RESEARCH ARTICLE

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Determination of Some Flour Characteristics

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ABSTRACT

Food based on cereals especially the flour as an end product has been frequently consumed all over the world. Different types of commercially available flour (wheat, oat, corn, rye, integral rye flour) were tested for several characteristics such as magnetic, microscopic, testing of carbonates in flour with hydrochloric acid and oxalic acid, determination of gluten content, pH value, moisture content, foam capacity, flour colour analysis and FT-IR analysis. The microscopic analysis with an optical microscope showed the structural properties of each flour type. The results show that colour indexes represented with values of L^*, a^*, and b^* showed good correlation in the evaluation of milling precision and flour grading (maximum value for wheat flour, L^* was 86.921). The FT-IR analysis showed the main peaks in the region of C-H, N-H, and C-N bonds. The proposed methods are easy to be handled for rapid determination of several flour characteristics such as pH value, moisture and gluten content, parameters directly connected to storage quality. Application of available less cost methods for determination of certain parameters for safe use of flour products.

Keywords: Colorimetry, gluten, flour, FT-IR spectroscopy, pH value.

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I. Introduction

Nutrient components in cereal products are one of the most important food products that make the products delicious and can be kept well. Nutrients provided by bread consumption in industrial countries meet close 50% of daily requirement of carbohydrates, one third of the proteins and 50–60% of vitamin B [1]. Minerals and trace elements are also present in cereal products [2]. The major cereals are wheat, rye, rice, barley, millet, and oats. The utilization of wheat and rye are in the bread-making industry. Flour is obtained as a raw product in the process of grain milling. Endosperm cells predominate in the obtained preferentially flour in the process of milling. In order to produce bread, pasta, cakes, and biscuits, flour is used [3]. The rheological characteristics of the dough are determined with the amount of flour. The balanced flour amount should be at the level, so the dough is elastic and at the same time with certain viscosity [1].

The parameters which are determined in the flour are related to the content of proteins, ash, minerals, colour, gluten (wet and dry), the level of enzyme activity, and moisture (%). White flours are characterized by ash content up to 0.55%.

Two types are recognized type 400 (T-400, ash up to 0.45%) and type 500 (T-500, ash between 0.46 and 0.55%). The white flour is characterized by low content of proteins and glutens. The quality of wheat flour can be defined for several parameters including protein, moisture, gluten, sedimentation, enzyme activity, and rheological properties [4]. Gluten consists of 90% protein, 8% lipids and 2% carbohydrates. After addition of water viscoelastic cohesive dough can be kneaded from wheat flour. The resulting gluten, which can be isolated as a residue after washing out the dough with water, removing starch and other ingredients, is responsible for plasticity and dough stability [1]. The gluten proteins, in association with lipids, are responsible for the cohesive and viscoelastic flow properties of dough. Such rheological properties give the dough gas-holding capacity during leavening and provide a porous, spongy product with an elastic crumb after baking. Some cereals contain no gluten, but in the process of storage and transportation gluten-containing grains can come in contact [1]. The baking quality of rye is due to pentosans and to some proteins which swell after acidification and contribute to gas-holding properties. Moisture values inform us indirectly about flour storage conditions. If the moisture content is high is associated with growing of moulds and under 12%, promotes rancidity in fats present in flour [1]. The typical functional groups can be tested with FT-IR spectroscopy [3]-[5], while the colour specificity is determined with indexes L^*, a^*, and b^* indicating the bright white colour in the refined flour L^*, the pigment in the endosperm b^*, and the pigmentation from red to green with index a^*[6], [7].

The main aim of this article is determination of some parameters for flour with methods easy to handle for rapid analysis.

II. Materials and Methods

Six flour types (Labeled from 1 to 6) from rye (1), integral rye flour (2), oat (3), corn (4), and wheat a and b (5 and 6) commercially available have been investigated. Hydrochloric acid and oxalic acid were with analytical pure grade and were purchased from Merck (Germany). Analytical balance (VWR, Austria) with 0.1 mg accuracy was used in the analysis.

A. Preliminary Studies

In the preliminary step, the flour types should be realized of impurities such as weed seeds, straw, soil particles, spoiled decayed grains, dust, etc. The investigation of

presence of metal parts in the flour was done by analyzing the magnetic properties using magnet for testing magnetic properties for the representative sample of the packet (5 g). In the testing tube, 5 g of each sample was used, and 10 mL distilled water was added analyzing if there is straw in the sample.

B. Microscopic Characteristics

The microscopic analyses were performed on an optical microscope Phenix Optics (P.R.C) with magnification of 40x. A digital camera Sony, Cyber-shot W, type DSCW830V.CE3 and lens ZEISS Vario-Tessar 8x (China) were used in the photomicrography. After analyzing the results of the slide collection were recorded by photomicrographs.

C. pH-meter

pH-meter (P. R. China) was used to determine pH value of the analyzed flour sample.

D. Testing of Carbonates in Flour with Hydrochloric Acid and Oxalic Acid

The qualitative analysis of the present of carbonates in flour samples was done where amount of each flour sample (5 g) was transferred to each testing tube and 5 mL of hydrochloric acid was added. The procedure was repeated using oxalic acid with another quantity (5 g) of flour sample.

E. Gluten

The strength of the flour is associated with the amount of gluten present in the flour. The dough obtained by mixing flour with water possesses are the main determinations for the characteristics of viscosity. The wet gluten is determined when 33.33 g of each flour sample is measured, and 17 mL water was added (the first method). The dough is kneaded until it becomes sticky and then put under the tap. The ball of dough is washed with water until all the starch is removed. In doing so, the entire gluten is collected in one ball. The water rinse is complete when the water does not show a cloudy appearance. The gluten is drained and placed on a watch glass and weighed. The obtained mass is multiplied by 3 and with that the mass share in percent of wet gluten is obtained. The second method for gluten determination was with use of 25 g of flour type, adding 15 mL water followed by immersion of dough ball in water for one hour to ensure proper hydratation. Washing was ended when the liquid is clear. The gluten was weighted to constant weight. Dried gluten is called dry gluten.

F. Moisture content

A small sample of flour (2-3 g) is weighed and placed in a moisturizing dish. The sample is heated at 130 °C for 1 hour. The sample is cooled to room temperature and the residue is weighed.

G. The Foam Capacity

Flour sample (1.0 g) was added to 50 mL distilled water at 30±2 °C in a graduated cylinder. The suspension was mixed and has been shaken for 5 min to foam. The volume of foam at 30 sec after whipping was expressed as foam capacity using the formula:$(V_2 - V_1)\times 100/V_1\times 100\%$, where the initial volume is represented as V_1 and the final volume as V_2.

H. FT-IR Spectroscopy

FT-IR Spectroscopic specific parameters were within running on Shimadzu FT-IR Spirit-L type (Japan) with ZnSe, 20 scans, Range 400-4000 cm^{-1}, Apodization Happ-Genzel, Measurement mode %Transmitance

I. Flour Colour Analysis

Flour color is determined by measuring the whiteness of a flour sample with the Program *Color Meter* where the results are reported in terms of 3-dimensional colour values based on the following rating scale (Table I).

TABLE I: RATING SCALE FOR FLOUR COLOUR ANALYSIS

L*	Whiteness	100 white 0 black
a^*	positive values negative values	+60 red colour -60 green colour
b^*	positive values negative values	+60 yellow colour -60 blue colour

The lightness/brightness of the flour is determined with L^*value. The value of 0 is classified for pure black, while value of 100 for pure white. The intensity from red to green is within scale +60 for pure red to -60 for pure green marked with a^* scale. The value of +60 at the b^* is a measure of pure yellow, while -60 is for pure blue. The L^* and b^* values are related to a bright white colour in refined flours (high L^* value) and the natural pigment in the endosperm which lighted during aging, respectively.

III. RESULTS AND DISCUSSION

A. Preliminary Studies

In the preliminary studies, the examined flour types were free from metal parts, straw, and soil particles. During the harvesting and then to obtaining the final product, the metal parts can be ended in the product.

B. Microscopic Characteristics

The preparation of flour samples and the photomicrographs were given in Table II.

Microscopic analysis has shown that it is possible the visualization and identify structural characteristics in the examined flour such as tissue, epidermis and to determine substances odd to its composition. Physical appearance and morphology of wheat grain is influenced by grain moisture content [8].

C. pH determination

The pH value is an indicator of the history of flour storage [1]. Too low acidity often reflects poorly aged flour. Acidity above 7.0 suggests microbial spoilage.

The values of pH for tested flours are given in Table III.

For controlling pH value, one wheat flour type from the same type labeled as 6 but beyond the expiration date was also tested where the determined pH value was 8.36.

D. Testing of Carbonates in Flour with Hydrochloric Acid and Oxalic Acid

Testing of carbonates in flour with Hydrochloric acid and oxalic acid. The results of testing carbonates in testing tubes in flour samples are given in Fig. 1 in the analysis with HCl (a) and with oxalic acid (b).

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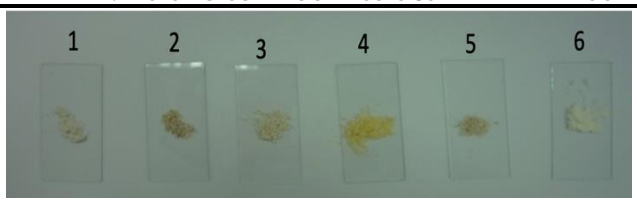
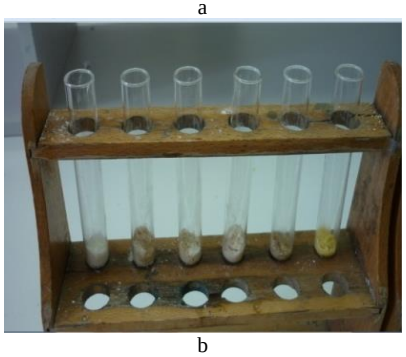
TABLE II: PHOTOMICROGRAPHS OF FLOURS USED IN THE ANALYSIS



Type of flour	***Photomicrograph***
Rye (1)	
Integral rye flour (2)	
Oat (3)	
Corn (4)	
Wheat a (5)	
Wheat b (6)	

a



b

Fig. 1. Testing of carbonates for 6 types of flour using HCl (a) and Oxalic acid (b).

TABLE III: DETERMINATION OFPHIN FLOUR

Type of flour	pH value (25 °C)
Rye (1)	6.55
Integrated rye flour (2)	5.20
Oat (3)	6.25
Corn (4)	5.68
Wheat a (5)	6.71
Wheat b (6)	6.75

The present of carbonates was recorded with the bubbles of the formed gas and the changing of the colour was present, respectively.

E. Gluten

The *gluten content*, which is the residue left after the dough is washed (10 g flour kneaded into a dough with 6 mL of 2% NaCl, then washed with tap water), provides an indication of flour quality. A very low gluten content (<20%) frequently results in dough deterioration when machine-handled and also in baking faults. A higher content of gluten will not guarantee good baking quality. Gluten, the protein component of flour which gives the dough elasticity and strength, can be defined as the rubbery mass that remains when wheat dough is washed to remove starch granules and water-soluble constituents. Gluten plays a key role in determining the unique baking quality of wheat by conferring water absorption capacity, cohesiveness, viscosity, and elasticity on dough. The gluten content is related to protein content. Stability of the gluten network is also due to noncovalent bounds as hydrogen or hydrophobic bounds and entanglement between chains [9]. During dough mixing, wheat flour is hydrated, and the gluten proteins are transformed into a continuous cohesive viscoelastic gluten protein network. Gluten from strong flour types is generally extensive and elastic. Wet gluten for good bread flour falls in the range of 30–36%. Dry gluten for good bread flour falls in the range of 10–12%. Biscuit and cake flour has dry gluten in the range of 7–10%.

The gluten content is represented in Table IV, showing the values of wet and dry gluten content.

TABLE IV: GLUTEN CONTENT IN TESTED FLOUR SAMPLES

Type of flour	Wet gluten content from the first method (g)	Dry gluten content from the first method (g)	Wet gluten content from the second method (g)	Dry gluten content from the second method (g)
1	47.0885	27.1792	79.8326	31.9229
2	78.8807	58.2597	46.3663	40.9639
3	50.7852	43.1193	56.8446	32.4007
4	52.1087	29.5471	23.9826	11.3440
5	64.4723	29.5263	40.8179	33.4807
6	64.5623	29.4363	40.7279	33.4317

Although oats and corn are naturally gluten free, they may come in contact with gluten-containing grains such as wheat, rye and barely in storage or during transportation.

F. Moisture Content

The moisture content in the flour samples was within 13.03%.

G. The Foam Capacity

The foam capacity of flour content was in the range between 15.5 % and 17.6%.

Plasticity and elasticity are significant during handling the dough as well as in its end performance. These properties are due to the interaction of water soluble proteins of flour with water. The albumins, globulins, and other smaller proteins as well as starch are washed along with water leaving behind a cohesive, elastic and rubbery mass. Colour of the gluten varies from pale yellow to greenish grey.

Weaker gluten generally has yellow colour, while strong gluten will have deeper greenish colour.

H. FT-IR Spectroscopy

Absorbance peak which was at 1707 cm^{-1}, 1860 cm^{-1}-1480 cm^{-1}, amide I (1690 cm^{-1}–1600 cm^{-1}) C=O, amide II (1580 cm^{1}-1480 cm^{-1}) N-H, C-N, wheat flour contamination in non-gluten breads [5]. Intense band in the range of 3600–3200 cm^{-1} is generated by stretching vibrations of C-H bond. The bands located in the spectral ranges of 1197–952 cm^{-1} and 952-886 cm^{-1} are for lipids (Fig. 2).

I. Flour Colour Analysis

The obtained colour for flours was represented in Table V.

TABLE V: RESULTS OF COLOUR ANALYSIS FOR FLOUR

Type of flour		1	2	3	4	5	6
L*	whiteness	62.17	58.00	55.18	84.30	69.03	86.92
*a**	positive values	/	3.79	2.40	4.62	/	3.47
	negative values	-0.36	/	/	/	-0.03	/
*b**	positive values	5.93	12.99	13.97	14.18	6.00	0.63
	negative values	/	/	/	/	/	/
hue	index	52.84	31.06	34.15	32.04	/	29.91

Flour colour and whiteness are important indexes of flour quality in evaluation of milling precision and flour grading. The whiteness as an index is in the relation of genes with high heritability [6], [7].

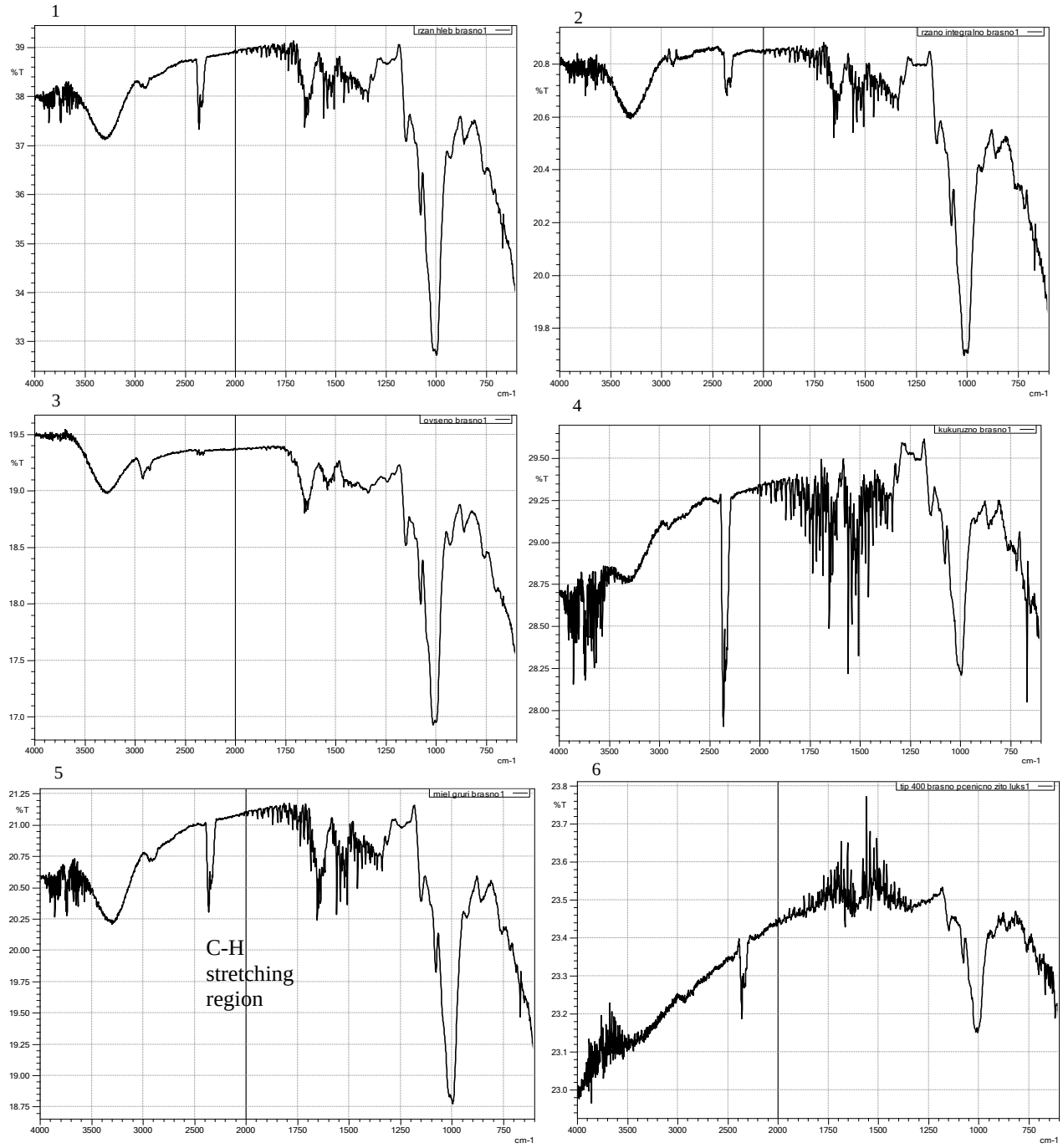


Fig. 2. FT-IR Spectra of analyzed flour types (1-6).

IV. CONCLUSION

The tested 6 different types of flour were within prescribed values for absence of magnetic parts of materials, straw and small particles. Colour visual perception as one of the dominant parameters was described using indexes L^*, a^*, and b^*. The pH value was an indicator of storage conditions of the flour. The microbiological activity was recorded for the flour beyond the expiration date. Analyses which were obtained from FT-IR spectroscopy showed the characteristic peaks according to the functional groups. The preliminary studies and also the determination of moisture and gluten content and also the value of foam capacity showed the good storage of the examined flour types and safety of their consumption.

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