Coconut Oil: Chemistry, Production and Its Applications - A Review

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Coconut oil is consumed in tropical countries for thousands of years. Studies done on native diets high in coconut oil consumption show that this population is generally in good health. Coconut oil has a long shelf life and is used in baking industries, processed foods, infant formulae, pharmaceuticals, cosmetics and as hair oil.

Abstract

Coconut oil is produced by crushing copra, the dried kernel, which contains about 60-65% of the oil. The oil has the natural sweet taste of coconut and contains 92% of saturated fatty acids(in the form of triglycerides), most of them (about 70%) are lower chain saturated fatty acids known as medium chain fatty acids (MCFAs). MCFAs are not common to different vegetable oils with lauric acid at 45-56%. Various fractions of coconut oil have medium chain triglycerides and are excellent solvent for flavours, essences, emulsifiers etc. These fatty acids are used in the preparation of emulsifiers, as drugs and also in cosmetics. Its metabolism is different from that of the normal vegetable oils containing long chain fatty acids. Hence, it cannot be generalized as an oil similar in properties to that of a 92% long chain saturated fatty acids containing oil/fat. More studies are required to prove the good effects of coconut oil, medium chain triglycerides (MCT) and the fatty acids on humans especially on the ill effects on cardiovascular and other diseases. The review covers the production of coconut oil, its chemistry, MCT and its applications taking a holistic approach on the good and bad effects of coconut oil reported in the literature.

Introduction

Coconut oil is an edible oil that has been consumed in tropical countries for thousands of years. As it has a long shelf life and a melting point of 76 °F, it is used in baking industries. A negative campaign against saturated fats in general, and the tropical oils in particular, led to most food manufacturers abandoning coconut oil in recent years in favor of hydrogenated polyunsaturated oils, particularly soy, which contain trans fatty acids. Studies done on populations consuming diets high in coconut oil show no adverse effects on the health of the population (1).

Coconut oil has >90% saturated fatty acids, hence is less attractive to consumers. Saturated fat is one that has no unsaturation or double bonds and tends to be solid at room temperature. Coconut oil is rich in short and medium chain fatty acids. Shorter chain length allows fatty acids to be metabolized without use of the carnitine transport system.

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Various fractions of coconut oil are used as drugs. Butyric acid is used to treat cancer, while lauric acid is effective in treating viral infections. Hence, the literature is reviewed in the context of increase of fat related disorders / diseases through consumption of highly unsaturated oils.

Importance of coconut as oil seed

The coconut palm is the most important perennial source of oil, which is grown in India. The cultivation of coconut is spread over the entire coastal belt and also some interior tracts. Compared to all other oil seed crops coconut has the highest productivity as well as consistency in production. Compared to other oil seed crops coconut is less susceptible to abnormal climatic condition.

Coconut oil production in India

Rotaries and expellers are used for crushing the dry coconuts (known as copra) for recovery of oil. The total production of edible grade coconut oil in the country is about 4.0 lakh tons which is 1.5 lakh tons more compared to that produced in 1980's (2).

Specification for coconut oil (3)

Indian-Standard; IS: 6220-1971 specifies the quality parameters of copra for grading for different uses in India. This standard prescribes the methods of grading and the requirements of copra for extraction of oil and for table use, together with methods of sampling and test. The 3 types of copra are defined: type 1 (grades 1, 2 and 3), ball copra for table purpose; type 2 (grades 1 and 2), cup copra for table purpose; and type 3 (grades 1, 2 and 3), milling copra for oil extraction. The material shall be the kernels obtained from the fruits of *Cocos nucifera Linn*. Requirements cover physical and chemical properties, packing, marking, sampling and test.

Table 1. Indian specification for coconut oil (4)

Characteristics	Expressed				Solvent-extracted		
	Refined Grade	Grade 1A (Raw)	Grade 1B (Raw)	Grade 2 (Raw)	Refined grade	Semi refined	Grade 1 (raw)
Moisture & insoluble impurities (max) (%)	0.1	0.25	0.25	0.25	0.1	0.25	1.0
Colour Lovibond colour scale in Y+5R	2	4	11	30	2	10	30
Refractive index at 40 °C	1.4480 to 1.4490	1.4480 to 1.4490	1.4480 to 1.4490	1.4480 to 1.4490	1.4480 to 1.4490	1.4480 to 1.4490	1.4480 to 1.4490
Specific gravity at 30 °C/30 °C	0.915 to 0.920	0.915 to 0.920	0.915 to 0.920	0.915 to 0.920	0.915 to 0.920	0.915 to 0.920	0.915 to 0.920
Saponification value (min)	250	250	250	250	250	250	250
Iodine value wijs)	7.5 to 10	7.5 to10	7.5 to10	7.5 to10	7.5 to 10	7.5 to10	8.0 to13
Acid value (max)	0.5	2.0	6.0	8.0	0.5	1.0	10
Unsaponifiable (max)	0.5	0.8	0.8	0.8	0.5	0.8	1.0
Polenske value (min)	13.0	13.0	13.0	-	13.0	-	-
Flash point, °C (min)	-	-	-	-	225	100	90

Ceylon-Standard; CS 32: 1968 describes the specification for coconut oil intended for export. Coconut oil is classified into 4 grades: refined, deodorized (neutralized, bleached, final steam deodorization); refined (no steam treatment); white oil (higher free fatty acids); and industrial oil (crude oil, not edible without processing). Part I specifies requirement for chemical and physical characteristics, analytical standards, appearance, freedom from adulterants and suspended matter, packaging and marking. Part II describes and illustrates equipment for sampling, with special reference to large bulk vessels, together with manipulative methods. Part III prescribes detailed laboratory techniques for determination of: colour (lovibond scale); sp. gr. (sp. gr. bottle); refractive index; moisture (by distillation); volatile matter (at 105 degree C/1 h); impurities (filtration and drying); free fatty acids; I value (modified Wij's); saponification value; unsaponifiable matter and mineral acidity (titration with 0.01N NaOH to methyl orange) (4).

Common methods of production of coconut oil

Different types of coconut oil for edible purposes are available viz, virgin coconut oil from wet coconuts (unrefined grade); coconut oil from dry coconuts (unrefined grade); and coconut oil by solvent extraction method (refined from coconut expeller cake). Virgin coconut oil is claimed to have more health benefits compared to coconut oil extracted from copra.

Table 2. Codex standards for coconut oil (5)

Characteristic	Coconut oil
Colour – Platinum cobalt scale (max)	50
Relative density at 40°C/20° C	0.908-0.921
Refractive Index at 40°C	1.448-1.450
Moisture & other volatiles at 105°C	0.1
Free fatty acids, calculated as lauric acid % by mass (max)	0.3
Peroxide value (millequivalents of active oxygen per kg)	Not more than 15
Iodine value	6.3-10.6
Sap. value	248-265
Unsaponifiables, % by mass, max g/kg	≤ 15
Reichert value	6 – 8.5
Polenske value	13 –18

Copra milling by traditional methods

The extraction of oil from copra is one of the oldest seed crushing operations. In India and Sri Lanka copra is still crushed for oil extraction in the primitive chekkus as well as in rotary ghanis, expellers and hydraulic presses.

The chekku is a fixed wooden or stone mortar inside which revolves on a hard wooden pestle. The pestle is attached to a long pole which is moved round via bullocks, donkey or by human labor. About 20 – 40 kg of copra can be handled by a chekku.

Copra processing by continuous pressing

This is done with the help of expellers. The oil expeller is essentially a mechanical screw press in which the oil is expelled from the copra by the pressure exerted by a continuous rotating warm shaft in the barrel or cage of the press. The barrel is built with openings to allow the escape of oil and these can be adjusted according to the type of seed being crushed.

Hydraulic presses

These are used in the large installations. They are of two main types-open or Anglo-American presses and the closed or cage type presses. In this the space between the plates above ram and the head is divided by plates between which copra is put wrapped in press clothes.

The common method is to extract oil from copra or the dry coconuts. Conventionally coconut oil is produced by expelling dry copra, followed by refining during which oil is exposed to high temperature. The copra based refined coconut oil or the solvent extracted and refined coconut oil will have a bland taste due to the refining processes.

Wet coconut processing

The wet coconuts are subjected to pressing to ooze the oil out along with coconut milk. This is processed afterwards without employing heat, shear, chemicals, refining and is known as virgin coconut oil. Virgin coconut oil has applications in pharmaceuticals and cosmetics. It is colorless with characteristic coconut flavor and finds several applications in medicinal, cosmetics and cooking purposes. Traditionally, virgin coconut oil is produced by fermentation method, where coconut milk expelled from freshly harvested coconuts is fermented for 24-36 hr, and during this period, the oil phase gets separated from aqueous phase. Further, the resulting wet oil is slightly heated for a short time to remove the moisture and finally filtered. The main disadvantages of this process are low oil recovery and fermented odor, which masks the characteristic coconut flavor of the oil.

In conventional methods for virgin coconut oil, freshly extracted milk is centrifuged to obtain cream which is heated upto 60-80°C before centrifuging to obtain the oil. Systematic research work has been carried out at CFTRI for the production of several value added products from coconut, one of them being virgin coconut oil. In the CFTRI process, virgin coconut oil is obtained by 'wet processing' without heat, shear and chemicals with an overall yield of 87.5%. Physicochemical properties and fatty acid compositions were evaluated. Sensory studies are also carried out and found that virgin coconut oil is superior to the commercial sample. Scale-up runs were carried out for the production of virgin coconut oil. The process technology has been transferred to several user industries through Coconut Development Board, Cochin.

Physico-chemical characteristics of coconut oil

Solubility

Coconut oil is insoluble in water. At temperature above its melting point it is completely miscible with

most of the non-hydroxylic solvents such as light petroleum, benzene, carbon tetrachloride etc. In alcohol, coconut oil is more soluble than most common fats and oils.

Chemical composition

Coconut oil contains a high proportion of glycerides of lower chain fatty acids (Tables 3, 4 & 5). The oil is highly stable towards atmospheric oxidation. The oil is characterized by a low iodine value, high saponification value, high saturated fatty acids content and is a liquid at room temperatures of 27°C.

Unsaponifiable matter

All natural fats contain minor quantities of substance other than fatty acid glycerides. The unsaponified constituent is mostly sterols. The unsaponifiable constituent of coconut oil include a small amount of tocopherols and phytosterols (Table 3).

Table 3. Physico-chemical Characteristics of coconut oil

	Virgin coconut oil from wet coconut	Unrefined coconut Oil from copra	Refined coconut oil
Appearance	Colorless	Slight brownish	Colourless
Odour	Coconut smell	Coconut smell	Odourless
Melting point °C	24	24	24
Moisture (%)	<0.1	<0.1	<0.1
Iodine value (cg I2/g)	12-15	12-15	10-12
Peroxide value (meq. O2/kg)	0-1	0-1	0-1
Saponification value(mg KOH/g)	245-255	245-255	250-255
Phospholipids(%)	0.1	0.1	0.0
Unsaponifiable matter(%)	—	0.42%	0.19%
Tocopherols mg/kg	150-200	150-200	4-100
Phytosterols mg/kg		400-1200	
Total phenolics mg/Kg	640	618	20
Fatty acid composition(relative %)			
Saturates	92.0	92.0	92.0
Monounsaturates	6.0	6.0	6.0
Polyunsaturates	2.0	2.0	2.0

Table 4. Fatty acid composition of coconut oil and some other vegetable oils

Vegetable oils	C8:0	C10:0	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C18:3	C20:0	C22:0	Others
Coconut	7.0	5.4	48.9	20.2	8.4	2.5	6.2	1.4	-	-	-	
Palm kernel	-	1.2	51.6	22.9	12.2	1.3	10.8	-	-	-	-	-
Sunflower	-	-	-	-	6.3	3.0	43.7	47.0	-	-	-	
Rice bran	-	-	-	0.4	22.9	1.8	42.5	30.5	1.4	0.5	-	
Safflower	-	-	-	0.3	11.9	2.3	29.2	55.9	0.4	-	-	
Sesame	-	-	-	-	10.3	5.8	42.9	41.0	-	-	-	
Groundnut	-	-	-	-	14.0	3.8	41.9	34.7	1.0	1.2	3.4	
Palm	-	-	0.2	1.1	42.6	3.8	41.9	10.4	-	-	-	
Olive	-	-	-	-	12.0	2.5	75.7	7.9	0.5	-	-	1.4
Soybean	-	-	-	-	11.6	4.0	18.8	56.1	8.5	-	-	1.0
Grape seed	-	-	-	-	7.2	4.8	19.4	68.1	0.1	-	-	0.4
Linseed	-	-	-	-	7.1	2.0	19.9	17.3	53.7	-	-	0.4

Chemistry of fatty acids and triglycerides

Medium chain triglycerides

Medium chain triglycerides (MCTs) are a class of lipids in which three saturated fats are bound to a glycerol backbone. What distinguishes MCTs from other triglycerides is the fact that each fat molecule is between six and twelve carbons in length (9). MCTs are a component of many foods, with coconut and palm oils being the dietary sources with the highest concentration of MCTs. MCTs are also available as a dietary supplement (10).

MCTs have a different pattern of absorption and utilization than long-chain triglycerides (LCTs) that make up 97 percent of dietary fats. For absorption of LCTs to occur, the fatty acid chains must be separated from the glycerol backbone by the lipase enzyme. These fatty acids form micelles, are then absorbed and reattached to glycerol, and the resultant triglycerides travel through the lymphatics *en route* to the bloodstream. Up to 30 percent of MCTs are absorbed intact across the intestinal barrier and directly enter the portal vein. This allows for much quicker absorption and utilization of MCTs compared to LCTs. MCTs are transported into the mitochondria independent of the carnitine shuttle, which is necessary for LCT-mitochondrial absorption. Oxidation of MCTs provides 8.3 calories per gram, while LCTs provides 9.2 calories per gram (11).

Coconut Oil as a source of medium-chain triglycerides

All fats and oils are composed of triglyceride molecules, which are tri

Table 5. TAG (triacyl glycerols or triglycerides) molecular species in coconut oil from India, Malaysia and Indonesia (12 & 13)

TAG Species	Coconut Oil (I)	RBDCNO (MAL)	MAL 1	MAL 2	MAL 3	MAL 4	MAL 5	IND 1	IND 2	IND 3	IND 4	IND 5
CaCC	1.1	-	-	-	-	-	-	-	-	-	-	-
CaCLa	3.4	-	-	-	-	-	-	-	-	-	-	-
CCLa	12.8	13.1	16.6	15.1	16.4	15.9	16.2	14.4	14.3	16.7	14.7	16.1
CpCpLa	-	1.2	0.8	1.1	1.3	1.0	1.4	0.9	1.1	1.3	0.7	0.9
CpCLa	-	3.5	4.0	3.9	4.2	4.2	4.2	3.3	3.6	4.3	3.7	3.5
CLaLa	17.8	17.2	21.4	19.8	19.7	19.8	20.0	19.5	19.2	21.1	19.9	20.3
LaLaLa	20.7	21.9	25.8	23.3	24.1	22.8	23.6	23.5	23.6	23.5	23.6	23.9
LaLaM	16.1	17.2	15.1	15.6	13.8	14.6	13.6	15.4	16.5	14.2	16.2	14.8
LaLaO	1.8	2.3	1.3	1.5	2.0	1.4	1.6	1.6	1.8	1.8	1.2	1.6
LaMM	10.1	10.2	8.6	9.5	7.8	9.1	8.2	9.1	9.4	7.4	9.5	8.6
LaMO	2.1	2.1	0.9	1.4	1.6	1.3	1.4	1.4	1.5	1.2	1.2	1.2
LLO/LaMP	6.2	5.8	4.8	4.8	5.0	4.9	4.8	5.7	5.5	4.8	5.4	4.7
LaOO	1.6	1.4	0.3	1.8	1.1	1.0	1.2	0.9	1.0	1.0	0.9	1.1
LOO/LaPP	2.9	3.0	0.4	1.3	1.9	2.0	2.0	2.0	1.9	1.7	1.8	2.0
PLO	0.9	-	-	-	-	-	-	-	-	-	-	-
MOO	-	0.7	-	0.6	0.4	0.6	0.6	0.6	0.3	0.5	0.5	0.5
MPO	0.8	-	-	-	-	-	-	-	-	-	-	-
OOO	0.2	-	-	-	-	-	-	-	-	-	-	-
POO	-	0.3	-	0.3	0.4	0.4	0.4	0.5	0.2	0.2	0.4	0.5
POP	0.8	-	-	-	-	-	-	-	-	-	-	-
PPP	0.2	-	-	-	-	-	-	-	-	-	-	-

esters of glycerol and fatty acids. The fats upon hydrolysis yield fatty acids and glycerol. There are two methods of classifying fatty acids, monounsaturated fatty acids, and polyunsaturated fatty acids. The second method of classification is based on molecular size or length of the carbon chain in the fatty acid.

The vast majority of the fats and oils whether they are saturated or unsaturated or from an animal or a plant, are composed of long-chain triglycerides. All fats we eat consist of LCT while, coconut oil is unique because it is composed predominantly of MCT. The size of the fatty acid is extremely important because physiological effects of medium-chain fatty acids in coconut oil are distinctly different from the long-chain fatty acids more commonly found in our diet (14). It is the MCT in coconut oil that make it different from all other fats and for the most part gives it its unique character and healing properties. Almost all of the medium-chain triglycerides used in research, medicine, and food products come from coconut oil.

MCT are easily digested, absorbed, and put to use nourishing the body. Unlike other fats, they put little strain on the digestive system and provide a quick source of energy necessary to promote healing. This is important for patients who are using every ounce of strength they have to overcome serious illness or injury. It's no wonder why MCT are added to infant formulas. MCT are not only found in coconut oil but also are natural and vital components of human breast milk. MCT are considered essential nutrients for infants as well as for people with serious digestive problems like cystic fibrosis (15, 16). Like other essential nutrients, one must get them directly from the diet.

Literature on coconut oil

Philippines, Indonesia, India, Sri Lanka, Mexico, West Malaysia, and Papua & New Guinea are the 7 countries which produce major quantities of coconut in the world. Coconut is available in two forms viz., wet and dry materials commonly known as wet coconut and dry coconut or copra. The oil can be extracted from both these raw materials. However, in India and Srilanka, it is a general practice to use only copra for oil extraction and the oil is used for food and cosmetic purposes. In Phillippines, the oil is extracted from wet coconut also and is known as virgin coconut oil. In some countries solvent extraction of the dry coconut followed by refining, bleaching and deodorization is carried out to get the refined bleached and deodorized coconut oil. The technology for the production of coconut oil through expellers is well developed and many medium scale industries in India produce oil by this method. However, some small scale industries produce the oil by processing fresh coconut also using local expeller press. Problems of sediments and rancidity persist in these oils.

The literature on coconut oil which has been reported as published papers and patents from 1970 onwards were reviewed and were classified under the following heads:

A. Production Methods and Oil quality

A number of reviews are available on the different types of extraction and processing methods for the preparation of coconut oil, coconut flour, protein and coconut cake and meal. Cornelius (17) has reviewed the aspects of coconut processing such as growing, harvesting, handling, storage, composition of nut, processing, primary products (copra, ball copra, desiccated coconut, fibre and shells), coconut oil (extraction methods, composition of coconut oil), uses of oil, coconut cake and meal, nutritional aspects, and the coconut industry in the 7 major producing areas (Philippines, Indonesia, India, Sri Lanka, Mexico, West Malaysia, and Papua & New Guinea). Dendy and Grimwood (18) have reviewed the various processes for wet treatment which have been proposed for extraction of oil and protein from fresh coconut meat: The Chayen, Robledano, ICAIT, Krauss-Maffei, Roxas and Sugarman processes, integrated processes, methods used by the Texas A&M University and the Tropical Products Institute, London. The problem of obtaining cheap protein-based food products, coconut milk and cream, frozen milk, syrup, etc. is then examined. A few indications are given regarding the nutritive and chemical aspects of coconut protein. Baltasar (19) has reviewed the extraction process of coconut oil by the dry processing technology. Coconut oil extraction employing dry processing technology is discussed under the following headings: preparation of raw material; drying or cooking; feeding the expeller presses; handling and filtering of crude oil; oil cooling system; and extraction by the solvent method. Loncin *et al* (20) reviewed the utilization of palm oil and coconut oil in the form of interesterified fat. The utilization of transesterified palm oil with 25% coconut oil for production of cooking fat of uniform consistency little affected by temperature. (solid fat index at 10, 20 and 30 degree C being 45.6, 33.6, 9.2, consistency in 0.1 mm ASTM penetration depth after 9 days' storage at 15, 21 and 25 degree C was 19, 38 and 44). Due to its low oxidation during heating, liquid oil is suitable for table and frying use.

Enzymatic process

Coconut oil is extracted from coconut paste by a new enzymatic process (1) and the method used less energy than the conventional processes. A Sri Lankan inventor (21) has developed a simple method for making high quality coconut oil and desiccated coconut. Using more manpower and little or no electricity, it involves breaking the coconut, scraping it and drying in a specially designed solar drier. The desiccated coconut produced can be used for mechanical extraction of colourless, odourless coconut oil suitable for direct consumption (22). Mojika (23) developed a simple process for producing coconut oil and food grade copra cake which has been patented. Nambiar (24) developed a method for the production of refined oil from the milk of fresh ripe coconuts and has been granted an Indian patent.

Wet processing of coconut

Nambiar (25) has developed a method of processing fresh ripe coconut to obtain refined oil and to simultaneously recover coconut products including solid coconut products for human consumption which has also been patented in India. Castellanos and Asturias (26) investigated the wet milling processes for the extraction of oil from decorticated fresh coconut under a variety of experimental conditions to get oil of better quality and it required less refining. Hagenmaier *et al* (27) identified the critical unit operations in the wet processing of fresh coconuts for the recovery of oil and food grade protein.

Solvent extraction

Cancel *et al* (28) has standardized conditions for coconut oil extraction from coconut milk press-cake. Gonzalez *et al* (29) studied the solvent extraction of residual oil from wet coconut meal using isopropanol. Bernardini (30) has described a new single solvent direct extraction process (by CMB, Pomezia) which obviates the need for pressing. Aliwalas and Buccat (31) studied the filtration-extraction of granulated coconut on a bench scale. Claudio *et al* (32) carried out laboratory scale studies on the preparation of a highly nutritious coconut flour from granulated coconut. Preliminary feeding expt. indicate a PER comparable with casein. Prepared foods (cakes, doughnuts, cookies, pastries) with 20-30% wheat flour replaced by coconut flour obtained high taste rating.

Fatty acid composition

Banzon and Resurreccion (33) carried out a study on the fatty acid

distribution in coconut oil obtained by four processing methods and secured from four Philippine types of coconuts. There was no observed change in the fatty acid distribution in samples of coconut oil obtained by 4 methods, namely: solvent extraction, fermentation, freeze-thawing and heating. Neither was there such a change observed in coconut oil samples obtained from 4 types of coconuts.

Phenolics and antioxidant activity

Kapila and Dissanayake (34) studied the phenolic compounds present in the nonsaponifiable fraction of coconut oil by high-performance liquid chromatography with florescence detection. Mass spectra of the phenolic compounds were also obtained separately by LC–MS to confirm the presence of the phenolic compounds. Caffeic acid, p-coumaric acid, ferulic acid and catechin were observed in coconut oil. Phenolic acid fraction of the coconut oil prepared by boiling coconut milk (traditional coconut oil) was more complex compared with that of coconut oil prepared by pressing copra (commercial coconut oil). Total phenol content of traditional coconut oil was nearly seven times higher than that of commercial coconut oil (618 ± 46 vs. 91 ± 11 mg kg)1), suggesting that the phenol content varies with the extraction method.

Kapila, Chamil and Sagarika (35) compared the antioxidant activities of coconut oil extracted under hot and cold conditions. The coconut oil extracted under hot conditions (HECO) contained more phenolic substances than the coconut oil extracted under cold conditions (CECO). However, high temperatures used in the hot extraction of coconut oil favor the incorporation of more thermally stable phenolic antioxidants into coconut oil. Therefore, the consumption of HECO may result in improvement of antioxidant related health benefits compared with the consumption of CECO.

Moura (6) studied the changes in some components of the unsaponifiable fraction of coconut oil during refining. 8 lots of coconut oil were sampled at 5 points in the refining process. The unsaponifiable matter (UNS) comprised hydrocarbons (including squalene), aliphatic alcohols and triterpenoid alcohols, sterols and a final group containing free fatty acids (FFA), campesterol and some unidentified components. Tocopherols were not detected in the coconut samples analysed. Manalac and Harder (36) analysed the tocopherol content of coconut oil from a commercial processing plant at different stages of refining. One sample of crude oil containing 721.06µg/g lost 94.5% resulting in 38.9µg/g in the final product.

It is observed from the above literature reports that there is variation in the composition of coconut oil with respect to natural antioxidants level with the method used for its extraction which may have a bearing on the nutritional quality of the oil.

B. Blending of coconut oil with other vegetable oils

Oxidative stability

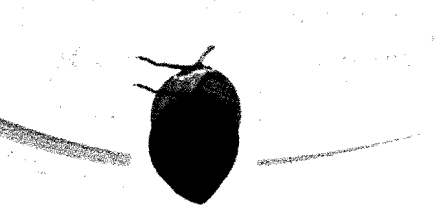
Coconut oil addition to other vegetable oils improves their oxidative stability indicating that coconut oil can be used as a natural antioxidant through the blending process. Bhatnagar *et al* (37) have observed that addition of coconut oil to either safflower oil, sunflower oil, rice bran oil increased the oxidative stability of the resultant blend.

Phase separation

Murthi *et al* (38) studied the storage stability of edible oils and their blends. Among the blends, sesame oil or groundnut oil blended with refined cottonseed oil showed the least increase in FFA. PV of raw edible oils and their blends tended to rise steadily to a maximum, declining gradually thereafter. Acceptability became poor for raw edible oils after 120 days, when the PV was between 5.9 and 16 m-equiv./kg, and for refined oils after 90 days (PV was 4.4-9) and for the blends after 90-120 days (PV 4-45). The consumer preference in various areas was for oil blends containing cottonseed oil with sesame oil or groundnut oil, coconut oil with palm olein, and rapeseed oil with mustard oil. Blends containing palm oil were less acceptable, as a waxy solid mass separates out in these oils.

Coconut oil emulsions

Garti and Arkad (39) studied the process of preparation of cloudy coconut oil emulsions containing dispersed TiO2 using atomizer. Rogov et al (40) studied the viscosity of the fat components of margarine emulsions. Technological procedures in margarine manufacture (dosage, transport, mixing) are affected by the viscosity of the fat component. Viscosities of some fats (hardened fat, qualities 1, 2 and 3, coconut oil, vegetable oil blends, etc.) and of the fat components used for margarine



emulsion preparation were determined at 40 degree C. The viscosities of different fat blend emulsions applied in Russian margarine formulations were also determined and are tabulated.

Nutritional effects of coconut oil blends

Bellenand *et al* (41) studied the effects of coconut oil on heart lipids and on fatty acid utilization in rapeseed oil. The cardiac lipidosis was proportional to the content of erucic acid in the diet. At 60 days, the high level of 22:6 in the cardiac phospholipids of rats fed rapeseed oil was reduced by the addition of sunflower oil but not by coconut oil. Thus, the blending of rapeseed oil with coconut oil apparently is less desirable than that of rapeseed oil and sunflower oil. McCutcheon *et al* (42) studied the cardiopathogenicity of rapeseed oils and oil blends differing in erucic, linoleic and linolenic acid content on male Wistar rats using semipurified diets. Lowest lesion incidence was obtained with safflower oil and hydrogenated coconut oil. It has been postulated that linolenic acid plays a role in the etiology of cardiac necrosis observed when rats are fed diets containing low erucic acid rapeseed oils.

Theuer (43) developed fat compositions for infant formulas containing vegetable fats with a fatty acid simulating that of human milk. Grandadam (44) developed processes to recover the proteins of the coconut from copra cake, or directly from fresh coconut meat by different processes. The improved Itipat process of double pressing allows recovery of 93.45% of the oil and 91.9%. Aliwalas (45) studied the following process for oil extraction from coconut meat: (i) wet method (using a De Laval centrifuge), (ii) hydraulic pressing, (iii) pressing plus solvent extraction, (iv) filtration extraction (direct solvent extraction). Oil extraction efficiencies obtained were: (i) 79.56% (increased to 96.3% by subsequent solvent extraction), (ii) 76.47%, (iii) 99.65%, (iv) 96.58. Protein contents of isolates from (i) ranged from 59 to 75%. Protein efficiency ratio (PER) biological value (BV), true digestibility (TD) and net protein utilization (NPU) of coconut flour from (ii), (iii) and (iv) were: PER 2.42, 2.55, 2.42; BV 77, 84, 79; TD 76, 74, 72; NPU 68, 64, 66. Values for coconut isolate prepared by heat coagulation of cream or aqueous portion of fresh coconut milk from (i) were: PER 1.50, 2.20; BV 72, 80; TD 88, 92; NPU 59, 65. The traditional rural method gave an oil extraction efficiency of 82.45, and a protein isolate with PER 1.25, BV 62, TD 86 and NPU 58.

Reena Rao and Lokesh (46, 47), Anitha Nagaraju and Lokesh (48, 49) and Reena and Lokesh (50) have used immobilized lipase systems for the synthesis of structured lipids from coconut oil and omega 6 and omega 3 fatty acids and carried out nutritional evaluation of the same in rats. They found beneficial effects in the lipid profile after enzymatic acidolysis of coconut oil with omega 6 and omega 3 fatty acids.

Indian Specification for blending of vegetable oils

As per the Prevention of Food Adulteration Act 1954 Rules and Regulations and updated amendments following is the specification for a vegetable oil blend.

A.17.24. "Blended Edible Vegetable Oil" means an admixture of any two edible vegetable oils where the proportion by weight of any edible vegetable oil used in the admixture is not less than 20 per cent. The individual oils in the blend shall conform to the respective standards prescribed by these rules. The blend shall be clear, free from rancidity, suspended or insoluble matter or any other foreign matter, separated water, added colouring matter, flavouring substance, mineral oil, hydrocyanic acid, castor oil and tricresyl phosphate. It shall also conform to the following standards, namely;

Based on the PFA specifications, a process has been developed at the Central Food Technological Research Institute, Mysore under sponsorship from the Coconut Development Board, Cochin and is ready for commercialization.

C. Edible applications of coconut oil

Coconut oil has a high degree of saturation with a high content of saturated fatty acids. Because of high content of saturated fatty acids coconut oil is highly resistant to oxidative rancidity, coconut oil is used as a component of infant milk powders because of its easy digestibility and stable flavor. Coconut oil is extensively used in the food industries as a confectionery fat particularly in the preparation of ice creams. In imitation chocolates coconut oil is used in place of cocoa butter along with cocoa powder.

Indian Specification for blending of two oils

a.	Moisture and volatile matter	Not more than 0.2 per cent by weight
b.	Acid Value	
	Nature of oil	*Acid value*
	1. Both raw edible vegetable oils in the blend	Not more than 6.0
	2. One raw edible vegetable oil and one refined edible vegetable oil in the blend	Not more than 5.0
	3. Both refined edible vegetable oils in the blend	Not more than 5.0
c.	Unsaponifiable matter:	
	1. Blend with rice bran oil	Not more than 3.0 per cent by weight
	2. Blend with other edible vegetable oils	Not more than 1.50 per cent by weight
d.	Flash point (Penske Martin closed method)	Not less than 250°C

1. Test for argemone oil shall be negative for the blend
2. However, blend may contain food additives permitted in these rules and Appendix 'C'.

Use in the synthesis of medium chain triglycerides

Medium chain triacylglycerols are unique categories of lipids produced by the esterification of glycerol with medium chain fatty acids, which come from high lauric oils. Coconut and palm kernel oils are the only commercially important sources of medium chain fatty acids (52). These oils are hydrolyzed to liberate their fatty acids from glycerol, and then the fatty acids are separated by fractional distillation. The lower boiling or top fraction of the fatty acids contains the medium chain acids (53).The esterification reaction between glycerol and the medium chain fatty acids is carried out at high temperatures with or without use of a catalyst. The water liberated in the reaction is removed continuously to drive the reaction to completion (54). When the esterification reaction is complete, excess fatty acids are removed from the reaction mixture by vacuum distillation. To remove the volatile odor and flavor components as well as any residual fatty acids, the crude MCTs are deodorized to get a final product that has a bland flavor and is odorless and colorless.

Functional benefits of medium chain triglycerides

Medium chain triglycerides are widely used in the flavor industries as they are more polar and therefore more hydrophilic and can dissolve a variety of polar substances that are insoluble in conventional fats and oils. Hydrocarbons, esters and natural oils as well as alcohols, ketones and acids are miscible with MCTs. These properties make MCTs superior carrier for flavors, vitamins and colors when compared to conventional oils. MCTs have a lower molecular weight than conventional oils. This gives MCTs a lower viscosity than conventional oils, even at low temperatures. MCTs oils have no unsaturated fatty acids present; therefore they are exceptionally stable to oxidation. MCTs have excellent keeping qualities and therefore help to increase shelf- life of finished products. MCTs are ideal for treating the surfaces of crackers to act as a moisture barrier. They adhere well to surfaces, including metals. They are excellent release agent for surfaces that come into contact with food products or raw materials. These MCTs can also be used as a glaze and polishing agent for confectionery products such as gummy- type candies. Solid MCTs can help to enhance aeration properties in bakery products (55, 56).

MCT derivatives- structured lipids

Medium chain triglycerides can be used to custom design fats. MCTs with conventional long chain fats give products with unique physical and nutritional products. MCT derivatives show unique properties compared to their corresponding physical blends. They may contribute nutritional and functional benefits to value added foods (57, 58, 59).

D. Non-edible applications of coconut oil

One of the major non-edible applications of coconut oil is in the soap industries; one important chemical derivative of coconut oil is methyl esters of coconut fatty acids, which are produced by treating coconut oil with methyl alcohol. These methyl esters constitutes an important raw material for the chemical industries as they are more stable and are easier to separate by fractional distillation. Coconut oil has many other industrial uses in the pharmaceuticals, cosmetics, plastics, rubber substitutes, synthetic resins etc. Coconut oil has also been found useful for mixing with diesel. These mixture in the proportion as 30:70 has given excellent road performance of diesel vehicles. Methyl esters of coconut oil fatty acids is also being used as lubricants and biodiesel in aviation industry.

E. Clinical Applications of medium chain triglycerides and saturated fatty acids

Malabsorption

Children with cystic fibrosis supplemented with up to 75 ml of MCTs per day experienced greater weight gain and reduced fecal fat compared to a trial period on a control diet (9). When MCTs are given concurrently with a pancreatic enzyme preparation, absorption is improved (58). MCTs have been used in other malabsorption syndromes, including short-bowel syndrome, celiac disease, and hepatic disease (15).

HIV/AIDS

MCTs may help with weight maintenance in AIDS patients. An enteral formula containing 85 percent of fat calories from MCTs (35% of total calories from fat) led to decreases in stool fat, number of bowel movements, and abdominal symptoms, as well as increased fat absorption compared to baseline (59). No improvement was seen in subjects taking a control LCT-containing formula. Another controlled trial confirmed these results (60). MCT-containing caloric supplements do not appear to cause weight gain in AIDS patients compared to a control diet. In 1978, Kabara and others (61) reported that certain medium chain fatty acids, such as lauric acid have adverse effects on other pathogenic microorganisms, including bacteria, yeast and fungi. These fatty acids and their derivatives actually disrupt the lipid membranes of the organisms and thus inactivate them (62).

Healing properties of coconut oil

Coconut oil is antiviral, anti-fungal (kills yeast too) and antibacterial. It attacks and kills viruses that have a lipid (fatty) coating, such as herpes, HIV, hepatitis C, the flu, and mononucleosis. It kills the bacteria that cause pneumonia, sore throats, dental cavities, urinary tract infections, meningitis, gonorrhea, food poisoning and many more bacterial infections (63). It kills the fungus/yeast infections that cause candida, ringworm, athletes foot, thrush, jock itch and diaper rash.

Use of saturated fats in therapeutic applications

Saturated fatty acids can be used to: boost the immune system, for weight management, as antimicrobials, to support the structure of gut mucosa, and as dietary adjuncts in cases of chronic degenerative disease, such as cardiovascular disease, liver disease and cancer. As far as the integrity of the gut mucosa is concerned, the use of short and medium chain fatty acids can reduce mucosal irritation characteristic of aliments such as: IBS, ulcerative colitis, and dysbiosis, to name a few. In particular, short chain fatty acids are antihistaminic and may find use in the treatment of allergic-type conditions, such as asthma, urticaria and food sensitivities. Studies have also shown that short chain saturated fatty acids can be used in the treatment of dental caries, peptic ulcers, BPH, genital herpes, and hepatitis (64).

Saturated fatty acids of coconut oil having medicinal properties

Roughly 45 to 50% of fatty acids of coconut oil form lauric acid. Lauric acid is known to kill viruses and bacteria that are enveloped in a phospholipid membrane. Examples of viruses with a fatty capsule are: influenza viruses and HIV. Coconut itself contains about 75% fiber, not bran fiber from wheat and grains (which contains phytic acid that absorbs calcium and other mineral from your body before it is excreted), but dietary fiber that feeds beneficial colon flora. As the fiber is metabolized by the naturally occurring bacteria, they by default, crowd out other potentially harmful pathogens and produce short chain fatty acids (SCFA's) like acetic acid (minute amounts of vinegar and butyric acid (originally isolate in butter) both compounds are known to have varying degrees of anti microbial activity. These fatty acids are absorbed directly into the colon and serve as energy in that way. Butyric acid has been shown to have anti-tumor properties. Many researchers have reported that coconut oil lowers cholesterol. The cholesterol-lowering properties of coconut oil are a direct result of its ability to stimulate thyroid function. In the presence of adequate thyroid hormone, cholesterol (specifically LDL-cholesterol) is converted by enzymatic processes to the vitally necessary anti-aging steroids, pregnenolone, progesterone and DHEA. These substances are required to help prevent heart disease, senility, obesity, cancer and other diseases associated with ageing and chronic degenerative diseases (64).

Anti-Cancer Effects of Coconut Oil

In 1987 Lim-Sylianco (64) published a 50-year literature review showing the anti-cancer effects of coconut oil. In chemically induced cancers of the colon and breast, Cohen *et al* (65) showed that coconut oil was by far more protective than unsaturated oils. For example 32% of corn oil eaters got colon cancer whereas only 3% of coconut oil eaters got the cancer. Animals fed unsaturated oils had more tumors. This shows the thyroid-suppressive and hence, immuno-suppressive effect of unsaturated oils.

Conclusions

Coconut oil is consumed in tropical countries for thousands of years. Studies done on native diets high in coconut oil consumption show that this population is generally in good health. Coconut oil has a long shelf life and is used in baking industries, processed foods, infant formulas, pharmaceuticals, cosmetics and as hair oil. The oil contains 92% of saturates consisting of medium chain fatty acids in the form of triglycerides, and about 8% of unsaturates consisting of oleic and linoleic acids as triglycerides. The oil has a small amount of unsaponifiable matter (< 0.5%), is colourless and has a odour typical of the coconuts. The oil has small amounts of tocopherols and tocotrienols and phytosterols. The oil is known to have antiviral and antibacterial effects and excellent healing properties. It gets easily absorbed in the body and is a nature mimic of the human breast milk fat and hence used in infant formulae. With all these good quality attributes, the side effects of the oil has also been reported especially in cardiovascular diseases due to the presence of less of unsaturated fatty acids in the triglycerides of the oil. It is hypothesized that due to lower amount of PUFA, there is a possibility of atherogenecity development during long term usage of the oil. However, more research is needed to clearly understand the many good effects of the oil.

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PCA discovers two new nemesis of brontispa pest

The Philippine Coconut Authority (PCA) has discovered new parasitoid insects which could prove to be of great importance in the country continuing battle against Brontispa longissima which has previously attacked more than 1.6 million coconut trees nationwide, this is according to PCA Administrator Oscar G. Garin.

"Our research center in the Davao City has identified two indigenous small insects that parasitize Brontispa by laying their eggs in the larva or pupa of the pest" Garin highlighted in the recently concluded Brontispa In-House Evaluation and Action Planning held in Quezon City.

The administrator revealed that the PCA-Davao Reseach Center conducted a Field Release Evaluation where a total of 1,948 parasitoid adults were released in infested barangays in Region XI and parallel laboratory tests.

"The parasitoids collected in the field inflicted about 30-50 percent parasitism on the pest's larva or pupa" Garin noted adding that laboratory results showed that around 7 to 47 adult parasitoids emerged from one larva/pupa 18 to 26 days from injection for parasitization.

"With the earwigs, we now have three indigenous species for biological control of this foreign pest" the administrator enthused as he underscored the need to adopt a long-term integrated pest management system.

The administrator further stressed that use of chemical insecticides through trunk injection or spraying should only be in severe cases and at first treatment, with the long term and sustainable approach to be comprised of biological control, use of entomophatogen fungi, good farming practices and strict quarantine controls.

"Our research centers are now mass rearing these parasitoids for immediate use in areas that may suffer recurrence of Brontispa infestation" he concluded.

http://www.pca.da.gov.ph/pr040109.php