366	0.375	0.523*	–0.506*	0.462*	–0.364	0.730*	–0.570*
C_{16min} -C2						0.382	0.519*	–0.452*

FWA, farinograph water absorption; FDDT, farinograph dough development time; FDS, farinograph dough stability; FS, farinograph degree of softening; MWA, mixolab water absorption; C_{8min}, C_{10min}, C_{12min}, C_{14min}, C_{16min} torque measure in 8, 10, 12, 14, 16 minute of mixolab analysis, respectively

Differences between farinograph and mixolab water absorption and dough development time and time T1 meet the requirements of reproducibility specified in the standard PN-ISO 5530-1. The interpretation of stability measured by mixolab is different than that obtained by farinograph. Farinograph stability is a difference of time between the point where the top part of the curve intercepts, for the first time, the line of 500 FU and the last point where it leaves this line. Mixolab stability is a period of time between toque in point C1 and 11% decrease of the torque. The standard deviation of mixolab stability is lower than farinograph stability (0.7 and 2.1, respectively). The sum of time T1 and stability, according to the AACC interpretation of the farinograph curve (PN-ISO 5530-1), can be determined as a resistance time of dough.

Table 4. Coefficients of correlation between parameters measured by farinograph, alveograph and mixolab of tested wheat flour type 750, significant at $p < 0.05$ and $p < 0.01$*, respectively

	FWA	FDDT	FDS	FS	W	P	L	P/L
MWA	0.979*	0.414				0.594*	–0.364	0.516*
Time T1		0.543*	0.670*	–0.463*			0.354	
Stability			0.353	–0.598*	0.366			
T1+stability		0.468*	0.700*	–0.589*			0.330	
C2				–0.469*				
C1–C2				0.323				
C_{8min}			0.696*	–0.734*				
C_{10min}			0.635*	–0.757*				
C_{12min}			0.459*	–0.699*	0.554*			
C_{14min}			0.469*	–0.688*	0.443*			
C_{16min}			0.365	–0.612*	0.340			
C_{8min}-C2			0.402			–0.354	0.522*	–0.509*
C_{10min}-C2			0.389				0.451*	–0.433*
C_{12min}-C2			0.479*	–0.596*	0.600*		0.398	
C_{14min}-C2		0.328	0.580*	–0.607*	0.496*		0.440*	
C_{16min}-C2			0.452*	–0.443*			0.495*	–0.365

FWA, farinograph water absorption; FDDT, farinograph dough development time; FDS, farinograph dough stability; FS, farinograph degree of softening; MWA, mixolab water absorption; C_{8min}, C_{10min}, C_{12min}, C_{14min}, C_{16min} torque measure in 8, 10, 12, 14, 16 minute of mixolab analysis, respectively

The results obtained by Codina *et al.* (2010, 2012) show a positive correlation between mixolab water absorption and alveograph parameters such as baking strength (W), tenacity (P) and P/L index. In this work significant correlation was found between mixolab water absorption and P, L and P/L index (Tabs 3 and 4).

According to Banu *et al.* (2011), there is a negative relationship between mixolab stability and baking strength (W). The results obtained in this work showed a positive correlation between mixolab stability and alveograph baking strength (W), which is in agreement with the observations of Peňa *et al.* (2007-2008), Koksel *et al.* (2009) and Codina *et al.* (2012). Coefficients of correlation between farinograph and alveograph properties and such mixolab parameters as torque in point C_{8min}, C_{10min}, C_{12min}, C_{14min}, C_{16min} were in most cases higher than with time T1, stability, C2 (Tab. 3 and Tab. 4).

In this study a multiple regression analysis indicated that there was more than one significant independent variable. Coefficients of determination, $R^2_{adjusted}$, obtained by multiple regression models for prediction of farinograph and alveograph properties of dough based on traditional parameters (Tab. 5) were lower than $R^2_{adjusted}$ based on mixolab values (Tab. 6). The regression equation models for farinograph water absorption explains 80.4 and 96.3%, respectively, of the variation of the water absorption variable of wheat flour type 550 and type 750. These models contain such mixolab parameters as mixolab water absorption and stability (Tab. 6). The coefficients of all variables are statistically significant. The standard errors of the estimate were 0.5 and 0.3%, respectively.

Table 5. Multiple regression models for prediction of farinograph and alveograph properties of dough based on protein content, gluten content, ash content and Zeleny index

Dependent variable	Type of flour	Regression equation	$R^2_{adjusted}$	SE
FWA	type 550	46.55 + 10.78AC + 0.132Z	30.2	0.9
	type 750	46.19 + 8.131AC + 0.227WG	31.2	1.2
FDDT	type 550	–0.032 + 0.077WG	17.0	0.3
	type 750	–13.81 + 7.42AC + 1.097DG	45.9	1.1
FDS	type 550	–16.24 + 0.739WG	41.7	1.6
	type 750	–12.84 + 3.05P – 1.95DG	50.5	1.3
FS	type 550	196.2 + 135.7AC – 17.41P	54.4	11
	type 750	174.6 + 67.6AC – 23.58P + 4.8WG	48.9	9
W	type 550	–80.98 – 277.6AC + 39.88P	56.2	24
	type 750	20.55 – 240.9AC + 30.79P	25.3	36
P/L	type 550	–1.332 + 2.389AC – 0.289WG + 0.503DG + 0.043Z	48.9	0.3
	type 750	1.62 + 2.73AC – 0.29P + 0.032Z	14.5	0.3

FWA, farinograph water absorption; FDDT, farinograph dough development time; FDS, farinograph dough stability; FS, farinograph degree of softening; P, protein content; WG, wet gluten content; AC, ash content; DG, dry gluten content; Z, Zeleny index; SE, standard error of the estimate

Table 6. Multiple regression models for prediction of farinograph and alveograph properties of dough based on mixolab values

Dependent variable	Type of flour	Regression equation	$R^2_{adjusted}$	SE
FWA	type 550	$7.6 + 0.87MWA$	80.4	0.5
	type 750	$-5.22 + 1.067MWA + 0.19MS$	96.3	0.3
FDDT	type 550	$-2.65 + 4.88C_{10min}$	25.1	0.3
	type 750	$1.43 + 20.96\,C_{14min} + 0.444T1 - 1.405MS$	43.6	1.1
FDS	type 550	$-20.28 - 28.29C1 + 55.08C_{8min}$	69.3	1.2
	type 750	$-33.61 + 36.58C_{8min} + 0.49T1$	69.9	1.0
FS	type 550	$705.9 - 4.98MWA - 204.2C_{10min} - 227.5C_{14min}$	72.4	10
	type 750	$328.2 - 164.2C_{8min} - 96.8C_{12min} - 1.96T1$	64.4	8
W	type 550	$-945 + 13.07MWA + 1039.9C_{12min} - 849.3MS - C_{16min}$	74.6	23
	type 750	$-703.8 + 9.71MWA + 979.8C_{12min} - 905.4C_{16min}$	47.4	30
P/L	type 550	$-7.97 + 0.204MWA - 0.26MS$	63.6	0.2
	type 750	$-9.92 + 0.145MWA - 6.54C_{8min} + 9.6C_{10min} - 0.084T1$	53.3	0.2

FWA, farinograph water absorption; FDDT, farinograph dough development time; FDS, farinograph dough stability; FS, farinograph degree of softening; MWA, mixolab water absorption; MS, mixolab stability; C_{8min}, C_{10min}, C_{12min}, C_{14min}, C_{16min} torque measure in 8, 10, 12, 14, 16 minute of mixolab analysis, respectively; T1, time T1; SE, standard error of the estimate

The regression models for dough development time including dough torque in points C_{10min} and C_{14min}, time T1 and stability were unsatisfactory. The value of the adjusted determination coefficient shows that the models explain 25.1 and 43.6%, respectively, of the variation of the dough development time dependent variable (Tab. 6). The standard errors of the estimate were 0.3 and 1.1 min, respectively. The models for farinograph dough stability time include three mixolab parameters: torque in points C1, C_{8min} and time T1. The value of the adjusted determination coefficient shows that the models explain 69.3 and 69.9%, respectively, of the variation of the dough stability time dependent variable (Tab. 6). The standard errors of the estimate were 1.2 and 1.0 min, respectively. The regression models for farinograph degree of softening explain 72.4 and 64.4%, respectively, of the variation of this parameter of wheat flour type 550 and type 750. The standard error of the estimate was 10 and 8 FU, respectively.

The differences between the $R^2_{adjusted}$ were the greatest in the regression models for baking strength (W) which explain 74.6 and 47.4%, respectively, of the variation of this parameter of wheat flour type 550 and type 750. The standard error of the estimate was 23 and 30, respectively. The models for P/L index contain such mixolab parameters as water absorption, stability and torque in point C_{8min}, C_{10min} and time T1. The standard error of the estimate was 0.2 for both types of flours.

CONCLUSIONS

1. Wheat flour types tested in this study were significantly different in protein and gluten content as a result of uneven distribution of chemical components of wheat grain and different milling fraction from which the type of flour was obtained. Rheological properties of dough such as farinograph water absorption, dough development time and P/L index were different between tested wheat flour types.

2. Rheological properties of dough tested by mixolab were different in terms of type of flour. Wheat flour type 750 was characterised by higher water absorption and time T1 and lower torque in points C2, C_{12min}, C_{14min}, C_{16min} than wheat flour type 550.

3. It was proved that torque in points C_{8min}, C_{10min}, C_{12min}, C_{14min}, C_{16min} gives higher correlation coefficients with farinograph and alveograph properties than torque in point C2.

4. Statistical analysis of wheat flour samples by multiple regression method showed that mixolab values can be used to elaborate predictive models for the estimation of values of the farinograph water absorption, dough stability, dough softening, alveograph baking strength (W) and P/L index.

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PROGNOZOWANIE WŁAŚCIWOŚCI FARINOGRAFICZNYCH I ALWEOGRAFICZNYCH MĄKI NA PODSTAWIE PARAMETRÓW Z MIXOLABU

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S t r e s z c z e n i e. Do określenia ilości i jakości białka w mące pszennej powszechnie stosowane jest oznaczenie zawartości białka, ilości glutenu, wskaźnika sedymentacyjnego Zeleny'ego oraz właściwości farinograficznych i alweograficznych. Mixolab może być wykorzystywany do badania w jednym teście cech ciasta pod kątem właściwości białka, aktywności enzymów amylolitycznych i retrogradacji skrobi. Celem pracy było określenie zmienności i związków między parametrami farinograficznymi i alweograficznymi a parametrami odczytanymi z mixolabu, które charakteryzują cechy białka. Badania wykonano dla 76 próbek mąki pszennej typ 550 i typ 750 wyprodukowanych w Polsce. Mąka pszenna typ 750 charakteryzowała się istotnie większą zawartością białka, wodochłonnością farinograficzną, czasem rozwoju i stałości ciasta. Właściwości reologiczne ciasta określone za pomocą mixolabu były zróżnicowane w zależności od typu mąki. Mąki pszenne typ 750 charakteryzowały się większą wodochłonnością i dłuższym czasem T1 oraz mniejszym oporem ciasta w punktach C2, C_{12min}, C_{14min}, C_{16min} niż mąki pszenne typ 550. Większe wartości współczynników korelacji uzyskano między czasem stałości i rozmiękczeniem ciasta a parametrami z mixolabu: C_{8min}, C_{10min}, C_{12min}, C_{14min}, niż z oporem ciasta w punkcie C2, który to jest powszechnie stosowanym parametrem w ocenie jakości białka. Parametry z mixolabu mogą być stosowane do wyznaczenia równań regresji opisujących wodochłonność farinograficzną, czas stałości, rozmiękczenie ciasta, wartość wypiekową (W) oraz wskaźnik P/L wyznaczone za pomocą alweografu.

S ł o w a k l u c z o w e: alweograf, farinograf, mixolab, jakość białka, mąka pszenna