Journal of Medicinal Plants Research Vol. 5(2), pp. 270-274, 18 January, 2011
Available online at http://www.academicjournals.org/JMPR
ISSN 1996-0875 ©2011 Academic Journals

Full Length Research Paper

Physico-chemical analysis and mineral composition of some sesame seeds (*Sesamum indicum* L.) grown in the Gizan area of Saudi Arabia

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Accepted 6 December, 2010

Seeds of two local cultivars (dark and white) of Sesame (*Sesamum indicum* L.) were chemically analyzed for their physico-chemical characters specific gravity, refractive index, acidity, peroxide value, iodine number, saponification number and unsaponification unsaponified matter. Six mineral nutrients calcium, phosphorus, potassium, magnesium, sodium and iron contents of the seeds were also determined. The mineral composition *S. indicum* seeds revealed 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) The results were compared with some other cultivars growing worldwide. Our results revealed that incorporation of sesame seeds in bakery industry at suitable levels may satisfy the recommended daily dietary allowances of minerals (N.R.C.), as shown by chemical analysis of sesame seeds, confirming it as the richest source of most of the inorganic nutrients.

Key words: Sesame, mineral composition, physico-chemical analysis, Saudi Arabia.

INTRODUCTION

Sesame (*Sesamum indicum*, L.) is an economically important crop which is widely cultivated all over the world and it is probably the most successful oil seed crop in Saudi Arabia. It is mainly cultivated in Makkah and Gizan regions (Al-Kahtani, 1989; Sher and Hussain, 2009). Sesame is called the “Queen of the oilseeds crops” because of its high oil yield, mildness and pleasant taste (Johnson et al., 1979). Based on archeological findings, it was reported that Sesame might have two routes of migration from Central Africa (Namiki and Kobayashi, 1989). One specific route was eastward, over Indian Ocean, and from there spreading to China, Japan, Central Asian Islands, reaching Australia. The second proposed route was north-wards to Egypt, and through the Mediterrean Countries, to Arabia, Central Asia, China and finally Europe. Sesame is grown mainly in the developing tropical and subtropical areas of Asia, Africa, South and Central America and has been adapted also to grow in semiarid regions (Brito and Nunez, 1982).

Information on physico-chemical analysis and mineral composition of some common Saudi foods is not well described, therefore, it was considered important to assess the dietary adequacy of Saudi food and nutrients. Sesame is recognized as an important source of protein and its seeds are known to be a good source of calcium, phosphorus and iron (Gopalan et al., 1982, Weiss, 1983). Sesame use has long been regarded in the oriental dishes as a healthy food which increases energy and prevents aging (Namiki and Kobayashi, 1989). The maintenance of dietary minerals homeostasis in the human body is very important, since they are part of enzymes involvement in fundamental biological processes (Piergiovanni et al., 1997). However, their potential contribution to dietary mineral needs, is less known as compared to other oil-seeds. The only literature reference available on the chemical composition and nutritional quality of Sesame in Saudi Arabia are on sesame-butter (locally called ‘tehineh’). While limited work has been done on peanut, corn, sesame and their extracted oils; protein and oil composition of locally grown sesame seeds (Sawaya et al., 1985; Al-Kahtani, 1989; Bahkali et al., 1989).

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The literature review revealed that only a few research papers are available on the chemical and nutritional quality of some Saudi Arabian dishes which are based on cereals and legumes (Al-Jebrin et al., 1985). There are also a few reports defining the nutritive value of some wheat based dishes consumed in the Saudi Arabia (Al-Kanhal et al., 1994); mineral content, and chemical composition of some important locally grown cereals like sorghum and millets (Basahy, 1995 and 1996). The protein and amino acid contents in seeds such as soy bean cultivars (Basahy, 1993) and the nutrient composition, and amino acid pattern of locally grown cowpea were also reported (Hussain and Basahy, 1998). Nevertheless, the variability in the chemical composition of sesame (Dhindsa and Gupta, 1973); trace element composition of some common Indian oilseeds (Deosthale, 1981), chemical composition and fatty acid profile of some high yielding Indian varieties of oilseeds have been well documented (Chowdhury et al., 2010).

Sesame is mostly utilized as a whole seed throughout the world in condiments or as an additives on breads, biscuits and other confectionery products. Sesame seeds as such, are also consumed in small amounts which in turn contribute well to daily intake of several nutrients. A perusal of the available literature revealed that there is a dearth of literature on physico-chemical and mineral composition of this important oilseed crop. Therefore, the present study was designed to investigate two local cultivars of sesame (that is black and white Sesame) for their physco-chemical characteristics, mineral composition and the results were compared with some other worldwide distributed cultivars of Sesame.

MATERIALS AND METHODS

Oil extraction and physico-chemical analysis

Sesame oils (black and White Sesame separately) were extracted by petroleum ether (60 to 80°C) using soxhlet apparatus. The oils were then analyzed for specific gravity (25/25°C), refractive index (27°C), acidity of free fatty acids (%FFA), peroxide value, iodine number, saponification number and unsaponifiable matters (Table 1) by standard methods as summarized for the analysis of oils, fats and derivatives (1979).

Mineral analysis

The samples were cleaned to remove grit and foreign matter, washed thoroughly with glass distilled water to remove surface contamination. Mineral constituents present in sesame seeds were analyzed using Atomic Absorption Spectrophotometer (Perkin-Elmer Model 2280).

About 5 g of seed flour was taken in a porcelain container, ignited and ashed in the muffle furnace (Gallenkamp Hot Spot) at about 500 to 650 ± 5°C. The percentage of the total ash was calculated after the ignition. The mineral solution prepared from the ash was used for the estimation of calcium, sodium and magnesium. Total phosphorus and iron were determined colorimetrically on dried samples after wet ashing in a mixture of two parts of nitric acid and one part of perchloric acid (AOAC, 1960).

RESULTS AND DISCUSSION

The only physical measurement on sesame seeds was the weight of a thousand seeds, as the seeds were small. The mean of dark and white coloured seeds were (2.3 and 3.6) grams per 1000 seeds respectively, which is in agreement with the results reported by Al-Kahtani (1989). Eckey (1954) reported that the weight of sesame seeds usually lie with in the range of 2 to 3.5 g/1000 seeds, however, the results may vary depending on variety and cultural conditions.

The physico-chemical characteristics of crude sesame oils are depicted in Table 1. The oils had a clear yellow colour free of haziness and there was no visual difference between the oil extracted from the dark and white seeds. The characteristics of both the oils generally fall within the ranges of the AOAC recommended standards for sesame oil (Formo et al., 1979; Sher et al., 2010). However the specific gravity of the dark coloured seeds (0.9418) was marginally low as compared with the white coloured seeds (0.9214).

The refractive index results recorded (1.4865 and 1.4740) were found to be within the given range (Binran, 1971; Seegeler, 1983), While, the results reported by Formo et al. (1979), were found to be marginally higher (2.200) and this deviation index could be used as a rapid check for adulteration and rancidity (Arya et al., 1969). The acid value results found in our study was lower (0.66 to 0.38) as compared to those reported earlier (1.90 to 2.00) (Seegeler, 1983; Weiss, 1983).

According to Artman (1969), this high acid value may be an indication of rancidity, oxidation, and high degree of biological activity and deterioration of non-oily constituents such as carbohydrates and proteins, which may also affect the nutritive value of oils.

The peroxide value ranged between (1.70 to 2.12) with a marginal difference of 1.12 compared with other results. The iodine value of the oil extracted from the seeds of these cultivars varied from 110.07 to 113.04 and the mean value was calculated to be 111.55, which agree favourably with the value of 110.5 reported by Binran (1971).

However, other workers reported the iodine value to be 117.2 and 116.5 for some Indian and Ethiopian *sesamum* cultivars (Seegeler, 1983).The results (163.0 and 161.0) reported by Weiss (1983) were found to be high. Earlier, it was suggested that the iodine value should not be too high because it will increase the rate of oxidation and it should also not be too low, because it will affect its physical property (Sher and Hussain, 2009).

Therefore, it is suggested that seed containing too high or too low acid value and peroxide values should not be cultivated. Cultivars bred by plant breeders should be tested for the above values prior to their cultivation as these tests will help in screening cultivars with higher oil

Table 1. Physico-chemical characteristics of *Sesamum indicum* (L) compared with some other cultivars of the world.

Characteristics/parameters	Sesame dark Saudi cultivars	Sesame white Saudi cultivars	Sesame [a] dark Saudi cultivars	Sesame [a] white Saudi cultivars	Japanese [b] brown sesame cultivars	Indian [c] sesame cultivars	Ethiopian [d] sesame cultivars	Weiss [e] sesame world collection	Nigerian [f] black sesame cultivars	Nigerian [f] white sesame cultivars
Specific gravity (25/25°C)	0.9214	0.9418	0.9008	0.9147	0.9215	-	0.9180	0.9230	-	-
Refractive Index (25°C)	1.4713	1.4734	1.4715	1.4715	1.4740	1.469	1.4685	1.458 (60°C)	-	-
Acidity (% FFA)	0.66	0.38	0.19	0.34	-	1.90	2.00	2.00	-	-
Peroxide value (meg/kg)	1.70	2.12	1.55	2.06	-	1.00	-	-	10.5	10.5
Iodine value of oil (%)	110.07	113.04	107.18	108.15	110.5	117.2	116.5	161.0	106.0	106.0
Saponification value of oil (Mg KOH/g)	195.04	192.43	193.58	189.49	190.5	190.7	192.5	190.5	188.0	189.0
Unsaponification matter (%)	1.40	1.96	1.01	1.47	1.45	-	1.60	1.60	-	-
Oil (%)	49.07	47.02	54.00	49.03	45.5	44.3	-	44.5	35.8	34.6

Source : [a] Al-Kahtani (1989), [b] Binran (1971), [c] Dhawan et al. (1972), [d] Seegeler (1983), [e] Weiss (1983) and [f] Dashak (1993).

content and better keeping quality.

The saponification values ranged between (189.49 to 195.04) with a difference of (5.55). However, the unsaponification matter ranged between (1.01 to 1.80) with a marginal difference of (0.79) between all the cultivars studied in our present investigation.

Mineral composition

The results (Table 2) of ash content found during current study were similar to those reported by earlier researchers (Naiki, 1995). However, the results (6.6%) reported by Deosthale (1981) were highest and (1.4%) reported by Pellet et al. (1970) were found to be lowest. The mineral composition of *S. indicum* seeds is shown in Table 2. The seeds of Sesame cultivars were found to be a rich source of certain minerals, particularly calcium, phosphorus, and iron. Our results of calcium (1130 to 1232 mg/100 g) were found to be similar to most of the Sesame cultivars grown else where. The highest recorded value was 1450 mg/100 g in some Indian sesame cultivars (Gopalan et al., 1982; Sher et al., 2010a), and the lowest Ca value (228.3 mg/100 g) was reported in some Lebanese Sesame cultivars (Pellet et al., 1970).

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 presence of greater amounts of calcium and oxalic acid may be due to calcium oxalate. However, calcium bound as oxalate salt is not biologically available, which is of prime importance in feeding of infants. Gandhi et al. (1983) reported sesame is rich in protein, calcium, phosphorus and vitamins, seeds mixed with peanut and bengal gram flours is as effective as skimmed milk in controlling the clinical manifestation of malnutrition. Sesame flour supplemented with fish protein concentrate has a nutritive value similar to animal proteins. Sesame flour mixed with green gram has been effectively used to cure 'Kwashiorkor', a disease mostly found in infants of 1 to 4 years of age and is due to deficiency of proteins in diets (Gandhi et al., 1983; Sher et al., 2010). Phosphorus content ranged between (540 to 640 mg/100 g) in all the cultivars studied, while the results reported by Deosthale (1981) on some Indian cultivars were found to be high (872 mg/100 g).

The results of current study showed iron to be in a range of 10.4 to 10.6 mg/g. Our value are good in agreement with those reported previously (Pellet et al., 1970; Deosthale, 1991; Gopalan et al., 1982), with a marginal difference of (0.8 to 1.1 mg /100 g), while the results reported by Al-Kahtani, (1989) were lower (8.6 mg/100 g).

Conclusion

Nutritional and mineral properties of sesame seeds (*S. indicum* L.) and oils are unique. The high mineral content and premium quality oil with minimal processing requirements is particularly attractive. However, more research is required in processing to improve removal of oxalic acid, identify and remove low levels of bitter principles

Table 2. Mineral composition of two *Sesamum indicum* L. cultivars compared with some Lebanese, Indian, Nigerian and World collection, concentration of minerals in mg/100 g ± SEM for dry weight of the sample

Mineral composition	Sesame dark Saudi cultivars	Sesame white Saudi cultivars	Lebanese [a] cultivars	Lebanese [b] cultivars	Indian [c] cultivars	Indian [d] cultivars	Japanese [e] brown	World [f] collection
Ash (%)	4.71	4.54	1.4	4.1	6.6	-	5.2	5.3
Sodium	78	72	-	-	-	-	2.0	60
Potassium	374	382	-	-	-	-	400	725
Calcium	1200	1228	228.3	1200	1232	1450	1200	1160
Magnesium	185	178	-	-	521	-	-	-
Iron	10.6	10.4	8.6	10,4	9.3	10.5	9.6	10.5
Zinc	3.8	3.6	-	-	-	-	-	-
Phosphorus	580	598	640	620	872	570	540	616

Source : [a] Kuzayli et al. (1966), [b] Pellet et al. (1970), [c] Deosthale (1981), [d] Gopalan et al. (1982), [e] Namiki (1995), [f] Watt et al. (1975).

improving the solubility, emulsification, gelling, whipping and antioxidative properties. It is concluded that a better understanding of the biochemical nature of Sesame seeds and oil are necessary for food application. In view of these facts, Sesame oil seeds warrant further studies to meet the future goals.

ACKNOWLEDGEMENT

The authors greatly thank the College of Science Research Center of King Saud University for their financial support. This research was made possible by the continuous support of the College of Science Research Center at King Saud University.

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