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Effect of Microwave and Sand Roasting on Physicochemical Values and Fatty Acids of *Cicer arietinum* (White Gram) and *Vigna mungo* (Black Gram) Oils

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Abstract. The oils extracted from raw seeds of *Cicer arietinum* and *Vigna mungo* of different areas of Punjab province of Pakistan were found to possess, more or less, the same physicochemical properties and fatty acid composition. The oils of both the grains showed an increase in the peroxide and free fatty acids values after both, sand and microwave roasting. Other physicochemical values did not show any significant change in the roasted seed oils. The oils of *Vigna mungo* showed a higher concentration of unsaturated fatty acids. The oils of both the species had a significant amount of linoleic acid in raw, microwave and sand roasted seeds.

Keywords: *Cicer arietinum*, *Vigna mungo*, fatty acids, microwave roasting, sand roasting

Introduction

Cicer arietinum (chickpea, locally known as Kabuli channa or white gram) and *Vigna mungo* (chickpea, locally known as Kala channa) are known as the poor man's meat owing to the rich amount of good quality protein content. These are the most popular legumes and are eaten traditionally by the local people. These legumes contain about 25.3% of protein in comparison to their oil content (Kritikar and Basu, 2000).

Both the species are considered valuable for human and animal consumption in the south east Asia from nutritional point of view due to their high protein and lysine content as well as energy components such as starch and lipid (Saini and Knights, 1984). In Pakistan, chickpea is eaten in sand roasted as well as in boiled/softened form. Traditionally roasting in sand is a very common method as it imparts appetizing flavour to the fresh warm product.

In the present work, effect of sand and microwave roasting on the lipids of *C. arietinum* and *V. mungo* has been studied. Microwaves are very short waves of electromagnet energy which interact with the food molecules changing their polarity with each cycle. This agitation heats up the food and may also change the composition of food (Maga *et al*., 1977).

Although a number of studies have been undertaken on chickpea as a rich protein source, little work is available on its fatty acid profile versus traditional and modern roasting practices. The earlier investigations indicate high percentage of unsaturated acids in the lipids of chickpea. The present study was undertaken in view of the importance of leguminous seeds as food items and the lack of earlier systematic investigations on lipids of these seeds, particularly in Pakistan. The study was focussed on comparing the traditional sand roasting with modern microwave roasting with reference to fatty acid changes.

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Materials and Methods

The seeds of three varieties of *C. arietinum* and *V. mungo*, each, from Mianwali, Bakhar and Layea districts of Punjab were purchased from the local market. After grinding, 100 g powder of each seed was extracted with hexane in soxhlet apparatus. The solvent was removed under nitrogen atmosphere using rotary evaporator. Pale yellow oils were obtained from all the three samples of *C. arietinum*, whereas the oil obtained from *V. mungo* of the above mentioned areas was of darker shade (brown). All the chemicals used in this study were of AR-grade.

Physicochemical values of the oils. The raw seed oils of *C. arietinum* and *V. mungo* samples were subjected to physicochemical investigations. Standard methods (AOAC, 2002) were used to determine refractive index, free fatty acids, saponification value, peroxide value and iodine value.

Microwave and sand roasting. Seeds of each sample (100 g) were roasted by microwave roasting at high microwave radiation intensity and sand roasting at 220 °C for 5 min, each. Oil were extracted from roasted seeds and their physicochemical values and fatty acid profile were determined.

Gas chromatographic analysis. The oils extracted from the samples were treated with borontrifluoride-methanol reagent

to prepare methyl esters of fatty acids for their identification by GC (AOAC, 2002). These esters were analysed on Shimadzu GC-14A gas chromatograph equipped with hydrogen flame ionization detector and data processor. A PEG capillary column (25 m x 0.2 mm i.d) was used and the column oven temperature was maintained at 180 °C for 5 min, then raised to 220 °C at a rate of 2 °C/min. The temperature of the injector and the detector was set at 250 °C and 300 °C, respectively. The peaks were recorded on Shimadzu C-R4A Chromatopac and identified by comparing their retention time with those of the standard methyl esters, analyzed under the same conditions. All the experimental work was done in triplicate to authenticate the results.

Results and Discussion

The percentage of oil extracted from *C. arietinum* of Mianwali, Bakhar and Layea were 3.72, 3.69 and 3.48% in raw seeds, 3.50, 3.70 and 3.65% in microwave roasted seeds and 3.71, 3.63 and 3.46% in sand roasted seeds, respectively. In case of *V. mungo* of the same localities, it was 3.34, 3.30 and 3.23% in raw, 3.33, 3.29 and 3.2% in microwave roasted seeds and 3.3, 3.27 and 3.22% in sand roasted seeds, respectively. These values are considered as low concentrations of oil. Some earlier studies in this regard have indicated 4-6% oil content in different cultivars of chickpea of different areas (Saini and Knights, 1984). The variation in oil content may be due to the soil composition and environmental effects of different geo graphical areas. The present study indicates that the oil contents in two varieties of chickpea of the same area, are almost equal. The colour of the oils of *C. arietinum* raw seeds is slightly lighter than that of *V. mungo* raw seeds. In all the varieties, the colour of seeds became darker after microwave and sand roasting both, irrespective of the place of origin. The colour change may be due to change in composition of pigments or decomposition of pigments present in the seeds, on heating.

In respect of the physicochemical properties of the oil extracted from the three samples of *C. arietinum* of Mianwali, Bakhar and Layea, it was observed that the iodione value of raw seeds ranged from 126.8-128.4. The values decreased to 127.0-127.9 in microwave roasted seeds and 123.9-124.7 in the sand roasted seeds of the three localities. Similarly a slight change was observed in the saponification value with a slight decrease in the oil of microwave roasted as well as sand roasted seeds. On the other hand an appreciable change was observed in the free fatty acid (FFA) and peroxide values (PV) of the oils after micowave roasting and sand roasting of the seeds of the *C. arietinum* (Table 1).

This change in FFA and PV during heating process may be confined to oxidation and hydrolysis at high temperature. Further more, the increase in FFA shows that high molecular weight fatty acids break into lower molecular weight fatty acids during heating which in turn increased the FFA. Such a change in PV and FFA has already been observed in the study of Vieira and Regitano D'Arce (1999). *V. mungo* of the three areas also showed the same trend of change (Table 2) in iodine value, saponification value and refractive index in raw, microwave roasted and sand roasted seed oils. In this case also, FFA and peroxide values of oils significantly changed after microwave and sand roasting. All the recorded physicochemical values recorded catagorise the oils as edible oils (Tables 1-2).

The extracted oils were further analysed for their fatty acid composition. It was found that Mianwali variety of *C. arietinum* contained 75.0% unsaturated fatty acids in the raw seed oil; the amount decreased to 74.48% and 74.5% when roasted in microwave and sand, respectively. Similar trend was observed in the Bakhar and Layea varieties of *C. arietinum*. The minor decrease in unsaturation in all the cases may be due to the oxidation and hydrolysis of the unsaturated acids on heating.

Table 1. Physicochemical values of raw, microwave and sand roasted seed oils of *C. arietinum* of different areas

Parameter	Raw seeds			Microwave roasted seeds			Sand roasted seeds		
	Mianwali	Bakhar	Layea	Mianwali	Bakhar	Layea	Mianwali	Bakhar	Layea
Oil percentage (DW)	3.72	3.69	3.48	3.50	3.70	3.65	3.71	3.63	3.46
Free fatty acid	1.22	1.25	1.30	1.29	1.30	1.40	1.28	1.34	1.40
Refractive index	1.4673	1.4675	1.4670	1.4688	1.4687	1.4683	1.4679	1.4680	1.4677
Iodine value	126.8	128.4	127.9	127.0	127.9	127.5	123.9	124.7	124.3
Saponification value	196.7	196.5	196.2	193.8	194.4	193.9	192.1	191.2	191.6
Peroxide value	5.25	5.27	5.26	14.23	14.29	14.30	19.12	19.25	19.43

DW = dry weight

The unsaturated acids contained a significant amount of linoleic acid which was about 45.5% in the raw seed oils of all the three samples of *C. arietinum*. A minor decrease was observed on heating in microwave and sand (1.3-1.5%). Amount of oleic acid was almost the same in all the three samples (23.69-26.35%) alongwith lesser amount of linolenic acid (4.0-5.59%) (Tables 3-4). The high amount of linoleic acid, which is an essential fatty acid, has beneficial effect on the health. It acts as carrier of and assists in the absoption of fat - soluble vitamins (A, D, E, K). It also provides a convenient source of stored energy to the body and seves as a precursor to the biologically important prostaglandins. Generally linolenic acid level in excess of 1% is considered to have an adverse effect on flavour stability (MacLeod and Coppock, 1976). Comparison of the two varieties of different areas is presented in Tables 3 and 4.

The range of saturated fatty acids was 24.07-25.27 in all the samples (Table 3). The predominant acids were myristic, palmitic and stearic acids which showed a significant increase after roasting in different ways (Table 4).

Table 2. Physicochemical values of raw, microwave and sand roasted seed oils *of V. mungo* of different areas

Parameter	Raw seeds			Microwave roasted seeds			Sand roasted seeds		
	Mianwali	Bakhar	Layea	Mianwali	Bakhar	Layea	Mianwali	Bakhar	Layea
Oil percentage (DW)	3.34	3.30	3.23	3.33	3.29	3.20	3.30	3.27	3.22
Free fatty acid	1.120	1.12	1.12	1.20	1.23	1.25	1.22	1.26	1.24
Refractive Index	1.4690	1.4675	1.4670	1.4690	1.4689	1.4682	1.4675	1.4685	1.4686
Iodine value	131.40	130.40	130.59	126.25	126.75	125.95	128.98	129.12	129.52
Saponification value	191.07	192.06	192.53	190.73	191.23	191.68	193.72	192.89	193.30
Peroxide value	6.76	6.27	5.72	19.32	19.12	19.52	19.65	19.75	19.53

DW = dry weight

Table 3. Fatty acid composition of raw, microwave and sand roasted seed oils of *C. arietinum* of different areas

Fatty acid	Raw seeds			Microwave roasted seeds			Sand roasted seeds		
	Mianwali	Bakhar	Layea	Mianwali	Bakhar	Layea	Mianwali	Bakhar	Layea
$C_{14:0}$	8.85	7.98	7.35	6.73	7.32	8.1	6.94	6.90	7.52
$C_{16:0}$	10.42	10.56	11.62	12.0	12.69	11.46	12.63	11.95	11.85
$C_{18:0}$	5.35	5.53	6.3	6.0	6.13	6.0	5.65	6.2	6.4
$C_{18:1}$	24.6	25.0	26.35	25.75	23.69	24.15	25.0	25.35	24.83
$C_{18:2}$	45.00	44.5	43.15	44.0	45.29	44.69	44.2	43.85	43.54
$C_{18:3}$	5.40	5.8	5.0	4.73	4.3	4.9	5.3	5.20	5.01
Unidentified	0.38	0.58	0.32	0.79	0.58	0.7	0.98	0.55	0.85

Table 4. Fatty acid composition of raw, microwave and sand roasted seed oils of *V. mungo* of different areas

Fatty acid	Raw seeds			Microwave roasted seeds			Sand roasted seeds		
	Mianwali	Bakhar	Layea	Mianwali	Bakhar	Layea	Mianwali	Bakhar	Layea
$C_{14:0}$	0.65	0.69	0.65	0.86	0.95	0.75	0.85	0.95	0.74
$C_{16:0}$	18.97	17.8	18.49	18.79	18.10	19.37	18.07	17.10	18.0
$C_{18:0}$	3.60	3.75	3.54	3.40	3.72	3.15	3.96	3.95	3.76
$C_{18:1}$	28.39	28.53	27.95	28.30	28.59	28.50	29.99	29.69	29.15
$C_{18:2}$	42.95	44.29	43.85	44.56	43.01	43.05	42.91	42.39	43.30
$C_{18:3}$	5.59	4.19	5.5	4.0	4.7	4.35	4.4	4.5	4.2
Unidentified	0.95	0.75	0.95	0.75	0.99	0.83	0.89	0.81	0.85

The oils extracted from *V. mungo* showed more unsaturation than *C. arietinum* oils as shown in Table 4. This high level of unsaturation may have marked influence on the functional properties and average stability of processed legume flours (Vieira and Regitano D'Arce, 1999). The fact that linoleic acid was again the prominent fatty acid among the unsaturated acids of *V. mungo* showed close relationship of the samples of different areas.

Generally the fatty acid composition of the oils, extracted after microwave roasting and sand roasting of seeds, was almost similar to that of raw oils which showed that both types of roasting did not have any significant effect on the fatty acid composition.

Comparison of fatty acids of the oils from seeds of the three localities is shown in Tables 3 and 4.

Earlier studies of Caponio *et al.* (2003) and Mai *et al.* (1980), indicated that microwave cooking did not change the fatty acid composition of many food lipids nor cause isomerization of the unsaturated fatty acids. Hassanein *et al.* (2003) had reported that microwave baked potatoes showed relatively lower percentage of total unsaturated fatty acids as compared to that of conventionally baked potatoes and in addition it increased the *trans* fatty acids. The present study in which *C. arietinum* and *V. mungo* were roasted by microwave and conventional sand roasting method did not show any significant change in the fatty acid pattern of both the legumes from three different areas, which corresponds to the study of Mai *et al*. (1980). However, the results are in contrast to the earlier study of Maga *et al*.(1977).

In conclusion the oils extracted from the raw seeds of *C. arietinum* and *V. mungo* of different areas have more or less the same properties but the fatty acid composition of *V. mungo* showed higher degree of unsaturation in comparison to *C. arietinum*; furthermore, the effect of microwave roasting and sand roasting did not produce any significant change in their fatty acid composition thus eliminating the presumption that such treatments lead to the formation of toxic compound.

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