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Mineral contents and some physico-chemical properties of some commercial sesame seeds used in halva (sweet) production

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ABSTRACT: The mean heavy metal and minerals of sesame seeds were determined by ICP-AES. The mean values of Ca, Mg, K, P and S contents of seeds varied from 7815, 1927, 4426, 3945 and 2228 (mg/Kg, dw), respectively. In addition, Fe, Zn, Cu, Mn, B, Mo and Cr values of sesame seeds were found at the levels between 63.27 to 254.28, 28.31 to 36.31, 15.06 to 19.76, 11.53 to 26.24, 8.36 to 10.78, 0.447 to 1.440 and 0.148 to 0.631 (mg/Kg, dw), respectively. In regard to protein contents of sesame seeds, the mean protein values of seeds were found between 21.83 (Nigeria Maidaguri) to 25.77 % (Etiopia Volega). Ash levels of samples were found between 2.6% (.Afganistan) to 3.4% (Nigeria Maidaguri). Crude oil contents of hulled sesame seeds were established between 57% (Mozambic) to 65% (Afganistan).

***Keywords*:** sesame seed, minerals, protein, ash, oil, ICP-AES

INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the most important oilseed crops world wide, and a flowering plant in the genus 'sesamin'. It is used in the making of tahin (sesame butter) and halva, and for the preparation of rolls, crackers, cakes and pastry products in commercial bakeries. There are numerous varieties and ecotypes of sesame adapted to various ecological conditions (Nzikou et al 2009; Adebowale et al. 2011). Sesame is an excellent source of high quality oil and protein, its oil is odourless and close in quality to olive oil. The oil is excellent edible oil that has high preservative qualities. It prevents rancidity, even though the seeds are prone to rancidity, the oil is resistant to oxidation and this is because of the natural preservative within the oil called sesamol (Yoshida and Kajimoto, 1994; Adebowale et al. 2011). Non-conventional oilseed are being considered because their constituents have unique chemical properties and may augment the supply of edible oils (Ramadan and Mörsel, 2002; Ramadan and Mörsel,2003). The beneficial effects of vegetable oils in the human diet have been well known, basically due to their high content in unsaturated fats and their high energy value. Tocopherols are particularly important functional component in foods. Phytosterols and tocopherols are components present in the unsaponifiable lipid fraction of foods. Phytosterols, primarily β-sitosterol, campesterol, and stigmasterol are integral natural components of plant cell membranes that are abundant in vegetable oils, nuts, seeds, and grains (Lopez Ortiz, Prats Moya & Berenguer Navarro, 2006; Ryan, Galvin, O'Connor & Maguire, 2007).

As consumers become more aware of the health implications of their dietary patterns, their food choices become more selective. The nutritional effect of dietary lipids is nowadays a major consumer issue, affecting consumption habits and food choices (Toro-Vazquez, Charo-Alonso, & Perez-Briceno,1999).

The aim of current work was to determine mineral contents and some physico-chemical properties of sesame seeds used for halva sweet production.

MATERIALS AND METHODS

Material

Sesame seed samples were collected from Gesaş A.Ş Company in Konya in Turkey (Table 1). Seeds were transported to the laboratory. They were cleaned in an air screen cleaner to remove all foreign matter such as dust, dirt, stones and chaff, and immature and broken seeds were discarded as well, and then stored in polypropylene bags at room temperature.

Determination of mineral contents

Sesame samples were dried at 70 ºC in a drying cabinet with air-circulation until they reached constant weight. Later, about 0.5 g dried and ground sample was digested by using 5ml of 65% HNO_3 and 2 ml of 35% H_2O_2 in a closed microwave system (Cem-MARS Xpress). The volumes of the digested samples were completed to 20 ml with ultra-deionized water and mineral concentrations were determined by inductively coupled plasma-optical emission spectroscopy (ICP AES; (Varian-Vista, Australia). Measurements of mineral concentrations were checked using the certified values of the related minerals in the reference samples received from the National Institute of Standards and Technology (NIST; Gaithersburg, MD, USA) (Skujins,1998).

Working conditions of ICP-AES

Instrument :ICP-AES (Varian-Vista
RF Power : 0.7-1.5 kw (1.2-1.3 kw for Axial)
Plasma gas flow rate (Ar) : 10.5-15 L/min. (radial) 15 " (axial)
Auzilary gas flow rate (Ar) :1.5 "
Viewing height : 5-12 mm
Copy and reading time :1-5 s (max.60 s)
Copy time : 3 s (max. 100 s)

Oil, protein and ash contents

The oil content was determined according to the method ISO 659:1998 (ISO,1998). About 2 g of the seeds were ground in a ball mill and extracted with petroleum ether in a Twisselmann apparatus for 6 h. The solvent was removed by a rotary evaporator at 40 °C and 25 Torr. The oil was dried by a stream of nitrogen and stored at – 20 °C until used. Crude ash was determined according to the Association of Official Analytical Chemists (AOAC, 2000). Protein content was determined by the Dumas Nitrogen Analyzer (DNA) (Velp NDA 701- Italy). Protein was calculated using the general factor (6.25).

Working conditions of DNA:

O_2 flow rate: 400 ml/min
He flow rate : 195 ml/min
Combustion reactor: 1030 ^oC
Reduction reactor : 650
Pressure (mbar) : 881.0

Statistical analyses

Results of the research were analysed for statistical significance by analysis of variance (Püskülcü and İkiz.1989). This research was performed by three duplicates with a replicate.

RESULTS AND DISCUSSION

The macro and micro element contents of sesame seeds are given in Table 2 and 3. In addition, crude protein, crude oil, and ash contents of sesame seeds were presented in Table 4.

The levels of heavy metal and micro elements were established by ICP-AES. The mean concentrations of Ca, Mg, K, P and S contents of seeds varied from 7815, 1927, 4426, 3945 and 2228 (mg/Kg, dw), respectively. In addition, Fe, Zn, Cu, Mn, B, Mo and Cr values of sesame seeds were found at the levels between 63.27 to 254.28, 28.31 to 36.31, 15.06 to 19.76, 11.53 to 26.24, 8.36 to 10.78, 0.447 to 1.440 and 0.148 to 0.631 (mg/Kg, dw), respectively (Table 2). While mean Fe, Zn, Mn and Cu contents of seeds were found at the high levels, others were found at the low levels. The highest Fe (254.28 mg/Kg) and Zn (36.31 mg/Kg) in seeds were established in S8 and S7 samples, respectively. In regard to macro elements of sesame seeds, the highest Ca (9435), Mg (2186), K (4854), P (4843) and S (2956) were found at S6, S2, S9, S2 and S2 samples, respectively. As seen Table 3, macro element concentrations of S2 samples were found at the high levels. Ca levels of samples were found at the highest concentrations.

1000 seed weight of sesame seeds ranged from 2.092 g (Nigeria-Maidaguri) to 2.946 g (Nigeria-Kanu). Crude protein contents of sesame seeds ranged from 21.83% to 25.77% (Table 4). The highest protein content was found in Etiopia volega sample. Ash contents of the same varied from 2.8 % (Nigeria Kanu and Mozambik) to 3.4% (Nigeria Maidaguri). Crude oil contents of sesame seeds were determined between 52% (Hindistan) and 57 % (Uganda and Afganistan). As a result, protein, oil and ash contents of seeds were found at the high levels. The oil contents of sesame were found between 50.3% to 55.0% (Yermanos, Hemstreet, Saleeb, & Huszar, 1972; Özcan and Akgül, 1995). In comparison with literature, it may be different values for almost all oil parameters. Differences among the values of seed oil content can be probably due to growing, climatic, environmental conditions and analytical conditions, locaties.

EL-Khier et al. (2008) studied on the physical characteristics and chemical composition of 10 sesame seed cultivars (3015, Kenanal, Local white, mixed and aswad (Sudanese genotypes) and zirra2, zirra7, zirra9, hurria11 and hurria49 (USA genotypes). 1000 seed weight of seeds were found between 2.98 to 2.88g. Moisture

contents of the cultivars ranged from 2.70 to 4.70%. While protein contents of all genotypes were found between 32.50% to 40.00%, oil contents of sesame seeds changed between 43.74% to 50.72% (ElKhier et al. 2008). The same researchers established that K, Ca and Fe contents (mg/100g) of sesame seeds were dfetermined between 0.10 to 0.27, 0.44 to1.20 and 2.30 to 3.73, respectively. Alyemeni et al. (2011) reported that sesame seeds contained relatively high amounts (mg/100g) of Ca (1200), P (580), K (374), Mg (185), Na (72), Fe (10.6) and low amount of Zn (3.8). Johnson et al. (1979) reported that an unusual feature of sesame is that it generally contains 2 to 3% oxalic acid and 1 to 2 % calcium, which is primarily in the hull, dehulling improves the nutritional and flavor characteristic. The highest recorded Ca value was 1450 mg/100g in some Indian sesame cultivars (Gopalen et al. 1982; Sher et al. 2010a), and the lowest Ca value (228.3 mg/100g) was reported in some Lebanese Sesame cultivars (Pellet et al. 1970). Nzikou et al. (2009) reported that the sesame seed contained 5.7% moisture, 20% crude protein, 3.7% ash and 54% fat. Also, the seeds were found to be good sources of minerals. In addition, potassium (851.35 mg/100g) was the highest, followed in descending order by phosphorus (647.25), Magnesium (579.53), Calcium (415.38) and Sodium (122.50 mg/100g). The high percentage of oil makes this seed a distinct potential for the oil industry. According to Egbekun and Ehieze (1997), variation in yield may be due to the differences in variety a plant, cultivation climate, ripening stage, the harvesting time of the seeds and the extraction method used. Potassium is an essential nutrient and has an important role is the synthesis of amino acids and proteins (Malik, 1982). Calcium and Magnesium plays a significant role in photosynthesis, carbohydrate metabolism, nucleic acids and binding agents of cell walls (Russel, 1973). Phosphorus is needed for bone growth, kidney function and cell growth. It also plays a role in maintaining the body's acid-alkaline balance (Falloz, 2001). The study showed that the sesame seed is a good source rich in protein, minerals and oil. Adebowale et al. (2011) determined that sesame seeds contained between 11.50% to 20.50% fat, 12.69% to 23.03% protein, 4.25 to 7.00% ash, 5.41 to 20.15% Ca, 0.50 to 3.02% Fe , 1.45 to 7.35% Mg and 2.88 to 12.88% . The results may vary depending on variety and cultural conditions. The results of calcium were found to be similar to most of the sesame cultivars grown else where. The values are good in agreement with those reported previously (Pellet et al. 1970; Russel, 1973; Johnson et al. 1979; Özcan and Akgül, 1995; Alyemeni et al. 2011).

Table 1. Origine of sesame seeds

Sample No	Origine Sesame samples
S1	Uganda
S2	Niger Maidaguri
S3	Niger Kano
S4	Niger Benue
S5	Afganistan
S6	India
S7	Burkina Faso
S8	Mozambic
S9	Etiopia Volega
S10	Etiopia Humera

Table 2. Macro element concentrations of sesame seeds (mg/kg, dw)

Samples	Ca	Mg	K	P	S
S1	6514 ± 54	1915 ± 7	4776 ± 106	4504 ± 7	1848 ± 9
S2	6259 ± 203	2186 ± 31	4553 ± 51	4843 ± 199	2956 ± 30
S3	7341 ± 403	1877 ± 84	4398 ± 102	3758 ± 165	1790 ± 14
S4	7786 ± 236	1909 ± 7	4560 ± 24	4349 ± 7	1764 ± 7
S5	7881 ± 194	1769 ± 49	3627 ± 74	2692 ± 93	2822 ± 93
S6	9435 ± 234	1872 ± 5	4514 ± 41	3830 ± 41	2337 ± 28
S7	7554 ± 190	1834 ± 9	4551 ± 111	3721 ± 127	1963 ± 29
S8	8995 ± 136	1805 ± 30	4091 ± 170	3334 ± 71	2023 ± 61
S9	8764 ± 187	2028 ± 26	4854 ± 43	4364 ± 65	2232 ± 38
S10	7620 ± 235	2072 ± 50	4336 ± 79	4060 ± 107	2548 ± 32
Minimum	6259	1769	3627	2692	1764
Maximum	9435	2186	4854	4843	2956
Mean	7815	1927	4426	3945	2228

Data are presented as means±SD, n=3 replicates

Table 3. Micro element concentrations of sesame seeds (mg/kg, dw)

Samples	Fe	Zn	Cu	Mn	B	Mo	Cr
S1	94.51 ± 1.26	31.65 ± 0.18	15.06 ± 0.35	16.51 ± 0.53	9.05 ± 0.09	1.110 ± 0.047	0.152 ± 0.019
S2	127.26 ± 5.68	32.60 ± 1.20	16.58 ± 0.45	24.72 ± 0.82	9.83 ± 0.42	1.440 ± 0.076	0.255 ± 0.019
S3	65.45 ± 3.16	32.74 ± 0.47	15.67 ± 0.93	19.47 ± 1.21	8.36 ± 0.11	0.834 ± 0.023	0.148 ± 0.016
S4	79.54 ± 0.54	32.87 ± 1.55	19.76 ± 0.51	23.89 ± 0.99	9.03 ± 0.23	1.149 ± 0.007	0.239 ± 0.022
S5	193.08 ± 1.03	34.24 ± 0.89	16.15 ± 0.61	16.28 ± 0.39	10.32 ± 0.17	1.160 ± 0.038	0.631 ± 0.032
S6	63.27 ± 2.18	28.31 ± 0.70	16.04 ± 0.46	12.67 ± 0.11	10.78 ± 0.18	0.447 ± 0.034	0.176 ± 0.013
S7	86.99 ± 3.49	36.31 ± 0.48	17.11 ± 0.58	18.15 ± 1.28	8.84 ± 0.09	0.886 ± 0.060	0.181 ± 0.020
S8	254.28 ± 9.39	31.80 ± 1.30	15.90 ± 0.40	26.24 ± 1.54	9.16 ± 0.04	1.035 ± 0.051	0.257 ± 0.019
S9	87.78 ± 3.56	32.02 ± 0.39	16.58 ± 0.47	13.46 ± 1.08	8.85 ± 0.21	0.714 ± 0.037	0.188 ± 0.018
S10	115.27 ± 2.59	36.04 ± 0.64	19.48 ± 0.12	11.53 ± 0.32	9.61 ± 0.31	0.508 ± 0.019	0.239 ± 0.015
Minimum	63.27	28.31	15.06	11.53	8.36	0.447	0.148
Maximum	254.28	36.31	19.76	26.24	10.78	1.440	0.631
Mean	116.74	32.86	16.83	18.29	9.38	0.928	0.247

Table 4. Some physico-chemical properties of sesame seeds

Samples	1000 seed weights (G)	Crude oil (%) non-hulled sesame	Crude oil (%) (hulled sesame)	Total ash in hulled sesame (%)	Crude protein in hulled sesame (%)*
S1	2.358±0.3	57±1.6	62±1.7	3.3±0.7	22.43±1.13
S2	2.092±0.1	55±1.2	59±1.9	3.4±0.9	21.83±1.29
S3	2.946±0.1	55±1.3	62±2.1	2.8±0.6	25.43±1.17
S4	2.206±0.2	56±1.7	60±1.0	3.3±0.5	23.43±1.21
S5	2.972±0.3	57±0.9	65±1.3	2.6±0.3	20.53±1.59
S6	2.772±0.4	52±1.1	58±1.7	3.2±0.7	25.50±1.45
S7	2.838±0.1	56±0.9	62±1.2	3.0±0.5	22.17±1.71
S8	2.843±0.3	52±1.1	57±1.1	2.8±0.9	24.13±1.09
S9	2.248±0.5	55±1.3	60±1.9	3.3±0.1	25.77±1.14
S10	2.416±0.1	53±1.2	59±1.6	3.3±0.6	24.24±1.23

*Nx6.25

CONCLUSION

Nutiritional and mineral properties of sesame seeds and oils are unique. The high mineral content and Premium quality oil with minimal processing requirements is particularly attractive. It is concluded that a beter understanding of the biochemical nature of sesame seeds and oil are necessary for food application. However, sesame oil seeds warrant further studies to meet the future aims (Alyemeni et al. 2011). The economic value of sesame seeds is dependent on its oil content rather than its protein content. In general, the oil contents of the cultivars were found within the range reported for sesame seed cultivars grown in various parts of the world (Bahki et al. 1998; Elleuch et al. 2007; ElKhier et al. 2008). Largest variations of mineral concentrations in sesame seeds were found. Significantly different concentrations of heavy metal and macro elements can be due to the constant genetical tolerance of accumulation, plant species, genetical difference, changing conditions of soil and climate. These are comparable to data previously reported in the literature within the limits of the slightly different analytical methods used around the world. As a result;

1- samples can be a good source oils.

2-The present study indicates that oil-bearing material used in this research are good natural sources of oil and protein. In addition, the results of these analysis has very important applications for the nutrition sciences.

3-The consumption of these materials is rising around the world and in some countries the traditional uses are still alive. The results may also be useful for the evaluation of nutritional information.

4- The differences among the values of different material oil can be probably due to growing, different parts, environmental and analytic conditions.

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