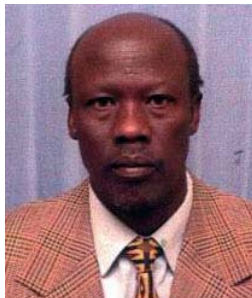


FATTY ACIDS IN THE NUT OF THE TURKANA DOUM PALM (*HYPHAENE CORIACEA*)

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ABSTRACT

The doum palms are important noncultivated fruit-plants in the arid and semiarid districts of Turkana, Samburu and Marsabit of Kenya. The plant has many domestic and commercial uses. However, despite the central place it occupies in the diets of all pastoral age groups living along the banks of the major rivers, its fatty acid profile is lacking in the literature. This study was conducted in order to document its lipid profile. Lipid extracts of the nut of the Turkana doum palm, *Hyphaene coriacea*, were obtained and the major fatty acids in the mesocarp and kernel oil extracts were determined. It was shown that the nut has an oil content of 0.4 and 10.3% in the mesocarp and kernel, respectively. The kernel and mesocarp lipid extracts contained 55 and 66% long-chain saturated fatty acids, C₁₂-C₁₆, and 76 and 66% total saturated fatty acids, respectively. The predominant fatty acids in declining order are lauric, oleic, myristic, palmitic and linoleic acid in the mesocarp, and lauric, oleic, capric, myristic, palmitic, linoleic and caprylic in the kernel. Both kernel and mesocarp oil extracts contained traces of stearic acid and no linolenic acid. Its hexane extract is therefore a typical lauric oil. The kernel oil extract had total monounsaturated fatty acids/total saturated fatty acids, total polyunsaturated fatty acids/total saturated fatty acids and total unsaturated fatty acids/total saturated fatty acids ratios of 0.29, 0.03 and 0.31, respectively. Due to the higher unsaturation, the oil extracts of the Turkana doum palm nut may be less stable with respect to oxidative deterioration than coconut and palm kernel oils. The knowledge of the nutrient composition of indigenous food plants such as the Turkana doum palm is important for the purpose of educating the public on the nutritional value of indigenous food plants available in their localities and for the purposes of conservation. The fatty acid profile of the lipid extracts of the nut of the plant showed that “eengol” is more unsaturated than coconut and palm kernel oils due to its higher oleic acid content. In this respect, it may be healthier to consume it in comparison to coconut and palm kernel oils.

Keywords: *Hyphaene coriacea*, Turkana, fatty acids

INTRODUCTION

Palms belong to the family *Palmae* (*Areceaceae*), which is made up of over 217 genera and 2500 species [1]. Among the palms are the African doum palms, represented by the genus *Hyphaene*, the plant of interest in the current study. All the palms in the family *Palmae* are chiefly tropical trees with a long columnar trunk bearing large extensive pinnate or palmate leaves [1]. The Turkana doum is costapalmate with an extensive aerial branching of its leaves [2]. It belongs to the African doum palms, which thrive naturally in many countries of tropical and subtropical Africa [3, 4]. The African doum palms are also found in the drier parts of South Africa, Namibia, Burkina Faso, Guinea Bissau, Guinea, etc. [1]. The date tree (*Phoenix dactylifera*) is a member of the palm family in North Africa and in many countries of the Middle East including Iraq, Iran and Israel. *Hyphaene compressa* and *H. coriacea* are the two species of the African doum palm that are found in Kenya, although there are approximately 26 species of the *Hyphaene* genus in Africa currently [4].

The fruits are oval, shiny, and red to orange in colour, with an average length and diameter of 6 and 5 cm, respectively [2]. The pericarp and the outer coat of the endocarp are inedible, while the mesocarp and kernel flesh are edible. The energy available from consumption of the edible portions of the nut is approximately 1300 Kcal/100 g [2]. The local people commonly use the name “eengol” to refer to both the doum palm tree and its fruit. In the current experiment, the lipid extracts from the mesocarp and kernel were obtained and the oil content determined. Both the kernel and mesocarp oil extracts were used to determine the fatty acids in the two edible portions of the fruit. No reports of the fatty acids profile in the nut of the species *Hyphaene compressa* or *H. coriacea* were found in the literature.

The Turkana doum palm plays many social and commercial roles in Turkana district. The stems of the tree are used as building material for housing, while the leaves are used as thatch for roofing houses and for making a large range of household items that include sleeping mats, carpets and table mats. One of the best selling handicrafts that are made from the leaves of the Turkana doum palm are laundry baskets which are merchandized in many urban centres in Kenya. There are indications that the unsustainable use of the plant over the last three decades has led to deforestation in many riverine areas formerly occupied by groves of the Turkana doum palm. There is a public realization that the loss of the Turkana doum palm could be disastrous for Turkana district, and, therefore, there is an apparent need to provide information on the various benefits of sustaining the plant in order to spur conservation efforts [2].

Due to the key role the Turkana doum palm plays in the commerce and the food supply in the Turkana District of Kenya, this study was done in order to determine the fatty acid composition of the nut to provide consumers with knowledge of its lipid composition. Also, studying the nature of fatty acids in the lipid extracts of eengol was important not only for Turkana, but also for other tropical areas of Africa, where members of the genus *Hyphaene* grow, and are used for food. This is also likely to be the first report of the fatty acids in the species *Hyphaene coriacea*, as the fatty acids profile of the nut of the plant were not available in the literature, although Hoebekke [5] provides the proximate composition and the content

of the minerals calcium, phosphorus and iron in the mesocarp of *H.compressa*, but not the free fatty acids profile.

MATERIALS AND METHODS

A reference standard of known fatty acids methyl esters (FAME) extracts can aid the identification of constituent fatty acids in a food sample. The nature of fatty acids in the lipid extract of our study was determined by gas liquid chromatography (GLC) by comparing the relative retention time of the eluants from ‘eengol’ food products, with the retention time of similar fatty acids in the standard mixture of known fatty acids. A standard pure soybean oil containing about 10 µg/mL of fatty acids was esterified and run through a GLC to identify the elution times of its constituent fatty acids at a temperature of 200 °C at the injector port, a column temperature of 170 °C and a detector temperature of 250 °C. A sample of the esterified mesocarp and kernel oil extracts of “eengol” were run under similar GLC conditions to give an idea of the nature of fatty acids in the samples relative to those in the soybean oil. After ascertaining the nature of fatty acids in the test samples a standard mixture of 8:0, 10:0, 12:0, 14:0, 16:0, 18:0, 20:0 and 16:1, 18:1, 18:2 and 18:3 (Department of Food Biosciences, University of Reading, Reading, U.K.) containing 10 ppm of each fatty acid was provided to test the efficiency of recovery. Pentaenoic and heptanoic acid (Sigma Chemical Co., Aberdeen, UK) were used as internal standards during fatty acid analysis.

Sample acquisition and storage

The sun-dried ripe fruits of the Turkana doum palm were shipped from Kenya by air to the Food Chemistry Laboratory at the Department of Food Biosciences, at the University of Reading in the United Kingdom. Ten days prior to the flight from Kenya to the United Kingdom (U.K.), doum palm materials were bought in the open-air market in Lodwarr, a town located in the Turkana District of Kenya, and stored at -10 degrees Celsius (°C) in the Food Chemistry Laboratory, Department of Dairy, Food Science and Technology at the Egerton University in Kenya. After the arrival of the doum palm materials in Reading in the U.K., they were stored at -20 °C until required for lipid extraction and fatty acid analysis. All chemicals used for the various analyses were analytical grade (Merck, Darmstadt, Germany) unless otherwise stated.

Sample preparation

The red-coated fruits of the Turkana doum palm were scrapped with a hand rasp to remove the epicarp and expose the mesocarp. About 30 grammes (g) of the mesocarp from each of the four fruits was sliced off using a knife, and ground at high speed in a Waring blender (Model 32BL60, AS Catering Co., Dorset, England) for a minute. The nut was broken up to remove the kernel. The slices from the kernel were not blended to avoid the loss of oil during the blending process. Instead, they were cut into very thin slices on grease-proof paper and used for lipid extraction.

Lipid extraction

The standard International Union of Pure and Applied Chemistry (IUPAC) Method 2.302 was used for lipid extraction in the current experiment [6]. About 4 x 10 g samples each containing the mesocarp powder (“apinet”) and the kernel, were measured into thimbles

containing cotton wool, and were placed into 250-millilitre (mL) extraction flasks held in a lipid extraction electric assembly (Model BBHS, Grant Boekel, Bournemouth, England). One hundred and fifty mL analytical grade hexane (boiling point 60 °C) was added into each pre-weighed extraction flask. The samples were refluxed at gentle boiling for two hours. This was followed by re-extraction for two hours. The lipid extracts in the pre-weighed extraction flasks were evaporated in a rotary vacuum evaporator (Model RE300, Esslab, Essex, England) to remove the solvent, and dried in an air oven (Model 579, Elite Thermal Systems, Leicestershire, England) at 105 °C for two hours to constant weight. The lipid extracts were cooled in desiccators for about one hour before the flasks were weighed. The main lipid content (%) resulted from the mean weight of the four extracts obtained from the samples of the mesocarp powder (“apinet”) and the slices of the kernel. The lipid extracts were used to determine the fatty acids profiles in the Turkana doum palm nut.

Esterification

The esterification of the lipid extracts obtained in this particular study was conducted according to the steps of the IUPAC Method 2.302 [6]. Three x 50 milligrammes (mg) lipid extracts (3 samples of each, the mesocarp flesh and the kernel) were dissolved in test tubes containing one mL of tetrahydrofuran and stored in a fume cupboard. Twenty 20 microgrammes (µg) of the internal standard mixture comprised of pentaenoic and heptaenoic acid was applied to each tube. Five mL of 0.5 molar (M) sodium methoxide in anhydrous methanol was added to each of the test tube mixtures, agitated, and kept in a water-bath maintained at 50 °C for 10 minutes. One mL of glacial acetic acid was added, followed by the addition of 5 mL of deionized distilled water and agitated. The esters (2 x 5 mL) from each test tube were extracted with hexane using a Pasteur pipette to separate the two layers. The top layer derived of hexane was dried on anhydrous sodium sulphate containing 10% of solid potassium bicarbonate and filtered through a Büchner funnel, before the solvent was removed in a rotary evaporator under reduced pressure. The methyl ester extract mixtures were combined for each of the two samples and the fatty acid methyl esters (FAME) were stored in brown, 50-mL volumetric flasks at -20 °C until needed for injection into the gas liquid chromatograph (GLC) (Model 204, Pye Unicam, Cambridge, England) for separating and identifying the constituent fatty acids.

Percentage recovery of esterified fatty acids in standards and “eengol”

Standard curves of standard esterified saturated fatty acids 8:0-20:0 and 16:1, 18:1, 18:2 and 18:3 were prepared within a range of 1-50 parts per million (ppm) of each fatty acid. The data were used for linear regression analysis and correlation coefficients of 0.96-0.98 were obtained. To test for the efficiency of recovery of sample extracts and the standards, duplicate samples of a standard mixture containing 10 ppm of each fatty acid were esterified and extracted separately with and without the test samples. The chromatographic peak areas of the FAME of each fatty acid in the standard mixture (see the GLC method described below) were compared with their peak areas in the FAME from the spiked test samples. Unspiked “eengol” products’ were esterified, extracted and run through the GLC as the controls. The percent recoveries of the FAME of the standard fatty acids mixture ranged between 92 and 97%, while recoveries of 99% were achieved for the pentaenoic and heptanoate standards.

Identification of fatty acids by GLC

Three x 20 microlitres (μL) each of the two FAME sample extracts were injected into the GLC separately. The GLC was operated at a temperature of 200 °C at the injector port, the column temperature was maintained at 170 °C and the detector temperature at 250 °C. The Perkins 6 ft long, 4 mm i.d. glass column (Model 3920 Perkins Elmer, Boston, Mass., USA) used for the GLC, contained a stationary phase of 10% diethyl glycol succinate (DEGS) adsorbed on chromosorb W (100-120 mesh). The column was acid washed and silanised. The mobile phase was nitrogen gas run at 45 mL per minute. The rest of the GLC consisted of: 1) a photometric flame ionization detector (Model 204, Pye Unicam), 2) an amplifier (Model 202, Pye Unicam) and an integrator (Model 33904, Hewlett Packard, London, England). The peak areas for the fatty acids were obtained from the integrator and the percentage of each fatty acid in the ester extract was calculated as a percent of the total fatty acid content in the FAME (g/100 g of fatty acids). The percent content of each fatty acid in the two samples was the mean of three injections. The percent recoveries of the fatty acids in the extracts ranged from 73 to 90%. The detection limit of the GLC was 0.5% of fatty acids.

RESULTS

Fatty acid profile of the Turkana doum palm nut

As shown in Table 1, the predominant fatty acids in decline order included lauric, oleic, myristic, palmitic and linoleic in the mesocarp, and lauric, oleic, capric, myristic, palmitic, linoleic, and caprylic in the kernel. Both kernel and mesocarp oil extracts contained traces of stearic and no linolenic acid (Table 1).

The Turkana doum palm nut contained an oil content of 0.4 and 10.3% in the mesocarp and kernel, respectively. The kernel and mesocarp lipid extracts contained 54 and 66% long-chain saturated fatty acids (LCFA), C_{12} - C_{16} , and 76 and 66% total saturated fatty acids (SAFA), respectively. The content of monounsaturated fatty acids (MUFA) (18:1) in the kernel and mesocarp was 22 and 31%, respectively. The polyunsaturated fatty acids (PUFA) (18:2) content accounted for 3.2% and 2.0% of the fatty acids in the mesocarp and kernel, respectively. The kernel of the Turkana doum palm nut, canola and olive contain 31, 55 and 74% of oleic acid, respectively. Although the Turkana doum nut has less oleic acid as compare to canola and olive oils, it is nevertheless a better source of oleic acid than either coconut or palm kernel oil, which contain 6 and 11% of oleic acid, respectively (Table 2). Moreover, it has a higher unsaturation of 24% compared to 13 and 18% in coconut and palm kernel, respectively. The kernel oil extract of the Turkana doum palm nut had MUFA/SAFA, PUFA/SAFA and UFA/SAFA ratios of 0.29, 0.03 and 0.31, respectively (Table 3).

DISCUSSION

From Table 1, the experimental results show that the mesocarp of the nut of the Turkana doum palm is lower in oil than the kernel (0.4 vs. 10.3%). Generally, the mesocarp or the pulp of fruits contain 0.1-1.0% oil, excluding the avocados, palms and olives [7] and are therefore not as an important oil source as the kernel. Coconut and palm kernel contain 63 to 74% [7] and 44 to 58% [8] of oil, respectively. The main differences in the oil content of the

coconut and the Turkana doum palm include the lower caprylic acid (8:0) (0.6%) content and the higher content of capric acid (10:0) (21.3%) in the kernel of the Turkana doum palm nut than in coconut kernel oil (7.5 and 6.0%), respectively [9]. The results also showed that the Turkana doum palm nut contains smaller amounts of the short-chain saturated fatty acids (SCFA, C₂-C₈), than coconut and palm. SCFA are associated with several health benefits of the colon mucosa and may play an important role in protecting against large bowel disease [10] and colon cancer [11].

The fatty acids with the highest concentrations in the kernel and mesocarp oil extracts of the Turkana doum palm nut included lauric and oleic acids. Since lauric acid is the largest fatty acid in the kernel of the Turkana doum palm nut as well as of the coconut (*Cocos nucifera*), the hexane extract of the Turkana doum palm nut is a typical lauric oil, similar to coconut oil [7]. Lauric, myristic and palmitic acids have been shown to be some of the most hypercholesterolemic dietary fatty acids [12]. The three nuts (that is, the Turkana doum palm, coconut and palm) are likely to contribute to hypercholesterolemia when regularly consumed in large quantities due to their considerable content of these particular fatty acids.

The mesocarp of the Turkana doum palm nut contains higher oleic acid content than the kernel (31 vs. 22%). This is advantageous to consumers since it is the mesocarp that is normally consumed. Oleic acid is the only monounsaturated fatty acid (MUFA) in the Turkana doum palm nut whereas traces of palmitoleic acid are present in the palm kernel and coconut oil extracts. All the three fruits contain substantial amounts of oleic acid. However, the kernel of the Turkana doum palm nut has a higher oleic acid content than the kernel oils of both, the palm and coconut (21.9, 11.4 and 5.8%, respectively (see Table 2). Oleic acid is the main MUFA in olive and canola oils, two oils whose global consumption continues to rise due to the claimed health benefits associated with their MUFA constituents. Replacement of dietary saturated fatty acids with oleic-rich diets has been shown to be as effective as the substitution with polyunsaturated fatty acids in lowering plasma low-density lipoprotein cholesterol (LDLC) levels [13]. Further, MUFA have the advantage of not simultaneously lowering high-density lipoprotein cholesterol (HDLC) levels in hypercholesterolemic subjects [13, 14, 15]. In addition, high-density lipoprotein (HDL) has been demonstrated to inhibit the oxidative modification of low-density lipoprotein (LDL) [16]. It is therefore likely that the health benefits associated with MUFA may be obtained by regular consumption of the Turkana doum palm nut and its products.

The kernel of the Turkana doum palm nut, canola and olive contain 31, 55 and 74% of oleic acid, respectively [17]. Although the Turkana doum nut has less oleic acid as compare to canola and olive oils, it is nevertheless a better source of oleic acid than either coconut or palm kernel oil, which contain 6 and 11% of oleic acid, respectively [7]. Moreover, it has a higher unsaturation of 24% compared to 13 and 18% in coconut and palm kernel, respectively.

The divergent ratios of MUFA/SAFA and UFA (unsaturated fatty acids) /SAFA (see Table 3), reflect the lower oleic acid in the palm kernel and coconut oils, as mentioned above. The almost similar ratios of 0.03, 0.03 and 0.02 for PUFA/SAFA in the Turkana doum palm nut, the palm kernel oil and coconut oil, respectively, are due to the similar content of linoleic

acid in the three nuts. In view of its higher unsaturation, the oil extract from the Turkana doum palm nut is likely to be relatively less stable to oxidative deterioration than coconut and palm kernel oils when stored under comparable conditions of temperature, relative humidity and oxygen uptake. Conditions such as elevated temperatures, increased oxygen uptake, high relative humidity, high unsaturation, and light, accelerate lipid peroxidation [18].

Due to the higher oleic and linoleic acid in the mesocarp oil extract of the mesocarp of the Turkana doum palm nut, it is prudent to encourage consumption of the fruit as is the current practice by all age groups, although consuming the kernel as well could be beneficial energywise due to its higher oil content. Linoleic acid (18:2n-6) is one of the two essential fatty acids (EFA), and is necessary for the metabolism of longer polyunsaturated fatty acids such as arachidonic and gamma linolenic acid, and is a precursor of the eicosanoids [19, 20]. Lack of EFA may lead to essential fatty acid deficiency (EFAD), whose symptoms include scaly dermatoses, reduced growth, fatty liver, increased basal metabolic rate, kidney deterioration, loss of hair, etc. [21, 22]. Due to the general nature of these symptoms, it is difficult to pinpoint them in the general population as being due to EFAD and not other causes. It is generally recommended that 2-3% of an adult's daily energy supply come from EFA [23]. For human infants this should preferably be 1% and up to 2% of energy as linoleic acid [22, 24]. It is recommended that it does not exceed 2% of energy in healthy adults [25]. These recommendations make EFAD unlikely to appear where there is access to adequate and varied food to meet metabolic requirements to maintain good health and well being. However, the symptoms are more likely to be observed where subjects go through periods of prolonged starvation or are on fat-free diets [26]. Turkana District is estimated to have 81% of the population with insufficient food and 74% living below the absolute poverty level [27]. It is therefore likely that some members of its population could show overt symptoms of EFAD.

The diets of most East African pastoralists have generally been shown to be low in energy and high in animal protein [28]. The calorie intake of Turkana pastoralists was estimated as 1430 and 1310 Kcal/person/day (or 1100 and 980 Kcal/day/person, respectively, excluding the males) in the wet and dry season, respectively [28]. A comparative estimate of energy intake for the Maasai of Tanzania was 1250 and 830 Kcal/person/day in the wet and dry season, respectively [29]. These figures are low, and are evidence of the seasonality of the low-energy foods available. The energy intake comes mainly from a low-energy, high-protein food, milk.

Since the Turkana doum palm nut can supply about 1300 Kcal/100 g of edible portions when consumed, it makes nutritional sense to encourage the use of the entire edible portions of the nut, despite its apparent inadequacy in energy. This may be beneficial in reducing energy deficiency among rural populations in the dry season, a period of food scarcity [2]. Similar to the majority of members of the palm family, the Turkana doum palm nut predominates in lauric, oleic and myristic acids.

CONCLUSION

Although the kernel of the Turkana doum palm nut has a higher oil content than the mesocarp (0.4 vs. 10.3%), it contains less oil (10.3%) than the coconut (63-74%) and palm kernel (44-58%). Lauric and oleic acids are the largest fatty acids in both the kernel and mesocarp oil extracts of the Turkana doum palm nut. The particular nut has lower caprylic and higher capric acids in its kernel oil than the coconut, while both nuts contain similar amounts of palmitic and linoleic acids in their kernel oil extracts. "Eengol" is more unsaturated than coconut and palm kernel oils due to its higher oleic acid content. Therefore, its oil extract may be less stable to peroxidation than coconut and palm kernel oils. The kernel oil extracts from the three nuts have many similarities in their constituent fatty acids as this work demonstrated. Similar to other members of the family *Palmae*, the Turkana doum palm nut contains substantial amounts of lauric, oleic and myristic acids.

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Table 1: Fatty acids profile of the methyl esters of the mesocarp and kernel of the Turkana doum palm nut

Retention time (minutes)	FA	% FA in kernel ester extract ¹ (g/100 g of total fatty acids)	% FA in mesocarp ester extract ² (g/100 g of total fatty acids)
0.45	8:0 (caprylic)	0.6±0.02	-
0.59	10:0 (capric)	21.3±0.1	0.9±0.04 ³
1.15	12:0 (lauric)	30.9±1.0	32.6±0.2
2.02	14:0 (myristic)	14.8±0.5	21.2±0.03
3.72	16:0 (palmitic)	8.5±0.7	11.6±0.5
-	18:0 (stearic)	Trace	Trace
7.94	18:1 (oleic)	21.9±0.3	30.6±1.0
9.86	18:2 (linoleic)	2.0±0.04	3.2±0.1
-	18:3 (linolenic)	0.0	0.0

Legend: 1-Oil content of kernel flesh is 10.3% (wet weight basis)

2-Oil content of mesocarp ground powder (“apinet”) is 0.4% (wet weight basis)

3-Includes caprylic acid (8:0)

FA=Fatty acids

Table 2: Fatty acids profiles in palm oil, coconut oil and Turkana doum palm kernel oil extracts

FA	Palm oil ^[10]	Palm kernel oil ^[8]	Coconut oil ^[8]	Turkana doum palm kernel oil extract
6:0 (caproic)	-	0.2	0.6	-
8:0 (caprylic)	-	3.3	7.5	0.6±0.02
10:0 (capric)	-	3.7	6.0	21.3±0.1
12:0 (lauric)	0.1	47.0	44.6	30.9±1.0
14:0 (myristic)	1.0	16.4	16.8	14.8±0.5
16:0 (palmitic)	43.5	8.1	8.2	8.5±0.7
16:1 (palmitoleic)	0.3	Trace	Trace	0.0
18:0 (stearic)	4.3	2.8	2.8	Trace
18:1 (oleic)	36.6	11.4	5.8	21.9±0.3
18:2 (linoleic)	9.1	1.6	1.8	2.0±0.04
18:3 (linolenic)	0.2	0.0	0.0	0.0
20:0 and 20:1	-	0.5	-	-

Source: [8]

Note: The sum total of saturated and unsaturated fatty acids of palm kernel oil and coconut oil do not add up to 100% because these oils consist of further lipid components which are not fatty acids.

FA=Fatty acids

Table 3: Comparative fatty acid profile of the kernel lipid extract of 3 palms

Property	The Turkana doum palm (<i>Hyphaene coriacea</i>)	The Guinea palm (<i>Elaeis guineensis</i>)	Coconut (<i>Cocos nucifera</i>)
Type of FA with largest concentration	Lauric (31%)	Lauric (47%)	Lauric (45%)
LCFA (C ₁₂ -C ₁₆)	54%	72%	70%
SAFA	76%	82%	87%
<u>Ratios</u>			
MUFA/SAFA	0.29	0.14	0.07
PUFA/SAFA	0.03	0.03	0.02
UFA/SAFA	0.31	0.17	0.09

Legend: FA=Fatty acids

LCFA=Long-chain saturated fatty acids

SAFA=Saturated fatty acids

MUFA=Monounsaturated fatty acids

PUFA=Polyunsaturated fatty acids

UFA-unsaturated fatty acids

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