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Comparison of chemical composition of two durum wheat (*Triticum durum* L.) and bread wheat (*Triticum aestivum* L.) germ oils.

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ABSTRACT

Wheat belong to the genus Triticum, as annual plants of the family Gramineae or Poaceae, grown in many countries, including Tunisia with one million hectares annually. Wheat grain is a particular fruit, caryopsis and the outer envelope is adherent to plant seed material. During milling, envelopes (hulls) are separated from the grain (endosperm + embryo). The embryo or germ is the essential part of the seed to plant reproduction and is containing a lot of fat (about 15%) or oils. The Soxhlet technique is used for the extraction of wheat germ oil. Normal hexane (n-hexane) is commonly used for edible oil extraction. Comparison of the extracted oil of durum wheat germ and soft wheat germ showed a marked difference in their chemical composition. The basic chemical composition analyses revealed low values of dry matter (14.77g /100g of durum wheat germ and 19.87g /100g of Soft wheat germ), low amounts of total ash content (5.3g/100g of durum wheat germ and 4.99g /100g of Soft wheat germ) and high fat contents (17.12g /100g of durum wheat germ and 15.96g /100g of Soft wheat germ). The yield of extraction by Soxhlet was about 13.12% for durum wheat germ and 11.22% for soft wheat germ. The fatty acid composition of these two wheat germ oils indicates the presence of C18:2, C16:0 and C18:1. The major one is C18:2 with 56.68% for Soft wheat germ oil and 53.43% for durum wheat germ oil.

***Keywords*:** germ oil, durum & soft wheats, soxhlet extraction, fatty acid composition, chemical composition

Introduction

Cereals have an important role in human nutrition, either for cooking or as raw material for obtaining flour for baking. Botanically they belong to the grass family (Gramineae), that include wheat, rice, barley, oats, rye, maize, sorghum, and millets (Belderok,2000). Wheat is one of the most important crops in the world with the largest production of any crop. This is because it is highly adaptative to environmental conditions and because of its unique characteristics where it can be processed into various types of edible products (Shewry and Tathmn, 1997). The different attributes of Triticum durum and Triticum aestivum are due to the differences in kernel physiochemical properties. Durum wheat grains are harder, larger and more vitreous than bread wheat grains. Durum wheat is tetraploid (AABB), While bread wheat is hexaploid (AABBDD), and consequently, the absence of D genome is to some extent- responsible for the

reduction in durum wheat baking performance (Kerber and Tipples 1969; Ceoloni et al, 1996; Pogna et al, 1996; Redaelli et al, 1997; Joppa et al, 1998; Lafiandra et al, 2000). The main components of the wheat kernel are barn, germ and endosperm (Dexter and Wood, 1996). Wheat germ is a by-product of the wheat milling industry. Germ constitutes about 2–3% of the wheat grain and can be separated in a fairly pure form from the grain during the milling process. Wheat germ contains about 11% oil (Sonntag, 1979). α-Tocopherol, polyunsaturated lipids, protein, threonine, methionine, lysine, raffinose, sucrose, thiamin and riboflavin were chosen since these are the components regarded as most important in commercial wheat germ. Compared to wheat, Tunisian barley varieties have also a high level of antioxidant capacity compared to that of other cereal (wheat bran 0.042 lmol of trolox equivalent/g of wheat bran) based on TEAC assay.

Solvent extraction is a common method of extraction of oils from vegetable matter. Normal hexane (n-hexane) is commonly used for edible oil extraction. Wheat germ oil is used in products such as foods, biological insect control agents, pharmaceuticals and cosmetic formulations (Kahlon, 1989). This valuable product is not only used in the food industry as various food additives, but also in various areas of medicine for the treatment of many diseases. Wheat germ oil is different from many vegetable oils. A distinctive feature of the wheat germ oil compared to most vegetable oils is its high content of "vitamin of youth" E (tocopherol) and polyunsaturated fatty acids (from 45 to 60%), linolenic (up to 11%) and oleic acid (12 to 30%). Both of which are of great importance in human metabolism and cannot be synthesized by the organism. Furthermore, linoleic acid helps to eliminate cholesterol and is a precursor of cell membrane phospholipids (Salinas R, 1993). Also in wheat germ oil in much smaller amounts are saturated fatty acids (14 to 17% palmitic, stearic 0.5 to 2.3%, and so one) (Nechaev A.P, 1975).

This work aim to study the chemical composition of two wheat germ oils, durum and bread wheat produced in Tunisia.

Materials and methods

Wheat germ material

Bread and Durum wheat germ samples, by-products used in the present study, were generated by one of the Tunisian milling [GMT], located in Tunis. Germ was obtained from milling of bread and durum wheat. Wheat germs were directly stored in a freezer at (-18 °C) until extraction and analysis.

Separation and clearing of wheat germ

Wheat germ contains significant amounts of organic impurities not oiled: mealy particulate grain (up to 4%), husks (5-6%), etc. The presence of impurities in processed embryos increases the losses of oil in cake or meal. Purification of wheat germ from husks and impurities was done by sifting wheat germ with a double sieve comprises a sieve of the order of 1000 µm and a sieve of the order of 630 µm. The sieving time was 3 to 4 minutes.

Oil extraction

Wheat germ oil extraction was carried out according to the AOCS Official methods using n-hexane (AOCS, 1998). Oil content of wheat germ samples was determined by using a Soxhlet apparatus with n-hexane as a solvent for 6 h. Solvent used for oil extraction is n-hexane, with a highest available purity. The n-hexane solvent was done from SIGMA - ALDRICH Company (USA). All other chemicals used in this study were of analytical grade.

The extraction procedure was repeated twice and the solvent was evaporated from the extract solvent mixtures at 40°C under vacuum using a rotavapor (Rotavapor R-210/215, 230V, 50/60 Hz) until constant weight was attained. The wheat germ oils obtained was drained under a nitrogen stream (N2) and was then stored in a freezer at (-18 °C) until analysis. The amount of oil extracted by solvent was gravimetrically determined. Extraction yield (Y) was defined by the following equation:

$$\mathbf{Y}\ (\%) = \frac{\text{amount of extract collected (g)}}{\text{amount of sample used for extraction (g)}} * 100$$

Analytical methods

Fatty acid composition

Fatty acid composition of the extracted oil was analyzed by gas chromatography (GC-SM) (Agilent 19091S-433). The GC unit was a HP-5MS equipped with a flame ionization detector (FID) and a polar phénylméthyl-siloxane capillary column (60m×25mm×0.25µm film thickness), was used for fatty acid analysis. Methylation of the fatty acids was carried out according to the AOCS Official Method Ce 2-66 (AOCS, 1998). The helium carrier gas flow rate was 1ml/min. The injector temperature was maintained at 230°C. A temperature program with total run time of 82 min was used. The column temperature, after an initial isothermal period of 2 min at 50°C, was increased to 220°C at a rate of 4°C/min, and maintained at this temperature for 37.5 min. The detector conditions were as follows: temperature 250°C, N2 flow 40 ml/min, air flow 450 ml/min and make-up gas (He) 45 ml/min. Germ

oil samples (1 ml) were injected by an auto sampler (HP-5MS, HP Company, Wilmington, DE). Peak areas were calculated and data collection was managed using an HP Chemstation.

Organic matter and ash contents quantification

Wheat germ samples (2.5g) induplicate for each sample were analyzed for residual water content and ash content using previously validated method (De Vasconcelos et al, 2009). Wheat germ samples were submitted to a drying processing in an oven at 105◦C for 12 h, and then the samples were weighed. Dried samples are incinerated at 550◦C for 3 h, and the ash content was obtained.

Chemical analysis

Official methods of American oil chemist's society (AOCS, 1998) were used for the determination of the refractive index, density, acid value and iodine value of the wheat germ oils. The antioxidant activity of the wheat germ oils was determined by a β-carotene/ linoleic acid system, as described by Matthus (2002).

Results and discussion

Chemical composition of wheat germs

Modern technologies of grain into flour can get the germ of up to 10-35% cuts that affect the composition and biological value of the finished product (Butkovsky et al, 2006). The extraction rate of oil through soxhlet was found 13.12% for durum wheat germ and 11.22% for bread wheat germ, which was in close agreement with the results found in the study of Dunford and Zhang (2003). Variation in oil yield could be attributed to differences in plant variety, cultivation climate, ripening stage and the extraction method used (Nyam et al, 2009). As illustrated in Table 1, the nutritional and biological value of durum and bread wheat germ were studied and found that the total ash, moisture, fat and protein levels were 4.99%, 19.87%, 15.96 % and 23.3% for bread wheat while they were 5.3%, 14.77%, 17.12% and 25.3% for durum wheat, respectively. Thus the difference in chemical composition of the two wheat germs depends significantly on the genetic characteristics of raw materials, climate, cultivation of grain, as well as its productivity. Such a chemical composition reveals the valuable potencies of such a wheat germ.

Chemical analysis of wheat germ oils

The results of physico-chemical parameters in Table 2 indicate that the characteristics of extracted wheat germ oils are in agreement with recent published values for these indices. The density or specific gravity of oil at any given temperature compared to water at a specified temperature is known to increase as the degree of unsaturation increases (i.e. with higher iodine value) (Muhammad, 2008). The densities values (g/ml) found for extracted durum wheat germ oil and bread wheat germ are 0.92 and 0.86. However, the iodine value for durum wheat germ oil was found to be 192.6 and 191.4 for bread wheat germ, which is also within the limits of literature (O'Brien, 2004 and Przybylski, 2004). It can be seen also that the acid values were 91.5 (g/100g) for bread wheat germ oil and 89.5(g/100g) for durum wheat germ oil. The antioxidant activity of wheat germ oils was measured by the bleaching of ß-carotene. The comparison of durum wheat germ oil and bread wheat germ oil showed an appreciable antioxidant activity. In addition, studying the data in table 2 shows that beta-carotene content from durum wheat germ oil (17.12 mg/g) is greater than bread wheat germ oil (15.96 mg/g). It is indicated by the results of this work that wheat germ oils were established, could serve as a source of natural antioxidants or nutraceuticals.

Fatty acid composition

Fatty acids contents of wheat germ oils were obtained by GC analyses. Table 3 shows the fatty acids composition, expressed as percentage of total fatty acids, of oil samples obtained by using organic solvents and Soxhlet extraction. Total unsaturated and polyunsaturated fatty acid content of bread wheat germ oil was about 81.64 and 18.51%, respectively. While for durum wheat germ oil it was about 82.08% and 17.91% of total unsaturated and polyunsaturated fatty acid content. The most abundant saturated fatty acid was palmitic acid with more than 94% of the saturated fatty acids for bread wheat germ oil and 94.6% for durum wheat germ oil. These results are in a good agreement with the previous results reported by Lancas et al, 1994, Michael et al 2006, Michael and Nurhan 2007 and Yuldasheva et al. 2010. Wheat germ n-hexane extracts consisted of about 69% linoleic acid (18:2 n6) for bread wheat germ oil and 53.9% for durum wheat germ oil, which is an essential fatty acid. It is worth mentioning that the high amount of linoleic acid makes wheat germ oil specifically prone to oxidation and degradation under the conditions used for conventional edible oil extraction and refining methods (Krings et al, 2000). It has been also suggested that unsaturated fatty acid, especially polyunsaturated fatty acid intake reduces cardiovascular heart disease (CHD) (Simopoulos, 1999). Also this fatty acid may have favorable nutritional implications and beneficial physiological effects in the prevention of cancer (Oomah et al, 2000).

Conclusion

The current study has revealed that the used technology for the production of wheat germ oil, as confirmed by the literature, showed a good composition and extraction yield. The Tunisian wheat germ is not used for human feeds, which allows us to think about industrial applications. The quantity of triturated wheat in Tunisia is about 9000 tons per day resulting in 6 tons of wheat germ, and the amount of oil that can be obtained is approximately 650 liters per day. Thus the present study can serve as an opportunity for the industrial to invest in this field. Yield and quality improvement of wheat germ oils needs other process as cold pressing and supercritical CO_2 extraction. The production of oil from wheat germ provides the use of renewable resource, and at the same time adding value to food products. Breeding for improved genetic material within quality parameters required somewhere phenotyping toward fonctionnal foods. Thus, incorporation of such materials into bakery products would enhance their nutritional and physiological properties, but their functionality and acceptability should be taken into consideration.

Table 1. Chemical composition (dry basis) of durum and bread wheat erms.

Component	Bread wheat germ oil	Durum wheat germ oil
Moisture content [a]	19.87	14.77
Crude oil [a]	15.96	17.12
Crude protein [a]	23.8	25.3
Total ash [a]	4.99	5.3

(w /w)[a]

Table 2. Physicochemical characterization of durum and bread wheat germ oils.

Parameter	Bread wheat germ oil	Durum wheat germ oil
Refractive index	1.48	1.46
Density (g/ml)	0.86	0.92
Acid value (g/100g)	91.5	89.5
Iodine value	191.4	192.6
β-carotene (mg/g)	15.96	17.12

Values are means of three determinations. (w /w)

Table 3. Fatty acids composition (expressed as % of total fatty acids), measured by a gas chromatography-flame ionization detection (GC-FID) method, of durum and bread wheat germ oils.

Fatty acids (%)	Bread wheat germ oil	Durum wheat germ oil
Myristic acid C14:0	0.186	0.12
Palmitic acid C16:0	17.47	16.95
Palmitoleic acid C16 :1	0.18	0.26
Stearic acid C18:0	0.64	0.71
Oleic acid C18 :1	15.24	20.47
Linoleic acid C18 :2	56.68	53.43
Linolenic acid C18 :3	8.11	6.67
Arachidic acid C20:0	0.22	0.13
Gadoleic acid C20 :1	1.25	1.25

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