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Physico-chemical composition of selected sunflower seed cultivars

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Abstract
Sunflower is a major oilseed crop in India. However, its kernels are underutilized. An evaluation of sunflower kernels was undertaken to determine their suitability for table purpose. Three varieties of sunflower namely, KBSH 44, KBSH 41 and Confectionery-1 were evaluated. Nutrient composition and physico-chemical characteristics were analysed. Per 100g of sample moisture content ranged from 3.13 to 5.2g, protein 19.78 to 26.69g, crude fat 40.3 to 54.06g, energy value 555.8 to 624.43 K cal, carbohydrate content 14.72 to 27.36g, and crude fibre 2.86 to 4.30g. The groundnut seeds had higher protein, fat, fiber and energy value compared to sunflower kernels. Ash and minerals such as calcium, phosphorous, iron and zinc ranged from 2.34 to 3.92g, 60.79 to 84.59mg, 296.7 to 670.49mg, 3.31 to 4.76mg and 2.98 to 4.05mg respectively. The ash and micronutrients were found higher in sunflower seed kernels compared to groundnut. Total sugars and tannic acid content ranged between 2.36 to 3.04g and 30.91 to 44.16 mg respectively. Significant differences existed between the varieties for all nutrients. Percent free fatty acid and peroxide values were higher in groundnut and KBSH 41 respectively compared to rest. The solubility, swelling power, water and oil absorption capacities were highest in KBSH 44. The solubility, swelling power, water and oil absorption capacities were similar to groundnut. The physico-chemical composition of sunflower and groundnut oil samples differed significantly. Sunflower seed kernels had higher saponification and Iodine value compared to groundnut.

Keywords: Sunflower kernels, physico-chemical, sunflower seeds, sunflower cultivars

Introduction
Sunflower (*Helianthus annuus* L.) noted as a rich source of edible oil and is an introduced crop in India. Sunflower is native to North America where it was used in dyes, food preparations, and medicines (Skrypetz 2003) [1]. Six states with Karnataka in the lead are the major producers of sunflower in the country. Karnataka with a production of 3.04 lakh tonnes from an area of 7.94 lakh hectares followed by Andhra Pradesh, Maharashtra, Bihar, Orissa and Tamil Nadu are major sunflower producing states of India (Anon, 2012) [2]. In some parts of India, dehulled sunflower seeds are sold in their roasted form and are also used in bakery and sweet items. Much research on sunflowers has been done on the agricultural aspects of sunflowers, but studies of the nutritional aspects of sunflower seeds are limited. In the health conscious world today, nutrition helps in selling new products prepared from novel nutrient sources and sunflower is power house of several nutrients. Physico-chemical characteristics are known to get influenced by agro-climatic conditions and variety. Sunflower seed kernels are rich source of many nutrients and could be used for the preparation of various protein enriched food products at lower cost. Due to this it is important to evaluate the nutritive value of new varieties. Thus keeping in the view of health benefits, nutrients, taste and economics of sunflower kernels the present investigation was undertaken to evaluate physico-chemical composition of selected sunflower seed cultivars. Popularizing sunflower kernel in the diet can help combat protein–calorie malnutrition in children to a certain extent in developing countries.

Materials and methods
1. Procurement of the sample: The different genotypes used for the study were, KBSH 44, KBSH 41 and Confectionery-1. The samples were procured from All India Coordinate Research Project on Sunflower, UAS, GKVK, Bengaluru.

Since the value added products selected in the study are traditionally made from groundnut. Groundnut was also included in the study. Groundnut sample was procured from the local market in Bengaluru.

2. Dehulling of sunflower seeds: Sunflower seeds were cleaned, graded and mechanically dehulled by agitating in mixer fitted with disc type blade. These kernels were packed in polyethylene bags, sealed and kept in a refrigerator until use. Good kernels were taken, powdered and used for macro and micro nutrient analysis.

3. Physical characteristics of sunflower cultivars: The parameter studied under physical characteristics includes kernel length, breadth, length/breadth ratio, 100 kernel weight and bulk density. Measurements were worked in triplicates.

3.1 Kernel length: Hundred kernels were placed on a smooth and flat surface. The length was marked and measurements were taken by using fibre glass tape to the nearest millimetre.

3.2 Kernel width: Hundred kernels were placed on a smooth and flat surface. The length was marked and measurements were taken by using fibre glass tape to the nearest millimetre.

3.3 100 Kernel weight: Kernels were counted and weighed in electronic balance (readability 0.0001g). The mean thousand kernel weight was expressed in grams.

3.4 Bulk density: The volume of 100g of each sample was determined by gently pouring the kernels into a 250 ml graduated cylinder. The volume was recorded in ml for bulk density. The values for bulk density were expressed as g/ml.

4. Functional properties of sunflower kernels

4.1 Water and oil absorption capacity (Rosario and Flores, 1981) [3]: One gram sample was mixed with 10ml of either distilled water or in 15ml oil for 30min. The contents were allowed to stand at 30ºC in a water bath for 30min and then centrifuged at 3000-5000 rpm for 20-30 min. After centrifuging the volume of the supernatant was recorded and used for determination of water and oil absorption and the results were expressed as g/g sample.

4.2 Solubility and swelling power (Iyer and Singh, 1997) [4]: Two hundred and fifty mg finely ground sample was thoroughly mixed with 15ml of distilled water and heated to 65ºC (being the initial temperature at which gelatinization of starch granules begins). The content was then cooled to room temperature and centrifuged at 5000 rpm for 10 min. The soluble solids content was calculated as percentage of sample soluble in water. At the same time, this can be used to calculate the swelling power, since the sample has been heated at 65ºC for 30 min, the residue was weighed and the increase in weight was calculated as the swelling power of the sample at that particular temperature.

5. Chemical characteristics: The method suggested by AOAC (1980)[5] was followed to analyze the nutrient composition of different genotypes.

Carbohydrate content was estimated by the difference of the other components using the formula; Carbohydrate content = 100-(% Protein + % Oil + % Ash) (Mestrallet *et al.* 2004) [6].

6. Physico-chemical analysis of the kernel oil: Oil from each genotype was extracted separately using chloroform methanol mixture (Bligh and Dyer, 1959) [7]. Acid value, iodine value, peroxide value, saponification number, per cent free fatty acids and specific gravity were carried out according to methods of AOAC (1995) [8] and Raghuramulu (2003) [9].

Results and Discussion

Physical characteristics of sunflower seeds: The physical characteristics of different genotypes of sunflower kernels in comparison with groundnut seeds were estimated. Kernel characteristics include kernel size, volume, bulk density, weight of 100 kernels. The results are presented in the Table 1. Kernel size of verities ranged between 2.03 (KBSH 41) and 2.15 (Confectionery-1) and no significant difference was found between the varieties. However the kernel size reported by Santalla and Mascheroni (2003)[10] was 2.30mm and 2.26mm. The average 100 kernel weight of sunflower seed kernel in present study ranged between 3.81 to 5.14g. KBSH 41 had higher kernel weight compared to rest. The kernel weight reported by Earle *et al* (1968)[11] ranged from 4.2 to 8.6g. The bulk density of sunflower kernels ranged between 0.43 to 0.65 (g/ml).

Table 1: Physical properties of kernels of selected varieties of sunflower

Varieties	Kernel size (L/B ratio)	Weight of 100 kernels (g)	Volume (ml)	Bulk density (g/ml)
KBSH 44	2.12	3.81	7.33	0.50
KBSH 41	2.03	5.14	10.00	0.51
Confectionery-1	2.15	4.93	11.17	0.43
F-value	NS	*	*	NS
SEm±	0.06	0.15	0.39	0.03
CD	0.23	0.54	1.37	0.12

*Significant at 5% level NS: Non-significant

Functional properties of sunflower kernels: Sunflower meal because of its unique nutritional and functional properties can be used as a potential source of protein in processed human foods. Functional properties of kernels of sunflower in comparison with groundnut are presented in Table 2. Pawar *et al.* (2001) [12] reported 2.0 and 1.80 per cent of water and oil absorption capacities in defatted sunflower flour. In the present study the values ranged between 1.03(Groundnut) and 2.0 (KBSH 44) per cent for water absorption and oil absorption capacity ranged between 2.30 (Confectionery-1) and 2.83 (KBSH 4). Slightly lower values were observed for water absorption capacity and higher values were observed for oil absorption capacity. Lower values of water absorption might be due to interaction of polyphenols and phytates with oilseed proteins thus lowering their availability. Pawar *et al.* (2001) [12] reported higher values of water absorption capacity which may be due to reduction of polyphenols and phytates, which might have made more protein available for holding the water. It may be noted that our values are on full fat basis. Solubility and swelling power ranged between 0.59 (Groundnut) and 0.93 (KBSH 44) and 8.80 (Groundnut) to 11.89 (Confectionery-1) per cent respectively. There was a significant difference between the varieties for all functional properties.

Table 2: Functional properties of kernels of selected varieties of sunflower in comparison with groundnut

Varieties	Solubility (%)	Swelling power (%)	Water absorption (g/ml)	Oil absorption (g/ml)
KBSH 44	0.93	13.90	2.00	2.83
KBSH 41	0.62	9.38	1.10	2.30
Confectonery-1	0.79	11.89	1.30	2.30
Groundnut	0.59	8.80	1.03	2.37
F-value	*	*	*	*
SEm±	0.012	0.19	0.046	0.03
CD	0.037	0.57	0.13	0.09

*Significant at 5% level

Nutrient composition of sunflower seed kernels: Nutrient composition of sunflower seed kernels in comparison with groundnut seed kernels are shown in Table 3, 4 and 5.

Macronutrient composition: Moisture values ranged between 3.13 and 5.2g per 100g (Table 3). Srilatha and Krishnakumari (2003) [13] reported moisture level of 6.54g/100g for dehulled sunflower seeds. In the present study the moisture content was higher in Confectionery-1. The higher per cent hull content of the confectionery type as well as the fact that the hulls are not closely attached to the kernels as in oilseed type lead to a higher adsorption from the external high moisture region (Miller 1986) [14]. The sunflower protein has a good nutritional value and digestibility (Gupta *et al.* 1996)[15]. Pawar *et al.* (2001) [12] reported that the crude protein content of dehulled seeds was 26.3 per cent respectively. In the present study the crude protein content of the different varieties fall within this range except groundnut seed kernels. Sunflower oil is good quality oil and an excellent source of linoleic acid and essential fatty acids (Purdy, 1996) [16]. In the present study the oil content of different varieties ranged between 40.33 (KBSH 44) to 54.06g (KBSH 41). This variation in fat content might be due to varietal difference or the season and location. The oilseed kernel (KBSH 41) of sunflower had higher fat content compared to confectionery type and the bold striped variety KBSH 44. Hartman *et al.* (1999) [17] reported that carbohydrate content ranged between 16.02 to 19.83g/100g. In the present study higher values were reported in all the varieties except KBSH 44 (14.72%). However Ologunde *et al.* (2008) [18] reported higher values for carbohydrate content which ranged between 25g to 26.59g/100g for HS 897 variety. Canibe *et al.* (1999) [19] reported energy values for sunflower seed kernel which ranged between 759.7 Kcal to 781.25 K cal. In the present study lower values were reported for sunflower seed kernels ranging from 555.8 K cal to 624.43 K cal. The lower values are a reflection of lower fat values. Hartman *et al.* (1999) [17] reported value of crude fibre which ranged between 2.32 to 1.97g/100g of sunflower seeds. In the present study slightly higher values (2.86 to 3.88 per cent) were found in sunflower seed kernels. However higher crude fibre values were reported by Anjum *et al.* (2006)[20]. Their values ranged between 7.01 to 9.50 per cent. It may be noted that their values were for whole seed and in the present study kernels were analyzed (Table 3).

Table 3: Macronutrient composition of kernels of selected varieties of sunflower in comparison with groundnut (per 100g)

Varieties	Moisture (g)	Protein (g)	Crude Fat (g)	Carbohydrate (g)	Energy (K cal)	Crude Fibre (g)
KBSH 44	4.48	20.84	40.33	27.36	555.80	3.43
KBSH 41	3.13	19.78	54.06	14.72	624.43	2.86
Confectionery-1	5.20	20.21	42.24	26.27	566.13	3.88
Groundnut	3.47	26.69	43.37	20.14	577.70	4.30
F-value	*	*	*	*	*	*
SEm±	0.08	0.30	0.15	0.52	0.98	0.12
CD	0.26	0.88	0.45	1.54	2.89	0.35

*Significant at 5% level

Ash and micronutrient composition: Total ash and micronutrient composition of sunflower seed kernels in comparison with groundnut seed kernels are shown in table 4. The variety Confectionery-1 had the highest ash content (3.92g/100g) followed by KBSH 44 (3.54g/100g), KBSH 41 (3.38g/100g) and least was found in groundnut (2.34g/100g). When statistically analyzed there was a significant difference between the varieties. Hartman *et al.* (1999) [17] reported that ash content ranged between 3.06 to 3.69g/100g in sunflower seed kernels. In the present study ash content of different varieties ranged between 2.34 and 3.92g/100g. The differences in ash content have been attributed to growth conditions, genetic factors and geographical variations (Ozcan 2006) [21]. Minerals are of critical importance in the diet, even though they comprise only 4 to 6 per cent of the human body. Minerals are of importance due to their pro-oxidant activity and health benefits. Oil bearing seeds and kernels are reported to be high in phosphorous and calcium (Ozcan, 2006) [21]. Ozcan (2006) [21] reported the calcium, phosphorous, iron and zinc content for sunflower seeds as well as groundnut seeds. The values of calcium 46.48mg/100g and 64.45mg/100g, phosphorous 960.79mg/100g and 397.2g/100g, iron 4.96mg/100g and 1.8mg/100gm and zinc 3.654mg/100gm and 2.659mg/100g were found in sunflower seed kernels and groundnut seed kernels respectively. In the present study the calcium content ranged from 60.79mg/100g to 84.59mg/100g, phosphorous 296.77mg/100g to 670.49mg/100g, iron 3.31mg/100g to 4.76mg/100g and zinc 2.98mg/100g to 4.05mg/100g. Slightly higher values were observed for calcium and lower values were observed for phosphorous content. Iron and Zinc content were within the range reported by others. Thus the sunflower kernels can be considered as a good source of minerals.

Tocopherols are important biological and nutritive components of human food. They are natural antioxidants that inhibit the lipid oxidation in foods and biological systems by stabilizing hydroperoxides and other free radicals (Kamal-Eldin and Appelquist, 1996) [22]. Murthy and Shobana (1997)

[23] stated that vitamin E is a component of the unsaponifiable fraction of lipids which serves as a major antioxidant. They reported that vitamin E content of sunflower seed was 192mg/100g and 491mg/100g in groundnut seeds. However in the present study lower values were found in groundnut seed kernels. The vitamin E content was found to be highest in KBSH 44 (37.47mg/100g) followed by Confectionery (34.77mg/100g), KBSH 41 (20.69mg/100g) and least was found in groundnut (14.84mg/100g). However Fisk *et al.* (2006)[24] reported 36mg/100g in parent sunflower seeds. Tocopherol content is believed to be influenced by refining status and shelf life of oil storage condition, plant source and maturation of oil seed and method of analysis (Murthy and Shobana, 1997) [23]. It is also stated to be influenced by other interfering pigments present in oils. Kamal-Eldin and Andersson (1997) [25] reported higher vitamin E values in sunflower seeds and lower values in groundnut seeds. They reported that positive correlation between linoleic acid (18:3) and alpha-tocopherol. They reported 56.5ppm and 35.5ppm linoleic acid in sunflower and groundnut respectively. In the present study lower vitamin E values were observed in groundnut seeds. This might be due to low linoleic acid content of groundnut seeds.

Table 4: Total ash and micronutrient composition of kernels of selected varieties of sunflower in comparison with groundnut (per 100g)

Varieties	Ash (g)	Calcium (mg)	Phosphorus (mg)	Iron (mg)	Zinc (mg)	Vitamin E (mg)
KBSH 44	3.54	84.59	640.59	4.67	3.77	37.47
KBSH 41	3.38	81.71	670.49	4.76	4.05	20.69
Confectionery-1	3.92	77.63	648.65	3.83	3.97	34.77
Groundnut	2.34	60.79	296.77	3.31	2.98	14.84
F-value	*	*	*	*	*	*
SEm±	0.11	0.59	3.67	0.03	0.02	0.27
CD	0.31	1.73	10.82	0.08	0.07	0.81

*Significant at 5% level

Total lipids, sugar and tannic acid: Total lipids, sugar and tannic acid content of selected varieties of sunflower seed kernels and groundnut seed kernels are presented in table 5. In the present study the total sugars ranged between 2.36 to 3.04g/100g of sunflower seeds. The total sugar in sunflower seed kernels reported by USDA (Anonymous, 2008) [26] was 2.62g/100g. Thus the values were found similar to the reported value. In the present study total sugar content in groundnut was 2.59g. KBSH 44 recorded maximum sugar content compare to groundnut and other sunflower varieties. Sugars provide a source of carbon for the production of flavor compounds (Koehler et al 1969) [27]. Glucose and fructose products of the hydrolysis of sucrose, are reducing sugars and can, upon heating react with specific amino acids to produce flavor compounds. Tannin is an astringent, bitter plant polyphenolic compound that binds to and precipitates proteins and various other organic compounds including amino acids and alkaloids. Ologunde *et al.* (2008) [18] reported that the tannin content ranged from 0.33mg/g catechin equivalent to 1.95mg/g catechin equivalent in sunflower cultivars. In the present study tannin content ranged from 3.09mg/g (Confectionery-1) to 4.41mg/g (KBSH 41) catechin equivalent. The tannin levels observed are higher compared to reported value. Nagi (1982) [28] reported that sunflower meals contained lower tannins than other seed meals. This low level may be a consequence of plant breeding. Thus interests for low sunflower tannin hybrids. The role of tannins as antioxidants can be considered as a positive feature. The chemical composition of the seeds of sunflower has been reported to vary with planting locations and seed genotypes (Barker and Hilditch 1950; Canvin 1965; Kinman and Earle 1964; Robertson et al 1971; Durrel 1978) [29, 30, 31, 32, 33].

Table 5: Total lipids, sugar and tannic acid content of kernels of selected varieties of sunflower in comparison with groundnut (per 100g)

Varieties	Total lipids (g)	Total sugars (g)	Tannic acid (mg)
KBSH 44	37.85	3.04	34.59
KBSH 41	50.47	2.36	44.16
Confectionery-1	40.10	2.96	30.91
Groundnut	40.70	2.59	33.00
F-value	*	*	*
SEm±	0.27	0.05	0.25
CD	0.79	0.16	0.75

*Significant at 5% level

Physico-chemical characteristics of sunflower oil: In chemical composition of sunflower kernel dominates oil, which is responsible for storage and shelf life of kernel as well as of the final product. Physico-chemical characteristics of oils such as specific gravity, per cent free fatty acid, peroxide value, iodine value and saponification number were analysed. The results are presented in the table 6.

The specific gravity of oil is the weight of a given volume of oil at the specified temperature compared with the weight of an equal volume of water at the same temperature. Ologunde *et al.* (2008)[18] reported specific gravity of sunflower seed oil (Hybrid HS 897) at 15.5ºC and it ranged between 0.918 and 0.923. In the present study the specific gravity ranged between 0.913 (KBSH 41) to 0.921 (groundnut) at 25ºC. Aremu *et al* (2006) [34] reported slightly nearer values and ranged from 0.85 to 0.88 at 25°C. The specified standard for specific gravity is 0.911-0.944 at 30ºC (Anonymous, 2003)[35]. The specific gravity less than one (<1) indicating that it is less dense than water.

According to Demain (1990) [36], acid values are used to measure the extent to which glyceride in the oil has been decomposed by lipase and other actions such as light and heat. Marmesat *et al.* (2005) [37] reported that the value of 0.10 per cent free fatty acid in high-oliec, high-palmitic sunflower oil. Hartman *et al.* (1999) [17] reported that the value of per cent free fatty acid ranged between 0.28 and 1.05meq/kg in sunflower seed kernel oil. In the present study the per cent free fatty acid ranged between 0.21meq/kg (KBSH 44) to 0.32meq/kg (groundnut). The groundnut had higher per cent free fatty acid and this might be attributed to the presence of only trace amounts of natural inhibitors in groundnut oil (Murthy *et al*., 1996) [38]. They reported that the per cent free fatty acid in groundnut oil was 1.02 per cent. In the present study slightly lower values were observed. The decrease of free fatty acids might be due to low unsaturated fatty acids which could have resulted due to oxidative changes. AOAC specification for crude oil is less than 4mgKOH/g. The Prevention of Food Adulteration specification suggests a maximum acid value of 4 per cent for crude oils and 0.6 per cent for refined oils. In the present study the values of per cent free fatty acid are within the range of AOAC specifications.

Peroxide value serves as an indicator of the extent of formation of primary oxidation products (Anwar *et al.,* 2005) [39]. Hartman *et al.* (1999) [17] reported peroxide value between

0.28 and 1.05meq/kg in sunflower oil. In the present study lower values were observed and ranged between 3.72meq/kg (KBSH 44) to 5.19meq/kg (KBSH 41). However Marmesat *et al.* (2005) [37] reported higher peroxide value 4.7meq/kg in high-oleic, high-palmitic sunflower oil. Anjum *et al.* (2006) [20] reported similar values which ranged between 3.77meq/kg (KL-39) to 2.60meq/kg (FH-330). AOAC specification for crude oil is less than 10meq/kg (Anon, 1996) [40]. In the present study the peroxide values were within the AOAC specification. Anyasor *et al.* (2009) [41] reported that the peroxide value ranged between 0.70 to 1.15meq/kg in groundnut oil. The groundnut oil had higher peroxide value and it might be attributed to the presence of only trace amounts of natural inhibitors in groundnut oil (Murthy *et al.*, 1996) [38]. However Semwal and Arya (2001) [42] reported higher peroxide values that ranged between 3.1meq/kg to 6.9meq/kg in unrefined groundnut oil.

Iodine number is an index of the degree of unsaturation which influences the solubility, hardness and resistance towards oxidation (Yegammai and Gowri, 1995) [43]. The oil of higher iodine value is of good edible quality oil due to higher unsaturation, as compared to the oil of lower Iodine value (Raghav 1999) [44]. The high IV denotes high degree of unsaturation of the oil caused by the extent of oxidation and degree of heat treatment during oil processing (Kirk and Sawyer 1991) [45]. Hartman *et al.* (1999) [17] reported that the calculated iodine value ranged from 120.5g I/100g (DK180) to 190.9g I/100g (M737). Lower iodine values were reported by Ologunde *et al.* (2008)[18]. The values ranged between 78.45g of I/100g of oil (KANO) to 82.50g of I/100g of oil (MINNA). Anjum *et al.* (2006) [20] reported that Iodine value ranged between 138.04g I/100g (KL-39) to 140g I/100g (FH-330). In the present study the iodine value ranged between 89.41g I/100g (groundnut) and 135.03g I/100g (KBSH 44). The values reflected the differences in degree of unsaturation. Codex specification of Iodine value in sunflower oil ranged between 110-143g I/100g of oil. In the present study the iodine value of oil extracted from different varieties of sunflower oil ranged between the Codex specifications (Anon, 1996). Lower values were observed in groundnut oil. The decrease in iodine value might be due to destruction of double bonds by oxidation and hydrolysis (Murthy et al., 1996)[38]. Semwal and Arya (2001) [42] reported Iodine value between 90.28 and 91.41g Iodine/100g in unrefined groundnut oil. The lower Iodine value might be due to destruction of double bonds by oxidation and hydrolysis. Murthy et al. (1996)[38] reported Iodine value of 123.2 in sunflower oil and 94.0 in groundnut oil. The natural antioxidants in sunflower oils such as tocopherol might have a role in delaying the oxidation process (Murthy *et al.*, 1996) [38].

Saponification is the measure of saponifiable glycerides and the average chain length in terms of caustic soda required for hydrolysis. Ologunde *et al.* (2008) [18] reported saponification value between 188.51mgKOH/g and 191.88mgKOH/g in different sunflower cultivars. In the present study slightly lower value were observed and ranged between 170.63mgKOH/g (groundnut) and 184.90mgKOH/g (KBSH 44). However Hartman et al. (1999) [17] reported that the calculated saponification value ranged from 116.7mgKOH/g to 191.3mgKOH/g. Codex specification of saponification value in sunflower oil is between 188mgKOH/g of oil to 194mgKOH/g of oil. In the present study the saponification value of oil extracted from different varieties of sunflower oil ranged slightly below the Codex specifications. Anjum *et al.* (2006) [20] reported saponification value between 189.07mg of KOH/g of oil and 185mg of KOH/g of oil.

Table 6: Physico-chemical properties of oil of selected varieties of sunflower seed in comparison with groundnut seed

Varieties	Specific gravity (25ºC)	% Free fatty acid	Peroxide value (meq/kg)	Iodine value (g I/100g)	Saponification value (mgKOH/g)
KBSH 44	0.920	0.21	3.72	135.03	184.90
KBSH 41	0.913	0.31	5.19	127.36	177.50
Confectionery-1	0.920	0.23	4.48	130.00	180.90
Groundnut	0.921	0.32	4.39	89.41	170.63
F-value	NS	*	*	*	*
SEm±	0.0032	0.0045	0.13	1.02	0.76
CD	-	0.01	0.39	3.02	2.24

*Significant at 5% level NS: Non-significant

Conclusion: The physical characters of all varieties were evaluated. There was considerable range of variation in the varieties for all characters studied. Values were nearly similar in all the varieties that were studied. The solubility, swelling power, water and oil absorption capacities were highest in KBSH 44. Values were nearly similar in all the varieties. The groundnut seeds had higher protein, fat, fibre and energy value compared to other sunflower varieties. Slightly lower values were observed in sunflower seed kernels. The ash and micronutrients were found higher in sunflower seed kernels compared to groundnut. The physico-chemical composition of sunflower and groundnut oil samples differed significantly. Sunflower seed kernels had higher saponification and Iodine value compared to groundnut. This research may provide an opportunity to consider sunflower kernel as an ingredient in new products by manufacturers of baked goods and snack foods.

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References

1. Skryptez S, Sunflower seed: Situation and outlook. Agric Agri-Food Can Bull. 2003; 16(16).
2. Anonymous. https://www.syngenta.co.in/success-stories-sunflower, 2012.
3. Rosario RD, Flores DM. Functional properties of flour types on mung bean flours. J Sci. Food Agric. 1981; 32:172-180.
4. Iyer L, Singh V. Functional properties of wheat and chickpea composite flours. Food Australia. 1997; 49:27-31.
5. AOAC. Official methods of analysis, 13th edition, Association of official analytical chemists, Washington. DC, 1980.
6. Mestrallet MG, Carnacini L, Días MJ, Nepote V, Ryan L, Conci S *et al*. Honey Roasted Peanuts and Roasted Peanuts from Argentina. Sensorial and Chemical Analyses. Grasas y Aceites. 2004; 55:401-408.
7. Bligh, EG, Dyer, WJ. Estimation of total lipids. Can. J. Biochem Physiol. 1959; 37:911.
8. AOAC. Official methods of analysis, Association of official analytical chemists, Washington. DC, 1995.
9. Santalla EM, Marcheroni RH. Physical properties of high oleic sunflower seeds. Food Science and Tescnology international. 2003; 9(6):435-442.

10. Earle CH, Vanetten TF. Clark IA Wolff. Compositional data on sunflower seed, JAOCS. 1968; 45(12):876-879
11. Raguramulu N, Madhavan Nair K, Kalyana Sundaran S. A laboratory techniques, NIN, ICMR publications., Hyderabad, 2003.
12. Pawar VD, Patil JN, Sakhale BK, Agarkar BS. Studies on selected functional properties of defatted sunflower meal and its high protein products. J Food Sci. Technol. 2001; 38(1):47-51.
13. Srilatha K, Krishnakumari K. Proximate composition and protien quality evaluation of recipes containing sunflower cake. Plant Foods for Human Nutrition. 2003; 58:1-11.
14. Miller N, Pretorius HE, Van Der Riet WB. The effect of storage conditions on mould growth and oil quality of confectionery and high-oil sunflower seeds. Journal of Food Science. 1986; 19:101-103.
15. Gupta H, Mehta U, Singha J. Characteristics of cookies and muffins supplemented with full fat sunflower grits. J. Food Sci. Technol. 1996; 33(6):513-515.
16. Purdy RH. Oxidative stability of high oleic sunflower and sunflower oils. J Am Oil Chem Soc. 1996; 62:523-525.
17. Hartman L, Antoniassi R, Freitas SP. Characterization of five sunflower varieties cultivated in Brazil. B. Ceppa, Curitiba. 1999; 17(2):145-152.
18. Ologunde MO, Adelani A, Liasu MO. Chemical compositions of sunflower (*Helianthus annus* L.) hybrids planted in different natural locations in Northern Nigeria. American-Europian Journal of Sustainable Agriculture. 2008; 2(3):229-234.
19. Canibe N, Pedrosa MM, Robredo LM, Knudsen KEB. Chemical composition, digestibility and protien quality of 12 sunflower (*Helianthus annus* L.) cultivars. J. Sci. Food Agric. 1999; 79:1775-1782.
20. Anjum F, Anwar F, Jamil A, Iqbal M. Microwave roasting effects on the physico-chemical composition and oxidative stability of sunflower seed oil. JAOCS. 2006; 83(9):777-784.
21. Ozcan MM. Determination of the mineral composition of some selected oil-bearing seeds and kernels using inductively coupled plasma atomic emission spectrometry (ICP-AES). GRASAS Y ACEITES. 2006; 57(2):211-218.
22. Kamal-Eldin A, Appelqvist LA. The chemistry and antioxidant properties of tocopherols and tocotrienols. Lipids. 1996; 31:671-701.
23. Murthy NK, Shobana S. Evaluation of total tocopherol content of selected edible oils in Indian markets. Ind. J. Nutr. Dietet. 1997; 34:169-172.
24. Fisk D, White DA, Carvalho A, Gray DA. Tocopherol-an intrinsic component of sunflower seed oil bodies. JAOCS. 2006; 83(4):341-344.
25. Kamal-Eldin A, Andersson R. Amultivariate study of the correlation between tocopherol content anf fatty acid composition in vegetable oils. JAOCS. 1997; 74(4):375-380.
26. Anonymous. https://www.fas.usda.gov/data/oilseeds-world-markets-and-trade, 2008.
27. Koehler PE, Mason ME, Newell JA. Formation of pyrazine compounds in sugar-amino acid model systems. J. Agric. Food Chem. 1969; 17:393-396.
28. Nagi SS. Tannins in salseed (*Shorea robusta*) and salseed meal limit tier utilization as livestock feeds. Animal Feed Science and Technology. 1982; 7:161-163.
29. Barker C, Hilditch TP. The influence of environment upon the composition of sunflower seed oils. I, Journal of the Science of Food and Agriculture. 1950; 1:118-121.
30. Canvin DT. The effect of temperature on the oil content and fatty acid composition of the oils from several oil seed crops. Canadian Journal of Botany. 1965; 43:63-65.
31. Kinman ML, Earle FR. Agronomic performance and chemical -composition of the seed of sunflower hybrids and introduced varieties, Crop Science. 1964; 4:417-420.
32. Robertson JA, Thomas JK. Donald Burdick, Chemical composition of the seed of sunflower hybrids and open pollinated varieties. 1971; 36(6):873-876
33. Aremu MO, Olaofe O, Akintayo ET. Chemical composition and physicochemical characteristics of two varieties of Bambara groundnut (Vignasubterrenea) flours J. Appl. Sci, 2006, 1900-1903.
34. Dorrell DG. Processing and utilization of oil seed sunflower. In: Carter, J. F. -(ed.) Sunflower Science and Technology, Wisconsin, USA, American Society of Agronomy, Inc, 1978, 407-436.
35. Anonymous. Prevention of food adultration, 2003.
36. Demain MJ. Principles of Food Chemistry, 2nd Ed. Van Nostrond Reinhold International Company Limited, London England, 1990, 37-38.
37. Marmesat S, Mancha M, Ruiz-Mendez MV, Dobarganes MC. Performance of sunflower oil with high levels of oleic and palmitic acids during industrial frying of almonds, peanut, and sunflower seeds. JAOCS. 2005; 82(7):505-510.
38. Murthy NK, Chitra A, Parvathamma R. Quality and storage stability of crude palm oil and its blends. The Ind. J. Nutr. Dietet. 1996; 32:238-249.
39. Anwar F, Anwar T, Mehmood Z. Methodological characterization of rice bran oil from Pakistan. Grasas Aceites. 2005; 56:126-127.
40. Anonymous. Official methods and recommended practices of the American Oil Chemists' Society. Champaign, IL. Sections, 1996, Aa 4-38, Ca 5a-40, Cd 8-53.
41. Anyasor GN, Ogunwenmo KO, Oyelana OA, Ajayi D, Dangana J. Chemical analysis of groundnut (Arachis hypogaea) oil. Pakistan Journal of Nutrition. 2009; 8(3):269-272.
42. Semwel AD, Arya SS. Studies on the stability of some edible oils and their blends during storage. J. Food Sci. Technol. 2001; 38(5):515-518.
43. Yegammai C, Gowri R. Comparative study of soya oil with other oils for their physico-chemical and culinary properties. The Ind. J. Ntri. Dietet. 1995; 32:143-146.
44. Raghav PK, Grover PC, Thapar VK. Storage stability of sunflower (*Helianthus annus*) oil in different packaging materials. J. Food Sci. Techno. 1999; 36(3):259-255.
45. Kirk RS, Sawyer R. Pearson's Composition and Analysis of Foods. 9th Edn, Longman Scientific and Technical, England, 1991, 607-617.