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Effect of heating process on oil yield and fatty acid composition of wheat germ

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RESEARCH ARTICLE

Abstract

In this study, fatty acid composition, antioxidant activity, total phenol and oil content of heat-treated wheat germs were investigated. Results of control samples were compared with heated wheat germs at different temperatures (100, 120, 150 and 180 °C) and times (5, 8 and 11 min). The maximum yield was obtained when heated at 120 °C/11 min with 7.293% and 120 °C/8 min with 7.256%, while the minimum oil content was observed at 100 °C/11 min with 5.794%. Linoleic, oleic acid and palmitic acids were the major fatty acids of wheat germ oil. The most dominant fatty acids of control samples were linoleic (58.382%), oleic acid (18.554%), palmitic acid (12.926%), and linolenic acid (6.848%). The fatty acid composition of wheat germ oil was not significantly affected by the heating treatment. On the other hand, a decrease was observed in antioxidant activity of heated samples. Wheat germ had the highest total phenol content.

Keywords: wheat germ, heat treatment, oil content, fatty acid composition, linoleic, GC

1. Introduction

Oils are generally obtained from the oil-bearing seeds or fruits where they occur in great abundance. Wheat is an excellent source of polyunsaturated fatty acids and vitamin E. Wheat seed consists of 2-3% germ, 13-17% bran and 80-85% endosperm on the dry matter basis (Belderok *et al.*, 2000; Durante *et al.*, 2012). Wheat germ oil has been used as a fertility agent, an antioxidant, and an additive in natural food and health and cosmetic products. In addition, wheat germ oil is highly valued due to its high content of unsaturated fatty acids of which it contains about 80%, mostly linoleic (18:2) and linolenic acid (Wang and Johnson, 2001). These two fatty acids are of great importance in human metabolism and cannot be synthesised by the organism. They are precursors of a group of hormones called prostaglandins, which play an important role in muscle contractions and in the proper healing of inflammatory processes (Coultae, 1989). Although wheat germ can affect the flour quality negatively (Rizzello *et al.*, 2010) because of lipase and lipoxygenase activities which increase the oxidation and reduce the flour storage stability (Dawe *et al.*, 2000), it is an significant nutritional source which contains 10% oil, 23% proteins, and 52% carbohydrate (Jiang and Niu, 2011). Wheat germ has also high content of α-tocopherol, B-group vitamins, dietary fibre and minerals (Amado and Arrigoni, 1992; Rizzello *et al.*, 2010). Additionally, wheat germ oil is a valuable source of unsaturated fatty acids (especially linoleic and linolenic acids) (Wang and Johnson, 2001) and vitamin E. Wheat germ and its oil have been used in food, pharmaceutical and cosmetic industries (Kan, 2012) due to beneficial effects on human health. The aim of this study was to investigate antioxidant activity, total phenol and oil content of both unheated and heat-treated wheat germ and also determine the fatty acid composition of oil extracted from the heated samples.

2. Material and methods

Material

Wheat germ was provided from a flour company located in Konya, Turkey. The material was ground in a mill (C.S. Bell Co., Tiffin, OH, USA) and the particle sizes ranged from 0.5 to 0.7 mesh.

Methods

Ground wheat germ samples were kept in a drying-oven (Termal La, Istanbul, Turkey) at different temperatures (100, 120, 150 and 180 °C) and times (5, 8, 11 min). After heat treatment applications, the samples were analysed.

Determination of oil content

The ground wheat germs were extracted with petroleum ether during about 6 h using a soxhelet apparatus (Ildam, Ankara, Turkey). The solvent was separated with a rotary vacuum evaporator (IKA, Staufen, Germany) at 50 °C and the oil contents of the samples were determined according the AOAC (1990) method.

Determination of radical scavenging activity and total phenol content

The free radical scavenging activity of the wheat germ methanol extracts was determined using 2,2-diphenyll-1-picryl-hydrazylhdrate according to Lee *et al.* (1998). Total phenol content was investigated using Folin Ciocalteu (FC) reagent as applied by Yoo *et al.* (2004) with some modifications. 0.1 ml wheat germ extract was mixed with 0.5 ml FC reagent and 1.5 ml Na_2CO_3. After 2 h keeping at room temperature, absorbance was measured at 760 nm using a spectrophotometer (Shimadzu, Kyoto, Japan). Results are given as mg/g gallic acid equivalents (GAE).

Determination of fatty acid composition

Heated and unheated wheat germ oils were esterificated according to the ISO-5509 method (ISO, 1978) with some modifications. Fatty acid methyl esters of samples were analysed by gas chromatograph (Shimadzu GC-2010; Shimadzu) equipped with a flame-ionisation detector and a capillary column (60 m × 0.25 mm, film thickness: 0.20 µm; Tecnocroma TR-CN100; Tecnocroma, Barcelona, Spain). The carrier gas was nitrogen with a 1.51 ml/min flow rate. The temperature of the detector and injection block was 260 °C. The total flow rate was 80 ml/min and the split rate was also 1/40. The column temperature was programmed at 120 °C for 5 min and increased to 240 °C at 4 °C/min and held for 25 min at 240 °C. A standard fatty acid methyl ester mixture (Sigma Chemical Co., St Louis, MO, USA) was used to determine the sample peaks. Commercial mixtures of fatty acid methyl esters were used as reference data for the relative retention times (AOAC, 1990).

Statistical analyses

The averages were calculated by analysing the cereal oils three times. Results of the research were analysed for statistical significance by analysis of variance (Püskülcü and Ikiz, 1989).

3. Results and discussion

Table 1 shows the oil contents of unheated and heat-treated wheat germs. According to the results, the oil content of unapplied heating process wheat germ was found to be 6.89%. Oil yields of samples which were heated at 100 °C and 180 °C decreased. The maximum yield was obtained when heated at 120 °C/11 min with 7.293% and 120 °C/8 min with 7.256%, while the minimum oil content was observed at 100 °C/11 min with 5.794%. Heated at 150 °C/5 min, wheat germ had a high yield, but a decrease was observed when the heating time was increased.

Suresh Kumar *et al.* (2014) determined the effect of different temperatures on physicochemical and nutraceutical properties of wheat germ and wheat bran. From the stand point of oil content, it was observed that the oil yield

Table 1. Antioxidant activity, total phenol and oil content of wheat germ samples (mean ± standard deviation).

Temperature (°C)	Time (min)	Antioxidant activity (%)	Total phenol content (mg GAE/100 ml)	Oil yield (%)
100	5	62.33±3.67	1.53±0.17	6.57±0.79
	8	60.88±4.32	1.73±0.45	6.38±0.83
	11	65.46±2.68	1.61±0.64	5.79±0.58
120	5	62.09±1.59	2.09±0.59	5.87±0.85
	8	59.88±1.53	1.93±0.85	7.26±1.07
	11	63.15±3.81	1.79±0.39	7.29±0.95
150	5	60.33±2.78	2.09±0.67	7.14±1.06
	8	61.61±4.72	2.071±0.28	6.87±0.82
	11	60.88±1.59	1.79±0.19	6.78±0.68
180	5	66.78±2.47	1.81±0.27	6.46±0.59
	8	59.59±1.29	1.97±0.21	6.29±0.76
	11	58.72±1.45	1.33±0.18	6.47±0.84
Control		67.00±2.87	1.79±0.13	6.89±0.59

showed an increase when the temperature was raised. The obtained oil yields were 7.7±0.14% (control sample), 7.8±0.54% (heated at 130 °C), and 8.1±0.31% (heated at 140 °C). According to the study of Vasconcelas *et al.* (2013), the crude oil content of wheat germ was found to be 9.77%. Our results obtained from heated and unheated wheat germs show a lower oil yield than the results of these studies.

The results of antioxidant activity and total phenol content are shown in Table 1. Antioxidant activity reduced with heating process. The highest value was found for the unheated sample. Concerning total phenol content, results of wheat germs which heated 120 °C/5 min, 150 °C/5 min and 8 min were found to be higher than in the control group. The least total phenol content was obtained from wheat germ that was heated at the maximum temperature and time (180 °C/11 min).

Zhu *et al.* (2011) investigated antioxidant activities and total phenolic contents of defatted wheat germ extracts. Total phenolic content was found to be 14.93±0.30 mg GAE/g with 100% ethanol extract. Antioxidant activity was also determined between 50-60%. In the experiments reported by Rizzello *et al.* (2010) total phenol content was 0.35 mg GAE/g with 80% methanol extract. It was ascertained that results of the antioxidant activity corresponded with the study of Zhu *et al.* (2011) but there were significant differences between other studies when comparing total phenol contents.

The fatty acid composition of heat-treated and unheated wheat germs are presented in Table 2. The most dominant fatty acids of control sample were linoleic (58.382%), oleic (18.554%), palmitic (12.926%), and linolenic acid (6.848%). The applied heat treatment did not affect the fatty acid composition of wheat germ oils significantly. Linoleic and linolenic acid contents of heated wheat germ oils showed a reduction in small quantities with reference to unheated samples.

The study of Niu *et al.* (2013) determined that wheat germ oil contained unsaturated fatty acids (83.45%) in high quantity, especially linoleic acid (64.82%). It was reported in the literature that the main fatty acids of wheat germ oil were linoleic (18:2), palmitic (16:0) and oleic (18:1) acid (Brandolini and Hidalgo, 2012; Kan, 2012). The concentrations of the major fatty acids ranged from 55.2 to 56.9% for linoleic acid; from 14.5 to 14.7% for oleic acid and from 16.4 to 16.6% for palmitic acid (Dunford and Zhang, 2003). Jiang and Niu (2011) studied with wheat germ oil extracted by supercritical CO_2 and observed that the oil content of sample was higher than our results and contents of particularly linoleic acid (64.82%) and palmitic acid (16.27%.) were higher, while the oleic acid (13.19%) and linolenic acid (4.91%) contents were lower than in our study. According to the study of Sakhawat *et al.* (2013), wheat germ oil is rich in essential fatty acids and contents of palmitic, oleic, linoleic and linolenic acid were 18.580, 14.030, 57.920 and 8.340%, respectively. Suresh Kumar *et al.* (2014) investigated the fatty acid composition of heated (130 and 140 °C) and unheated wheat germ and determined that the most dominant fatty acids were palmitic (19.4, 19.7, 19.1%), oleic (17.0, 17.2, 16.9%), linoleic (56.3, 57.1, 56.7%) and linolenic acid (6.6, 5.3, 5.6%) for control samples, samples heated at 130 °C and at 140 °C, respectively. Özcan *et al.* (2013) reported that the percentages of palmitic, oleic, linoleic and linolenic acid determined in the cold pressed oil were 15.89, 15.48, 54.88 and 7.34% of total fatty acids, respectively.

The composition of germ oil was partly influenced by the heat processing. The qualitative and quantitative analysis differences between our results and literature may depend on analytic conditions, heat processing, and germ

Table 2. Fatty acid composition of wheat germs (%).

Temperature (°C)	Time (min)	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid	Arachidic acid	Linolenic acid	Behenic acid
100	5	12.335	1.178	19.206	57.535	0.169	6.691	0.218
	8	12.661	1.072	18.468	57.254	–	6.595	0.192
	11	11.318	1.048	18.767	56.854	0.200	6.568	0.227
120	5	11.800	1.036	18.897	57.133	0.154	6.616	0.232
	8	11.779	1.198	19.293	57.560	0.160	6.738	0.219
	11	11.648	1.208	19.456	57.736	0.186	6.588	0.236
150	5	11.848	1.105	18.587	55.514	0.307	6.630	0.208
	8	11.942	1.023	18.026	56.994	0.186	7.849	0.318
	11	12.239	1.062	18.195	58.186	0.155	6.917	0.236
180	5	11.976	1.060	17.900	54.884	0.209	6.550	0.227
	8	12.491	1.019	18.358	57.269	0.159	6.839	0.242
	11	12.800	1.059	18.677	57.779	0.179	6.689	0.228
Control		12.926	1.082	18.554	58.382	0.175	6.848	0.240

differences. In conclusion, the present study indicates that wheat germ oil is a good natural source of fatty acid.

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