Nutritional composition and fatty acid profile of some promising sesame cultivars

Farhan Saeed, Aiza Qamar, Muhammad Tahir Nadeem, Rabia Shabir Ahmed, Muhammad Sajid Arshad and Muhammad Afzaal

Institute of Home & Food Sciences, Government College University Faisalabad-Pakistan

Corresponding Author: far1552@yahoo.com

ABSTRACT

The three different cultivars of sesame seeds (white, black & brown) procured from local market in Faisalabad, Pakistan were explored for nutritional composition, physico-chemical characteristics, antioxidant activity as well as fatty acid profile. Results showed that seeds contain oil contents ranged from 43.40% to 50.17% with brown seeds having the highest oil contents compared to black & white. Moreover, sesame oil is a rich source of mono and polyunsaturated fatty acids especially oleic acid (56.88%), linoleic acid (50.73%) and palmitic acid (21.67%). These mono and polyunsaturated fatty acids were highest in black sesame seeds compared to white and brown seeds. In addition, total phenols were also highest (30.65%) in black sesame cultivar together with high antioxidant activity (14.83%). Conclusively, black sesame cultivar was found to be the best among all cultivars owing to its high nutritional profile and antioxidant potential.

Key words: sesame, nutritional quality, fatty acid profile, black sesame

INTRODUCTION

One of the most ancient crops cultivated by humans is considered to be the Sesame (Sesamum indicum L). It was firstly recorded as a crop in Babylon and Assyria over 4000 years ago. Seeds of the crop were used both as condiment and oil source. The Babylonians made wine and cakes with sesame seeds, whereas sesame oil was used for cooking, medicinal and cosmetic purposes. Ancient Indians used sesame oil as lighting oil, and sesame seeds were commonly used in the religious means of Hindus. Chinese believed that sesame seeds could promote health and prolonged existence (Bedigian, 2003).

Sesame plays an important role in human nutrition. The seeds are typically used for oil extraction and the rest are fit for human consumption (El Khier et al, 2008). Its color varies from cream-white to charcoal-black but the most common varieties are white and black. Other colors of sesame seed varieties include, yellow, black, red or brown (Naturland, 2002). These seeds have antioxidant effects, as well as useful in lowering the cholesterol level and prevention of hypertension (Kang et al., 1998).

In East Asian countries, black sesame seed is one of the leading oil seed crop and is familiar as chief source of protein and its seeds are identified to be a good source of calcium, iron and phosphorus. Its consumption has long been regarded in different oriental dishes as a healthy food which is helpful to increase energy and to prevent aging. Many of its distinctive chemical and physiological effects such as antioxidant activities are due to the compounds present in sesame oil that are sesame lignans (Fukuda et al., 1996). Lignans reduce the incidence rates of breast and prostate cancer and reduce serum cholesterol level. Phenolic compounds are extensively distributed in the plants. Sesame seed is the world’s most important and ancient oilseed crops with a high level of antioxidants (Abou-Gharbia and Shahidi, 1997).

Sesame oil is a superior vegetable oil and has a pleasant flavor. It ranks second after olive oil with regard to nutritional value. Worldwide, fatty acids composition in sesame oil is variable among the different cultivars of sesame seeds such as black, brown and white. Oil composition of sesame seeds depends on different factors such as climatic situation, soil condition and ripeness of plant (Rahman et al., 2007). Fatty acids that are present in abundance are oleic (44 %), linoleic (34 %), palmitic (10 %) and stearic (7 %) acids which mutually comprise about 95 % of the total fatty acids (Yoshida et al., 2000).

In addition to being an imperative source of oil, sesame seeds also contain significant amount of protein (18-25 %), carbohydrate (13.5 %) and ash (5 %) (Borchani et al., 2010). Around 35 % of oil present in sesame consists of monounsaturated fatty acids and 44 % polyunsaturated fatty acids, whereas 20 % of the
meal consists of proteins (Ghandi, 2009; Hansen, 2011). Protein in sesame seeds has immobilized amino acid profile with good nutritional value similar to soybean (Naerls, 2010).

Sesame seeds are not only used for culinary purposes due to their nutritive, preventive and curative properties but also used in traditional medicines. Sesame oil seeds are sources for some phyto-nutrients such as flavonoid, phenolic anti-oxidants, omega-6 fatty acids, vitamins and dietary fiber with presented anti-cancer as well as health promoting properties. In South India and Asia, sesame oil is used as cooking oil because it is proved from previous studies that it is fit for human consumption and also frequently used as a flavor enhancer in Chinese, Japanese, Korean, and in South Asian cuisine (Cooney et al., 2001).

Sesame is grown in all provinces of Pakistan and is well scattered in irrigated as well as rain fed zones. Pakistan is rich of sesame genetic diversity, more than 172 sesame accessions are there in different regions of the country (Masood et al., 2003). The local varieties can be employed as a raw material for agricultural development (Ali et al., 2009).

Sesame varieties are widely produced in Pakistan that has higher nutritional profile i.e. edible oil, protein and antioxidant contents that show therapeutic potential against various maladies. Thus, keeping in view the nutritional value of sesame seeds, the current study has been designed to characterize the three cultivars of sesame seeds i.e. white, black and brown sesame seeds.

MATERIAL AND METHODS

Procurement of raw material

Three promising indigenous cultivars of sesame seeds i.e. white, black and brown sesame seeds were procured from local market, in Faisalabad. The selected raw materials were cleaned to remove the adhered dirt, dust and other foreign particles.

Chemical Analysis of Sesame seed cultivars

All three cultivars were analysed for moisture content, crude fat, crude protein, ash content, NFE and crude fiber by using methods described in AACC (2000). Minerals (K, Mg, Zn, Fe and Ca) were analyzed by methods described in AOAC (1990). To determine phosphorus content in the sample, colorimetric estimation method was used as described by (Kitson and Mellon, 1944). All the measurements were made in triplicate and results presented in this paper are the means of these three measurements.

Extraction of Sesame Oil

A laboratory scale screw press was used to extract the oil from sesame seeds. Sesame seeds were placed into the screw press and to minimize heat and moisture losses the container were then inverted and emptied directly into the press hopper. The percentage recovery of oil was calculated by the formula:

\[
\text{Sesame oil (%) = \frac{\text{Wt. of oil (g)}}{\text{Wt. of sample (g)}} \times 100}
\]

Extracted oil was collected in glass container and stored for further analysis (AOAC, 2000).

Determination of Fatty Acid (FA) Composition

Methyl Esters Preparation:

Methylation of fatty acids in the oils under investigation was carried out according to the procedure with some modifications as described by Yaliet et al. (2001). The procedure adopted was as under: The lipid samples (75mg) were dissolved in toluene (1ml) in a test tube fitted with a condenser followed by the addition of 2ml of H2SO4 (1% in methanol). The mixtures were left over night in a stopper tube at 50°C after which 5ml of sodium chloride solution (5%) was added. The required esters were then extracted with hexane (2x,5 ml), and the organic layer was separated using Pasteur pipettes for all samples. The hexane layers were washed with potassium bicarbonate solution (4ml, 2%) and dried over anhydrous Na2SO4 and filtered. The organic solvent was removed under reduced pressure on a rotary evaporator to give FAMEs and other lipids.

The samples prepared in this way were further analyzed using GC-MS (Model number) equipped with a flame ionization detector. A silica column (30 mx 0.25 mm I.D.) coated with OVI was utilized. The initial temperature was 40°C for 4 min after injection. Then increased to 280°C (80°C /min) with a final hold at 28°C for 20min. The injector and detector temperature were maintained at 270°C and 250°C respectively. Helium was used as a carrier gas at a flow rate of 0.8 ml/min.

Antioxidative profiling

Different antioxidant assay were performed by following their respective procedures.

Total phenolic content

Total phenolic contents (TPC) were measured by using Folin-Ciocalteu method following the protocol of Singleton et al. (1999).
Free radical scavenging activity (DPPH assay)
DPPH radical scavenging activity of sesame cultivars was measured according to the method of Brand-Williams et al. (1995).

Physico chemical analysis
The specific gravity, pH value, refractive index, viscosity, iodine value (Hanus method), saponification value and peroxide value of oil samples were determined by AOAC (1990) methods. Acid value was assayed by AOCS (1997).

RESULTS AND DISCUSSIONS
Chemical Composition of Sesame cultivars
Sesame seeds contain high levels of fat and protein. The chemical composition of sesame seed varies with the variety, origin, color, and size of the seed. Table 1 shows the results of chemical composition of the sesame seed cultivars. Moisture, crude fiber and NFE content were higher in black sesame cultivar, protein and ash contents were higher in white seeds whereas fat contents were higher in brown sesame seeds. The protein contents of all cultivars studied were lower than the range reported by El Tinay (2009). While fat, moisture, crude fiber and ash levels in the cultivars were consistent with the range reported by Murwan et al., (2008).

In case of mineral content, significant (p<0.05) differences were found among the three sesame cultivars (Table 2). Results also indicated that sesame seeds contain variable levels of Ca, Fe, Mg, Zn, Ph and K. Black sesame cultivar had significantly higher Calcium (703.3ppm), iron (8.56ppm), Zinc (0.76ppm) and Potassium (54.03ppm) content compared to the other two cultivars. Magnesium and Phosphorus content were higher in white cultivar as shown in Table 2. Similar findings were obtained by Gandhi, A. P. and J. Srivastava, who investigated the defatted sesame seed (Sesamum indicum) flour and their nutritional profile.

Table1. Proximate composition (%) of three cultivars of Sesame seeds

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Moisture</th>
<th>Protein</th>
<th>Fat</th>
<th>Crude Fiber</th>
<th>Ash</th>
<th>NFE</th>
</tr>
</thead>
<tbody>
<tr>
<td>White seeds</td>
<td>3.290c</td>
<td>35.80a</td>
<td>43.407c</td>
<td>3.956b</td>
<td>11.291a</td>
<td>5.546b</td>
</tr>
<tr>
<td>Black seeds</td>
<td>4.226*</td>
<td>33.31c</td>
<td>47.153b</td>
<td>4.523a</td>
<td>8.127c</td>
<td>6.746a</td>
</tr>
<tr>
<td>Brown seeds</td>
<td>3.557b</td>
<td>33.43b</td>
<td>50.173a</td>
<td>3.733c</td>
<td>7.484b</td>
<td>4.636c</td>
</tr>
</tbody>
</table>

Values with different letters in a column are highly significant (p < 0.05)

Table2. Mean Values for mineral composition (ppm) of three cultivars of Sesame seeds

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Ca</th>
<th>Fe</th>
<th>Mg</th>
<th>Zn</th>
<th>Ph</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>White sesame seeds</td>
<td>638.33a</td>
<td>2.1667c</td>
<td>566.6a</td>
<td>0.600b</td>
<td>6196.7a</td>
<td>42.500b</td>
</tr>
<tr>
<td>Black sesame seeds</td>
<td>703.33b</td>
<td>8.566a</td>
<td>366.6b</td>
<td>0.7667a</td>
<td>5836.7b</td>
<td>54.003a</td>
</tr>
<tr>
<td>Brown sesame seeds</td>
<td>451.67c</td>
<td>7.5333b</td>
<td>366.6b</td>
<td>0.5667b</td>
<td>4742.7c</td>
<td>53.667a</td>
</tr>
</tbody>
</table>

Values with different letters in a column are highly significant (p < 0.05)
Table 3: Mean Values for Fatty Acid composition of three cultivars of Sesame seeds

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>C16:0</th>
<th>C16:1</th>
<th>C18:0</th>
<th>C18:1</th>
<th>C18:2</th>
<th>C18:3</th>
<th>C20:0</th>
<th>C20:1</th>
</tr>
</thead>
<tbody>
<tr>
<td>White sesame seeds</td>
<td>11.12b</td>
<td>0.220c</td>
<td>2.433c</td>
<td>42.43c</td>
<td>43.717a</td>
<td>0.466b</td>
<td>0.510c</td>
<td>0.188c</td>
</tr>
<tr>
<td>Black sesame seeds</td>
<td>21.670a</td>
<td>0.423a</td>
<td>5.466a</td>
<td>56.88a</td>
<td>50.733a</td>
<td>0.696a</td>
<td>0.750a</td>
<td>0.380a</td>
</tr>
<tr>
<td>Brown sesame seeds</td>
<td>12.46b</td>
<td>0.353b</td>
<td>4.606b</td>
<td>48.26b</td>
<td>34.033b</td>
<td>0.420b</td>
<td>0.633b</td>
<td>0.240b</td>
</tr>
</tbody>
</table>

Values with different letters in a column are highly significant ($p < 0.05$)

Table 4: Mean Values for Antioxidant Indices of three cultivars of Sesame seeds

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>TPC</th>
<th>DPPH percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>White sesame seeds</td>
<td>10.837b</td>
<td>4.833b</td>
</tr>
<tr>
<td>Black sesame seeds</td>
<td>30.65a</td>
<td>14.86a</td>
</tr>
<tr>
<td>Brown sesame seeds</td>
<td>9.20c</td>
<td>2.133c</td>
</tr>
</tbody>
</table>

Values with different letters in a column are highly significant ($p < 0.05$)

Table 5: Mean Values for Physical Characteristics of three cultivars of Sesame seeds

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Refractive Index</th>
<th>Specific gravity</th>
<th>pH</th>
<th>Viscosity (cps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>White sesame seeds</td>
<td>1.472a</td>
<td>0.102b</td>
<td>5.09c</td>
<td>18.903c</td>
</tr>
<tr>
<td>Black sesame seeds</td>
<td>1.473a</td>
<td>0.107a</td>
<td>6.05a</td>
<td>19.527b</td>
</tr>
<tr>
<td>Brown sesame seeds</td>
<td>1.472a</td>
<td>0.101b</td>
<td>5.47b</td>
<td>26.407a</td>
</tr>
</tbody>
</table>

Values with different letters in a column are highly significant ($p < 0.05$)
Table 6: Mean Values for Chemical Characteristics of three cultivars of Sesame seeds

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Saponification \n Value (mg/g)</th>
<th>Iodine value \n (g/100g)</th>
<th>Peroxide value \n (meq)</th>
<th>Acidity \n (mg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>White sesame seeds</td>
<td>183.16c</td>
<td>97.553c</td>
<td>4.466c</td>
<td>5.56c</td>
</tr>
<tr>
<td>Black sesame seeds</td>
<td>196.17a</td>
<td>101.12b</td>
<td>5.513b</td>
<td>2.72b</td>
</tr>
<tr>
<td>Brown sesame seeds</td>
<td>186.08b</td>
<td>108.29a</td>
<td>9.120a</td>
<td>9.59a</td>
</tr>
</tbody>
</table>

Values with different letters in a column are highly significant ($p < 0.05$)

Fatty acid Composition

The fatty acid composition of the extracted oils is presented in Table 3. Principal fatty acids in sesame seed oil are palmitic (C16:0), stearic (C18:0), Oleic (C18:1) and linoleic (C18:2) acids (Kamal-Eldin et al. 1992). The results illustrate that the oleic acid and linoleic acid of black seeds (56.8%, 50.7% respectively) were marginally higher than those of white and brown cultivars. Saturated fatty acids, mainly palmitic (27.6%) and stearic (5.46%) acids were also higher in black cultivar. The results are in accordance with earlier published literature (Murwan et al., 2007).

Physico-Chemical Characteristics

The physico-chemical compositions analyzed for three sesame cultivars are presented in Table 5 and 6. Sesame cultivars (white, black and brown) had almost similar values of Refractive index and specific gravity while the values for pH and viscosity differed and significant ($p<0.05$) differences were found among the three cultivars. The findings of this study are in consistent with the range reported by Murwan et al. but higher than the values reported by FAO.

The iodine value of the sesame seed cultivars, as shown in table 6, was found to be in the range of 97.5 to 108.2 g/100g with all the three cultivars showing significant difference ($p<0.05$). Saponification value was higher in black cultivar (196.1) while per oxide value and acidity was higher in brown cultivar (9.12and 9.56 respectively). These results are in consistent with those stated by Murwan et al. but higher than the findings of El Tinay. FAO recommended that the acid value and per oxide value should not exceed 6 mg/g for trading purpose.

CONCLUSION

Sesame oil is a rich source of mono and polyunsaturated fatty acids especially oleic acid (56.88%), linoleic acid (50.73%) and palmitic acid (21.67%) which is highest in black sesame seed cultivar. Black sesame cultivar has the high nutritional profile along with high antioxidant (14.83%) and total phenols (30.65%). In addition, nutritional profile of black sesame cultivar is better than brown and white sesame cultivars. Likewise, mineral profile is the best for black cultivar than the other two cultivars. Black sesame seed has highest Ca, Fe, Zn and K content than the other varieties of sesame. Conclusively, black sesame cultivar is the best among all cultivars due to high nutritional profile and antioxidant potential.

REFERENCES