Characteristics of Seed Oils and Nutritional Compositions of Seeds from Different Varieties of *Momordica charantia* Linn. Cultivated in Bangladesh

M. Abbas ALI[1], M. Abu SAYEED[2], M. Sultanur REZA[3], Mst. Sarmina YEASMIN[4] and Astaq Mohal KHAN[4]

[1]Department of Chemistry, Rajshahi University of Engineering and Technology, Rajshahi, Bangladesh; [2]Department of Applied Chemistry and Chemical Technology, Rajshahi University, Rajshahi, Bangladesh; [3]Department of Chemistry, Rajshahi College, Rajshahi, Bangladesh; [4]BCSIR Laboratories, Rajshahi, Bangladesh

Abstract

Ali M.A., Sayeed M.A., Reza M.S., Yeasmin Mst.S., Khan A.M. (2008): **Characteristics of seed oils and nutritional compositions of seeds from different varieties of** *Momordica charantia* Linn. **cultivated in Bangladesh**. Czech J. Food Sci., **26**: 275–283.

Farmers in rural areas of almost all the districts of Bangladesh cultivate different varieties of edible plant karela to satisfy nutritional requirements. Herein, we report on the characteristics of seed oils and nutrients and mineral contents of seeds from three varieties of karela. Most of the physicochemical characteristics were significantly ($P < 0.05$) affected with the samples tested. Seed oils of all varieties displayed a higher degree of unsaturation and in GLC reported herein, only five fatty acids were identified. The profiles of fatty acid composition were not wholly similar in all varieties in which unsaturated fatty acids represented more than 72%, α-eleostearic acid having been detected in the amount of 50.36–53.22%. Acylglycerol classes were estimated to be monoacylglycerols (1.18–2.01%), diacylglycerols (1.83–2.98%), and triacylglycerols (91.11–93.03%) whereas lipid classes included neutral lipids (86.83–91.09%), glycolipids (4.37–7.43%), and phospholipids (3.22–4.62%). Of the major energy producing nutrients, all varieties contained large amounts of lipid (33.93–36.21%) and protein (18.23–21.36%), and potentially useful amounts of calcium (383.45–440.96 μg/g), iron (41.10–45.03 μg/g), and other essential minerals. The nutrient information presented in this report should stimulate the local public health authorities in Bangladesh to consider the question of recommending the vegetable karela to be consumed by adults and children alike in Bangladesh, including pregnant women and others with higher than normal nutritional requirements.

Keywords: karela; seed oil; fatty acid; mineral content

Momordica charantia Linn., known as bitter melon or karela, is a cucurbit vine native to Asia with eastern India and southern China proposed as the centers of domestication (Yang & Walters 1992). It is now widely cultivated throughout the world for the immature fruits, and sometimes for the tender leafy shoots or the ripe fruits. The plant is adapted to a wide variation of climates although the production is the best in hot areas (Binder *et al*. 1989). It is a revolutionary plant for its versatility as foodstuff and therapeutic applications. Although the seeds, leaves, and vines

of karela have all been used as food and remedy, the fruit is the safest and most prevalent part of the plant used (Assubaie & El-Garawany 2004). Karela seeds have been found potentially rich in oil, with the content of 35% as reported elsewhere (Airan & Shah 1942), which is higher than that contained in many of other plant sources (Amoo *et al*. 2006; Akubugwo & Ugbogu 2007; Daramola & Adegoke 2007; Stevenson *et al*. 2007). From the viewpoint of nutritional value, the fruit is highly nutritious due to the high contents of protein, ascorbic acid, calcium, iron, and phosphorus (Madaan & Lal 1984; Assubaie & El-Garawany 2004).

Some research works have been carried out on the seed oil and nutritional compositions of karela seed (Toyama & Tsuchiya 1936; Lakshminarayana *et al*. 1982; Madaan & Lal 1984; Assubaie & El-Garawany 2004) but the information regarding these types of research works on different varieties of this plant cultivated in Bangladesh is very scanty. Hence the present investigations were highlighted with a view to find out the physico-chemical characteristics and fatty acid composition of seed oil and also some important nutrients and mineral contents of seeds obtained from three varieties of karela as a basis for comparison, all cultivated in homogeneous conditions in the experimental plot located at Rajshahi city, Bangladesh.

MATERIALS AND METHODS

Plant materials and chemicals. Ripe fruits of karela used in this work were collected in the year 2005 from the experimental plot located at Rajshahi city, Bangladesh. The varieties reported herein, which were all cultivated in homogeneous conditions and differed morphologically from each other, were: Goj (fruit long, green, covered with long triangular tubercles and bitter), Guti (fruit small, deep green, covered with small triangular tubercles and strongly bitter), and Majhari (fruit medium, light green, covered with medium triangular tubercles and slightly bitter) karela commonly known in Bangladesh. The seeds were separated from the fruits manually and washed several times with water to remove the foreign materials. Afterward, the seeds were dried in the sunlight for four consecutive days and again in an electric oven at 40°C until a constant weight was reached. The seeds were ground to a fine powder, packed, and stored in a refrigerator at 4°C prior to the analysis. The solvents were obtained from Merck (Germany) and BDH (England). Silica gel (60–120 mesh) and Silica gel (HF_{254}) were products of Merck (Germany). Esters of fatty acids and bovine serum albumin were from Sigma Chemical Co. (USA).

Analysis of karela seed oil. The oil was extracted from powdered seed material in a Soxhlet apparatus with light petroleum ether (40–60°C) for about 24 h and the solvent was removed in rotary vacuum evaporator (Buchi, Switzerland). The crude oil thus obtained was purified in a column (neutral alumina in petroleum ether) using petroleum ether-diethylether (70:30) as the eluting solvent and the percentage of the oil content was computed.

Physical and chemical characteristics. Specific gravity of the oil was determined at 25°C with the help of a pycnometer. The refractive index of the clear oil was estimated at 25°C using Abbe Refractometer following IUPAC (1979) method. ASTM (1958) testing methods were followed for determining pour, flash, and fire points, and smoke point was estimated according to the method of AOCS (1980). Chemical characteristics i.e. iodine value (Wijs), unsaponifiable matter, Reichert-Meissl value and Polenske number were determined by the methods depicted by Ranganna (1986) while the saponification value, saponification equivalent, acid value, percentage of free fatty acid (FFA), ester value, and peroxide value were determined according to the methods described elsewhere (Williams 1966).

Separation of acylglycerols. The oil was separated into mono-, di- and triacylglycerols by silica gel (60–120 mesh) column chromatography. The solvent systems used for elution were similar to those described by Gofur *et al*. (1993). For quantitative determination of acylglycerol classes, the sample (750 mg in 3 ml petroleum ether) was adsorbed on the top of the column; triacylglycerols were eluted with benzene, diacylglycerols with a mixture of diethyl ether and benzene (1:9, v/v), and monoacylglycerols with diethyl ether. Approximately 1.5–2 ml/min fractions were collected. The elution was monitored by TLC. The purity of the acylglycerol classes was confirmed by TLC using silica gel developed with *n*-hexane-diethyl ether 80/20 (v/v) and visualisation with chromic-sulphuric acid at 180°C. The acylglycerol classes were identified by comparing R_f values

with standard references. The weight percentage of each acylglycerol class was determined by the gravimetric method. The amount of diacylglycerols was calculated by subtracting the weight of free fatty acid (FFA) as determined by standard method (Williams 1966) from the weight of diacylglycerol fraction.

Fractionation of lipids. A total of 750 mg lipid extracted from karela seeds by the method of Bligh and Dyer (1959) was fractionated into three major lipid groups: neutral lipid, glycolipid and phospholipid, using silica gel column chromatography. Neutral lipids were eluted with diethyl ether, glycolipids with acetone, and phospholipids with methanol (Rouser *et al.* 1967). Approximately 0.5–1.0 ml fractions were collected per minute and elution the was monitored by TLC. The solvents were evaporated in vacuum rotary evaporator. Lipids of different classes were identified by comparing their R_f values with those of standards and the percentages of these fractions were determined by gravimetric method.

Fatty acid composition of oil. Fatty acid composition of karela seed oil was determined as their methyl esters prepared by boron-trifluoride methanol complex method (Morrison & Smith 1964). The resultant methyl esters were analysed by GLC (Model 5890, Hewlett Packard) equipped with a flame ionisation detector and a 15 m × 0.24 mm DB-23 capillary column (J&W, Deerfield). The column, injection port, and detector were operated at 200, 220, and 240°C, respectively. Helium was used as a carrier gas at a flow rate of 1 ml/min. 18:3 conj. was confirmed by the same method as reported by Lakshminarayana *et al.* (1982).

Analysis of karela seed. Moisture, ash, and crude fiber contents were determined by AOAC (1990) methods. Lipid content was estimated by the method of Bligh & Dyer (1959) using a solvent mixture of chloroform and methanol (2:1 v/v). Total protein content was calculated from total nitrogen by using N × 6.25 after the determination of the total nitrogen by micro-Kjeldahl method (AOAC 1990). Water soluble protein was determined by Lowry method (Lowry *et al.* 1951) using bovine serum albumin as the standard. Starch content (Clegg 1956) and total carbohydrate (Rahim 1999) were also estimated. The samples for mineral analysis were subjected to acid digestion and analysed following the procedures described by AOAC (1990). Phosphorus was determined by the vanado-molybdate calorimetric method while AAS (atomic absorption spectrometer, Pye Unicam model SP9, Cambridge, UK) was used for other elements.

Statistical analysis. All data were expressed on dry weight basis as the mean and standard deviation (SD) of three experiments and were subjected to one way analysis of variance (ANOVA). The mean values were compared at $P < 0.05$ significance level by Duncan's multiple range test using SPSS 11.5 software package.

RESULTS AND DISCUSSION

The solvent extracts of three varieties of karela seeds yielded on average about 26% oil, which is appreciably less than the value 35% reported elsewhere (Airan & Shah 1942). The information on detailed characteristics of seed oil and nutritional

Table 1. Physical characteristics of karela seed oil

Characteristics	Goj karela	Guti karela	Majhari karela
Specific gravity at 25°C	0.9978 ± 0.00040^{b}	0.9709 ± 0.00481^{a}	0.9715 ± 0.00145^{a}
Refractive index at 25°C	1.4995 ± 0.000451^{c}	1.4888 ± 0.00050^{a}	1.4914 ± 0.000529^{b}
Pour point (°C)	-6 ± 0.20^{a}	-6 ± 0.10^{a}	-6 ± 0.17^{a}
Flash point (°C)	80 ± 3.00^{a}	85 ± 1.17^{b}	89 ± 1.78^{b}
Fire point (°C)	93 ± 1.00^{a}	95 ± 0.20^{b}	92 ± 1.33^{a}
Smoke point (°C)	*	*	*

Values are mean ± standard deviation of three experiments. Means in the same row with different superscripts are significantly ($P < 0.05$) different

*Smoke points of all the samples could not be determined due to their low burning characteristics, soaking tendency, fluidity etc.

compositions of seeds from other plant sources are too scanty for a meaningful comparisons.

As shown in Table 1, specific gravities determined with karela seed oils (0.9709–0.9978 at 25°C) are in agreement with the value 0.9962 at 25°C mentioned by Airan and Shah (1942) for the same oil. Refractive indices of the oils found in the present investigations were 1.4888–1.4995 at 25°C, being close to the value 1.4985 at 25°C reported by Airan and Shah (1942) for the same oil. Smoke points could not be determined due to the oils low burning characteristics, soaking tendency, fluidity etc. Smoke, fire and flash points of a fatty material are measures of its thermal stability when heated in contact with the air. Fatty acids are much less stable than acylglycerols; hence the smoke, fire and flash points of ordinary oils depend principally upon their contents of free fatty acids (Mattil *et al*. 1964). Significantly higher ($P < 0.05$) values for specific gravity and refractive index were both found in the Goj karela seed oil while pour points of all the samples were found to be the same.

As given in Table 2, the iodine values of the karela seed oils were estimated to be 125.21–131.06, and were thus lower than the value 140.10 for the same oil reported elsewhere (Toyama & Tsuchiya 1936). The iodine values obtained in this study indicate that the karela seed oil has a higher degree of unsaturation. The saponification values of the three samples of oils were in the range 184.08–187.01 whereas the saponification equivalents, calculated from the saponification values, were 299.98–304.76. No significant differences ($P < 0.05$) were found in the saponification values between the samples tested. These comparatively low saponification values as estimated indicate the presence of a higher proportion of higher fatty acids. The percentages of free fatty acids (0.86–1.12) were lower than the value 1.71 cited in the literature (CSIR 1962) for the same oil. The degree of edibility of a fat is generally considered to be inversely proportional to the total amount of free fatty acids (Deuel 1951). The results regarding free fatty acids content indicate that karela seed oil could be probably used for edible purposes as it contained a lower percentage of free fatty acids. The ester values of oils in the three samples were calculated as 181.84–185.28 from the acid and saponification values. The iodine, acid, and ester values did not differ significantly ($P < 0.05$) between the samples of Goj karela and Majhari karela.

Karela seed oils in the samples of different varieties contained unsaponifiable matters ranging from 1.12% in Goj karela to 1.71% in Guti karela, being higher than the value 0.91% for the same oil reported elsewhere (Toyama & Tsuchiya 1936). The significantly ($P < 0.05$) lower percentage of unsaponifiable matters as obtained in the sample of Goj karela (1.12%) points to lower amounts of hydrocarbons, higher alcohols and sterols than those contained in the rest of the samples. The oils in the samples of karela seeds displayed the peroxide values of 6.13–8.50 mEq/kg which were determined in normal laboratory conditions. The present experimental results revealed that karela

Table 2. Chemical characteristics of karela seed oil

Characteristics	Goj karela	Guti karela	Majhari karela
Iodine value (Wijs)	131.06 ± 1.16^{b}	125.21 ± 2.29^{a}	128.39 ± 1.76^{ab}
Saponification value	184.08 ± 0.94^{a}	187.01 ± 2.04^{a}	186.15 ± 1.18^{a}
Saponification equivalent	304.76 ± 1.55^{a}	299.98 ± 3.28^{a}	301.36 ± 1.90^{a}
Acid value	2.24 ± 0.09^{b}	1.73 ± 0.14^{a}	2.19 ± 0.05^{b}
Free fatty acids (%) as oleic	1.12 ± 0.04^{b}	0.86 ± 0.07^{a}	1.10 ± 0.03^{b}
Ester value	181.84 ± 0.92^{a}	185.28 ± 1.96^{b}	183.95 ± 1.16^{ab}
Unsaponifiable matter (%)	1.12 ± 0.07^{a}	1.71 ± 0.12^{b}	1.52 ± 0.11^{b}
Peroxide value (mEq/kg)	8.50 ± 0.09^{b}	6.13 ± 0.13^{a}	7.56 ± 0.34^{ab}
Reichert-Meissl value	1.98 ± 0.11^{a}	2.13 ± 0.16^{a}	2.02 ± 0.07^{a}
Polenske number	0.61 ± 0.04^{a}	0.63 ± 0.02^{a}	0.57 ± 0.07^{a}

Values are mean ± standard deviation of three experiments. Means in the same row with different superscripts are significantly ($P < 0.05$) different

Table 3. Acylglycerol composition of karela seed oil (weight %)

	Monoacylglycerols	Diacylglycerols	Triacylglycerols
Goj karela	1.80 ± 0.04[b]	2.81 ± 0.07[b]	91.44 ± 1.45[a]
Guti karela	1.18 ± 0.05[a]	1.83 ± 0.04[a]	93.03 ± 0.67[a]
Majhari karela	2.01 ± 0.15[c]	2.98 ± 0.12[c]	91.11 ± 1.49[a]

Values are mean ± standard deviation of three experiments. Means in the same column with different superscripts are significantly ($P < 0.05$) different

seed oils are quality oils. Reichert-Meissl values of the samples were estimated as 1.98–2.13, being lower than the reported value 2.52 (Airan & Shah 1942) in the same oil. The low Reichert-Meissl values thus obtained indicate a low content of lower volatile soluble fatty acids, and this value is also in agreement with the low saponification value obtained. Polenske numbers (0.57–0.63) estimated in this study were similar to that determined by Airan & Shah (1942) who talked about a Polenske number of 0.62. No dramatic difference ($P < 0.05$) in the values ofr Reichert-Meissl and Polenske numbers in the analysed sample means were noticed.

The total amount of oil was separated into mono-, di-, and triacylglycerol fractions by means of column chromatography and the results are shown in Table 3. The triacylglycerols varied from 91.11 to 93.03% while diacylglycerols from 1.83 to 2.98% and monoacylglycerols from 1.18 to 2.01%. No significant differences ($P < 0.05$) were recorded between the three samples in triacylglycerol compositions which accounted for about 91.86% (average) of the total weight of oil. But mono- and diacylglycerol compositions showed significant differences ($P < 0.05$). Moreover, the total recovery of acylglycerol was about 96.06% (average) which indicated that karela seed oils contained a lower amount of nonacylglycerol than that found in *Mesua ferrea* seed oil (Abu Sayeed *et al*. 2004). Of the three varieties, Majhari karela seed oil contained significantly higher ($P < 0.05$) amount of monoacylglycerols, that can be used as an emulsifier.

The fractionation of karela seed lipids by silica gel column chromatography into neutral lipids, glycolipids, and phospholipids revealed their quantities of 86.83 to 91.09%, 4.37 to 7.43% and 3.22 to 4.62%, respectively (Table 4). Significant differences ($P < 0.05$) in the glycolipid contents of different sources were observed as well as a higher value obtained in Guti karela seed lipid. The results also indicated that neutral lipids were found to be over 86% of the total weight of the lipid. In all the three varieties Karela seed lipid under investigations contained a lower percentage of neutral lipids and higher percentages of glycolipids and phospholipids in comparison with the results found in *Mesua ferrea* seed oil (Abu Sayeed *et al*. 2004).

Fatty acid compositions of karela seed oils were determined by GLC and are presented in Table 5. The results show that the fatty acid contents (except oleic acid) in different varieties were significantly different ($P < 0.05$). GLC data reveals that karela seed oil contained a higher amount of ∞-eleostearic acid (50.36–53.22%) while linoleic and oleic acid contents were found to be 4.81–6.98% and 15.26–16.01%, respectively. The saturated fatty acids estimated were stearic (20.21–24.20%) and palmitic (3.20–5.29%). The fatty acid profiles evaluated in this study are not in complete agreement

Table 4. Lipid composition of karela seed lipid (weight %)

	Neutral lipids	Glycolipids	Phospholipids
Goj karela	91.09 ± 2.42[b]	4.37 ± 0.42[a]	3.22 ± 0.24[a]
Guti karela	86.83 ± 1.14[a]	7.43 ± 0.06[c]	4.62 ± 0.07[b]
Majhari karela	88.40 ± 1.40[ab]	5.52 ± 0.51[b]	4.48 ± 0.12[b]

Values are mean ± standard deviation of three experiments. Means in the same column with different superscripts are significantly ($P < 0.05$) different

Table 5. Fatty acid composition (in %) of karela seed oil

Fatty acids	Goj karela	Guti karela	Majhari karela
Palmitic acid (C_{16}:0)	4.84 ± 0.13^{b}	3.20 ± 0.13^{a}	5.29 ± 0.07^{c}
Stearic acid (C_{18}:0)	20.21 ± 0.40^{a}	24.20 ± 0.32^{c}	22.05 ± 0.24^{b}
Oleic acid (C_{18}:1)	15.36 ± 0.12^{a}	15.26 ±.0.49^{a}	16.01 ± 0.47^{a}
Linoleic acid (C_{18}:2)	6.37 ± 0.46^{b}	6.98 ± 0.12^{c}	4.81 ± 0.18^{a}
∞-Eleostearic acid (C_{18}:3)	53.22 ± 0.36^{c}	50.36 ± 0.35^{a}	51.84 ± 0.81^{b}

Values are mean ± standard deviation of three experiments. Means in the same row with different superscripts are significantly ($P < 0.05$) different

with the works reported (Lakshminarayana *et al.* 1982; Armougom *et al.* 1998). The fatty acid composition alters with the variety, soil, and climatic conditions (Egan *et al.* 1981). We have found some differences between the samples studied, regarding the contents in fatty acids. The oleic acid content appeared to be fairly constant in all varieties. Regarding the polyunsaturated fatty acids, α-eleostearic acid was the major one, its average percentage being 51.80, which was lower than the value 65% detected by Cahoon *et al.* (1999) with the same seed oil. GLC data also indicated that karela seed oils contained mainly unsaturated fatty acids 72.60–74.95%, while saturated fatty acids detected represented 25.05–27.40%. The saturated/unsaturated fatty acids ratio of the oils ranged from 0.3342 to 0.3774; however, Goj karela seed oil displayed a higher degree of unsaturation as compared to the other two, with a saturated/unsaturated fatty acids ratio of only 0.3342. These ratios indicate that the samples had a high content of unsaturated fatty acids, which may make them more attractive for the consumer who wishes to ingest this type of acids. Vegetable oils that contain fatty acids with conjugated double bonds, such as tung oil, are valuable drying agents in paints, varnishes, and inks (Cahoon *et al.* 1999). Karela seed oils reported herein that are enriched in α-eleostearic acid (> 50% of the total fatty acid) possessing conjugated double bonds, are used commercially in coating materials and inks. As for α-eleostearic acid, the best sources appeared to be Goj karela seed (53.22%) and then Majhari karela seed (51.84%), followed closely by Guti karela seed (50.36%).

Significant differences ($P < 0.05$) in the contents of most nutrients contents of karela seeds were observed in the samples tested. The moisture contents ranged from 7.62–8.20%, the low amount was found in Guti karela. Karela seeds contained 33.93–36.21%, of total lipids, which was lower than the value 47.50% reported by Lakshminarayana *et al.* (1982). The ash contents were estimated to be 2.25–2.73%. No significant differences ($P < 0.05$) in the ash and lipid contents were observed between the samples of Guti karela and Majhari karela. Total

Table 6. Nutritive compositions of karela seeds

Parameters (%)	Goj karela	Guti karela	Majhari karela
Moisture	7.99 ± 0.12^{b}	7.62 ± 0.11^{a}	8.20 ± 0.20^{b}
Lipid	36.21 ± 1.06^{b}	35.17 ± 1.07^{ab}	33.93 ± 0.96^{a}
Ash	2.73 ± 0.13^{b}	2.29 ± 0.14^{a}	2.25 ± 0.16^{a}
Total protein	18.23 ± 0.96^{a}	21.36 ± 0.76^{b}	19.02 ± 0.12^{a}
Water soluble protein	4.99 ± 0.12^{a}	6.33 ± 0.28^{b}	6.52 ± 0.38^{b}
Starch	3.12 ± 0.17^{a}	4.02 ± 0.22^{b}	3.50 ± 0.43^{ab}
Crude fiber	1.16 ± 0.14^{a}	1.02 ± 0.07^{a}	1.20 ± 0.15^{a}
Total carbohydrate	33.68 ± 2.05^{a}	32.51 ± 1.31^{a}	35.52 ± 0.81^{a}

Values are mean ± standard deviation of three experiments. Means in the same row with different superscripts are significantly ($P < 0.05$) different

Table 7. Mineral contents of karela seeds

Parameters (μg/g)	Goj karela	Guti karela	Majhari karela
Calcium	383.45 ± 1.56[a]	411.56 ± 3.18[b]	440.96 ± 6.14[c]
Copper	3.52 ± 0.12[b]	2.85 ± 0.14[a]	3.33 ± 0.19[b]
Iron	41.10 ± 1.13[a]	42.57 ± 1.47[ab]	45.03 ± 1.23[b]
Zinc	12.41 ± 0.93[a]	13.47 ± 0.65[a]	12.85 ± 0.39[a]
Phosphorous	142.39 ± 2.39[b]	136.51 ± 2.87[a]	134.65 ± 1.59[a]

Values are mean ± standard deviation of three experiments. Means in the same row with different superscripts are significantly ($P < 0.05$) different

protein (N × 6.25) of karela seeds was found to be 18.23–21.36% of which 4.99–6.52% was water soluble, and this value for total protein was higher than 18.02% as estimated in the same fruit by Yuwai *et al*. (1991). The present results reveal that karela seed is qualified as protein-rich to satisfy the protein needs of the consuming population. The protein content estimated by micro-Kjeldahl method showed a considerably higher value than that given by Lowry method. The reason is that Lowry method was applied to a water extract and took into accounts, in this case, the water soluble proteins only. Further, micro-Kjeldahl method takes into account both the protein and non-protein nitrogen. The starch contents were found to be 3.12–4.02%. Crude fiber (1.02–1.20) and carbohydrate (32.51–35.52) contents in the three samples of karela seeds did not differ significantly ($P < 0.05$).

With regard to minerals, all three varieties of karela seeds, on which we report herein (Table 7), appeared to contain relatively large quantities of calcium (383.45–440.96 μg/g) and useful amounts of copper (2.85–3.52 μg/g), this amount of copper being higher compared to the values 1.85–2.60 μg/g for the same plant fruit (Assubaie & El-Garawany 2004). Although karela seeds of all varieties contained only modest amounts of iron (41.10–45.03 μg/g), these quantities were still higher than those for karela fruit (12.35–32.33 μg/g) (Assubaie & El-Garawany 2004); thus, karela seeds could contribute significant amounts of iron to the diet. The contents of zinc in karela seeds were substantial (12.41–13.47 μg/g) and higher than those in karela fruit (7.76–10.50 μg/g) (Assubaie & El-Garawany 2004). A higher amount of calcium content was obtained in the sample of Majhari karela seed, but no significant differences ($P < 0.05$) in the amount of zinc were observed. As assessed in terms of the mineral contents, karela seeds cultivated in Bangladesh have the levels of aforesaid minerals comparable to those reported by Assubaie and El-Garawany (2004); however, the amounts of these minerals we found herein were higher than they reported, assuming that whole fruits were used for analyses in the latter case.

It is seen that karela seeds, consumed widely and frequently by the inhabitants of Bangladesh, contain a higher amount of total lipid and considerable amounts of other nutrients. The findings imply that karela seeds may, therefore, be used as a potentially attractive source of lipid and protein and some common minerals. The protein content also commends karela seeds as a nutritive complement. Moreover, the present study highlights the importance of understanding the cultural context and uses of cultivated plant foods. It may be that not all cultivated plant foods are consumed by all the members of a community. The consumption patterns, for example, can vary by gender or age, or even physiologic state (e.g., pregnancy). The nutrient information would be critical to the success of the efforts to promote a wider use of indigenous plant foods as part of a broader program aimed at educating local populations with regard to the nutritional benefits of the many cultivated plant foods that exist in their environment.

CONCLUSION

On the basis of the analytical data stated above it may be concluded that the physicochemical constants studied herein can be helpful to identify the quality of oil and oil products for possible industrial or commercial uses. From the quality point of view, karela seed oil is comparable to other oils and can be utilised in the paint, varnish, and

ink industries and also recommended for possible human consumption after proper refining. On the other hand, in terms of both quantity and quality, all three varieties of karela seeds dealt with here represent potentially useful and important nutritional sources for the people of Bangladesh. Moreover, in the context of calcium and iron deficiency problems that prevail in the country, different varieties of karela seeds may help to increase the dietary intake of the minerals. In assessing the nutritional value of this edible plant, it is important to know how well the various nutrients it contains are absorbed through the intestine. Therefore, there is a need for studies on the digestibility and overall bioavailability of the nutrients contained in karela. In addition, it would be useful to know the contents of important anti-nutrients such as nitrate, lectins, saponins, and phytic acid in this plant food from Bangladesh. Our results agree with the literature data and these analytical data will be helpful for the variety selection.

References

Abu Sayeed M., Abbas Ali M., Sohel F.I., Astaq Mohal Khan G.R.M., Sarmina Yeasmin Mst. (2004): Physicochemical characteristics of *Mesua ferrea* seed oil and nutritional composition of its seed and leaves. Bulletin of the Chemical Society of Ethiopia, **18**: 157–166.

Airan J.W., Shah S.V. (1942): Fatty oils from the seeds of *Momordica charantia* and *Momordica* dioica. Journal of University Bombay, **11**: 105–108.

Akubugwo I.E., Ugbogu A.E. (2007): Physicochemical studies on oils from five selected Nigerian plant seeds. Pakistan Journal of Nutrition, **6**: 75–78.

Amoo I.A., Adebayo O.T., Oyeleye A.O. (2006): Chemical evaluation of winged beans (*Psophocarpus tetragonolobus*), pitanga cherries (*Eugenia uniflora*) and orchid fruit (*Orchid fruit myristica*). African Journal of Food, Agriculture, Nutrition and Development, **6**: 1–12.

AOAC (1990): Official Methods of Analysis. 15th Ed. Association of Official Analytical Chemists, Washington.

AOCS (1980): Official and Tentative Methods. Vol. 1. 3th Ed. American Oil Chemists' Society, Chicago.

Armougom R., Grondin I., Smadja J. (1998): Fatty acid composition of lipid extracts of some tropical cucurbit seeds. Oleagineux Corps Gras Lipids, **4**: 323–328.

Assubaie N.F., El-Garawany M.M. (2004): Evaluation of some important chemical constituents of *Momordica charantia* cultivated in Hofuf, Saudi Arabia. Journal of Biological Sciences, **4**: 628–630.

ASTM (1958): American Society for Testing and Materials: Method Nos. D 97 and D 92.

Binder R.G., Flathand R.A., Mon T.R. (1989): Volatile components of bitter melon. Journal of Agricultural and Food Chemistry, **37**: 418–420.

Bligh E.G., Dyer W.J. (1959): A rapid method of total lipid extraction and purification. Canadian Journal of Biochemistry and Physiology, **37**: 911–915.

Cahoon E.B., Carlson T.J., Ripp K.G., Schweiger B.J., Cook G.A., Hall S.E., Anthony K.J. (1999): Biosynthetic origin of conjugated double bonds: Production of fatty acid components of high-value drying oils in transgenic soybean embryos. Proceedings of the National Academy of Sciences of the United State of America, **96**: 12935–12940.

Clegg K.M. (1956): The application of the anthrone reagent to the estimation of starch in cereals. Journal of the Science of Food and Agriculture, **7**: 40–44.

CSIR (1962): The Wealth of India: A Dictionary of Indian Raw Materials and Industrial Products. Vol. 6. Council of Scientific and Industrial Research, New Delhi: 408–412.

Daramola B., Adegoke G.O. (2007): Nutritional composition and antimicrobial activity of fractionated extracts of *Garcinia kola* Geckel. Pakistan Journal of Scientific and Industrial Research, **50**: 104–108.

Deuel H.J. (1951): The Lipids. Vol. 1. Interscience Publishers, New York: 238–242.

Egan H., Kirk R.S., Sawyer R. (1981): Pearson's Chemical Analysis of Foods. 8th Ed. Churchill Livingstone, Edinburgh: **11**: 519–536.

Gofur M.A., Rahman M.S., Ahmed G.M., Hassain A., Haque M.E. (1993): Studies on the characterization and acylglycerol composition of tobacco (*Nicotiana tabacum*) seed oil. Bangladesh Journal of Scientific and Industrial Research, **28**: 25–31.

IUPAC (1979): Standard Methods for the Analysis of Oils, Fats and Derivatives. 6th Ed. International Union of Pure and Applied Chemistry, Pergamon Press, Paris: 126.

Lakshminarayana G., Kaimal T.N.B., Mani V.V.S., Devi K.S., Rao T.C. (1982): Fatty acid changes during maturation of *Momordica charantia* and *Trichosanthes anguina* seeds. Phytochemistry, **21**: 301–303.

Lowry O.H., Rosebrough N.J., Fan A.L. Randal R.J. (1951): Protein measurement with the folin-phenol reagent. Journal of Biological Chemistry, **193**: 265–275.

Madaan T.R., Lal B.M. (1984): Some studies on the chemical composition of cucurbit kernels and their seed coats. Plant Foods for Human Nutrition, **34***:* 81–86.

Mattil K.F., Norris F.A., Stirton A.J., Swern D. (1964): In: Swern D. (ed.): Bailey's Industrial Oil and Fat Products. 3rd Ed. Wiley and Sons, New York: 122–123.

Morrison W.R., Smith L.M. (1964): Preparation of fatty acid methyl esters and dimethylacetals from lipids with boron trifluoride-methanol. Journal of Lipid Research, **5**: 600–608.

Rahim A.T.M.A., Rayhan Q.A., Ahmed F. (1999). Analysis of nutrient content and quality evaluation of grafted tomato grown over wild eggplant *S. sisymbrilifolium*, by a novel grafting technique. Bangladesh Journal of Nutrition, **12**: 33–40.

Ranganna S. (1986): Hand Book of Analysis and Quality Control for Fruit and Vegetable Products. 2nd Ed. Tata McGraw-Hill Publishing Company Limited, New Delhi: 218–229.

Rouser G., Kritch G., Simon G., Nelson G.J. (1967): Extraction of lipids by column chromatography. Lipids, **2**: 37–42.

Stevenson D.G., Eller F.J., Wang L., Jane J.L., Wang T., Inglett G.E. (2007): Oil and tocopherol content and composition of pumpkin seed oil in 12 cultivars. Journal of Agricultural and Food Chemistry, **55**: 4005–4013.

Toyama Y., Tsuchiya T. (1936): Balsam pear seed oil. Journal of the Society of Chemical Industry, **39**: 220–221.

Williams A.K. (1966): Oils, Fats and Fatty Foods. 4th Ed. J.& A. Churchill Ltd., London: 124–370.

Yang S-L., Walters T.W. (1992): Ethnobotany and the economy role of the cucurbitaceae of China. Economic Botany, **46**: 349–367.

Yuwai K.E., Rao K.S., Kaluwin C., Jones G.P., Rivett D.E. (1991): Chemical composition of *Momordica charantia* L. fruits. Journal of Agriculture and Food Chemistry, **39**: 1762–1763.

Received for publication July 9, 2007

Corresponding author:

Dr. M. Abbas Ali, Rajshahi University of Engineering and Technology, Department of Chemistry, Rajshahi-6204, Bangladesh

tel.: + 880 721 750 742 ext. 550, e-mail: radwiya44@yahoo.com