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CHEMICO-TECHNOLOGICAL CHARACTERISTICS AND ANTIOXIDANT ACTIVITY OF WHOLEMEAL EINKORN FLOUR AND BREAD

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Abstract

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The study determined the ash content of wholemeal Einkorn wheat flour (23 g.kg^{-1}), which is rich in potassium and phosphorus, as well as its amylase activity (374 s) and wet gluten yield (10 g.kg^{-1}).

Compared to the total amount of fractional protein, the low-solubility fractions of gliadin and glutenin were 3.0 g.kg^{-1} and 2.4 g.kg^{-1}, respectively. The dietary fibre in wholemeal Einkorn wheat flour was 11.63 g.100 g^{-1} product of which 23.1 g.kg^{-1} of soluble fibre and 93.2 g.kg^{-1} of insoluble fibre, whereas the total amount of dietary fibre in Einkorn wheat bread was 12.25 g.100g^{-1} product, of which 63.2 g.kg^{-1} of soluble fibre and 55.4 g.kg^{-1} of insoluble fibre. It was proven that Einkorn wheat flour has a balanced amino acid composition. The oils of wholemeal Einkorn wheat flour and Einkorn wheat bread are of linoleic and oleic type. Wholemeal Einkorn wheat flour and Einkorn wheat bread have a high anti-oxidant activity (AO activity), the lutein content of wholemeal Einkorn wheat flour and Einkorn wheat bread being 207.4 μg.100g^{-1} and 226.8 μg.100g^{-1}, respectively.

Key words: Einkorn (*Triticum monococcum* L.), Einkorn wheat, Einkorn wheat bread, wholemeal Einkorn wheat flour, chemico-technological assessment

Introduction

Tetraploid wheat *(Triticum mono- and dicoccum*) has become a crop preferred in marginal agricultural areas as well as in organic farming. Einkorn (*Triticum monococcum* L.) is characterized by a lower yield, a specific quality and an outstanding nutritive value, which explains its good prospects in terms of cultivation.

Wholemeal Einkorn wheat flour is high in proteins, fat, mostly unsaturated, trace elements and antioxidants. According to Hidalgo et al. (2009, 2006), in flour production most proteins and substances with an antioxidant effect are retained.

Czech researchers have analyzed the amino acid composition of Einkorn wheat from different geographical regions and published the following figures: threonine in the range of 1.77–2.45 g.100 g^{-1} product and a chemical score of 0.66; valine in the range of 2.88–3.69 g.100 g^{-1} product and a chemical score of 1.14; isoleucine in the range of 5.23–6.02 g.100 g^{-1} product and a chemical score of 0.82; leucine in the range of 2.16–3.23 g.100 g^{-1} product and a chemical score of 1.99; tyrosine and phenylalanine in the range of 1.93–2.69 g.100 g^{-1} product and 3.5–3.92, respectively; lysine in the range of 1.72–2.66 g.100 g^{-1} product and a chemical score of 0.40 (Konvalina et al., 2008).

The variability in figures demonstrates the significance of the geographical region concerning the quality and amino acid composition of proteins.

With some Einkorn wheat genotypes, gluten typically amounts to 20–60 g.kg^{-1}. Some *in vitro* analyses show that

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Einkorn wheat (*T. monococcum*) gliadin is less toxic to patients suffering from celiac disease (gluten enteropathy). It is believed that this fact may enhance the preparation of non-toxic low-gluten Einkorn wheat food products to be consumed by such patients (Pizzuti et al., 2006; Vincentini et al., 2007).

Einkorn wheat is rich in polyphenols, carotenoids, tocols (tocotrienols and tocopherols) and selenium, which accounts for its higher AO activity when compared to common (bread) wheat and durum wheat (Hidalgo et al., 2009; Suchowilska et al., 2009). Egidio et al. (1993) maintain that Einkorn wheat flour has a yellow tinge due to the carotenoids in its composition which, in the authors' opinion, are of better quality than those in polyploid wheat.

Einkorn wheat flour is suitable for the development of lutein-rich functional foods because lutein amounts to 8.41 $\mu g.g^{-1}$ d.m. on average (Hidalgo et al., 2006). Such food products are extremely healthful in old age because ageing patients suffer from macular degeneration which may result in blindness (Abdel-Aal, 2009).

Concerning Einkorn wheat bread production, it has been established that lutein content gets lower although it maintains higher values ($p < 0.05$) in comparison to cultured wheat samples (Mariotti et al., 2010).

The interest in Einkorn wheat has recently increased in the Czech Republic as well where the requirements concerning the colour and quality of foodstuffs have been growing steadily (Konvalina et al., 2007a,b).

Some studies demonstrate that Einkorn wheat is high in the following nutrients: Zn, Fe, Cu, Mn, P and Mg (Erba et al., 2011).

All that has been said up to now proves how valuable the crop is in terms of nutritional qualities.

The literature dealing with Einkorn wheat shows that recent years have witnessed an increasing interest in this crop. In Bulgaria, the land strips where Einkorn wheat is grown get bigger every year. The data on the AO activity, amino acid content and minerals of Einkorn wheat vary, which is attributable to the differences in soil and climate characterizing the regions where the crop is grown.

We have not been able to discover data on the period of maturation of Einkorn wheat flour and the changes that Einkorn wheat flour and bread undergo with respect to AO activity, ash content, amino acid and fatty acid content, and dietary fibre. Such studies are necessary for the development of technologies for the production of Einkorn wheat bread on an industrial scale. Bulgarian Einkorn wheat has not been subjected to a chemico-technological analysis.

The objective of the present study is to analyse Einkorn wheat (*Triticum monococcum* L.) flour and bread from a chemico-technological point of view.

Materials and Methods

We analyzed Bulgarian Einkorn (*Triticum monococcum* L.) wheat grain, wholemeal Einkorn wheat flour, and Einkorn wheat bread. Einkorn wheat grain was milled to wholemeal flour in a stone mill. The experiments were conducted at the UFT – Plovdiv, Bulgaria; the Bulgarian Academy of Sciences – Sofia and the Institute for Plant Genetic Resources in the town of Sadovo, Bulgaria. The following parameters were determined: humidity (moisture) [$g.kg^{-1}$] according to the Bulgarian State Standard (BSS) EN ISO 712:2010; hectolitre mass [$кg.100\ dm^{-3}$] according to BSS EN ISO 7971-1:2007; mass of 1000 grains (specific weight) [g] according to BSS EN ISO 520:2010; vitreosity [%] according to BSS 13378:1976; titratable acidity [H] according to BSS 754-80/4:2003; wet gluten yield [$g.kg^{-1}$] according to BSS EN ISO 21415-2:2008; wet gluten quality [mm] according to BSS 754:80/4:2003; volume [cm^3] applying the displacement method to small, homogeneous kernels with the help of a volume meter according to BSS 3412-79, AACC 10-05 2000; specific loaf volume [$cm^3.g^{-1}$] (the ratio of loaf volume to loaf mass) according to BSS 754:80/4:2003 (8); ash content [$g.kg^{-1}$] according to BSS ISO 2171:1999; fat content [$g.kg^{-1}$] according to BSS EN ISO 11085:2010; Hagberg Falling Number [s] according to BSS EN ISO 3093:2008; Zeleny sedimentation value [cm^3] according to BSS ISO 5529:1997; protein content [$g.kg^{-1}$] according to BSS EN ISO 20483 (14); total carbohydrate [$g.100\ g^{-1}$] using the method described by M. Dubois et al. (1956); starch content [$g.kg^{-1}$] according to BSS 13488:1976; dietary fibre (soluble and insoluble) [$g.kg^{-1}$] according to ICC Standard №156; fatty acid content [$g.kg^{-1}$] according to EN ISO 5508:2000; amino acid composition using the methods described by Tkachuk, 1966; Marco et al., 2007, fractional protein content using the method described by Lookhart at al., 1995. With the exception of phosphorus, ash content was determined with the help of the AAC Perkin Elmer instrument, model 380. The amount of phosphorus was established on the basis of the Gericke-Kurmies method (1965) and optical density was measured with Spekol 11 at a 470-nm wavelength. Lutein, lycopene and carotene content were determined using an HPLC system with a UV-detection. The AO activity of the extracts was evaluated with the help of four widely used spectrophotometric methods (DPPH, ABTS, FRAP and CUPRAC) (Ivanov et al., 2014). The experimental laboratory roasting of the grain was carried in accordance with a modified method developed in the Technology of Grain, Fodder, Bread, and Confectionery Products Dept. at the UFT – Plovdiv (Gogova et al., 2012).

Statistical analysis

Depending on the type of parameter analyzed, the experiments were repeated between 3 and 5 times. The data was processed statistically in Excel (Microsoft) and Statistica 6.0 (StatSoft).

Results and Discussion

The basic milling technological parameters of Einkorn wheat grain were analyzed: mass of 1000 kernels (specific weight) – 24 g; hectolitre mass – 79.9 kg.100 dm^{-3} which shows that the kernels are firm and well filled, and a very low vitreosity of 15%.

In order to determine the maturation period of Einkorn wheat flour, milling was followed by experimental laboratory roasting of wholemeal Einkorn wheat flour on the first, second, third, fourth, fifth, tenth, fifteenth, and twentieth day.

Bread quality was evaluated on the basis of the parameters presented in Table 1.

The results of the analysis of the bread loaves demonstrate that the physical parameters of the bread loaves roasted on Day 3 after grain milling have the best values. The loaves have the highest values for mass (211g), volume (310 cm^3) and shape retention (H/D; 0.54) as well as the lowest values for technological and total losses. In contrast to wheaten flour which needs 10–14 days to mature after milling, Einkorn wheat matures in three days. We recommend that Einkorn wheat flour be processed within three days following grain milling.

Our experiments continued with the characterization and quality evaluation of wholemeal (integral) Einkorn wheat flour. Table 2 shows the quality-determining parameters of the flour.

Wholemeal Einkorn wheat flour is characterized by organoleptic properties typical of wholemeal wheaten flours. However, its colour is creamy yellow, which may be due to the presence of carotenoids. Einkorn wheat flour is rich in ash (23 $g.kg^{-1}$), as compared to wheat (in the range of 15–22 $g.kg^{-1}$) and different Einkorn wheat batches (in the range of 21–28 $g.kg^{-1}$) (Arzani, 2011). The predominant minerals in wheat are phosphorus in greatest amounts, followed by potassium and magnesium. Einkorn wheat is richest in potassium, followed by phosphorus. Einkorn wheat is very low in wet gluten (10 $g.kg^{-1}$) which amounts to 240–350 $g.kg^{-1}$ in wheat types used in bread production. Its falling number is 374 s, while the restricted values for wheaten flours are in the 270–340 range.

Table 2

Physico-chemical and organoleptic parameters of wholemeal Einkorn wheat flour

Parameters	Wholemeal Einkorn wheat flour
Organoleptic	
Colour	Creamy yellow
Aroma	Typical of wholemeal Einkorn wheat flour, with no stale or mouldy smell
Flavour	Typical of wholemeal Einkorn wheat flour, with no aftertaste
Crunch	Not felt in chewing
Physico-chemical	
Moisture content, $g.kg^{-1}$	120
Ash content (d.m.), $g.kg^{-1}$	23
Acidity, °N	3.7
Wet gluten content, $g.kg^{-1}$	10
Falling number, s	374.0
Sedimentation value, cm^3	14.0
Minerals, mg:	
Iron	2.55
Phosphorus	210.02
Potassium	689.50
Zinc	4.24
Manganese	3.64

We also determined the biochemical composition of wholemeal Einkorn wheat flour and Einkorn wheat bread. The results are presented in Table 3.

The data in the table shows that the protein content of the flour is higher (147 $g.kg^{-1}$).

Table 1

Parameters of Einkorn wheat bread with varying flour maturation length after milling

№	Parameter	Day 1	Day 2	Day 3	Day 4	Day 5	Day 10	Day 15	Day 20
1.	Loaf mass, g	208	210	211	206	205	204	206	207
2.	Loaf volume, cm^3	265	298	310	260	265	274	285	295
3.	H/D	0.32	0.39	0.54	0.38	0.34	0.36	0.37	0.37
4.	Specific volume, $cm^3.g^{-1}$	1.27	1.40	1.47	1.26	1.36	1.38	1.40	1.42
5.	Technological losses, $g.kg^{-1}$	96	81	80	104	196	174	168	120
6.	Total losses, $g.kg^{-1}$	108	88	85	141	146	140	135	110

Table 3

Biochemical properties of wholemeal Einkorn wheat flour and Einkorn wheat bread

№	Parameter	Wholemeal Einkorn wheat flour	Einkorn wheat bread
1.	Raw protein, g.kg^{-1} d.m.	147	159
2.	Carbohydrate, g.100 g^{-1} product	67.33	68.36
3.	Starch, , g.kg^{-1}	546.9	536.7
4.	Low molecular weight sugars, g.100 g^{-1} product	1.01	2.44
5.	Fat, g.kg^{-1}	32	19
	Dietary fibre, g.100 g^{-1} product:		
	– total	11.63	12.25
	– soluble	2.31	6.32
	– insoluble	9.32	5.54

The analyzed flour was high in dietary fibre (11.63 g.100 g^{-1} flour), the insoluble fibre amounting to 9.32 g.100 g^{-1} and the total fibre in the bread – to 12.25 g.100 g^{-1}, thus demonstrating a 406 g.kg^{-1} increase in soluble fibre, which means that during heat processing part of the insoluble fibre in the flour turns into soluble fibre in the end product. We assume that the huge difference in the amount of soluble fibre is due to the process of fermentation and baking of the dough. This assumption rests on the premise (Enriched, Sugar Reduced Fermented Bakery Products 2007) that during fermentation yeasts use soluble fibre as a substrate manifesting greater preference for fructooligosaccharides which are part of the soluble fibre. In Einkorn wheat bread, low molecular weight sugars increase almost 1.5 times in comparison to those in Einkorn wheat flour because during dough fermentation starch produces additional amounts of sugars under the influence of ß–amylase.

Next, we determined the fractional protein composition of Einkorn wheat, which was done largely in order to establish the quantities of gliadin and glutenin fractions. The data can be seen in Table 4.

Table 4

Total nitrogen content, protein content, and fractional protein composition of wholemeal Einkorn wheat flour

№	Parameter	Wholemeal Einkorn wheat flour
1.	Total nitrogen, g.kg^{-1}	22.8
2.	Pure protein , g.kg^{-1}	122.4
3.	Globulins, g.kg^{-1}, with respect to the total fractional protein	4.3
4.	Gliadins, g.kg^{-1}, with respect to the total fractional protein	3.0
5.	Glutenins, g.kg^{-1}, with respect to the total fractional protein	2.4
6.	Low-solubility proteins, g.kg^{-1}, with respect to the total fractional protein	1.4

The fractional composition of spare protein in Einkorn wheat flour illustrates that the gliadin and glutenin fractions, when compared to the total fractional protein, are quite low: 3.0 g.kg^{-1} and 2.4 g.kg^{-1}, respectively. These values are significantly lower than the ones for cultured wheat: for instance, Sadovo 1 (*Triticum aestivum*) wheat – 243.5 g.kg^{-1} and 252.2 g.kg^{-1} (Stoyanova et al., 2007). The data substantiates the claim of Pizzuti et al. (2006) concerning the negligible amount of the gliadin fraction in the flour which, according to the authors, is a good raw material for baked goods to be consumed by patients suffering from celiac disease since it does not have a toxic effect.

Einkorn wheat flour and bread have a balanced amino acid composition (Table 5).

The results presented in the table show that Einkorn wheat flour contains the following essential amino acids: valine, leucine, isoleucine, lysine, and phenylalanine. When compared to the chemical score based on FAO data as of 1985 (threonine 3.4; valine 3.5; leucine 6.6; isoleucine 2.8; tyrosine and phenylalanine 6.3; lysine 5.8; FAO/WHO 1991), Bulgarian Einkorn wheat is richer in the following essential amino acids: phenylalanine* (7.7 g.100 g^{-1} protein) which accounts for the yellowish colour of the flour; L-lysine (7.4 g.100 g^{-1} protein) and L-threonine (6.3 g.100 g^{-1} protein). The amounts of L-leucine and L-tyrosine are significantly lower, while that of L-valine is less so. As regards the amino acid composition of the bread, the quantity of almost all amino acids is decreased, with the exception of L-leucine and L-proline which are present in much higher amounts. This may be due to the effect of carbonyl compounds (aldehydes and ketones) on bread aroma development which results in changes in amino acid amounts. The balanced amino acid composition of Einkorn wheat protein, which is retained in Einkorn wheat bread, accounts for its high biological value.

According to Hidalgo et al. (2009), although the rela-

Table 5

Amino acid composition of wholemeal Einkorn wheat flour and Einkorn wheat bread

Amino acids, g.100 g^{-1} protein	Wholemeal Einkorn wheat flour	Einkorn wheat bread	Pattern FAO (1985)	Requirements per person (based on FAO data)
L-valine*	2.8 4.6*	0.7	3.5	4.2
L-leucine*	3.5 6.9*	9.3	6.6	4.8
L-proline	1.0	3.1	–	–
glycine	13.5	9.8	–	–
serine	13.8	13.1	–	–
L-threonine*	6.3 2.6*	5.9	3.4	2.8
L-aspartic acid	13.2	12.8	–	–
5-oxo-proline	6.6	6.3	–	–
glutamic acid	20.4	20.7	–	–
phenylalanine* and L-tyrosine*	7.7 + 2.6 4..3*	7.4+2.3	6.3	2.8
L-lysine*	7.4 2.6*	7.1	5.8	4.2
L-cystine	1.4	1.5	–	–

* Ahmad Arzani (2011)

tive proportion of the germ to grain mass in common wheat and Einkorn wheat is almost the same, Einkorn wheat is richer in lipids by 50% (4.2 vs 2.8 g.100 g^{-1} d.m.).

The data in Table 6 show that the oils in wholemeal Einkorn wheat flour and Einkorn wheat bread are of linoleic-oleic type. Concerning unsaturated fatty acids, Einkorn wheat flour and Einkorn wheat bread are high in linoleic acid (490.2 g.kg^{-1} and 459.6 g.kg^{-1}, respectively). The amount of the valuable linolenic acid, representing omega-3 and omega-6 fatty acids, is also relatively high (24.3 g.kg^{-1} in Einkorn wheat flour and 23.5 g.kg^{-1} in Einkorn wheat bread). This is also true for oleic acid which is contained in omega-9 fatty acids (315.1 g.kg^{-1} in Einkorn wheat flour and 314.5 g.kg^{-1} in Einkorn wheat bread). In common bread wheat, linoleic acid is the predominant fatty acid and the quantity of palmitic acid is higher than that of oleic acid but the levels of the other acids are almost the same. Hidalgo et al. (2009) claim that Einkorn wheat lipids are richer in monounsaturated and polyunsaturated fats than common wheat.

Table 6

Fatty acid content of wholemeal Einkorn wheat flour and Einkorn wheat bread

№	Fatty acids	Wholemeal Einkorn wheat flour		Einkorn wheat bread
		Mean	Range*	
	Saturated fatty acids, g.kg^{-1}			
1.	Butyric acid C_4:0	–		2.6
2.	Hexanoic acid C_6:0	–		19.4
3.	Capric acid C_8:0	1.9		5.3
4.	Caprylic acid C_{10}:0	0.5		2.8
5.	Lauric acid C_{12}:0	1.6		4.6
6.	Myristic acid C_{14}:0	0.9	4.9÷6.0	5.5
7.	Palmitic acid C_{16}:0	134.0	160.7÷177.3	119.3
8.	Margaric acid C_{17}:0	1.	1.0÷1.3	1.4
9.	Stearic acid C_{18}:0	12.2	11.0÷12.6	13.7
10.	Arachidic acid C_{20}:0	–	1.5÷1.9	2.1
	Unsaturated fatty acids, g.kg^{-1}			
11.	Palmitoleic acid C_{16}:1 n7	3.1	1.6÷2.0	4.9
12.	Margaroleic acid C_{17}:1	–		5.2
13.	Oleic acid C_{18}:1n9	315.1	232.3÷265.1	314.6
14.	Linoleic acid C_{18} :2n6	490.2	498.9÷514.7	459.6
15.	Linolenic acid C_{18} :3n3	24.3	18.2÷20.8	23.5
16.	Gonodic acid C_{20}:1	15.0		15.5

* Ahmad Arzani (2011)

Borghi et al. (1996) and D'Egidio et al. (1993) demonstrated that the antioxidants in fruits, vegetables and cereal grains help in the treatment of chronic diseases. Einkorn wheat flour and bread were also tested with respect to their AO activity (Table 7) and lutein, lycopene, and carotene content (Figure 1).

There are scanty data on the AO activity of *Tr. monococcum*. Our figures show high values for the AO activity of Einkorn wheat flour and bread, assessed through the radical-scavenging activity of the flour and bread extracts (463.51 and 388.80 mmol in Trolox equivalents.100 g^{-1}, using the ABTS method) and the reduction of iron (110.22 and 126.55 mmol in Trolox equivalents.100 g^{-1}, using the FRAP method) and copper (201.12 and 109.43 mmol in Trolox equivalents.100 g^{-1}, using the CUPRAC method) ions. No manifestation of the ability of the extracts to in-

Table 7

AO activity of Einkorn wheat flour and bread

Sample	Mass, g	$TEAC_{DPPH}$		$TEAC_{ABTS}$		$TEAC_{FRAP}$		$TEAC_{CUPRAC}$	
		mMTE. $100g^{-1}$	SD	mMTE. $100g^{-1}$	SD%	mMTE. 100g-^{1}	SD	mMTE. $100g^{-1}$	SD
Wholemeal Einkorn wheat flour	1.0172	–	–	463.51	5.55	110.22	0.72	201.12	1.64
Einkorn wheat bread	1.0095	–	–	388.80	19.7	126.55	0.84	109.43	0.39

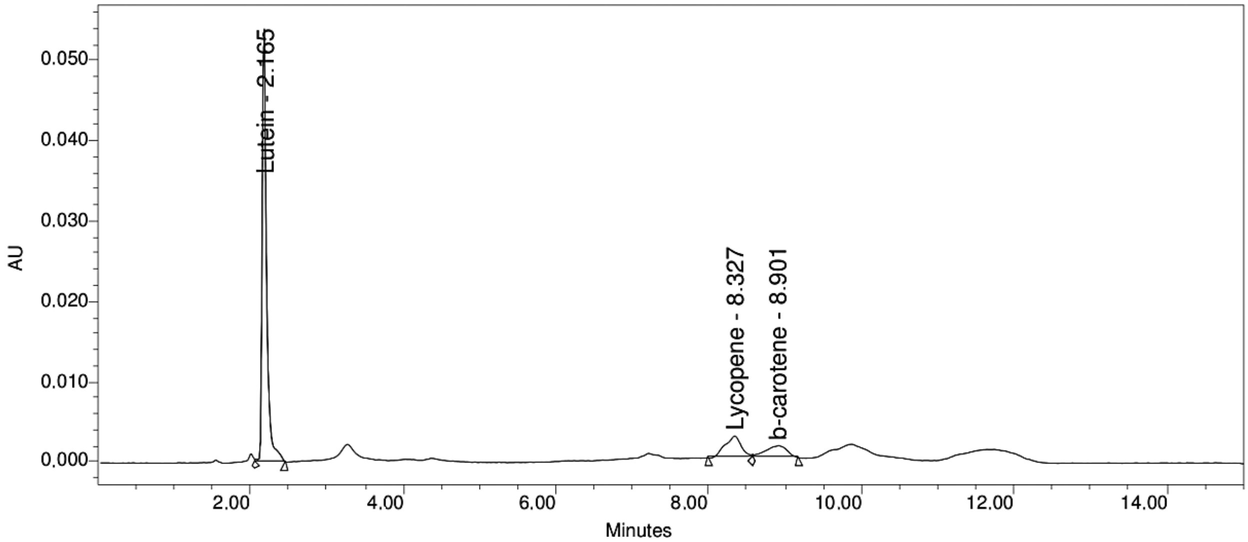

Fig. 1. HPLC of lutein, lykopene and ß-carotene

hibit the formation of DPPH radicals was detected. The high values obtained via the ABTS method (at a neutral pH, the major mechanism being HAT) presuppose that the antioxidant effect of Einkorn wheat flour and bread is largely due to hydrogen transfer (HAT mechanism). The values obtained using the FRAP assay (solely SET-based) presuppose that the electron transfer reaction (SET) is utilized to a lesser extent. The high value for Einkorn wheat flour (201.12 mmol in Trolox equivalents.100 g^{-1}), obtained via the CUPRAC method (the assay with the lowest redox-potential) is probably due to the fast repetition of the redox cycles, which is believed to be an indicator of a possible pro-antioxidant activity of the essential oil under study (Prior et al., 2005). The capacity of the flour to neutralize reactive oxygen species (ROS) with the help of a number of reaction mechanisms demonstrates its potential in the prevention of oxidative stress diseases such as accelerated ageing.

The lutein content of Einkorn wheat flour is high (207.4 µg.100 g^{-1}), while that of Einkorn wheat bread is increased slightly (226.8 µg.100 g^{-1}). This undermines the assertion of some authors that the lutein content of Einkorn wheat bread decreases (Mariotti et al., 2010). Lycopene and carotene in both Einkorn wheat flour and bread are present in trace amounts only.

Conclusions

The study determined the ash content of wholemeal Einkorn wheat flour (23 $g.kg^{-1}$), potassium and phosphorus being the predominant minerals, amylase activity (374 s) and wet gluten yield (10 $g.kg^{-1}$).

The study established the content of the low-solubility gliadin and glutenin fractions with respect to the total amount of fractional protein: 3.0 $g.kg^{-1}$ and 2.4 $g.kg^{-1}$, respectively.

The amount of dietary fibre in wholemeal Einkorn wheat flour was determined: 11.63 g.100 g^{-1} product, of which 23.1 $g.kg^{-1}$ of soluble fibre and 93.2 $g.kg^{-1}$ of insoluble fibre.

The analysis showed that heat processing increases the amount of soluble fibre in bread by 406 $g.kg^{-1}$ and low molecular weight sugars – almost 1.5 times, as compared to the figures for Einkorn wheat flour.

The study proved that Einkorn wheat flour has a balanced amino acid composition.

The data demonstrated that the oils in wholemeal Einkorn wheat flour and Einkorn wheat bread are of linoleic-oleic type. In Einkorn wheat flour and Einkorn wheat bread, linoleic acid amounts to 490.2 $g.kg^{-1}$ and 459.6 $g.kg^{-1}$, respectively; linolenic acid amounts to 24.3 $g.kg^{-1}$ and 23.5 $g.kg^{-1}$, respectively; and oleic acid – to 315.1 $g.kg^{-1}$ and 314.5 $g.kg^{-1}$, respectively.

Wholemeal Einkorn wheat flour and Einkorn wheat bread are characterized by a high AO activity, assessed on the basis of the radical-scavenging activity of the extracts (463.51 and 388.80 mmol $Trolox.100g^{-1}$, using the ABTS assay) and the reduction of iron (110.22 and 126.55 mmol Trolox.100 g^{-1}, using the FRAP assay) and copper ions (201.12 and 109.43 mmol Trolox.100 g^{-1}, using the CUPRAC assay).

The lutein content of wholemeal Einkorn wheat flour and Einkorn wheat bread was found to be 207.4 μg.100 g^{-1} and 226.8 $μg.100g^{-1}$, respectively.

We recommend that Einkorn wheat flour be processed within three days after the grain has been milled.

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