



The Fatty Acid Composition and Properties of Oil Extracted from Fresh Rhizomes of Turmeric (*Curcuma longa* Linn.) Cultivars of Bangladesh

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Abstract

The fresh rhizomes of *Curcuma longa* Linn. (Turmeric or Holud) collected from three different places of Bangladesh were investigated to extract oil, its fatty acid composition and its physico-chemical properties. The rhizomes contained 8.76 - 10.92% oil. The percentage compositions of fatty acids were identified and quantified by GLC. The saturated and unsaturated fatty acid contents of three places were found to vary within 22.25 - 23.44% and 76.11 - 77.59%, respectively. Among identified six fatty acids, oleic acid contributed the highest proportion (56.24 - 58.88%), followed by myristic acid (16.25 - 17.71%); whilst, palmitic (5.59 - 6.00%), linoleic (10.90 - 12.82%), linolenic (4.15 - 5.46%) and eicosenoic acid (2.72 - 3.25%) together contributed the rest. Physico - chemical properties of the extracted oil were also investigated. The specific gravity, refractive index, optical rotation were recorded as 0.892 to 0.919 at 30°C, 1.431 to 1.465 at 30°C and +11.54° to +13.56° at 26°C, respectively. The chemical properties like saponification value (195.23 - 205.33), iodine value (75.53 - 90.47), peroxide value (23.25 - 36.16), acid value (11.08 - 11.32), ester value (56.30 - 64.13) and percentage of unsaponifiable matter (8.31 - 15.04%) were determined. Overall fresh Turmeric oil can be considered as a good source of oleic acid.

Keywords: *Curcuma longa*, Fresh turmeric oil, Fatty acid composition, Oleic acid, Gas liquid chromatography.

Introduction

Curcuma longa Linn. (*Zingiberaceae*, Turmeric or Holud) is a rhizomatous perennial herb and its medicinal extract is called curcumin. Curcumin has been traditionally used as a good source of coloring matter for foods, cosmetics, textiles and as a medicinal ingredient in formulations of the several medicines for ailments from jaundice, other liver disorder, ulcers, parasitic infections, various skin diseases, sprains, inflammation of the joints, cold and flu (Anonymous, 1950). It possesses anti-inflammatory, hepatoprotective, antimicrobial, anticancer, antitumor, blood purifying, stomachic, anti-septic and anti-viral activities (Anonymous, 1950; Yusuf *et al.*, 1994; Simal, 1997; Ghani, 2003, Shaha, 1997). Curcumin also possesses the remarkable activities of preventing or treating alzheimer disease, immunomodulation and correcting cystic fibrosis defects (Balasubramaniam, 2006; Ringman *et al.*, 2005; Egan *et al.*, 2004). The rhizome oil of *C. longa* L. oil is also used as scenting agents in detergents, soaps, air fresheners and insect repellents, intermedi-

ate in the synthesis of perfume chemicals and as a pharmaceutical aid (Bakowski and Michalik, 1986).

Holud (Turmeric) grows abundantly in India, Indonesia, Srilanka and Cambodia; whilst in Bangladesh it grows at Sreemongal, Bogra, Joydebpur, Comilla, Satkhira, Chittagong, Barisal and Khulna. Though enormous work have been done on various activities of *C. longa* (Joshi *et al.*, 2003; Kitsupa *et al.*, 2004), no work has been found in literature on the fatty acid composition of the oil of the Bangladeshi fresh rhizomes of *C. longa* L. and its physico - chemical properties. Hence the present investigation was carried out to (a) estimate the chemical composition of the extracted rhizomes oil, (b) compare the quality and quantity of fatty acids and (c) evaluate whether the oil could be used in edible purpose and as pharmaceutical aid.

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Materials and Methods

Plant materials

The fresh rhizomes of Turmeric were collected from Shamnagar (Sathkhira); Jalalabad (Sylhet) and Lalmy (Comilla). The rhizomes were harvested in March, 2009. The samples were cleaned to separate from dirt, sun-dried, steam-distilled to remove essential oil and again sun-dried.

Extraction

The steam distilled sun-dried samples were powdered by a warring blender. About 100 g of powder were then extracted with petroleum ether (b.p. 40 - 60°C) in a Soxhlet apparatus for 72 h for each variety with three replications. The extract was first filtered and then vacuum distilled to remove solvent completely. The yield of oils were calculated and stored in a refrigerator for further analyses using (Official Methods of Analysis, 1984).

Physico-chemical study of the oil

The physico - chemical properties of the extracted Turmeric oils were investigated with three replications for a particular variety as per cited standard methods (Official Methods of Analysis, 1984; A Manual of Lab. Tech., 1976; British Pharmacopoeia, 2004; Kirk and Sawyer, 1991).

Identification and quantification of fatty acids

The fatty acid contents (qualitative and quantitative) were determined by GLC of methyl esters. The fatty acid methyl esters (FAMES) were prepared by complete esterification (checked by TLC) of oil using $\text{BF}_3\text{-MeOH}$ complex (Official Methods of Analysis, 1984; Metcalfe *et al.*, 1966; Bannon *et al.*, 1982; Saleh-E-In and Roy, 2007). Standard FAMES (E. Merck) were used for the identification and quantification of the peaks.

For methylation, the lipid was at first, saponified with alcoholic sodium hydroxide, then cooled and diluted with water. After evaporation of alcohol, the acidified aqueous mixture was extracted with ether. Ether was then removed from ethereal solution to get fatty acid mixture. The fatty acid mixture was esterified with $\text{BF}_3\text{-MeOH}$ complex. After esterification, the reaction mixture was dissolved in diethyl ether in a separating funnel and was washed with dilute sodium carbonate solution until the effervescence was ceased. It was then

washed with water, dried over anhydrous sodium sulphate and finally ether was removed to get methyl ester mixture (Official Methods of Analysis, 1984; Metcalfe *et al.*, 1966; Bannon *et al.*, 1982; Saleh-E-In and Roy, 2007).

Instrument and separation conditions

The FAMES were analyzed on a Trace GC ULTRA, Thermo Electron Corporation, Gas Chromatograph fitted with a flame ionization detector and an electronic integrator. An SE-54 quartz capillary column (30 m \times 0.25 mm *i.d.* and 0.25 μm film thicknesses) packed with 10% diethylene glycol succinate on 100-200 mesh solid support was used. Nitrogen was used as carrier gas at a flow rate of 1.5 mL/min. The separation was affected at 100°C-220°C. The following temperature program was chosen in GC analyses: Initial temperature 150°C, increasing at 7°C/min to 260°C for 30 min. The oven, injection and detection temperatures were fixed at 150°, 180° and 220°C respectively. The fatty acids were identified by comparison of relative retention times and peak positions of the chromatogram with that for the standard FAMES. The amounts of fatty acids were calculated from the peak areas computed by LKB 2220 electronic recording integrator.

Results and Discussion

The comparative results of the physico-chemical properties and fatty acid compositions of fresh Turmeric rhizomes oil of different places of Bangladesh are presented in Tables I and II, respectively. Turmeric rhizomes contained 8.76 to 10.92% fatty oil. The amounts of oils extracted were 8.76%, 10.51% and 10.92% in Sahmnagar, Lalmy and Jalalabad samples, respectively.

Regarding physical properties, the oils were homogenous, opaque, almost liquid and yellowish colored with a characteristics odor of turmeric having mild but not pungent taste. It was freely miscible in chloroform, carbon tetrachloride, petroleum ether, n-hexane, diethyl ether and alcohol but immiscible with water.

The optical rotations were measured as +11.54° to +13.56° at 26°C. The refractive indices (RI) of the oils were found from 1.431 to 1.465 at 30°C. The refractive indices indicated that the oil contained fairly large amount of long chain unsaturated fatty acids (Mabaleha *et al.*, 2004; Ali *et al.*, 1998; Saleh-E-In and Roy, 2007).

Table I: Physico-chemical properties of *C. longa* (Turmeric) rhizomes of different regions of Bangladesh

Characteristics	Values in the sample of		
	Shamnagar, Sathkhira	Jalalabad, Sylhet	Lalmy, Comilla
Oil yield (%)	8.76±0.25	10.92 ± 0.13	10.51 ± 0.53
Appearance at room temperature 30°C	A homogenous, opaque, almost liquid with yellowish in color and lighter than water		
Odor and taste	Characteristics odor of Turmeric having mild but not pungent taste		
Miscibility and solubility	Insoluble in water but freely miscible in chloroform, carbon tetrachloride, pet-ether, n-hexane, diethyl ether and alcohol		
Specific gravity at 30°C	0.892 ± 0.037	0.919 ± 0.027	0.896 ± 0.022
Refractive index $[\eta]^{30^\circ\text{C}}$	1.431 ± 0.023	1.465 ± 0.091	1.450 ± 0.097
Optical rotation $[\alpha]_D^{26^\circ\text{C}}$	+11.54° ± 0.20	+11.96° ± 0.10	+13.56° ± 0.04
Acid value	11.08 ± 0.50	11.32 ± 0.26	11.14 ± 0.36
Ester value	58.13 ± 0.60	56.30 ± 0.39	64.13 ± 0.35
Saponification value (mg KOH/g)	195.23 ± 0.59	205.33 ± 0.54	199.57 ± 0.36
Unsaponifiable matter (%)	10.59 ± 0.35	15.04 ± 0.79	8.31 ± 0.86
Iodine value (Hanus method)	90.47 ± 0.99	80.32 ± 0.76	75.53 ± 0.65
Peroxide value	23.25 ± 0.30	36.16 ± 0.30	27.07 ± 0.35

* Each value represents the average of three replicate analyses ± SD

Table II: Fatty acid composition (in wt %) of *C.longa* (Turmeric) rhizomes of different regions of Bangladesh determined by GLC

Name of fatty acid	Values in the sample of		
	Shamnagar, Sathkhira	Jalalabad, Sylhet	Lalmy, Comilla
Myristic (C _{14:0})	16.25 ± 0.23	16.76 ± 0.23	17.71 ± 0.09
Palmitic acid (C _{16:0})	6.00 ± 0.13	5.59 ± 0.35	5.73 ± 0.61
Oleic acid (C _{18:1})	58.88 ± 0.51	56.24 ± 0.18	56.99 ± 0.61
Linoleic acid (C _{18:2})	10.90 ± 0.41	12.82 ± 0.31	11.91 ± 0.32
Linolenic acid (C _{18:3})	4.15 ± 0.33	5.46 ± 0.32	4.49 ± 0.65
Ecosenoic acid (C _{20:1})	3.25 ± 0.39	3.07 ± 0.31	2.72 ± 0.13

* Each value represents the average of three replicate analyses ± SD

The specific gravity of the oils (0.892 - 0.919 at 30°C) indicated that the oil contained higher molecular weight fatty acids similar to those existing in olive oil (0.914 - 0.918) and cotton seed oil (0.917 - 0.918) (Meyer, 1987; Lange, 1944; Mowla *et al.*, 1990; Ching, 2000).

Properties of the oil such as acid value, iodine value and saponification value usually give the structural, stability and quality information about the oils (Saleh-E-In and Roy, 2007). Saponification values were found within 195.23 to 205.33 mg KOH/g indicating the presence of higher molecular weight fatty acids in oils. High molecular weight fatty

acids are not good for human health. In that sense, fats or oils having low saponification number should be preferred (Meyer, 1987). The saponification values were quite similar to the range of olive oil (185 - 196), palm oil (200 - 205) and cotton seed oil (194 - 196) (Meyer, 1987; Lange, 1944; Mowla *et al.*, 1990; Ching, 2000; Jacobs, 2006; Nollet, 2004), representing typical C₁₆ and C₁₈ oils.

The extracted fatty oils had the iodine value within 75.53 to 90.47 which were almost similar to those for olive oil (76 - 90) and safflower oil (85 - 93) (Meyer, 1987; Lange, 1944; Ching, 2000; Jacobs, 2006; Nollet, 2004). Iodine value is a

measure of the degree of unsaturation of fatty acids content of any fat or oil (as the value increases unsaturation increases). So, the result indicates that the oil possesses high unsaturation (Saleh-E-In and Roy, 2007). Therefore, the extracted oil possesses high proportion of higher unsaturated fatty acids.

Acid values of turmeric fatty oils were found to vary from 11.08 to 11.32 indicating that the proportion of free fatty acid content were very high than those in edible oils like soybean oil (0.38 - 0.54), mustard oil (3.65 - 4.5) and palm oil (0.17 - 1.06) (Meyer, 1987; Lange, 1944; Mowla *et al.*, 1990; Ching, 2000; Jacobs, 2006; Nollet, 2004). If the concentration of free fatty acid in a fat or oil is very high then the oil is hazardous for human health (Saleh-E-In and Roy, 2007). So, this oil cannot be used for edible purpose directly. However, it may be used for edible purpose after refining or for industrial purposes.

Ester numbers and peroxide values were found within 56.30 - 64.13 and 23.25 - 36.16, respectively. Peroxide value showed that the oil had much free active oxygen enabling autoxidation of the oil (Mowla *et al.*, 1990; Jacobs, 2006).

Unsaponifiable matter contents (8.31 - 15.04%) which were very much higher than those in any other edible or non-edible oils like soybean oil (0.015%), rapeseed oil (0.02%), sesame seed oil (0.02%) and palm oil (0.012%) (Nollet, 2004; Mowla *et al.*, 1990; Jacobs, 2006). This oil is supposed to be contaminated with mineral oil, higher aliphatic alcohols, sterols, pigments, hydrocarbons and sufficient amount of tocopherols (Patterson, 1983; Ali *et al.*, 1998; Mowla *et al.*, 1990; Jacobs, 2006). Tocopherols play important role as antioxidant (Patterson, 1983; Ali *et al.*, 1998). The investigation on drying property indicated that the extracted oils were of non-drying in nature.

GLC analyses showed that oleic acid (56.24 - 58.88%) was the major fatty acid found in the extract and the saturated fatty acids present in the oil sample were mainly myristic acid (16.25 to 17.71%) and palmitic acid (5.59 to 6.00%). Other unsaturated fatty acids were linoleic acid (10.90 to 12.82%), linolenic acid (4.15 to 5.46%) and eicosenoic acid (2.72 to 3.25%). The oleic acid percentage was comparable to those in olive oil (55 - 83%) and safflower oil (79.7%). On the other hand, the palmitic acid content was almost comparable to that in safflower oil (5.5 - 6.5) (Nollet, 2004; Meyer, 1987; Lange, 1944; Mowla *et al.*, 1990; Ching, 2000).

Healthful fats are lower saturated and higher mono-unsaturated fatty acid containing. Poly-unsaturated such as linolenic acid containing fats are prone to oxidation; whilst a high oleic acid helps to reduce the raised level of total plasma cholesterol without reducing the high density lipoprotein (HDL) cholesterol level (Francie *et al.*, 1995).

As common vegetable oils usually contain 6 -15% saturated fatty acids (Norton, 1989; Golfman and Bohme, 2001; Kamal Eldin and Yanishlieva, 2002) and fresh Turmeric rhizomes oil contain 22.25 to 23.44% saturated fatty acids of the total oil, so it is slightly higher in respect of the lower limit of the said percentages range but it is comparatively better for human consumption owing to its high percentages of the unsaturated fatty acids (76.11 to 77.59%) especially the oleic acid (56.24 to 58.88%) content.

Conclusion

Demand of quality oils and fats is increasing all over the world. To cope with the increasing demand of oils and fats the non-conventional sources are getting importance. The present study shows that fresh Turmeric rhizomes contain 8.76 to 10.92% fatty oil and this oil is better than other vegetable oils with respect to health benefit. The fatty acid composition of the extracted oil is found in good agreement with the content of unsaturated acids (56.24 to 58.88% oleic acid). But the deviation in the content of saturated acids is noticeable. It is concluded that Turmeric rhizomes of Bangladeshi origin has suitable nutritional properties and therefore, may be used as edible oil after proper refining. Otherwise, the extracted oil may be tapped as a source of oleic acid and myristic acid with an aim to be used in the food and pharmaceutical industries.

Acknowledgement

Authors are thankful to the Director, F. Begum (P.S.O), K. Nada (P.S.O), J. Rahman (S.S.O), S. M. M. Hasan (S.O), S. Ajij (S.O), M. M. Hossain (S.O), S. Ahmed (S.O), F. Jahan (R.C), M. M. Hossain (Jr. Tech.) and T. Islam (Jr. Tech.) of BCSIR Laboratories, Dhaka.

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Received : April 05, 2009;

Accepted : August 04, 2010