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Full Length Research Paper

Chemical and elemental characterization of wheat germ oil (*Triticum* spp. L.) cultivated in Turkey

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The cultivation of wheat (*Triticum* spp. L.) has been on for thousands of years and is commonly used in animal feed and human food in many regions of Turkey. Therefore, wheat is considered to be one of the most important grain cereals in Turkey. Wheat germ is another important by-product of the wheat milling industry constituting relatively small amount of the whole wheat grain by volume. However, the wheat germ is an important nutritional natural resource, which contains important fatty acids and minerals. Both the wheat germ and wheat germ oil are usually utilized in food, pharmaceutical and cosmetic industries increasingly, today. In this study, both the distribution of saturated and unsaturated fatty acids and the mineral contents of wheat germ of the Turkish samples were reported. The fatty acids were analyzed after Soxhlet extraction and derivatization by gas chromatography/mass spectroscopy (GC/MS), whereas the mineral contents were analyzed by various techniques, such as N being determined by the dry combustion method using elemental analyses, P measured by a colorimetric method, whereas K and Na was measured by flame photometry. Finally, the elements Ca, Mg, Fe, Cu, Zn and Mn were detected and quantified by atomic absorption spectroscopy (AAS), respectively. The compositions were 19.9% saturated fatty acid and 80.1% of unsaturated fatty acids. The major components of the germ oil were identified as linoleic acid (56.1%), palmitic acid (17.4%) and oleic acid (17.4%).

Key words: *Triticum* spp, wheat germ oil, fatty acids, elements and minerals, gas chromatography/mass spectroscopy (GC/MS), atomic absorption spectroscopy (AAS).

INTRODUCTION

Wheat (*Triticum* L.) is an annual plant of the Poaceae. Its cultivating area is larger than 10 million ha, mainly in Central Anatolia (Anonymous, 2007). Wheat is mainly used as energy and protein source in the human diet throughout the world (Rehman, 2006). Additionally, with the growth of the world population, there will be an increasing demand for vegetable products. Therefore, the search for new alternative and cheap sources of good-quality and vegetable is an important research trend. Whole wheat grain includes the endosperm, bran and germ. Wheat Germ (WG), one of the main by-products from the flour milling industry is the most nutritious part of the wheat kernel. It is a rich source of vitamin E, vitamin B group, unsaturated fatty acids, proteins, dietary fiber and minerals. It is also reported to contain some functional phytochemicals at a relatively low cost such as flavonoids, sterols, octacosanols and glutathione. Therefore, WG is considered to be healthy foods that can help people prevent certain cancers and other health problems. Raw wheat germ (RWG), containing as much as 10 to 15% oil is mainly used in food, medical and cosmetic industries as a source of oil (Zhui et al., 2006). Recently, many researchers have focused on the development of wheat as a potential functional material. Wheat germ oil protects and nurtures the skin, is a

Abbreviations: N, Nitrogen; **K,** potassium; **P,** phosphorous; **Ca,** calcium; **Mg,** magnesium; **Na,** natrium; **Fe,** iron; **Zn,** zinc; **Mn,** Manganese; **Cu,** cupper; **GC/MS,** gas chromatography / mass spectroscopy; **AAS,** Atomic absorption spectroscopy; **spp,** species; **L,** linne; **WG,** wheat germ; **RWG,** Raw wheat germ; **h,** hour; **min,** minute; **s,** second; **m,** meter; **cm,** centimeter; **mm,** millimeter; **µm,** micrometer; **ml,** milliliter; **µl,** microliter; **ppm,** parts per million; **C,** Celcius; **AOCS,** American Oil Chemical Society.

laxative and reduces lipids. It is a valuable dietetic because of the high level of polyunsaturated fatty acids and vitamin E (Gruenwald et al., 2004). Vitamin E compounds (tocopherols and tocotrienols) are effective inhibitors of lipid oxidation in food and biological systems. Tocopherols are a very important dietary nutrient for human and animals because they are only synthesized by plants (Kupczyk and Gogolewski, 2003).

Wheat germ oil is usually dark-colored and may have strong odor and flavor depending on the oxidative condition of the oil (Wang and Lawrence, 2001). The composition of fatty acid from crude oil is usually very variable, depending upon the conditions of germ storage and oil extraction. Wheat germ oil is obtained by either mechanical pressing or solvent extracting the germ, which is separated during milling of the wheat to flour. Although, solvent extraction usually recovers more of the wheat germ oil (90%) than pressing (50%); pressing is usually preferred by consumers because wheat germ oil obtained this way is accepted as natural and preferentially used (Dunford and Zhang, 2003; Modey et al., 1996). Wheat germ oil is also very popularly used and known as “ruşeymi” in Turkey. Wheat seeds are rich in nutrients.

The products are valuable as dietetics due to the high level of polyunsaturated fatty acids, minerals and elements. Several nutritionally important macro and micro trace elements (N, P, K, Mg, Ca, Na, Mn, Zn, Fe and Cu) constitute an important part of the composition. The composition of wheat germ has previously been studied by several research groups. Principal constituents of wheat germ were found to differ in their fatty acid and mineral contents (Yu et al., 2002; Hışıl and Ötleş, 2001; Krings et al., 2000). The improvement of the genotypes of wheat samples was also subject to several previous studies (Rad et al., 2012). The aim of this present work was to determine both the wheat germ oil and mineral composition obtained from wheat samples cultivated in Turkey to the best of our knowledge for the first time in this context.

MATERIALS AND METHODS

Domestic samples of wheat germ were kindly provided in 2010 from the wheat milling companies (Demirpolat Company) in Konya, Turkey. The plant samples were subjected to Soxhlet solvent extraction for isolation of the oil and mineralized for elemental analyses without prolonged deposition or storage. During the short storage time, the plant samples were kept at -20°C until use.

Oil extraction

The wheat germ oil was obtained from the plant material freshly by Soxhlet extraction using diethyl ether for approximately 6 h. The extraction yield was defined as; (amount of extract collected/ amount of sample used for extraction) × 100. Solvent was evaporated from the extract carefully at 40°C under vacuum using a Rapidvap evaporator until constant weight was attained. Fatty acid composition of the extracted oil was analyzed by gas chromatography/mass spectroscopy (GC/MS). Methylation of the fatty acids was carried out according to the AACC Official Method (1999).

GC-MS conditions

The analyses were performed on a Agilent 6890N Network GC system combined with Agilent 5975C VL MSD Network Mass Selective Detector. DB Wax column (60 m × 0.25 mm × 0.25 µm) was used. The oven temperature program was set to 300°C. The column programmed initially at 60°C for 1 min after injection and increased to 185°C with 1°C/min heating ramp for 10 min and then increased to 200°C with 5°C/min heating ramp without hold, respectively. The injector temperature was set to 250°C; the carrier gas was He; inlet pressure was adjusted to 25.36 psi and the linear gas velocity was 7 cm/s with an initial flow rate of 0.3 ml/min. The split ratio was set to 30:1 with an injected volume of 1.0 µl.

Identification of the components

Identification of the fatty acid components were carried out by comparison of their relative retention times with those of authentic samples or by comparison of their relative retention index (RRI). Database content matching against commercial (Wiley GC/MS Library, NIST and Famed 23) as well as, MS literature data was used for the identification (AOCS Official Method, 2002).

Mineral element analysis

Macro and micro trace elements were determined by using various techniques. Initially, the plant material was mineralized to eliminate the matrix appropriately. Thereafter, N was determined by the dry combustion method using elemental analyses and P was measured by a colorimetric method, whereas K and Na by flame photometry. Finally, Ca, Mg, Fe, Cu, Zn and Mn was detected and quantified by atomic absorption spectroscopy (AAS). All experiments were performed qualitatively and quantitatively with comparison to a “certified reference plant” material statistically (Kan et al., 2005).

RESULTS

The fatty composition of wheat germ

Table 1 summarizes the results of fatty acids composition from wheat germ oil (WGO). The fatty oil of wheat germ was obtained by solvent extraction with yields 10.97%. In the course of the present study, 7 main components amounting to 100% of the germ oils were identified in the sample. Its compositions were 19.9% saturated fatty acid and 80.1% of unsaturated fatty acids. The major components of germ oil were linoleic acid (56.1%), palmitic acid (17.4%) and oleic acid (17.4%). In this study, the minor components of germ oil were found to be linolenic (6.4%), eicosenoic (1.4%), stearic (0.9%) and arachidonic (0.2%).

The mineral composition of wheat germ

The most challenging aspect of providing trace elements in plant-based material is to obtain a sufficient

Table 1. Fatty acid composition of wheat germ oils (%).

Fatty acid	RI	% *
Palmitic acid (C16:0)	1286	17.4
Stearic acid (C18:0)	1565	0.9
Oleic acid (C18:1)	1592	17.1
Linoleic acid (C18:2)	1656	56.1
Linolenic acid (C18:3)	1741	6.9
Arachidonic acid (C20:0)	1843	0.2
Eicosenoic acid	1886	1.4

*Results are given as mean (n=3).

Table 2. Mineral content of wheat germ.

Elements	Mean (ppm)
Nitrogen (N)	5.31*
Potassium (K)	11240
Phosphorus (P)	10700
Calcium (Ca)	268
Magnesium (Mg)	2950
Sodium (Na)	242
Iron (Fe)	88
Manganese (Mn)	236
Zinc (Zn)	158
Copper (Cu)	10

*Expressed as %.

concentration for the supplements to be ingested without consuming large quantities of plant tissue. Table 2 shows the mean value of the tested macro (N, P, K, Ca, Na and Mg) and micro trace elements (Zn, Fe, Mn and Cu) in wheat germ.

DISCUSSION

The fatty composition of wheat germ

One study on the germ oil in USA revealed the oil composition to consist of palmitic (16.4%), stearic (0.7%), oleic (16.4%), linoleic (58.0%), linolenic (6.4%), arachidonic (0.2%) and eicosenic (1.4%) being quite similar from the germ oil of its Turkish counterpart in this study (Wang and Lawrence, 2001). However, the results of our analysis are in agreement with those reported by other international research groups (Dunford and Zhang, 2003; Panfili et al., 2003).

The mineral composition of wheat germ

The most abundant minerals in wheat germ were nitrogen (5.31%), potassium (11240 ppm) phosphorus (10700 ppm), magnesium (82950 ppm) and calcium (268 ppm), sodium (242 ppm), manganese (236 ppm) while zinc (158 ppm), iron (88 ppm) and copper (10 ppm) were in minor amount. In another study, the mineral content of wheat germ were found to be potassium (1087.39 ppm), magnesium (220.57 ppm), calcium (44.59 ppm), manganese (17.21 ppm), zinc (16.89 ppm), sodium (10.56 ppm), iron (10.19 ppm) and copper (1.02 ppm) content were much lower than that of our samples (Kupczyk and Gogolewski, 2003). Although, several factors may affect the elemental contents of plants such as the variety, harvesting time, soil type, soil conditions, fertilization, irrigation and weather etc (Ahmet and Bouhadjera, 2010; Kan et al., 2005). This study shows a comprehensive presentation of macro and micro elements of wheat germ samples cultivated in Turkey. Wheat germ is a by-product of the wheat milling industry, constituting about 2 to 3% of the whole wheat grain. It ranges from about 10 to 15% oil and 4 to 5% minerals.

Conclusion

Wheat germ contains a relatively high amount of oil. Furthermore, the composition of mineral showed an excellent balance as good nutritional quality. However, further detailed studies on the functional properties of nutritional quality of wheat germ are required. In conclusion, wheat germ contains many valuable materials and ingredients that are of importance to humans.

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