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PHYSICO-CHEMICAL CHARACTERISTICS OF *MESUA FERREA* SEED OIL AND NUTRITIONAL COMPOSITION OF ITS SEED AND LEAVES

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ABSTRACT. Studies on the physico-chemical characteristics of seed oils of *Mesua ferrea* collected from different districts of Bangladesh revealed specific gravity (0.9287-09312), refractive index (1.4690-1.4739), solidification point [-4.0-(-4.3)], pour point [-1.0-(-1.3)], cloud point (5.5-6.0), flash point (90-98), fire point (110-116), smoke point (44-47), iodine value (89.17-93.01), saponification value (199.03-206.40), saponification equivalent (271.80-281.86), acid value (9.64-11.87), free fatty acid (4.85-5.96), ester value (188.95-1.95.44), unsaponifiable matter (1.44-1.50), acetyl value (2.70-2.84), peroxide value (3.58-3.64), Reichert-Meissl value (5.852-6.031) and polenske number (0.7891-0.8401). Glyceride classes were estimated to be monoglycerides (1.05-1.35 %), diglycerides (2.12-2.32 %) and triglycerides (87.65-89.50 %) whereas total lipid extracts were fractionated into neutral lipid (89.83-92.18 %), glycolipid (3.65-4.15 %) and phospholipid (1.98-2.68 %). Saturated and unsaturated fatty acids present in the oils were separated and amounted to be (27.40-29.11 %) and (65.85- 68.31 %), respectively, depending upon the areas from where the seeds were collected. GLC analysis of the oil indicated the presence of palmitic acid (10.87%), linoleic acid (13.68%), oleic acid (55.93%) and stearic acid (14.19%) as major fatty acids in the oil. In addition, myristic acid (2.13%) and arachidic acid (2.921%) were also present in minor amount. In biochemical analysis, *Mesua ferrea* seeds contained total lipid (66.91-70.23 g %), moisture (4.02-5.05 g %), ash (1.46-1.50 g %), total protein (6.99-7.19 g %), water soluble protein (2.98-3.11 g %), starch (5.51-5.85 g %), crude fiber (1.22-1.98 g %), carbohydrate (15.88-18.68 g %) and energy value (700.55-724.15 kcal/100 g), while its leaves contained total lipid (2.32-2.44 g %), moisture (65.12-72.19 g %), ash (2.60-2.71 g %), total protein (4.23-4.85 g %), water soluble protein (1.47-2.01 g %), starch (3.06-3.27 g %), crude fiber (3.12-3.29 g %), carbohydrate (14.82-22.30 g %) and energy value (100.24-128.40 kcal/100 g). The present investigations demonstrate that the results vary to some extent but not significantly enough with the locations from where samples were collected.

KEY WORDS: *Mesua ferrea*, Seed oil, Glyceride compositions, Fatty acid compositions, Nutritional composition

INTRODUCTION

The plant *Mesua ferrea*, commonly known as nageshwar in Bangladesh, is frequently planted on city roads and avenues in almost all the districts of Bangladesh and used in traditional medicine for several indications such as rheumatism, cough, dysentery, vomiting, sore throat, fever, itch, etc. from the time immemorial [1]. Fats and oils are very important indigenous raw materials for many purposes especially for edible and nonedible purposes. The physico-chemical properties of fats or oils are directly related to their glyceride composition and chemical constitution [2]. Hence, knowledge of these compositional factors is important in connection with research

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aimed at improvement of fat and fat products for specific uses. Some research works have been carried out on the characterization of *Mesua ferrea* seed oil and nutritional compositions of its various parts but till now no detailed studies were made [3-5]. Rahman *et al.* studied the physico-chemical properties of rice bran oils and the nutritional compositions of rice brans collected from different districts of Bangladesh [6]. Moreover, Sayeed *et al.* studied the characterization and glyceride composition of *Cassia fistula* seed oil collected from different districts of Bangladesh [2].

Hence the present investigations were carried out to find out the physico-chemical characteristics and fatty acid composition of seed oil and some important nutritional constituents of seeds and leaves obtained from the plant *Mesua ferrea* collected from four different districts viz., Naogaon, Dhaka, Rajshahi and Dinajpur of Bangladesh.

EXPERIMENTAL

Ripe fruits and matured leaves of *Mesua ferrea* were collected from four different districts viz., Naogaon, Dhaka, Rajshahi and Dinajpur. The seeds were separated from the fruits, deshelled manually and washed several times with water to remove the adhesive materials. Then the seeds were dried in the sunlight for four days. The sun-dried seeds were finally crushed into fine powder with the help of a grinding machine and dried in the oven at a temperature of 105 ^{o}C for an hour. For biochemical analysis, fresh seeds and leaves were used. All reagents used were of analytical grade unless otherwise specified and the results were depicted as the mean value of three replicates.

Analysis of Mesua ferrea seed oil

The oil was extracted in a Soxhlet apparatus with light petroleum ether (40-60 ^{o}C) from powdered seed material for about 24 hours. The solvent was removed by rotary vacuum evaporator and the percentage of oil content was calculated. 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. The purity of the oil was checked by normal TLC.

Physical and chemical characteristics

The specific gravity of the oil was calculated at 31 ^{o}C with the help of a pycnometer. Refractive index of the clear oil free from water and air bubbles was determined at 30 ^{o}C using Abbe Refractometer following IUPAC method [7]. Solidification, flash, fire, pour and smoke points were determined according to the standard methods [6, 8]. Cloud point was estimated by the method described by Mowlah *et al*. [9].

The acid value, percentage of free fatty acid (FFA), saponification value, saponification equivalent, unsaponifiable matters in the oil, ester value, acetyl value, Reichert-Meissl value, peroxide value and Polenske number were determined by the standard methods [8, 10]. Hanus method was followed to determine the iodine value of the oil [11].

Separation of glycerides

The oil was separated into mono-, di- and triglycerides by silica gel (E. Merck, Germany, 70-230 mesh) column chromatography [12]. A slurry of 25 g of silica gel in chloroform was poured into the column (2.2 cm i.d.). 1 g oil was dissolved in 15 mL of chloroform and quantitatively transferred to the column. The triglycerides were eluted with benzene, diglyceride with a

mixture of diethyl ether and benzene (1:9, v/v) and monoglyceride with diethyl ether. The elution was controlled at a flow rate of 1.5-2 mL/min. The amount of free fatty acid eluted with the diglyceride fraction was determined [10].

The elution of each fraction was monitored by microslide thin layer chromatography (TLC) to ensure uniformity of separation of each class of glyceride during silica gel chromatography. The purity of glyceride classes was checked by TLC. The glyceride classes were identified by comparison of R_f values with standard references. The weight percentage of each glyceride class was based on total glyceride applied.

Fractionation of lipids

Total lipid extracted by Bligh and Dyer method [13] was fractionated into three major lipid groups: neutral lipids, glycolipid and phospholipid by silica gel column chromatography on about 750 mg *Mesua ferrea* seed lipids. Neutral lipids were eluted with chloroform, glycolipids with acetone and phospholipids with methanol [14]. The elution was controlled at a flow rate of 0.5-1.0 mL/min. The complete elution of each fraction was monitored by microslide TLC during silica gel column chromatography. Solvents of individual fractions were evaporated by means of a vacuum rotary evaporator. Lipids in different classes were assigned by comparing their R_f values with those of standard references.

Separation of saturated and unsaturated fatty acids

Separation of saturated and unsaturated fatty acids from about 50 g of oil was carried out by lead-salt ether method [2]. The oil was saponified with alcoholic caustic soda to obtain soap solution. A slight excess of lead acetate solution was added to the soap solution to form lead salts of fatty acids, which were then separated. Ether was added to the mixture of lead salts and the whole mixture was warmed and then cooled at 0 ^{o}C for 24 hours. The precipitated lead salts of saturated fatty acids so formed were separated from the solution of lead salts of unsaturated fatty acids by filtration. The lead salts of the unsaturated fatty acids were obtained by removing the ether from the ethereal solution. Each group of lead salts was suspended in water and treated with sufficient hydrochloric acid to form fatty acids and lead chlorides. The mixture was then extracted with ether to obtain the ethereal solution of the fatty acids of each group. On evaporating the ether, the fatty acids were obtained in separated groups.

Fatty acid composition of oil

Fatty acid composition of *Mesua ferrea* seed oil (collected from only Rajshahi district) was analyzed as their methyl esters, which were prepared by boron-trifluoride methanol complex method [15]. A GCD PYE Unicam gas chromatograph equipped with a flame ionization detector was used to determine the fatty acid methyl esters. Nitrogen carrier gas was used at a flow rate of 30 mL/min. Fatty acids were separated on a 1.8 x 1/8 i.d. glass column packed with 6% BDS (butanediol succinate polyesters) on solid support Anakorm ABS (100/120) mesh. Analysis was carried out at isothermal column temperature 190 ^{o}C, injector and detector temperatures for all GLC analysis were 230 ^{o}C. Gas chromatographic peaks were identified by comparison with standard methyl esters with respect to retention time and by plotting the log of retention times against equivalent carbon length (ECL). Peaks were measured by Pye Unicam electronic integrator. The percentage of each peak was calculated as the percentage of the total area of all the peaks.

Analysis of Mesua ferrea seeds and leaves

Moisture contents of seeds and leaves were determined by weight loss of the sample on drying at 105 ^{o}C for 5 hours [16]. The sample was charred to a constant weight, the residue being quantified as ash by the method described by Ranganna [10]. Lipid contents of seeds and leaves were estimated by Bligh and Dyer method [13] using a solvent mixture of chloroform and ethanol (2:1 v/v). Total protein contents of seeds and leaves were calculated from total nitrogen by using N x 6.25 after determination of the total nitrogen by micro-Kjeldahl method [17]. Water soluble proteins of leaves and seeds were determined by Folin-Lowry method [18] using bovine serum albumin as the standard. Crude fiber contents of seeds and leaves were estimated by the method of ICOMR [16]. The nitrogen free extracts (NFE) were considered as total carbohydrate and was calculated by the following equation: carbohydrate (g/100 g) = 100 - (moisture + protein + lipid + fiber + ash) g/100 g. On the other hand, energy values of the samples were estimated and expressed in kilocalories by multiplying the percentage of protein, lipid and carbohydrate by the Atwater-Bryant factors 4, 9 and 4, respectively [19].

RESULTS AND DISCUSSION

The solvent extraction of *Mesua ferrea* seed collected from four different districts viz., Naogaon, Dhaka, Rajshahi and Dinajpur yielded average of about 63% oil which is appreciably lower than that of 70% reported in the literature [3]. The physical and chemical properties of the oil purified by normal TLC were determined by conventional methods and the results are given in Table 1 and 2.

Table 1. Physical characteristics of *Mesua ferrea* seed oil.

Characteristics	Name of the districts from where seeds were collected			
	Naogaon	Dhaka	Rajshahi	Dinazpur
Specific gravity at 31 °C	0.9292	0.9287	0.9312	0.9301
Refractive index at 30 °C	1.4739	1.4690	1.4734	1.4720
Solidification point (°C)	– 4.0	– 4.2	– 4.0	– 4.3
Pour point (°C)	– 1.3	– 1.2	– 1	– 1.1
Cloud point (°C)	5.8	6	6	5.5
Flash point (°C)	98	96	95	90
Fire point (°C)	116	114	110	115
Smoke point (°C)	44	43	45	47

As shown in Table 1, specific gravities of seed oils obtained from four different districts Naogaon, Dhaka, Rajshahi and Dinajpur were found to be 0.9292, 0.9287, 0.9312 and 0.9301 at 31 ^{o}C, respectively, which are slightly higher than the values 0.9202 at 32 ^{o}C for *Mesua ferrea* seed oil reported by Chittaranjan [3] and 0.9241 at 30 ^{o}C for *Cassia fistula* seed oil reported by kafuku *et al.* [20]. Refractive index of the oils obtained from Naogaon and Dhaka were found to be 1.4739 and 1.4690 at 30 ^{o}C, respectively, whereas the refractive index of the seed oils obtained from Rajshahi and Dinajpur were estimated to be 1.4734 and 1.4720 at 30 ^{o}C, respectively. These values are slightly differing to each other and are close to those for sunflower seed oil (1.4659-1.4721) at 30 ^{o}C [21] and *Cassia fistula* seed oil 1.4695 at 30 ^{o}C [20]. Thermal properties, i.e. smoke point, flash point, cloud point, etc. of the oil samples of *Mesua ferrea* seed do not appear to be significantly different from each other.

Table 2. Chemical characteristics of *Mesua ferrea* seed oil.

Characteristics	Name of the districts from where seeds were collected			
	Naogaon	Dhaka	Rajshahi	Dinazpur
Iodine value	91.17	93.01	89.17	90.35
Saponification value	200.82	199.03	205.82	206.40
Saponification equivalent	279.35	281.86	272.57	271.80
Acid value	11.87	9.64	10.38	11.13
Free fatty acids (%) as oleic	5.96	4.85	5.22	5.59
Ester value	188.95	189.39	195.44	195.27
Unsaponifiable matter (%)	1.50	1.46	1.48	1.44
Acetyl value	2.70	2.81	2.84	2.79
Peroxide value	3.58	3.60	3.64	3.62
Reichert-Meissl value	5.961	5.871	6.031	5.852
Polenske number	0.7891	0.8104	0.8401	0.8314

As depicted in Table 2, the iodine values of the seed oils of *Mesua ferrea* collected from Naogaon, Dhaka and Rajshahi districts were found to be 91.17, 93.01 and 89.17 followed by Dinajpur district 90.35. Iodine value of the oil collected from Dhaka district was slightly higher than those of the other three samples. Present values are consistent with the literature value 90 for the same oil [4] and are close to that of *Cassia fistula* seed oil 89.47 [20]. The saponification values of the oils in the samples of Naogaon, Dhaka, Rajshahi and Dinajpur were determined to be 200.82, 199.03, 205.82, 206.40 whereas saponification equivalents were calculated from saponification values to be 279.35, 281.86, 272.57 and 271.80, respectively. The experimental values are in good agreement with the value 203.20 reported in the literature [3] and also with the value (197-207) for palm oil [8]. In the present investigation, the acid values of *Mesua ferrea* seed oil collected from Naogaon, Dhaka, Rajshahi and Dinajpur were found to be 11.87, 9.64, 10.38 and 11.13 which are higher than the value 8.8 depicted in the literature [3] and the percentage of free fatty acids were calculated to be 5.96, 4.85, 5.22 and 5.59, respectively, for the same oil. The present results suggest that the *Mesua ferrea* seed oil is not suitable for edible purpose, as the free fatty acid contained in it more than 1.15% [22]. Comparatively lower free fatty acids and saponification values were found in the sample collected from Dhaka district. The ester values of oils in the two samples were estimated to be 188.95 (Naogaon), 189.39 (Dhaka) which are close to each other whereas ester values of oils in the samples collected from Rajshahi and Dinajpur were found to be 195.44 and 195.27, respectively, which are almost similar to each other. The *Mesua ferrea* seed oil present in the samples of Naogaon, Dhaka, Rajshahi and Dinajpur contained 1.50, 1.46, 1.48 and 1.44% unsaponifiable matters, respectively, which are much higher than the values 0.1 % for orange pip oil [8] and 0.800 % for gemsbok oil [23]. Comparatively higher value of unsaponifiable matters indicates *Mesua ferrea* seed oil contains higher amount of sterols, tocopherols, vitamins A and D, hydrocarbons, etc. than those contained in orange pip and gemsbok oils. The acetyl values of seed oils collected from Dhaka, Rajshahi and Dinajpur were estimated to be 2.81, 2.84 and 2.79, respectively, which are slightly higher than the value 2.70 of the sample of Naogaon district and all the values are in the range of cotton seed oil (0.7-4.0) [24]. The oils in the samples of Naogaon, Dhaka and Rajshahi showed the peroxide values of 3.58, 3.60 and 3.64, respectively, followed by 3.62 in case of the sample of Dinajpur district, which were determined in normal laboratory conditions. Reichert-Meissl values of the samples of Naogaon, Dhaka, Rajshahi and Dinajpur districts were assayed as 5.961, 5.871, 6.031 and 5.852, respectively, which are close to the values 6.10 for *Attalea funifera* seed oil [8] and 6.30 for *Attalea spectabilis* seed oil [8]. Polenske numbers of the *Mesua ferrea* seed oils were estimated to be 0.7891 (Naogaon), 0.8104 (Dhaka), 0.8401 (Rajshahi) and 0.8314 (Dinajpur). The oil of the sample collected from Rajshahi district

revealed highest acetyl, peroxide and Reichert-Meissl values and also highest polenske number than those of the samples collected from other three districts.

The total amount of the oil was separated into mono-, di-, and triglyceride fractions by means of column chromatography and the results are given in Table 3. The triglycerides varied from 87.65 to 89.50%, diglycerides from 2.12 to 2.32% and monoglycerides from 1.05 to 1.35%. From the results, it is seen that no appreciable change in triglyceride composition accounted for about 88.27% (average) of the total weight of oil, among the four samples (Naogaon, Dhaka, Rajshahi and Dinajpur) was noticed. Highest amount of triglycerides was observed in the oil of the sample collected from Dhaka region (about 89.50%). Moreover the total recovery of glyceride was about 91.70% (average) that indicated *Mesua ferrea* seed oil contained a higher amount of nonglyceride (8.30%) whereas rice bran oil contained 5.20 to 5.90% nonglyceride [25] and pumpkin seed kernal oil contained 1.50% nonglyceride [26].

Table 3. Glyceride composition of *Mesua ferrea* seed oil (weight %).

Name of the districts from where seeds were collected	Monoglyceride	Diglyceride	Triglycerides
Naogaon	1.14	2.22	88.19
Dhaka	1.05	2.12	89.50
Rajshahi	1.25	2.27	87.77
Dinazpur	1.35	2.32	87.65

Fractionation of *Mesua ferrea* seed lipids by silica gel column chromatography into neutral lipids, glycolipids and phospholipids amounted to 89.83-92.18%, 3.65-4.15% and 1.98-2.68%, respectively (Table 4). The results also indicated that neutral lipids in all the four samples were found to be over 89% of the total weight of the lipid. On the other hand, neutral lipids were found to be highest in the sample collected from Naogaon and lowest in the sample collected from Dhaka. The saturated and unsaturated fatty acids present in the oil were separated by lead salt ether method and varied from 27.40-29.11% and 65.85-68.31%, respectively, depending upon the areas from where the seeds were collected (Table 5). No appreciable differences in unsaturated fatty acids of the oil in two samples collected from Naogaon (67.13%) and Dhaka (67.58%) districts and of saturated fatty acids in two samples collected from Rajshahi (28.19%) and Dinajpur (28.45%) districts were noticed.

Table 4. Lipid composition of *Mesua ferrea* seed lipid (weight %).

Name of the districts from where seeds were collected	Neutral lipids	Glycolipids	Phospholipids
Naogaon	92.18	3.65	1.98
Dhaka	89.83	4.15	2.39
Rajshahi	91.30	3.75	2.68
Dinazpur	91.61	3.87	2.38

Table 5. Percentage of saturated and unsaturated fatty acids.

Name of the districts from where seeds were collected	Saturated fatty acids	Unsaturated fatty acids
Naogaon	27.40	67.13
Dhaka	29.11	67.58
Rajshahi	28.19	65.85
Dinazpur	28.45	68.31

Fatty acid composition of *Mesua ferrea* seed oil (collected from only Rajshahi district) was determined by GLC and is presented in Table 6. It was found that *Mesua ferrea* seed oil contained the highest amount of oleic acid 55.93% while linoleic acid, stearic acid and palmitic acid contents were found to be 13.68%, 14.19% and 10.87%, respectively. Besides these fatty acids, the oil also contained small amount of myristic acid (2.13%) and arachidic acid (2.92%). The GLC data also indicated that the *Mesua ferrea* seed oil contained mainly unsaturated fatty acid 69.61%, while saturated fatty acid was found to be 30.11%. Percentage composition of saturated and unsaturated fatty acids is in good agreement with the results as obtained by the method of separation of saturated and unsaturated fatty acids depicted above.

Table 6. Fatty acid composition of *Mesua ferrea s*eed oil.

Retention time	Fatty acids	Relative percentage (%)
16.63	Myristic acid (C_{14} : 0)	2.13
21.70	Palmitic acid (C_{16} : 0)	10.87
25.72	Linoleic acid (C_{18} : 2)	13.68
25.86	Oleic acid (C_{18} : 1)	55.93
26.48	Stearic acid (C_{18} : 0)	14.19
30.92	Arachidic acid (C_{20} : 0)	2.92

Biochemical compositions of *Mesua ferrea* seeds and leaves collected from four different districts viz., Naogaon, Dhaka, Rajshahi and Dinajpur of Bangladesh were determined and the results are given in Table 7 and 8. From Table 7, it is found that *Mesua ferrea* seeds contained moisture 4.02-5.05 g % which were lower than those of 7.81 g % for *Cassia fistula* seed [27] and of 7.00 g % of *Hydnocarpus kurzii* seed [28]. Lowest moisture content was found in the sample collected from Naogaon district whereas highest moisture content was obtained in the sample of Dhaka district. *Mesua ferrea* seeds contained total lipids 66.91-70.23 g % which are much higher than the values 4.00 g % of *Cassia fistula* seed [27] and 9.58 g % of *Xylopia aethiopica* seeds [29] and the ash contents (1.46-1.50 g %) as determined from the seeds are lower than the values 4.62 g % of *Teramnus labialis* seed reported by Viswanathan *et al*. [30] and 4.00 g % for *Hydnocarpus kurzii* seed reported by Faruk *et al*. [28] Total protein of *Mesua ferrea* seeds was constituted to be 6.99-7.19 g % in which 2.98-3.11 g % of it was water soluble. The present experimental value for total protein is close to the value 7.12 for *Attalea cohune* seed [8] and is much lower than those of 27.50 g % for *Vicia faba* seed [31] and of 22.86 g % for *Teramnus labialis* seed [30]. Starch contents were determined and found to be 5.51-5.85 g %, are comparable to 5.52 g % for loofah seed [32]. Among the samples, the sample of Rajshahi district contained highest amounts of total protein and starch. Crude fiber and carbohydrate contents of *Mesua ferrea* seeds were estimated to be 1.22-1.98 g % and 15.88-18.68 g %, respectively. Crude fiber content as assayed from *Mesua ferrea* seeds is much lower than those of 4.68-6.92 g % for *Cassia hirsuta* seeds [33] and of 8.66 g % for *Xylopia aethiopica* seeds [29] whereas carbohydrate content as estimated from *Mesua ferrea* seeds is much lower than those of *Xylopia aethiopica* seeds (63.65 g %) reported by Barminas *et al*. [29] and *Cassia fistula* seed (50.36 g %) reported by Roskoski *et al.* [34]. Energy values (700.55-724.15 kcal/100 g) calculated for *Mesua ferrea* seeds are higher than that of *Cassia hirsuta* seeds (370.57-390.90 kcal/100 g) [33] and of *Teramnus labialis* seed (378.94 kcal/100 g) [30] and the sample collected from Naogaon district was found to be highest than those contained in the other three samples.

Table 7. Major proximate nutritional compositions of *Mesua ferrea* seeds.

Parameters	Name of the districts from where seeds were collected			
	Naogaon	Dhaka	Rajshahi	Dinazpur
Moisture (g %)	4.02	4.22	4.32	5.05
Ash (g %)	1.48	1.50	1.46	1.47
Lipid (g %)	70.23	67.30	68.17	66.91
Total protein (g %)	7.14	6.99	7.19	7.02
Water soluble protein (g %)	3.11	2.98	3.09	3.12
Starch (g %)	5.71	5.77	5.85	5.51
Crude fiber (g %)	1.25	1.31	1.22	1.98
Total carbohydrate (g %)	15.88	18.68	17.64	17.57
Energy value (Kcal./100 g)	724.15	708.38	712.85	700.55

From the above results, it is seen that *Mesua ferrea* seeds contained higher amount of total lipid and lower amount of other nutritional compositions than some common plant seeds as compared above. It may be concluded from the findings that *Mesua ferrea* seeds may, therefore, be used as a rich source of lipid and a good source of protein also.

On the other hand, as shown in Table 8, *Mesua ferrea* leaves contained moisture 65.12-72.19 g %, ash 2.60-2.71 g % and total lipid 2.32-2.44 g %. The highest values of moisture and total lipid contents were obtained in the sample collected from Dinajpur district whereas the highest amount of ash was observed in the sample of Rajshahi district. Lowest amounts of moisture and ash were noticed in the sample of Dhaka district. Moisture and ash contents of *Mesua ferrea* leaves are lower than those of *Pterocarpus mildbraedii* leaves (85.12 g %) reported by Akpanyung *et al*. [35] and healthy mulberry leaves (3.05-3.40 g %) as depicted by Tang Md. Abul Kashem [36], respectively. Total protein and water soluble protein of *Mesua ferrea* leaves were constituted to be 4.23-4.85 g % and 1.47-2.01 g %, respectively. The sample of Naogaon district contained highest amount of total protein (4.85 g %) followed by Dinajpur (4.75 g %), Dhaka (4.40 g %) and Rajshahi (4.23 g %). The present values are nearest to that of 4.08-4.62 g % for healthy mulberry leaves [36]. Starch and crude fiber contents were assayed to be 3.06-3.27 g % and 3.12-3.29 g %, respectively. The sample of Naogaon district contained highest percentage of crude fiber whereas the amount of starch was determined to be highest in the sample of Dhaka. Total carbohydrate and calorie contents of leaves were determined to be 14.82-22.30 g % and 100.24-128.40 kcal./100 g, respectively and the sample collected from Dhaka district was assayed to be highest than those contained in the other three samples.

Table 8. Major proximate nutritional compositions of *Mesua ferrea* leaves.

Parameters	Name of the districts from where leaves were collected			
	Naogaon	Dhaka	Rajshahi	Dinazpur
Moisture (g %)	70.25	65.12	69.44	72.19
Ash (g %)	2.61	2.60	2.71	2.68
Lipid (g %)	2.33	2.40	2.32	2.44
Total protein (g %)	4.85	4.40	4.23	4.75
Water soluble protein (g %)	2.01	1.47	1.84	1.80
Starch (g %)	3.14	3.27	3.06	3.12
Crude fiber (g %)	3.29	3.18	3.21	3.12
Total carbohydrate (g %)	16.67	22.30	18.09	14.82
Energy value (Kcal./100 g)	107.05	128.40	110.16	100.24

However, the results, as estimated above, in the analysis of *Mesua ferrea* seed oil and in the nutritional compositions of its seed and leaves imply that the results differ to some extent but not significantly enough with the location from where samples were collected. This variation may be possible due to the compositional variation in the soil and climatic conditions as well as on the nature of rainfall of the places from where the seed/leaves were collected. Similar comments on the analysis of rice bran and its oils collected from different rice growing districts of Bangladesh were made by Rahman *et al*. [6].

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