Chemical Characteristics and Pasting Properties of Commercial Slovak Common and Spelt Wheat Flours

Zlatica KOHAJDOVÁ (✉)
Jolana KAROVIČOVÁ

Summary

The objective of this paper was to show differences among qualitative parameters of commercially produced Slovak fine and wholemeal wheat flours prepared from *Triticum aestivum* L. (common wheat) and *Triticum aestivum ssp. spelta* L. (spelt wheat). The selected chemical parameters (protein, starch, ash, glucose, fructose, sucrose, maltose, pH, lactic acid, acetic acid, citric acid, succinic acid, calcium, iron and zinc), gluten characteristics (wet and dry gluten, extensibility of gluten and swelling of gluten) and pasting properties (pasting temperature, peak viscosity, hot paste viscosity, peak viscosity temperature and breakdown value) of flours were analysed.

Spelt wheat wholemeal flour produced in ecological system of farming differed from other commercially produced wheat flours mainly in ash (1.82 %), proteins (16.5 %), wet gluten (43.2 % in dry matter), minerals (Ca, Fe, Zn) and organic acids content. Maltose was found as the most predominate saccharide in the common wheat fine flour (0.46 g/100g) and sucrose was prevalent in common and spelt wheat wholemeal flours (0.68 and 0.76 g/100g). It was also stated that commercially produced common wheat fine flour was characterised by lower pasting temperature (59 °C), peak viscosity (575 BU) and breakdown value (210 BU) than common and spelt wheat wholemeal flours.

Key words

common wheat, spelt wheat, flours, chemical composition, gluten characteristics, pasting properties

Institute of Biotechnology and Food Industry, Faculty of Chemical and Food Technology, Slovak University of Technology, Radlinského 9, 812 37 Bratislava, Slovak Republic
✉ e-mail: zlatica.kohajdova@stuba.sk

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Introduction

Wheat is unique in its ability to produce a diverse array of food products, including staple foods such as bread and pasta. It is also the principal source of energy, protein and dietary fibre for a major portion of the world population (Abdel-Aal and Hucl, 2002). While most of the world wheat crop arises from production of common *(Triticum aestivum)* and durum *(Triticum durum)* cultivars, there is increasing interest in ancient wheat species (Abdel-Aal et al., 1995). Of the ancient wheats, einkorn, spelt, emmer and Khorasan are currently of interest for use in specialty bakery products (Abdel-Aal and Hucl, 2002).

Spelt wheat (*Triticum aestivum subsp. spelta*) is a low-input plant, suitable for growing without the use of pesticides, in harsh ecological conditions and in marginal areas of cultivation (Bonafaccia et al., 2000). Even with low fertilizing spelt wheat gives a good harvest and has a better mineral uptake in comparison with *Triticum aestivum* L. (Bojňanská and Frančáková, 2002). There are few, but marked, differences between spelt and common wheat (Campbell, 1997; Onishi et al., 2006). Compared with common wheat, spelt is taller (150±200 cm), has long, lax ears (15±20 cm), a brittle rachis and adherent glumes (Yan et al., 2003; Bertin et al., 2001). For many years, cultivation of spelt declined, but recent interest in use of spelt for ecologically grown foods has led to resurgence in its cultivation (Bonafaccia et al., 2000; Zielinski et al., 2008).

Spelt has shown good potential in a variety of end-uses (Abdel-Aal and Hulc, 2002). Today, more spelt-based products are available including flour, bread, breakfast cereals, pasta, crackers (Marques et al., 2007) and number of regional specialties (e.g., the Grünkern of southern Germany) (Büren et al., 2001). As the consumption of spelt food products is steadily increasing, there is a need to evaluate their nutritional quality in comparison with common wheat products (Abdel-Aal, 2008).

The objective of this paper was to determinate differences in composition of Slovak commercially produced wheat flours and spelt wheat flours produced in ecological system of farming.

Materials and methods

A commercial flour types (common wheat fine flour T650, common wheat wholemeal flour and spelt wheat wholemeal flour produced in ecological system of farming without fertilisation and any chemical treatments) from a Slovak local market were used for this study. Flours were characterised with the following analyses: pH (LABOR-pH-meter, CG-834, Schott, Mainz, Germany), moisture (laboratory dryer KCW 100, PREMED, Marki, Poland) (ISO 711:1985), ash (muffle furnace, Veb Electrobad, Frankenhausen, Germany) (ISO 2171:1993), starch using the Ever's method (Moreels and Amylum, 2006), proteins by the Kjeldahl method, using a nitrogen to protein conversion factor of 5.7 (Sangronis et al. 2006) and gluten characteristics (wet and dry gluten, extensibility of gluten and swelling of gluten) (ISO 21415-1:2006 and ISO 21415-3:2006). Saccharides (glucose, fructose, sucrose and maltose) were determined by HPLC with RI detector (K2301, Knauer, Berlin, Germany). The HPLC system (Watrex, Bratislava, Slovakia) consisted of SDS 030 pump and column thermostat DELTA Chrom CTC 100. The analyses of saccharides were performed according to Kohajdová et al. (2007). Organic acids (lactic, acetic, citric and succinic) were determined by capillary isotachophoresis (isotachophoretic analyser ZKI 01 Vill Labeco, Spišská Nova Ves, Slovkia) using a conductivity detector according to Karovičová and Kohajdová (2005) and Kohajdová and Karovičová (2005). Fe, Ca and Zn were determined by AAS with flame atomisation (Perkin-Elmer, Ramsey, Minnesota, USA) according to Ruibal-Mendieta et al. (2005).

Pasting properties of flours were investigated with viscograph (Brabender, Germany). The measurements and the evaluation of viscogram were carried out according to Bhattacharya and Sowbhagya (1979). The pasting temperature (PT), peak viscosity (PV), hot paste viscosity (HPV), peak viscosity temperature (PVT) and breakdown (PV-HPV) were analysed.

All chemical and pasting measurements were performed in triplicate; the results are presented as means of the measurements ± standard deviations.

Results and discussion

The nutritive value of spelt wheat is high and it contains all the basic components which are necessary for human beings (Bojňanská and Frančáková, 2002). Chemical characteristics of analysed flours are illustrated in the Table 1.

A parameter as simple as ash content allows the discrimination of spelt from wheat milling products (Kohajdová and Karovičová, 2008). Spelt flour and wholemeal spelt wheat flour are presented by higher ash content (in average 0.54 % and 1.83 %) in comparison with fine and wholemeal wheat flour (in average 0.42 % and 1.49 %) (Ruibal–Mendieta et al., 2005). Similar results were determined also in the Slovak common wheat fine (0.73 %) and wholemeal flours (1.11 %) and in the spelt wheat wholemeal flour (1.82 %). The high ash content was due to the high content of macro- and microelements, confirming previous observation that spelt grain is a richer source of these compounds when compared with other cereal grains (Forssell and Wieser, 1995; Ruibal-Mendieta et al., 2005; Zielinski et al., 2008). Our results showed higher content of selected minerals (Zn, Ca, Fe) in common and spelt wheat wholemeal flours in comparison to common wheat fine flour.

Spelt is reported to have a higher protein content and a higher participation of the aleurone layer in the kernel than common bread wheat (Bojňanská and Frančáková, 2002; Pruska-Kedzior et al., 2008). Spelt wheat wholemeal flour analysed in this study was characterised by higher content of proteins (16.5 %) than common wheat fine and wholemeal flours (11.2 and 12.0 %). Similar protein content in spelt wheat was determined by Marconi et al. (1999) and Loje et al. (2003) in different spelt cultivars (14.3-18.4 % and 15.4 %).

Table 1. Chemical composition of Slovak common and spelt wheat commercial flours

Flour component/parameter	Fine flour (Common wheat)	Wholemeal flour (Common wheat)	Wholemeal flour (Spelt)
Dry matter (g /100 g)	90.60±1.1	93.6±3	89.4±1.2
Ash (in dry matter) (g per 100 g)	0.73±0.02	1.11±0.02	1.82±0.02
Starch (g/100 g)	67.33±0.7	63.56±0.5	55.81±0.3
Proteins (g/100 g)	11.20±0.2	12.0±0.2	16.50±0.3
Saccharides (g/100 g)			
Glucose	0.06±0.003	0.09±0.02	0.18±0.03
Fructose	0.06±0.02	0.02±0.001	0.09±0.004
Sucrose	0.27±0.02	0.68±0.03	0.76±0.04
Maltose	0.46±0.03	0.15±0.02	0.10±0.01
pH	6.15±0.02	5.94±0.01	5.90±0.02
Organic acids (g/kg)			
Lactic	0.48±0.02	0.93±0.03	1,94±0.03
Acetic	0.77±0.01	1.98±0.04	1,68±0.04
Citric	1.1±0.04	1±0.02	1,46±0.04
Succinic	2.0±0.05	2.61±0.03	2,93±0.06
Elements (mg/kg)			
Ca	205±3	290±4	338±6
Fe	10±0.2	27±0.5	57±4
Zn	6.40±0.1	29.6±0.3	47.20±2

Table 2. Gluten characteristics of Slovak common and spelt wheat commercial flours

Flour component/parameter	Fine flour (Common wheat)	Wholemeal flour (Common wheat)	Wholemeal flour (Spelt)
Wet gluten (% in dry matter)	35.60±0.2	32.3±0.3	43.2±0.4
Extensibility of gluten (cm)	10.70±0.2 (moderately extensible)	10±0.3 (extensible)	17.5±0.2 (very extensible)
Swelling of gluten (cm^3)	17±0.4	10±0.2	4.5±0.5
Dry gluten(% in dry matter)	20.60±0.4	19.5±0.4	25.00±0.4

Table 3. Viscograph data of Slovak common and spelt wheat commercial flours

Flour component/parameter		PT (°C)	PVT (°C)	PV (BU)	HPV (BU)	PV-HPV (BU)
Common wheat	Fine flour	59.0±0.5	90.5±0.5	575±4	365±2	210±1.5
	Wholemeal flour	61.5±0.3	87.0±0.5	915±4.5	330±1.5	585±2
Spelt	Wholemeal flour	60.7±0.3	88.5±0.4	790±5	335±2	455±3

Starch is the primary component of wheat flour and plays an important role in the quality of the end product (Brites et al. 2008). Spelt wheat wholemeal flour contained lesser content of starch (55.81 g/100g) compared to common wheat samples. These results were similar with findings of Bojňanská and Frančáková (2002) who determined 48.29-66.8 % of starch in the five spelt cultivars ('Rouquin', 'Bauländer Spelz', 'Schwabenkorn', 'Franckenkorn' and 'Holstenkorn').

In generally, the total concentration of maltose, sucrose, glucose and fructose is rather low in wheat flours and varies from 1.50 g to 2 g/100 g, maltose being the most abundant fermentable carbohydrate (Robert et al., 2006). Content of saccharides in analysed flours is showen in the Table 1. Maltose was found as the most abundant saccharide in the common wheat fine flour, while sucrose was prevalent saccharide in common and spelt wheat wholemeal flours.

Considering the amount of organic acids from Table 1, spelt wheat wholemeal flour was characterised by higher amount of organic acids than common wheat fine and wholemeal flours.

Gluten proteins, representing the major protein fraction of the starchy endosperm, are predominantly responsible for the unique position of wheat amongst cereals (Anjum et al., 2007). Gluten characteristics of analysed flours are presented in the Table 2. The amount of wet gluten as an indicator is closely connected with the baking quality of bread grains (Bojňanská and Frančáková, 2002). Wholemeal spelt wheat flour contained in average about 17.6 % and 25.2 % more of wet gluten than common wheat fine and wholemeal flours. These findings are in agreement with results of Schober et al. (2002, 2006) and Pruska-Kedzior et al. (2008) which stated that spelt wheat is presented by higher yield of wet gluten and higher gluten spreadability, i.e. weaker gluten structure.

The pasting parameters of analysed flours are shown in Table 3. Common fine wheat flour was characterised by lower pasting temperature (59 °C) comparing to common spelt wheat wholemeal flours. Similar pasting temperature was also determined in commercial Japan wheat flours (Miyazaki and Morita, 2005). Higher pasting temperature was demonstrated with Naruenartwongsakul et al. (2004) (60.7 °C) and Rojas et al. (1999) (66.8 °C) in the commercial wheat flours. Viscosity behaviour during heating from 25 °C to 95 °C reflects the starch capacity to retain water and swell as the slurry is heated. When flour dispersion is heated, the starch granules retain water and swell. The viscosity of the paste increases to the point where the number of swollen-intact starch granules is maximum (Sciarini et al., 2008). Maximum viscosity reflects the ability of the starch granules to swell freely before their physical breakdown. Starch with a high swelling power also yields a high maximum viscosity (Rojas et al., 1999). Wholemeal Slovak wheat flours showed substantially higher peak viscosity (790 BU and 915 BU) comparing to fine wheat flour (575 BU). Similar peak viscosity than as in Slovak common wheat fine flours was determined by Naruenartwongsakul et al. (2004) (567 BU). But Rojas et al. (1999) determined higher value of this parameter in commercial Spanish wheat flours (646 BU). It was also found that common fine wheat flours had considerably lower breakdown value (210 BU) than common wheat and spelt wheat wholemeal flours (455 BU and 585 BU).

Conclusion

The objective of this study was to investigate chemical composition, gluten characteristics and pasting properties of commercial Slovak common wheat and spelt wheat flours. Wholemeal flours (common wheat and spelt wheat) were characterised by higher protein, ash, sucrose, selected organic acid and lower starch content in comparison to common wheat fine flour. It was also concluded that spelt wheat wholemeal flour contained more gluten but the spelt gluten was characterised by higher extensibility in comparison with common wheat flours. Fine and wholemeal Slovak common and spelt wheat flours were also presented by different pasting properties. Wholemeal wheat flours were characterised by higher pasting temperature (61.5 and 60.7 °C) peak viscosity (915 and 790 BU) and breakdown (585 and 455 BU) values than Slovak fine wheat flour.

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