EXTRACTIBILITY OF OIL FROM COCONUT AT LOW TEMPERATURE AND UTILIZATION OF RESIDUE FOR FOOD USES.

By

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DECLARATION

The work is described in this thesis was carried out by me at the Food research Unit, Gannoruwa and Faculty of Applied Sciences, buttala, under the supervision of Mr. T.D.W.Siriwardane and Dr.K.K.D.S.Ranaweera. A report on this has not been submitted to any other University for another degree.

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AFFECTIONATELY DEDICATED

TO MY EVER LOVING

PARENTS.

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Abstract

Coconut is a valuable commodity in Sri Lanka as it provides a range of edible and non-edible products. Among the edible commodities of coconut oil and coconut milk are very important. However techniques of oil extraction need to be improved because contamination and denature of protein due to high heat applied. By products of oil extraction have a big potential for further utilization. Therefore study was carried out to investigate the extractibility of coconut oil at lower temperature and to utilize the residue as a source of coconut milk.

Dried coconut scrape was pressed by using domestic coconut oil making instrument at room temperature to obtain oil which was then heated 60°C for 10 – 15 minutes. After heating the oil was filtered for purification. The residue, partial defatted coconut scrape, was micropulverized to get uniform phase. The micropulverized powder was either directly packed or used for obtaining a finer powder form. For these purposes milk extracted from the micropulverized powder was mixed with 10 % malto dextrin dry matter basis. Subsequently the milk was spray dried, the powder resulted was packaged.

According to the chemical analysis conducted on defatted and spray dried samples are relatively rich in protein and low in fat. They are 21%, 7.43 % protein and 35.26 %, 41% fat respectively. Free Fatty Acid value of coconut oil was changed during the period of four months by 0.01 although it still remains within the standard level. According to the result of triangle test there is no significant difference for coconut **sumbol** and coconut milk curry (**kirihodhi**) prepared by using freshly scrape coconut and developed defatted coconut. According to the sensory evaluation where the panelists who correctly identify odd sample in triangle test, average difference were moderate for both **sumbol** and milk curry. It was also found that the water activity in the spray dried powder was in the range 0.11 – 0.32. After the powder stored in a polyethylene, showed an increased water activity up to the range of 0.64 – 0.70. Therefore, the product is hygroscope and need moisture proof material for packing. According to the analysis of fiber content in the residue of milk separation was14.4 %. Therefore the residue can be a good source of fiber.

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Chapter 1

1.1. Introduction

The coconut is the most widely cultivated tree in the world, and plays an important role in life of the man. The coconut tree is a multipurpose palm as every part of it is used for one or more essential purpose. Coconut, to the people in the tropical region, much more important than what statistics points out, because hundreds of millions of people depend upon it for their livelihood.

The total extent of land under coconut cultivation in Sri Lanka is 442,402 hectares (Coconut Statistics 2000) and the average annual production of coconut is about 3,096 million nuts. (Coconut Statistics 2000). Currently, about hundred thousand of employees are work in coconut plantations and over35, 000 in the processing sector. (Coconut Statistics 2000).

In general coconut oil is commercially produced by using copra, dried kernel in the fruit. But there are several drawbacks in this process. Copra produced for this purpose can be contaminated with microorganisms, macroorganisms and particles like dust. In addition, as the method practiced for oil extraction from copra involves use of expellers coupled with heat treatment. The end product of this process is called Refined Bleached Deodorized (RBD) coconut oil. (www.Coconut-info.com). The heat applied in this process can partially distroy nutrient in the final product for a example protein can be denatured due to high temperature. Chemicals used can be unintentional additives to the product. More over RDB oil can be often completely or partially hydrogenated during the oil extraction process becoming a factor contributing to increase of serum cholesterol. (www. Coconut info.com). By products of the oil extraction by using the above conventional methods is Poonac which cannot be used as a food but an animal feed. As the oil extraction process is heat energy consuming one the cost effectiveness is reduced to certain extent.

As a remedy to the above problems a processing method can be proposed where fresh coconut meat is subjected to lower temperature treatments followed by filtration. This method is called as "cold press" (www. Coconut info.com). and this method resulting virgin coconut oil and residue, which is partially defatted. As this residue could have a big potential in the preparation of partially defatted coconut powder for food applications.

The following objectives were set in the present study.

1. Study on extractibility of coconut oil at low temperature.
2. Production of low fat, high protein, coconut milk powder by utilizing the residue of oil extraction.
3. Study of the consumer acceptability on new product.

Chapter 2

Literature Review

2.1. Coconut

- **Scientific Name:** *Cocos nucifera* Linn.
- **Family:** Arecaceae

2.1.1. Origin

Comparatively little is known about the origin and early distribution of the coconut palm, probably because it was so widely spread throughout the tropical areas of the world so many years ago. It is believed to be native to the Malay Archipelago or the South Pacific.

2.1.2. Distribution

The coconut is widespread throughout the tropics, typically being found along sandy shorelines. It has been spread largely by man but also by natural means. Commercial plantings are confined to the tropical lowlands, but it will also fruit in a few warmer subtropical areas.

2.1.3. Importance

The coconut is the most extensively grown and used nut in the world and the most important palm. It is an important commercial crop in many tropical countries, contributing significantly to their economies. The chief product is copra, the source of coconut oil used for making soap, shampoo, cosmetics, cooking oils and margarine. Much of the fruit is consumed locally for food. The coconut palm more than any other plant, gives a tropical effect to landscape drink made from the water inside green coconuts.

2.1.4. Description

Tree. Large single-trunked palm tree with a smooth, columnar, light grayish browns trunk, and topped with a terminal crown of leaves. Tall varieties may attain a height of 80 to 100 feet (24 to 31 m) while dwarf varieties are shorter in stature. The trunk is slender and often swollen at the base.

Leaves. The pinnate leaves are feather-shaped, up to 18 feet (5.5 m) long and 6 feet (1.8 m) wide. The leaf stalks are 3 to 5 feet (0.9 to 1.5 m) in length and spineless.

Flowers. Male and female flowers are borne on the same inflorescence. Male flowers are small, light yellow, and are found at the ends of the branchlets. Female flowers are larger than male flowers, light yellow in color, and are found towards the base of the branchlets. Coconut palms begin to flower at about 4 to 6 years of age.

Fruit. Roughly ovoid, up to 15 inches (38 cm) long and 12 inches (30 cm) wide, composed of a thick, fibrous husk surrounding a somewhat spherical nut with a hard, brittle hairy shell. The nut is 6 to 8 inches 15 to 20 cm) in diameter and 10 to 12 inches 25 to 30 cm) long. Three sunken holes of softer tissue called "eyes" are at one end of the nut. Inside the shell is a thin, white, fleshy layer, about one inch thick at maturity, known as the "meat" or copra. The interior of the nut is hollow but partially filled with a watery liquid. The meat is soft and jelly-like when immature but it becomes firm at maturity. The fruits are green at first turning brownish as they mature.

2.1.5. Production

The coconut palm starts fruiting 6 to 10 years after the seed germinates and reaches full production at 15 to 20 years of age. It continues to fruit until it is about 80 years old with an annual production of 50 to 200 fruits per tree, depending on cultivar and climate. The fruits require about a year to develop and are generally produced regularly throughout the year.

2.1.6. Cultivars

Several cultivars of coconut palms are grown .On the basis of the growth of the stem and the age of fretting, coconut palms can be classified into two groups:
The "draft" and the "tall", both groups having many varieties. (Menon –Pandalal). the dwarf varieties may be fairly clearly differentiated because unlike the usual tall coconut palm, which are predominately cross- pollinated, dwarfs show a degree of self pollination and from moderately stable populations. The principle characteristics apart from the height of the tree are colour, size, shape and other properties of the fruit.

2.1.7. Climate and Soils

The coconut palm is typically found along tropical, sandy shorelines since it can tolerate brackish soils and salt spray. However, salt is not required for the growth of healthy plants and they can be successfully grown well inland. Coconut palms grow well in a wide range of soil types, provided they are well-drained, and a wide pH range, from 5.0 to 8.0. Successful growth requires a minimum average temperature of 72°F and an annual rainfall of 30 to 50

inches or more. The trees may be injured by cold when the temperature falls below 32°F (0°C). They require full sunlight and are tolerant to wind and temporary flooding.

2.1.8. Harvesting

Coconut fruit must be harvested fully ripe to obtain the maximum quality oil. The nuts are picked about one month short of full maturity that is about eleven months from setting of female flowers. Coconuts are picked by human climbers, or cut with knives attached to long bamboo poles.

2.2. Some Facts about Coconut

2.2.1. Production

Area planted: 11.9 Million Hectares
Production: 10.0 Million Tons in copra equivalent
6.0 Million Tons in oil equivalent
Main Producing Countries: India: 1.11
(Million Tons in oil equivalent) Indonesia: 1.55
Philippines: 1.57
96% produced on smallholdings of 0.5 to 4.0 ha.
Average yield: 850 kg of copra per ha/year.

2.2.2. Consumption

About 1/3 of production consumed fresh.
70% domestic consumption in producing countries.

2.2.3. Trade

Main Exporter: Philippines: 1.08 Million Tons of oil
0.08 Million Tons of desiccated coconut
Main Importers: Europe 0.7 Million Tons of oil
USA 0.6 Million Tons of oil
Sources: Oil World, APCC, 1997

Table: 2.1. Sri Lanka Coconut Industry 2000 – In a nut shell

Area under Coconut	
No of holdings	704,448
Total Area (Ha)	442,402*
Total Area (Acres)	1,093,197*
Bearing (Ha)	362,790
Bearing (Acres)	896,091
Cultivation Subsides	
Area benefited (Ha)	1,542
Area benefited (Acre)	3,318
Amount (Rs.Min)	28.44
Total Production	3,096
Domestic consumption (Min nuts)	2,126
Exports (Min nuts)	846
Unutilized stocks at the end of the year (Min nuts)	191
Value of Exports	
Coconut Products (Rs.Min)	12,504.2
As % of total exports	2.97
Contribution to GNP (Constant factor cost prices 1996) %	
Total Agriculture	15.9
Total Plantation/ Agriculture	3.6
Coconut Products	1.8
Employment	
Coconut Plantations	100,000
Processing Industries	35,000

Sources: Department of Census & Statistics
Central Bank of Sri Lanka
Coconut Development Authority

* Based on survey Agricultural Crops &livestock 1992/1993

Table: 2.2. Coconut: Pattern of utilization 1999/2000

	1999			2000		
	Qty MT	NUT Eqvt. (Min.Nuts)	As a % of Tot.Nut Production	Qty MT	NUT Eqvt. (Min.Nuts)	As% of Tot. Nut Production
1.Coconut oil production	35125	309.10	10.93	44407	390.78	12.62
2.Desiccated Coconut Production	67584	540.67	19.11	89030	712.24	23.00
3. ** Net Copra Exports	10242	59.15	2.09	14563	84.10	2.72
4.Fresh nut Exports(Nos.)	22998541	22.99	0.81	29024981	29.02	0.94
5.Coconut cream Export	1044	8.35	0.30	1249	9.99	0.32
6.*Fresh nuts for local consumption	-	1818.99	64.31	-	1849.17	59.73
7.Defatted Coconut	-	-	-	-	-	-
8.Coconut Milk Powder	2058	16.48	0.58	2585	20.68	0.67
9.Adjustment for year end stock	-	53.00	1.87	-	-	-
Total Nut Production	-	2828.71	100.00	-	3095.98	100.00

* Based on the per capita consumption of fresh Coconut as per consumer Finance Survey Central Bank 1996/1997

** Net Copra Exports = Copra Exports – Copra imports 2000

Table: 2.3.

Coconut production, exports of kernel products and domestic consumption 1971-2000

year	* Tot.C' nut Production (Min.Nuts)	Exports of Kernel Products (Min.Nuts Equivalent)	Manufacture Of Kernel Products (Min.Nuts)	** Domestic Consumption. (Min.Nuts)	*** Population (Min)	Exports Surplus As a % of production.
1971	2668	1110	1517	1558	12.8	41.6
1972	2818	1259	1637	1559	13.0	43.7
1973	1948	423	751	1525	13.2	18.0
1974	2030	468	809	1562	13.4	24.4
1975	2585	914	1319	1671	13.6	35.4
1976	2330	794	1122	1536	13.7	34.1
1977	1821	233	601	1588	13.9	12.9
1978	2207	507	928	1700	14.2	23.0
1979	2393	561	1076	1832	14.5	23.6
1980	2026	242	718	1784	14.7	23.6
1981	2258	439	893	1819	14.9	19.4
1982	2521	628	1125	1893	15.2	31.7
1983	2312	572	976	1740	15.4	24.7
1984	1942	282	527	1660	15.6	14.5
1985	2958	931	1438	2027	15.8	31.5
1986	3039	1162	1620	1877	16.1	38.2
1987	2292	561	967	1731	16.4	24.5
1988	1937	236	460	1701	16.6	12.2
1989	2484	588	957	1896	16.8	23.7
1990	2532	514	1010	2018	17.0	20.3
1991	2184	389	633	1795	17.2	17.8
1992	2296	437	637	1859	17.4	19.0
1993	2164	317	473	1847	17.6	14.6
1994	2622	473	909	1982	17.9	18.0
1995	2755	608	1042	2009	18.1	22.0
1996	2546	508	809	2042	18.3	20.0
1997	2630	613	869	2015	18.6	23.3
1998	2522	461	742	2053	18.8	18.3
1999	2828	648	934	2063	19.0	22.9
2000	3096	846	1218	2126	19.3	27.3

Notes: * Coconut Production estimates are the aggregate of the nut equivalent of oil and desiccated coconut production, domestic fresh nut consumption, nut equivalent of copra exports and change in copra stocks.

** Domestic Consumption is taken at 95.52 fresh nuts and 2 bottles of coconut oil per head per annum (approximately)

*** Population figures are mid- year estimates by Department of Census and Statistics.The following conversion factors are used for the estimation of nut equivalent of export products.

1MT Copra –5775 nuts, 1 MT D.C. – 8000 nuts, 1MT oil – 8800 nuts Unutilized at the end of the year 2000 –191 (min Nuts)

2.3. Chemical composition and nutritive value

2.3.1. Coconut fruit

The total weight of one fresh coconut fruit may vary from 1 to 5 kg with an average of 3 kg. The approximate composition of account fruit is as follows (in weight percentage):

Husk (Coir layer)	31%
Shell (hard layer)	15%
Meat (endosperm +seed coat)	30%
Water	24%

As a source of food to millions of people, the coconut fruit has nourished Far Eastern trade and life. The inhabitants of coconut growing areas receive the full benefits from coconuts by eating them fresh from the trees.

2.3.2. Endosperm (coconut meat with out seed coat)

Fresh coconut meat (endosperm) contains much water, is rich in fat and carbohydrates and has amounts of proteins. The approximate composition of coconut meat as follows. (Woodroof).

Table: 2.4. Composition of coconut meat

	Unripe meat	ripe meat
Moisture	90.8%	46.3%
Protein	0.9%	4.1%
Fat	1.4%	37.3%
Carbohydrate	6.3%	11.3%
Ash	0.6%	1.0%
Thiamine	151 I.u*	-
Vitamin C	1 mg*	-
Vitamin A	traces	-
Tocopherol	0.2 mg*	-

*For every 100 g of endosperm

Table: 2.5. Amino acid composition

Composition of amino acid composition of coconut meat protein with some other products (calculated to 16.0 g of Nitrogen) in percentages (FAO and Thio Goan Loo).

	Coconut	Soya bean	Rice	Beef	Eggs
Arginine	13.2	7.1	7.2	7.7	6.4
Cystine	1.2	1.9	1.4	1.3	2.3
Histidine	2.0	2.3	1.5	2.9	2.5
Isoleucine	3.6	4.7	5.1	6.3	7.0
Leucine	6.7	6.6	9.0	7.7	9.3
Lysine	3.5	5.8	3.2	8.1	7.1
Methionine	1.9	2.0	3.4	3.3	3.7
Phenylalanine	4.5	5.7	6.3	4.9	5.9
Threonine	3.4	4.0	3.9	4.6	4.9
Tryptophan	1.1	1.2	1.3	1.3	1.5
Tyrosine	2.7	4.1	5.6	3.4	4.5
Valine	5.4	4.2	6.4	5.8	7.3

From the essential amino acids pattern in table 2.5, It can be seen that coconut meat proteins have a reasonable high nutritive value. Therefore it will be worthwhile to use the residue of the oil extraction for human consumption.

2.3.3. Coconut milk

Coconut milk should not be confused with coconut water. The milky fluid is obtained by grating and pressing the coconut meat. The average composition of coconut milk is shown in the table 2.6.

2.3.4. Coconut oil

Coconut oil (fat) consists of the fatty acids combined with glycerol. (Menon Pandalai).
Table 2.7, shows the average composition of the principal fatty acids of coconut oil as compared to those of several other commonly consumed vegetable and animal oils (fats) (Thio Goan Loo).

Table: 2.6. Composition of coconut milk

Constituent	Composition (%)			
Moisture	54.1	50.0	52.0	47.0 – 53.0
Fat	32.2	39.8	27.0	39.8
Protein	4.4	2.8	4.0	2.6 – 2.9
Sugars	–	3.0	–	2.8 – 3.2
Total solids	–	10.4	–	10.3 – 10.5
Ash	1.0	1.2	1.0	1.1 – 1.3
Carbohydrates	8.3	–	–	–
Starch	–	0.09	–	0.08 – 1.0

Source: Nathanicl, 1964; Popper *et al.*, 1966; Clemente and Villacorte, 1933.

Table: 2.7. Average composition of fatty acids in several oils and fats

	Coca-nut	soya baan	Sun flower	maize	ground nut	cow	pig
Saturated Fatty acids							
Caprylic acid	8.3	-	-	-	-	-	-
Capric acid	7.2	-	-	-	-	-	-
Lauric acid	47.3	-	-	-	-	0.5	0.5
Myristic acid	17.0	0.5	0.5	-	-	3.0	2.0
Palmatic acid	8.3	12.0	6.8	13.2	10.0	26.8	27.5
Stearic acid	2.2	4.0	3.5	2.5	3.0	17.5	13.3
Unsaturated fatty acids							
Oleic acid	6.3	23.3	24.7	32.3	53.0	40.5	42.8
Linoleic acid	1.8	52.3	63.2	49.3	27.0	2.5	7.3
Linolenic acids	-	7.2	7.2	1.0	-	0.8	0.8

It appears that coconut oil has a comparatively high content of saturated fatty acids and low content of the poly unsaturated fatty acids. (linoleic acid and linolenic acid).

Table: 2.8. Composition of coconut cake

Constiuent	Solvent extacted meal (%)	Blend of solvent extracted with hydralic press meal(%)	Hydralic press (%)	Expeller (%)	Ghani (%)	Chekku (inefficientl y pressed) (%)
Moisture	10.95	10.82	11.0	10.0	9.4	13.3
Fat	0.53	3.26	6.0	10.0	12.9	26.7
Protein (6.25* N)	20.38	19.38	19.8	19.1	20.5	14.3
Carbohydra tes	-	-	45.3	43.8	40.1	32.8
Fiber	-	-	12.2	11.8	11.9	8.9
Ash	-	-	5.7	5.3	5.2	4.0

Source: Nathanacl,1960; Rajaschharan *et al.*,1962.

2.4. Coconut oil

2.4.1. Definitions

- Coconut Oil: Oil obtained from the kernel of the coconut (*Cocos nucifera Linn.*) by a process of expression or solvent extraction.
- Edible Coconut Oil: Coconut oil, which is edible or used in food industry.
- Industrial Coconut Oil: Coconut oil, which is not edible.
- Virgin Coconut Oil: Edible coconut oil obtained by mechanical processes or application of heat only, which may have been purified by washing, setting, filtering or centrifuging only. (www.foodmarketexchange.com).
- Processed Coconut Oil (or Refined Coconut Oil): Edible coconut oil which has been refined by neutralization with alkali, bleached with bleaching earth and/or activated carbon, no other chemical agents being used and which may or may not be deodorized. (www.foodmarketexchange.com).

2.4.2. Types of Coconut Oil

Coconut oil is classified into 2 types as follows. (www.foodmarketexchange.com)

1. Edible coconut oil
    - Refined coconut oil
    - Virgin coconut oil
2. Industrial coconut oil

2.4.3. Requirements

Coconut oil, when left standing at 30°C for 24 hours, shall be clear and free from precipitate, and be of the colour and flavour characteristic of coconut oil free from rancid and other foreign odour and taste.

Table: 2.9. Specifications for white coconut oil (Sri Lanka standard 32,1978).

(1) Colour in a 1" cell on the Lovibond Colour scale, expressed as Y + 5R	less than 4
(2) Specific gravity at 30°C	0.915 to 0.920
(3) Refractive index at 40°C	1.4480 to 1.4492
(4) Total of moisture, volatile matter and insoluble impurities percent by weight max.	0.40
(5) Free fatty acids, calculated as lauric acids, Percent by weight, max.	1.0
(6) Iodine value	7.5-9.5
(7) Saponification value	255 min
(8) Unsaponifiable matter percent by weight, max.	0.8
(9) Mineral acidity	Nil.

2.4.4. Processing of oils from copra

The fresh coconut kernel is a high oil bearing material, which also contains a high percentage of water. Thus, the kernel of mature, seasoned coconuts (once they are split open), contain about 43.3% water and 42.0% oil. (Tillekeratne, 1995).

This high content of water renders the exposed wet kernel, susceptible to rapid decomposition and also complicates any attempt to mechanically extract oil from the kernel.manufacture of copra as an intermediary product in oil extraction serves a dual purpose; it subsides the coconut kernel against microbial attack and spoilage by reducing its moisture content to below 6%. So that it could be stored for a period ranging from a few to

several weeks; it renders the process of oil extraction easier. The essential principle involved in copra manufacture is the reduction in moisture content of the kernel from 43.3% to below 6% as quickly as possible after splitting open the coconut, but in such a manner, as to retain the composition, quality and quantity of oil. Copra curing is therefore, essentially a controlled process. (Tillekeratne, 1995).

Coconut oil is contained in innumerable minute cells within the dehydrated coconut kernel or copra. The walls of these oil bearing cells must be softened and ruptured before processing,if a good yield of oil is to be obtained.
Copra is therefore subjected to pre treatment in preparation for oil extraction. Pre treatment consist of, (Tillekeratne, 1995).

1.Disintergration into small pieces of about 0.4 cm to 0.8cm
2.Exposure of the cut meat to dry heat or to steam.

Extraction of oil from pre treated copra is carried out using expellers.

2.4.5. Virgin Coconut Oil

Virgin Coconut Oil can only be achieved by using fresh coconut meat or what is called non-copra. Chemicals and high heating are not used in further refining. There are currently two main processes of manufacturing Virgin Coconut Oil: (www.coconut-info.com.)

1. Quick drying of fresh coconut meat which is then used to press out the oil. Using this method, minimal heat is used to quick dry the coconut meat, and the oil is then pressed out via mechanical means.

2. Wet-milling. With this method the oil is extracted from fresh coconut meat without drying first. "Coconut milk" is expressed first by pressing. The oil is then further separated from the water. Methods, which can be used to separate the oil from the water, include boiling, fermentation, refrigeration, enzymes and mechanical centrifuge.

2.4.6. The different between Virgin Coconut Oil from other coconut oils

Most commercial grade coconut oils are made from copra. Copra is basically the dried kernel (meat) of the coconut. It can be made by; smoke drying, sun drying, or kiln drying, or derivatives or a combination of these three. If standard copra is used as a starting material, the unrefined coconut oil extracted from copra is not suitable for consumption and must be

purified, that is refined. This is because the way most copra is dried is very unsanitary. Most of the copra is dried under the sun in the open air, where it is exposed to insects and molds. The standard end product made from copra is RBD coconut oil. RBD stands for refined, bleached, and deodorized. Both high heat and chemicals (e.g. solvent extractions) are used in this method.

RBD oil is also often hydrogenated or partially hydrogenated. Hydrogenated oils have been shown to increase serum cholesterol levels, which contribute to heart disease.

One of the main differences between Virgin Coconut oil and refined coconut oils is the scent and taste. All Virgin Coconut Oils retain the fresh scent and taste of coconuts, whereas the copra-based refined coconut oils have no taste at all due to the refining process. (www.coconut-info.com.)

2.4.7. Effect of Coconut oil for heart diseases

The tropical oils were very popular in the US food industry prior to World War II. With the war and the shortages of imported tropical oils, an effort was made to promote local oils, like soybean and corn oil. The US is the largest exporter of soybeans. Studies were done to show that coconut oil, and all saturated fats, were bad for one's health because they raised serum cholesterol levels. However, these studies were done on hydrogenated coconut oil, and "*all* hydrogenated oils produce higher serum cholesterol levels", whether they are saturated or not. Recent research shows that it is the presence of trans fatty acids that causes health problems, as they are fatty acid chains that have been altered from their original form in nature by the oil refining process.

In addition, numerous studies now show that the high lauric acid content of coconut oil is very beneficial in attacking viruses, bacteria, and other pathogens, and that it builds the body's immune system just as human mother's milk does, which also contains lauric acid. Promising studies have been done on patients suffering from immune deficiency diseases, such as AIDS. With polyunsaturated seed oils now largely replacing coconut oil in the American diet, there is a huge deficiency of lauric acid in the American diet that was present prior to World War II. The need for quality coconut oil, like Virgin Coconut Oil, is greater than ever! (www.coconut-info.com.)

2.4.8. Health Benefits

Health benefits of coconut products, particularly virgin coconut oil is as follows.
Coconut oil is rich in lauric acid, which is known for being antiviral and antibacterial. Studies have been done on its effectiveness in lowering the viral load of HIV/AIDS patients. Coconut oil is also being used by thyroid sufferers to increase body metabolism, and to lose weight. Virgin coconut oil is also used for making natural soaps and other health products, as it is the healthiest thing one can put on their hands.

At one time coconut oil received negative press in the US because of its high level of saturated fat. However, modern research has shown that not all saturated fats are alike and that the fatty acids in coconut oil, the medium chain tryglycerides, do not raise serum cholesterol or contribute to heart disease like the long chain tryglycerides found in seed oils. Also, most research done on coconut oil in the past was done on hydrogenated coconut oil, which has been altered from its original form.

Much research on the nutritional and medicinal benefits on coconut oil has surfaced in recent years. Coconuts has classified as a "functional food," which provides health benefits over and beyond the basic nutrients, and specifically identified lauric acid as a key ingredient in coconut products:

"Approximately 50% of the fatty acids in coconut fat are lauric acid. Lauric acid is a medium chain fatty acid, which has the additional beneficial function of being formed into monolaurin in the human or animal body. Monolaurin is the antiviral, antibacterial, and antiprotozoal monoglyceride used by the human or animal to destroy lipid coated viruses such as HIV, herpes, cytomegalovirus, influenza, various pathogenic bacteria including listeria monocytogenes and heliobacter pylori, and protozoa such as giardia lamblia. Some studies have also shown some antimicrobial effects of the free lauric acid."

As a "functional food," coconut oil is now being recognized by the medical community as a powerful tool against immune diseases. Several studies have been done on its effectiveness, and much research is currently being done on the incredible nutritional value of pure coconut oil. (www.coconut-info.com.)

2.5. Coconut Milk Powder

Spray dried coconut milk powder if dissolved in water will result in coconut milk which can be used in place of fresh coconut milk for food preparations, beverages in households and food industries by dissolving it in water.

The process begins with selection of kernels to ensure that only the most suitable raw material is used. Colour and flavour are the most important criteria at this stage. The coconut kernels are pressed to extract all of the liquid, which is then filtered, pasteurised and chilled for storage. The chilled milk is then pumped from holding tanks, heated and mixed with small quantities of sodium caseinate and maltodextrin, which act as drying aids. The mixture is homogenised and spray dried using modern stainless steel equipment. The resulting powder is allowed to cool before being packed into polyethylene lined paper sacks ready for despatch.

Chemical and microbiological tests on both raw materials and finished product are routinely carried out on a daily basis to ensure a consistently high quality product. Coconut has many uses within the food industry, in confectionery as well as in prepared dishes based on curry and Chinese recipes. More recently coconut has become a popular ingredient in cocktails, ice creams and frozen desserts. Coconut products are ideally suitable for such applications, coconut milk powder providing an authentic and natural coconut flavour.

2.5.1. Ingredients

Coconut milk solids – 86%, Malto dextrin (modified starch) – 8.5% and Sodium Caseinate (milk proteins) - 3.5%

2.5.2. Physical

Appearance: White/Creamy
Texture: Free Flowing fine powder (35°c 48 Hrs)
Moisture: Max 2.5%
Bulk Density: 0.3 – 0.45 g/cc

Dispensability at 30 Deg: 100% in One minute

2.5.3. Microbiological

White Total plate Count : Max 5000/g
Coliforms : Absent

E.Coli : Absent
Salmonella : Negative in 25 g
Yeast : Max 50 /g
Mold : Max 50 /g
Staphylococcus : Negative
Lipasic Activity : Negative

2.5.4. Nutritional Analysis

Fat: Min 60 %
Protein: Min 10 %
Carbohydrate: Max 23 %
Calcium: Max 15 mg / 100 gm
Crude fiber: Max 0.1 %
Vitamin C: 20 IU /kg
Niacin: 1.1 mg/kg
Vitamin A: 40 IU /kg
Thiamin: 0.002 mg/kg
Riboflavin: 0.08 mg /kg
Saturated Fat: 95 %
Unsaturated Fat: 5 %
Energy Value per 100 g : 750 cal

2.5.5. Chemical

Free oil: Min 60 %
FFA as Lauric acid: max 0.15 %
Peroxide Value: 0.15 mg/Kg of oil
Cadmium: Max 1.0 mg /kg
Ash content: 3.0 % maximum
Iron: 3.5 mg/kg
Arsenic: Not Detectable
pH Value: 6 - 6.5
Lead: Max 1.0 mg / kg

2.6. Spray Drying

Spray drying involves pumping a concentrated liquid food through a device that forms small droplets that are sprayed into hot air to force rapid drying and produce a fine powdered product. Many different products can and have been produced by spray drying.

There are several specific elements to spray drier, including, the atomization system, the air handling system, and the device for separating powder from air after drying has been completed. Advantages of spray drying include continuous operation with the possibility for automatic control and constant product quality at large throughput rates.

2.6.1. Atomization

In order to achieve rapid drying in a spray dryer, many small droplets of liquid must be formed. This produces a cloud of particles with very large surface area for drying. In the food industry, two main types of devices are used to create liquid droplets in spray drying. The first is a high-pressure nozzle. The liquid food is pumped at high pressure (700 to 1000kpa or 100 to 140 psi) through a small orifice at the end of piping system into the spray dryer chamber. This produces a coarse spray of liquid droplets with size from about 100 to 300μm. The second device for forming small droplets is the centrifugal atomizer. Liquid food is pumped into a spinning disk, where it is accelerated by centrifugal force and expelled from the ends of the disk shaped atomizer.

The intent of atomization is to form many small droplets, usually in sizes between 12 and 500μ m. these small droplets provide a large surface area for drying to take place. Thus water is removed from the liquid at a rapid rate, usually within 1 minute of the droplets entering the drying chamber. (Dennis and Richard, 1996).

2.6.2. Air handling

Ambient air is taken in through a vent and heated prior to circulation into the drying chamber. Heating can be accomplished in several ways. Air can be passed either through steam coils or an electric heater to attain elevated temperatures, typically between 150 and 300°C.

Once the air has contacted the food droplets, it picks up moisture and loses heat as drying occurs. Once drying is complete, the air is withdrawn from the dryer, with outlet

temperatures between 50 and 100°C.The choice of air temperature depends greatly on the thermal stability of the product being dried. Sensitive products such as eggs and milk, cannot withstand, high temperatures (>100°C) since the proteins denature. (Dennis and Richard, 1996).

2.6.3. Dryer chamber

The residence time of droplets in the spray drying chamber, which may be anywhere from a few meters to 30 m long, is typically between 5 and 100 seconds. In this time, the droplets go from a moisture content in the range of about 60%total solids to containing only about 5 – 10% water. Droplets exit the atomizer at perhaps 50m/s but quickly decelerate to thermal velocity (0.2 to 2m/s).

Typically, the food droplets are sprayed at the top of the chamber and fall down to the bottom by gravity. In spray drying of foods, air is fed in the same direction as the food droplets in a cocurrent operation. Thus, both air and food droplets enter the drying chamber at the top and gradually fall to the bottom of the chamber, where air is separated from dry powder and the product is removal from the dryer.

Cocurrent operation, with air and drying droplets moving in the same direction, is desired in most foods due to the thermal sensitivity. Food droplets with the highest moisture content come in to contact with air of the highest temperature. Since water being removed from the droplet provides an evaporative cooling effect, the product generally does not heat above the wet-bulb temperature for the air, typically bellow 50°C.When the product reaches its driest state, the air has also cooled, and chances of thermal degradation are reduced. Nevertheless, some products are heated with low temperature air to reduced product degradation due to protein denaturation. Any protein denaturation affects the resolubilization of the milk and affects product quality. In fact, specifications for powdered milk include a protein denaturation ratio. Highest quality powdered milk are produced bv low temperature drying, with air temperatures of about 65 to 70°C. (Dennis and Richard, 1996).

2.6.4. Powder Separation

Once air and dried powder reach the bottom of the dryer, they are separated and the powdered product removed for either further processing or packaging. Primary separation of powder is accomplished by gravitational setting of the heavier powder particles. Separation

of air and finer powder particles is usually accomplished in a cyclone device. The air containing fine powder particles circulated tangentially into the cyclone separator. Centrifugal force causes the particles to segregate from the air and settle to the bottom of the conical separator. Air flows back out the top of the cyclone, while powdered product is removed from the bottom, where it rejoins the main powdered product from the dryer. (Dennis and Richard,1996).

2.6.5. Stickiness and Agglomeration

One problem in spray drying occurs due to sticking of powder particles. During spray atomization, the particles are sprayed outwards towards the wall of the drying chamber. If these droplets have not sufficiently dried when they come in contact with the wall, they stick and form a scale on the inside of the drying chamber or stick to one another to form agglomerated particles. The chamber must be designed to ensure that the droplets have dried sufficiently so that they are no longer sticky as they approach the chamber wall. The velocity of the particles outwards into the dryer must be balanced by the diameter of the drying chamber, taking into account the rate of drying of the food droplets.

The sticky point of a product depends on both moisture content and temperature, and generally correlates with a viscosity of about 10^6 pa-s . When the fluid remaining in the droplet attains a viscosity greater than 10^8 pa-s, the droplet is no longer sticky. However, during the early stages of drying, viscosity is not that high, and droplets that come in contact with either the wall or each other may adhere and cause caking. In the dryer, and during later storage and packaging, it is important to maintain appropriate temperature and relative humidity to prevent or reduce caking. (Dennis and Richard,1996).

2.6.6. Product Quality

Certain characteristics of spray-dried powders are desirable. These include the ability to be wetted by water during reconstitution, dispensability of the powder into water and solubility in water. Changes in product attributes, particularly at the case-hardened surface of the droplets, decreases the ability of a powder to be wetted and dispersed into water. Agglomeration of particles may also influence the amount of surface available for wetting. The rate of dissolution, and final solubility of the power in water, also depends on the nature of the particle surface.

Although the large surface area provides rapid moisture loss in spray drying, volatile flavour compounds are also lost. Thus, spray dried products typically have slightly less flavour than

similar products produced in other drying technologies. However, certain operational conditions lead to maximal flavour retention during spray drying. Flavour losses in spray drying may be minimized by producing the largest possible droplet size to decrease the amount of surface area, and by using the lowest possible feed and air temperatures to reduce diffusional loss of volatile flavours. In principle, the faster a fluid product is brought to a highly viscous state, the slower the loss of volatile flavours. (Dennis and Richard,1996).

2.7. Microencapsulation

Microencapsulation is a process where droplets of liquids, solids, or gases (core) are coated by thing films (coatings) which protect the core until it is needed (Sheu and Rosenberg, 1995). The core can be released at different times depending on the properties of the coatings that are applied. (www.wsu.edu).

2.7.1. Uses

Microencapsulation can be used for many different products. The major use for encapsulation in the food industry is for liquid flavors. Encapsulation makes the liquid flavors act like dry powders, creating less volatility and oxidation. Acids have been encapsulated in food products to control the acid release, protect the acid from light and heat damage, and to separate the acid from other ingredients, preventing color and flavor changes. Lipids are also encapsulated in food products. Encapsulated flavor oils can be added to dry ingredients which slows oxidation and other deteorative reactions (Gorski, 1994).

2.7.2. Considerations for Encapsulation Materials

The encapsulation agent should have certain ideal characteristics, depending on the chemical characteristics of the core material, the inteded use of the core material, the conditions under which the product will be stored, and the processing conditions to which it will be exposed. Some general characteristics of the encapsulating agent are that it is insoluble in and non-reactive with the core material, have solubility in the end-product food system, and be able to withstand high temperatures of the spray-drying process. Some typical encapsulation agents are dextrans, gums, starches or proteins. (www.wsu.edu).

2.7.3. Description of Technology

There are many methods to encapsulate food products, and selection of a method depends on the properties of the core and coating materials. Spray drying is the most used encapsulation method, and is the least expensive (Sheu and Rosenberg, 1995). The entrapped ingredient is usually a fat, oil, or flavor compound, and the coating is usually a carbohydrate. An emulsion is formed between the core and coating, and the emulsion is dried in a hot air drying chamber. This process allows the coating material to trap the core material (Jackson and Lee, 1991).

2.7.4. Process

The microencapsulation process occurs in a spray dryer, and the process involves three steps (Dziezak, 1988): first, preparation of the emulsion or dispersion to be processed; second, homogenization of the dispersion; and the last step is atomization of the mass in the drying chamber (Dziezak, 1988). Dispersing the active material into the coating material, which is immiscible, makes the dispersion. An emulsifier is then added to the dispersion and the dispersion is then heated and homogenized. This homogenization creates an oil-in-water type of an emulsion (Dziezak, 1988). The emulsion is then atomized into a heated air stream supplied to the drying chamber. These atomized particles assume a spherical shape as they fall through the gaseous medium, and the oil is encased in the aqueous phase. The rapid removal of water from the coating material by the cyclone keeps the core material below 100°C, even if the temperature in the drying chamber is much greater (Dziezak, 1988).

2.8. Sensory evaluation

2.8.1. Introduction

A sensory evaluation is made by the senses of taste, smell, touch, and hearing when food is eaten. The complex sensation that result from the interaction of our senses is used to measure food quality control and new product development. This evaluation may be carried out by one person or by several hundred.

The first and simplest form of sensory evaluations made at the bench by the research worker, who develops the new food products. He relies on his own evaluation to determine gross difference in products. Sensory evaluation is conducted in a more formal manner by laboratory and consumer panels.

Most aspects of quality can be measured only by sensory panels, although advances are being made in the development of objective tests that measure individual quality factors. As Instrument are developed to measure quality, sensory evaluation will be used to prove and standardize new objective tests. (Larmond, 1977).

2.8.2. Methods for sensory testing

Several different sensory evaluation methods have been developed. The most practical and efficient method should be selected for each situation. No one method can be used universally.

There are three fundamental types of sensory tests: preference/acceptance tests, discriminatory tests, and descriptive tests. Preference/acceptance tests are affective tests based on a measure of preference or a measure from which relative preference can be determined. Discriminatory tests are used to determine whether a difference exists between samples. Descriptive tests are used to determine the nature and intensity of the differences. (Larmond, 1977).

2.8.3. Difference tests

The tests to determine a difference between samples include the triangle test, the sample paired comparisons test, the scheffe paired comparisons test, the duo-trio test, the multiple

comparisons test, ranking, scoring, and ratio scaling. Examples of these tests and sample questionnaires follow. (Larmond, 1977).

2.8.4. Triangle test

The panelist receives three coded samples. He is told that two of the samples are the same and one is different and he is asked to identify odd sample. This method is very useful in quality control work to ensure that samples from different production lots are same. It is also used to determine if ingredient substitution or some other change in manufacturing results in a detectable difference in the product. The Triangle test is often used for selecting panelists.

Analysis of the results of Triangle test is based on the probability that if there is no detectable difference, the odd sample will be selected by chance one –third of the time. Tables for rapid analysis of Triangle test is based on the probability that if there is no detectable difference, the odd sample will be selected by chance one-third of the time.

Tables for rapid analysis of triangle test data were prepared by Roessler et al. (1948)(appendix 3) As the number of judgments increases, the percentage of correct responses required for significance decreases. For this reason, when only a small number of panelists are available, they should perform the Triangle test more than once in order to obtain more judgments.

The results of Triangle test indicate whether or not there is a detectable difference between two samples. Higher levels of significance do not indicate that the difference is greater but that there is less probability of saying there is a difference when in fact there is none. (Larmond, 1977).

2.9. Water Activity

2.9.1. Water activity in food

Water in food, which is not bound to food molecules, can support the growth of bacteria, yeast and moulds (fungi). The term water activity (a_w) refers to this unbound water.

The water activity of a food is not the same thing as its moisture content. Although moist foods are likely to have greater water activity than are dry foods, this is not always so; in fact a variety of foods may have exactly the same moisture content and yet have quite different water activities. (www.dfst.csiro.au)

Table: 2.10. The typical water activity of some foodstuffs

Type of product	Water Activity (a_w)
Fresh meat and fish	.99
Bread	.95
Aged cheddar	.85
Jams and jellies	.8
Plum pudding	.8
Dried fruit	.6
Biscuits	.3
Milk powder	.2
Instant coffee	.2

Source: www.dfst.csiro.au

2.9.2. Measuring water activity (a_w)

The water activity scale extends from 0 (bone dry) to 1.0 (pure water) but most foods have a water activity level in the range of 0.2 for very dry foods to 0.99 for moist fresh foods.

Water activity is in practice usually measured as equilibrium relative humidity (ERH).

The water activity (a_w) represents the ratio of the water vapour pressure of the food to the water vapour pressure of pure water under the same conditions and it is expressed as a fraction. If we multiply this ratio by 100, we obtain the equilibrium relative humidity (ERH) that the foodstuff would produce if enclosed with air in a sealed container at constant temperature. Thus a food with a water activity (a_w) of 0.7 would produce an ERH of 70%. (www.dfst.csiro.au)

2.9.3. Predicting Food Spoilage

Water activity (a_w) has its most useful application in predicting the growth of bacteria, yeast and moulds. (www.dfst.csiro.au)

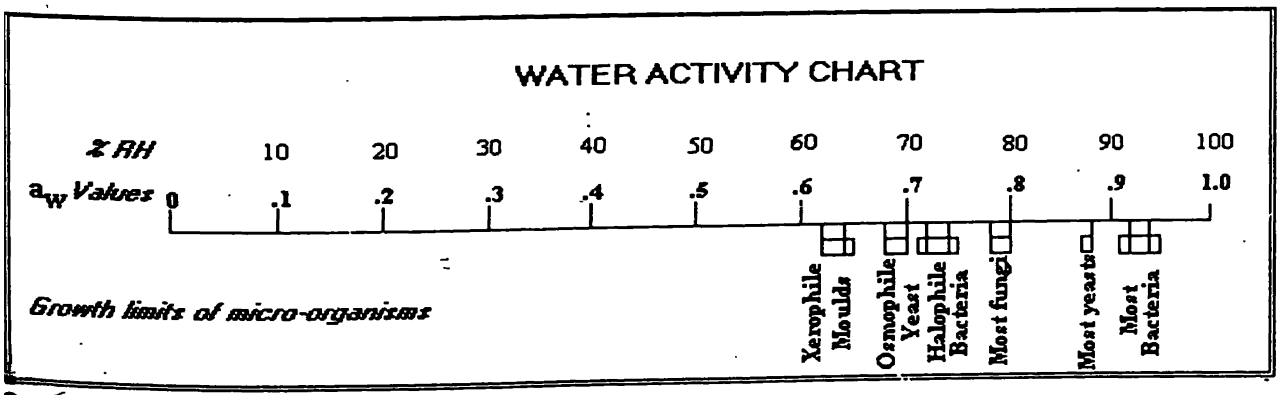
For a food to have a useful shelf life without relying on refrigerated storage, it is necessary to control either its acidity level (pH) or the level of water activity (a_w) or a suitable combination of the two. This can effectively increase the product's stability and make it possible to predict its shelf life under known ambient storage conditions.

Food can be made safe to store by lowering the water activity to a point that will not allow dangerous pathogens such as *Clostridium botulinum* and *Staphylococcus aureus* to grow in it. The diagram below illustrates the water activity (a_w) levels, which can support the growth of particular groups of bacteria, yeast and moulds. For example we can see that food with a water activity below 0.6 will not support the growth of osmophilic yeast. We also know that *Clostridium botulinum*, the most dangerous food poisoning bacterium, is unable to grow at an a_w of .93 and below. (www.dfst.csiro.au).

The risk of food poisoning must be considered in low acid foods (pH > 4.5) with a water activity greater than 0.86 a_w. (www.dfst.csiro.au).

Staphylococcus aureus, a common food poisoning organism, can grow down to this relatively low water activity level.

Figure: 2.1.Water Activity chart



Source: (www.dfst.csiro.au).

Chapter 3

Materials and Method

3.1. Materials

3.1.1. Oil extraction

3.1.1.1. Raw materials

- Coconut nuts

3.1.1.2. Implements and tools

- Coconut scraper
- Knife
- Domestic coconut milk making instrument
- Drier
- Trays

3.1.2. Determination of moisture content at maximum oil extraction

3.1.2.1. Apparatus

- Metal dish with a lid
- Oven maintained at 105-+2°C
- Desiccator with a suitable desiccant
- Electronic balance

3.1.3. Determination of free fatty acid value in the oil

3.1.3.1. Apparatus

- Electronic balance
- Burette
- Conical Flask

3.1.3.2. Reagents

- 18g of coconut oil
- 200ml of distilled water
- 0.05M NAOH solution
- Phenolphthalein

3.1.4. Preparation of partially defatted Coconut milk powder

3.1.4.1. Raw materials

- Residue after oil extraction
- Malto dextrin
- Water

3.1.4.2. Implements and tools

- Micropulverizer
- Blender
- Pans
- Spoons
- Muslin Cloth
- Spray drier

3.1.5. Sensory evaluation

Questionnaire was prepared according to the triangle test (Appendix 1,2). Twenty-four untrained panelists were invited to the panel.

3.1.5.1. Raw materials

- Samples from freshly prepared Coconut **sumbol** & Partially defatted coconut **sumbol**.
- Freshly prepared **Kirihodi** samples from normal and defatted conditions.
- Cream cracker.

3.1.5.2. Implements and tools

- Plates
- Water glasses.
- Serviette paper.
- Non stick pans
- Spoons.
- Ballet papers.
- Pens.

3.1.6. Proximate Analysis

3.1.6.1. Determination of moisture

3.1.6.1.1. Principle

A known weight of food sample is dried to constant weight in the oven and the loss of weight is equated to the moisture content of the food. (Appendix 4).

3.1.6.1.2. Apparatus

- Metal dish with a lid
- Oven maintained at 105 °C ± 2°C
- Desiccator with a silica gel
- Electronic balance

3.1.6.2. Determination of the fat

3.1.6.2.1. Principle

In the Soxhlet system of fat estimation, lipids are extracted out of the food by continuous extraction with petrolium ether. The Soxtec system is based on the use of a commercial instrument allowing a safer and more efficient extraction. (Appendix 4).

3.1.6.2.2. Apparatus

- Soxhlet distillation flask and extractor
- Oven maintained at 105 ± 2°C
- Fat free extraction thimble
- Heating mantel
- Reflux condenser
- Dessiccator
- Electronic balance

3.1.6.2.3. Regents

- Petrolium ether , boiling point 60°C
- Ether ,boiling range 40°C to 60°C
- Anti bumping

3.1.6.3. Determination of crude fibre

3.1.6.3.1. Principle

The residue of cellulose, hemicelleulose and lignin represent the insoluble dietary fiber. (Appendix 4).

3.1.6.3.2. Apparatus

- oven maintained at 105°C ± 2°C
- Distillation flask
- Buchner funnel
- Reflux condenser
- Crucible with a thin compact layer or ignited asbestos
- Muffle furnace, maintained at 550 °C ± 2 °C

3.1.6.3.3.Regents

- Sulfuric acid c.(H_2SO_4) 0.128 mol / l solution
- Sodium hydroxide C.NaOH
- Alcohol 95% (v/v)

3.1.6.4. Determination of ash content

3.1.6.4.1. Principle

The total mineral content of a food may be estimated as the ash content, which is the inorganic residue remaining after the organic has been burnt away. (Appendix 4).

3.1.6.4.2. Apparatus

dish of silica or plentium

- oven maintained at 105 ± 2°C
- muffle furnace maintained at 550°C
- desicator ,with a silica gel

3.1.6.5. Determination of protein

3.1.6.5.1. Principle

The KJeldahl method determines the total nitrogen presents as -NH- in the food. That is true protein N, amino N and amide N. (Appendix 4).

3.1.6.5.2 Apparatus

- Kjeldahl flasks
- Kjeltec unit
- 250 ml conical flasks
- Burette

3.1.6.5.3 Reagents

- Concentrated sulphuric acid
- Catalyst tablets
- 40% Sodium hydroxide solution
- 2%Boric acid indicator solution
- 0.1M sulphuric or hydrochloric acid

3.1.7. Determination of water activity

3.1.7.1.Apparatus

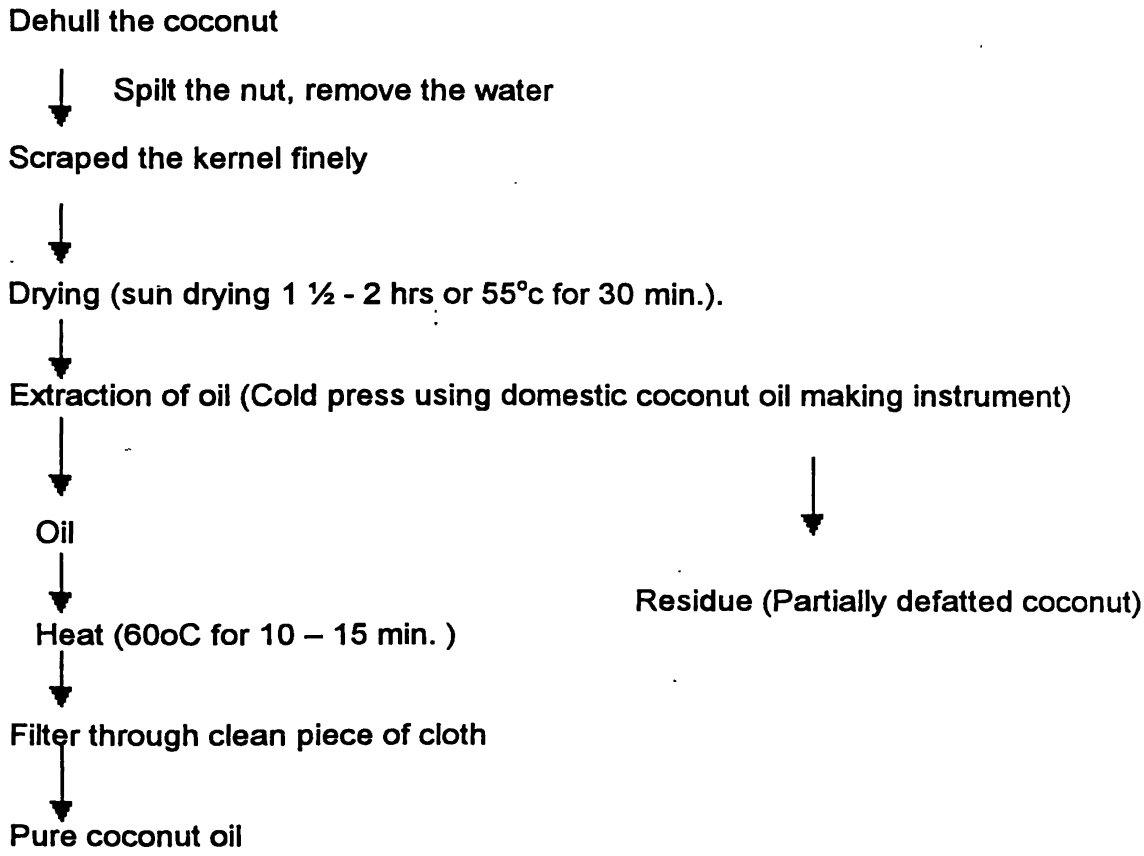
- Test tubes
- Boiling tubes
- Parafilms

3.2. Methodology

3.2.1. Oil Extraction

Well-matured Coconut nuts were taken and they were scraped finely. Then they were placed in trays and kept in the oven, which maintained at 55°C for 15 minutes. Then these were placed in the domestic coconut oil making instrument and subjected to pressing until maximum oil was recovered Oil was heated at 60°C. For 15 minutes and was packed in an airtight container.

Figure: 3.1. Flow chart of oil extraction



3.2.2. Determination of moisture content at maximum oil extraction

Moisture was determined according to the standard method SLS 913 – 1991

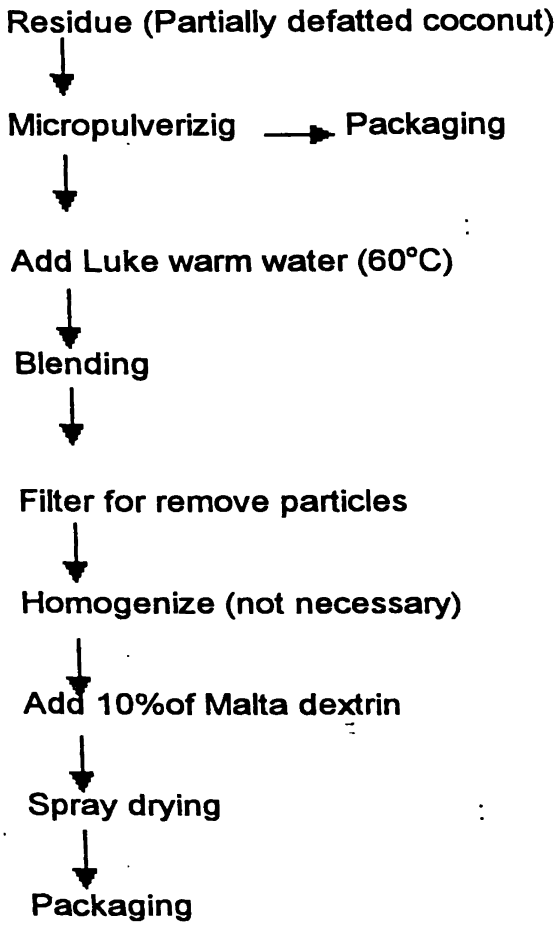
3.2.3. Free Fatty acid value in coconut oil

18g of coconut powder in 200 ml of distilled water in a conical flask were placed in a hot water bath at 40°C for one hour with the flask loosely stopped. Then this was filtered. 100 ml of clean filtrate was titrated with 0.05 M NaOH solution with Phenolphthalein.

3.2.4. Preparation of partially defatted, spray dried, coconut milk powder

The residue after oil extraction was subjected to micropulverizing and packed in a moisture proof packing. Another portion of residue was put in the blender. By adding of minimal amount of luke warm water it was subjected to blending and the milk obtained is taken by removing the solid portion from the liquid. Milk was mix with 10% of malto dextrin and spray dried (inlet temperature 180-190°C and outlet temperature 80 –90°C)

Figure: 3.2. Flow chart of the utilization of residue in form of partially defatted, spray dried, coconut milk powder



3.2.5. Sensory evaluation

Group of 12 panelist used to conduct the sensory evaluation. Each panelist of a group was given three samples, one is different from the others. He was asked to identify the odd sample. (Appendix 1and 2). In order to carry out a comparative sensory evaluation samples were prepared in forms of sumbol and curry (**kirihodhi**). Both curry and sumbol were prepared by using defatted milk powder and normal coconut scraped in domestic conditions.

Data obtained by the sensory evaluation were statistically analyzed.

Table: 3.1. Preparation of samples for triangle test

Treatment	Sample code	No.of samples required
A	314	6
A	542	12
B	628	12
B	149	6

A – Samples which defatted coconut is used

B – Samples which prepared under normal condition

Same thing was repeated for **kirihodi** instead of **sumbol** and the result was taken.

3.2.6. Chemical analysis

Chemical analyses were conducted by using standard methods according to the table3.2.

Table: 3.2. Reference test method for chemical analysis

	Reference test method
Moisture	SLS 913 -1991
Total Ash	SLS 913 -1991
Crude Fibre	FAO 14/7- 1986 AOAC 7.066 (1989)
Crude Fat	ISO 5498 - 1981
Protein	FAO 14/7 Food and nutrition paper (1984)

3.2.7. Determination of Water activity

About 3 – 4 g of sample was kept in a boiling tube. Then small amount of crystals were applied in the test tube wall and after sealing it with a parafilm it was kept on the table horizontally. After 3 hours and 16 hours measurements were taken. Chemicals are applied according to the table 3.2.

Table 3.3. Method of applying chemicals for determination of water activity

Tests tube No.	Chemical	Water activity
1	KOH	0.08
2	LiCl	0.11
3	$MgCl_2$	0.32
4	K_2CO_3	0.43
5	$CoCl_2$	0.64
6	NaCl	0.75
7	KCl	0.84
8	KNO_3	0.93

Chapter 4

Result and Discussion

4.1. Result

4.1.1. Oil extraction and extractibility

Oil was extracted according to standard method practiced by NERD. However the extractibility of coconut oil was studied by changing the temperature and the duration of heat treatment. According to that the best result in the extractibility were at 55°C for 30 minutes.

4.1.2. Moisture content at the maximum oil extraction

Average value for moisture at the time of maximum oil extraction was 14.4 %

4.1.3. Free Fatty Acid value of coconut oil (FFA)

FFA value of coconut oil samples extracted was analyzed. (Table 4.1.). Usually FFA content should be below 1 according to the Sri Lanka standard 32,1978.). All the samples studied contain FFA value within satisfactory limits.

Table: 4.1. Free Fatty Acid value of coconut oil

	Average value
Soon after Preparation	0.16
After 1 month	0.16
After 2 months	0.16
After 3 months	0.17
After 4 months	0.17

4.1.4. Result of Sensory evaluation

4.1.4.1. Milk curry (kirihodhi)

The odd sample was correctly identified by six judges.

According to the statistical chart 1 (Appendix 3.) 6 correct judges out of 12 in a triangle test indicate that there is no detectable difference existed between the samples.

The degree of difference indicated by six judges who correctly identified the odd sample was;

Table: 4.2. The degree of difference for milk curry

	No. Of judges	Value
Slight	-	-
Moderate	4	× (2) = 8
Much	2	× (3) = 6
Extreme	-	
Total		14
Mean		2.33

The average difference was 2.33 (Moderate)

Two judges out of six, who identified odd sample correctly, mentioned that our new product is more acceptable.

4.1.4.2. Coconut Sumbol

The odd sample was correctly identified by six judges.

According to the statistical chart 1 (Appendix 3.) 6 correct judges out of 12 in a triangle test indicate that there is no detectable difference existed between the samples.

The degree of difference indicated by six judges who correctly identified the odd sample was;

Table: 4.3. The degree of difference for sumbol

	No. Of judges	Value
Slight	3	× (1) = 3
Moderate	-	-
Much	3	× (3) = 9
Extreme	-	-
Total		12
Mean		2

The average difference was 2 (Moderate)

Four judges out of six, who identified odd sample correctly, mentioned that our new product is more acceptable.

4.1.5. Result of Chemical Analysis.

4.1.5.1.Chemical Composition of defatted powder

Chemical Composition of defatted powder was according to the table 4.4.

Table: 4.4. Chemical Composition of defatted powder

Component	Average value
Moisture	12.57 %
Crude fat	35.26 %
Protein (N × 6.25)	21.00 %
Crude fiber	5.12%
Total ash	3.49 %

4.1.5.2. Chemical Composition of spray dried powder

Chemical Composition of spray dried powder was according to the table 4.5.

Table: 4.5. Chemical Composition of spray dried powder

Component	Average value
Moisture	4.05 %
Crude fat	41.00 %
Protein (N × 6.25)	7.43 %
Crude fiber	0.2 %
Total ash	2.90 %

4.1.5.3. Chemical Composition of residue

Chemical Composition of residue was according to the table 4.6.

Table: 4.6. Chemical Composition of residue

Component	Average value
Moisture	11.49 %
Crude fiber	14.83 %
Total ash	1.43 %

4.1.6. Water activity of spray dried sample

Water activity of sample was determined immediate after preparation and after four months.

4.1.6.1. Immediately after preparation

Table: 4.7. Water activity of the sample immediately after preparation

Test tube No.	Chemical	Water activity	Result after 3 hours.	Result after 16 hours.
1	KOH	0.08	10 % liquefied	75 % Liquefied
2	LiCl	0.11	10 % liquefied	50 % Liquefied
3	$MgCl_2$	0.32	No change	No change
4	K_2CO_3	0.43	No change	No change
5	$CoCl_2$	0.64	No change	No change
6	NaCl	0.75	No change	No change
7	KCl	0.84	No change	No change
8	KNO_3	0.93	No change	No change

The water activity of the sample is in between 0.11 – 0.32

4.1.6.2. After 4 months of preparation

Table: 4.8. Water activity of the sample 4 months after preparation

Test tubes No.	Chemical	Water activity	Result after 3 hours.	Result after 16 hours.
1	KOH	0.08	50 % liquefied	Liquefied
2	LiCl	0.11	50 % liquefied	Liquefied
3	$MgCl_2$	0.32	50 % liquefied	Liquefied
4	K_2CO_3	0.43	No change	Liquefied
5	$CoCl_2$	0.64	No change	Change into pink
6	NaCl	0.75	No change	No change
7	KCl	0.84	No change	No change
8	KNO_3	0.93	No change	No change

The water activity of the sample is in between 0.64 – 0.75

4.2. Discussion

Coconut oil is contained in innumerable minute cells within the coconut kernel. The walls of these oil-bearing cells must be softened and ruptured before processing, if a good yield of oil is to be obtained.

Kernel is therefore subjected to pre treatment in preparation for oil extraction. Pre treatment consists of,

1.Disintegration of the kernel into small pieces, by scraping finely.
2. Exposure to heat.

Accordingly a special attention was given to finely scrape the kernel to get a fine, even yield of oil.

The fresh coconut kernel is a high oil bearing material, which also contains a high percentage of water. Thus, the kernels of mature, coconuts contain about 43.3% water and 42.0% oil. (Tillekeratne, 1995). This high content of water renders the exposed wet kernel, susceptible to rapid decomposition and also complicates any attempt to mechanically extract oil from the kernel. Manufacture of copra as an intermediary product in oil extraction serves a dual purpose; it subsides the coconut kernel against microbial attack and spoilage by reducing its moisture content to below 6%. So that it could be stored for a period ranging from a few to several weeks; it renders the process of oil extraction easier. The essential principle involved in copra manufacture is the reduction in moisture content of the kernel from 43.3% to below 6% as quickly as possible after splitting open the coconut, but in such a manner, as to retain the composition, quality and quantity of oil. Copra curing is therefore, essentially a controlled process. (Tillekeratne, 1995).

In our case, moisture content of the kernel should be reduced to 14 %. If the moisture content is more than 14 %oil will be not extracted properly and completely, and due to high moisture, coconut milk will be produced instead of oil. If the moisture content is lower than required level, efficiency of oil extraction is reduced, because due to low moisture, water in oil emulsion formation will not happen properly. Therefore it does not permit the maximum oil extraction. Due to all these reasons drying of coconut scrapes prior to oil extraction is critical and important.

In all steps involved in processing should be carried out in highly hygienic conditions. Contamination due to human contact during processing should be minimized in order to obtain a quality product.

Low processing temperature and without adding of chemicals makes the way to obtain high quality, virgin coconut oil. Processing of fresh coconut into oil does not need processing factories with hydraulic pressures or expellers; it can be carried out by any small holder by means of simple utensils. But the use of domestic coconut oil making instrument for oil extraction is inefficient and less in productivity. It is much difficult to extract maximum amount of oil by using it. By using efficient instrument productivity can be increased.

Dehydration of coconut milk into a powdered product, which retains the natural flavour and texture of coconut milk can be followed by rehydration. Rehydrated coconut milk has a good keeping quality, while making possible to use as ready to use product, saving the time and energy. Less space would be required for storage and extended storage would be possible. Further less fat level and higher protein content in the powder form makes it healthy friendly.

The purpose of spray drying is to produce a powdered in one step by drying an 'atomized' liquid feed in heated air medium. By atomizing the feed into fine droplets a very large surface area per unit mass is generated with a very short path for heat and mass transfer. (www. Kilburnengy.com)

The heated air supplies latent heat of evaporation to the droplets and brings about rapid drying which in turn brings about rapid cooling of the drying gas. At the same time the particle temperature is kept low by adiabatic Cooling. Drying can take place in a very short time, Typically 5 – 10 seconds. By atomizing the feed into fine droplets a very large surface area per unit mass is generated with a very short path for heat and mass transfer. (www. Kilburnengy.com)

Percentage of crude fat in developed defatted coconut is 35.26 %. This value should be reduced than that level hence yet it has high percentage. In order to make the methodology perfect efficient equipment should be used for the oil extraction.

Percentage of moisture in spray dried sample is 4.05%. This level is much greater, because the product is most hygroscope. The percentage of moisture should be below 2.5% (www.srihasta.com). Chemical analysis was done after 3 months of preparation and the

product was stored in polyethylene. That is the reason for an increased the moisture level in the product.

Residue has 14.8% of fiber. And therefore it is a very good source of fibre.

Within the 4 months of studied period, the Free Fatty Acid value of the oil has been increased in 0.01. But it was below the standard level. (Sri Lanka Standard 32,1978).

Water activity studies indicate that the water activity in the range 0.11 – 0.32. After four months which is stored in a polyethylene, was increased its water activity up to the range 0.64 – 0.70 .So water was sorbed by the product within the polyethylene layer. Therefore, the product is most hygroscope and need moisture proof material for packing.

According to the result of triangle test there is no significant difference for coconut **sumbol** and coconut milk curry (**kirihodhi**) prepared using of freshly scrape coconut and developed defatted coconut. As well as according to the panelists who correctly identified odd sample in triangle test, average difference is moderate for both **sumbol** and milk curry. So it provide an excellent idea about the consumer acceptability for the product.

Today the price of the nuts, oil and coconut products growing very rapidly. Due to all these reasons there is a big potential in introducing this product to the market.

Chapter 5

Conclusion and Recommendation :

5.1. Conclusion

According to the present study, moisture content of coconut scrapes should reduced down to 14 % in order to get maximum amount of oil. This can be achieved by drying 55°C for 30 minutes at a dryer.

There is no significant difference in organoleptic properties between freshly scrape coconut and developed defatted product.

Free fatty acid value of coconut oil within standard for period of four months.

Due to low fat and high protein content, developed product is healthy friendly.

The residue after milk separation is a good source of fiber.

The product is most hygroscopic and need moisture proof material for packaging.

5.2. Recommendation

- The product should be further analyzed for its microbiology.
- Sorption isotherm of the product should be determined.
- Coconut oil should be further analyzed for its composition.

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Appendix 1

Statistical chart 1

Questionnaire for triangle test

Name ..... **Date** .....

Product .....

Two of these three Samples are identical, the third is different.

1.Taste the samples in the order indicated and identify the odd sample.

Code	Check odd sample
314	...
628	...
542	...

2. Indicate the degree of difference between the duplicate samples and the odd sample.

Slight	...
Moderate	...
Much	...
Extreme	...

3. Acceptability:

Odd sample is more acceptable	...
Duplicate sample is more acceptable	...

4. Comments:

Appendix 2

Statistical chart 2

Questionnaire for triangle test

Name ..... **Date**.....

Product .....

Two of these three Samples are identical, the third is different.

1.Taste the samples in the order indicated and identify the odd sample.

Code	Check odd sample
149	...
628	...
542	...

2. Indicate the degree of difference between the duplicate samples and the odd sample.

Slight	...
Moderate	...
Much	...
Extreme	...

3. Acceptability:

Odd sample is more acceptable	...
Duplicate sample is more acceptable	...

4. Comments:

Appendix 3

Statistical chart 1 Triangle test, Difference analysis

No. of tasters	No. of correct answers necessary to establish level of significance			No. of tasters	No. of correct answers necessary to establish level of significance		
	. 5 %	.. 1 %	... 0.1		. 5 %	.. 1 %	... 0.1
7	5	6	7	57	27	29	31
8	6	7	8	58	27	29	32
9	6	7	8	59	27	30	32
10	7	8	9	60	28	30	33
11	7	8	9	61	28	30	33
12	8	9	10	62	28	31	33
13	8	9	10	63	29	31	34
14	9	10	11	64	29	32	34
15	9	10	12	65	30	32	35
16	10	11	12	66	30	32	35
17	10	11	13	67	30	33	36
18	10	12	13	68	31	33	36
19	11	12	14	69	31	34	36
20	11	13	14	70	32	34	37
21	12	13	15	71	32	34	37
22	12	14	15	72	32	35	38
23	13	14	16	73	33	35	38
24	13	14	16	74	33	36	39
25	13	15	17	75	34	36	39
26	14	15	17	76	34	36	39
27	14	16	18	77	34	37	40
28	15	16	18	78	35	37	40
29	15	17	19	79	35	38	41
30	16	17	19	80	35	38	41
31	16	18	19	81	36	38	41
32	16	18	20	82	36	39	42

33	17	19	20	83	37	39	42
34	17	19	21	84	37	40	43
35	18	19	21	85	37	40	43
36	18	20	22	86	38	40	44
37	18	20	22	87	38	41	44
38	19	21	23	88	39	41	44
39	19	21	23	89	39	42	45
40	20	22	24	90	39	42	45
41	20	22	24	91	40	42	46
42	21	22	25	92	40	43	46
43	21	23	25	93	40	43	46
44	21	23	25	94	41	44	47
45	22	24	26	95	41	44	47
46	22	24	26	96	42	44	48
47	23	25	27	97	42	45	48
48	23	25	27	98	42	45	49
49	23	25	28	99	43	46	49
50	24	26	28	100	43	46	49
51	24	26	29	200	80	84	89
52	25	27	29	300	117	122	127
53	25	27	29	400	152	158	165
54	25	27	30	500	188	194	202
55	26	28	30	1000	363	372	383
56	26	28	31	2000	709	722	737

Appendix 4

Mathematical formulae for determination of moisture

Moisture content (H) = 100 $(M_1 - M_2) / (M_1 - M_0)$

Where,

M_0 – Mass of empty weighing bottle

M_1 – Mass of empty weighing bottle and content

M_2 – Mass of empty weighing bottle and content after drying

Mathematical formulae for determination of total ash

Total ash % by mass (dry basis) = $10000(M_2 - M_0) / (M_1 - M_0) (100 - H)$

Where,

M_0 – Mass of the empty crucible

M_1 - Mass of the empty crucible and sample

M_2 - Mass of the empty crucible and total ash

H - Moisture percentage

Mathematical formulae for determination of crude fiber

Crude fiber % by mass (dry basis) = $10000 (M_1 - M_2) / M_3 (100 - H)$

Where,

M_1 – Mass of grouch crucible and contents before ashing

M_2 – Mass of grouch crucible containing ash

M_3 – Mass of sample taken for test

H – Moisture percentage

Mathematical formulae for determination of crude fat

Crude fat % (ether extract) = $(w_2 - w_1) 100 / S$

Where,

w_1 – weight of empty round bottom flask

w_2 – weight of empty round bottom flask and content after drying

S – Sample weight in g

Mathematical formulae for determination of crude protein

$$\text{Crude N \%} = \frac{0.0014 \times \text{required vol. standard } H_2SO_4 \text{ ml (0.1 N)} \times \text{Strength of acid} \times 250 \times 100}{0.1 \times \text{weight of the sample} \times 25}$$

Crude protein = 6.25 × crude N %

Percentage of protein (on dry basis) = Crude Protein × 100 / (100 –H)

Where,

H – Moisture percentage

Mathematical formulae for determination of Free Fatty Acid value (FFA)

1 ml of 0.05 M NaOH = 0.0068 g (Pearson D. 1976)

Free Fatty Acid amount = 0.05 M NaOH amount × 0.0068

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