Virgin Coconut Oil

production manual for micro- and village-scale processing

Divina D. Bawalan
Keith R. Chapman

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FAO Regional Office for Asia and the Pacific
39 Phra Artit Road
Banglamphu
Bangkok 10200 Thailand
Tel: 66-2-6974000 Fax: 66-2-6974445
Email: fao-rap@fao.org
Web: www.fao.org/world/regional/rap/highlights.asp

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Virgin coconut oil (VCO) is the newest, high-value coconut product very much sought after for its human, nutraceutical benefits and as a functional food. World demand for VCO is rapidly increasing. VCO production, which at present is mostly done at household, micro- or village-scale levels, is rising rapidly and has excellent potential for improving coconut farm incomes by five to eight-fold over traditional copra production or sale of fresh nuts.

Asian Pacific Coconut Community (APCC) and member countries are strongly promoting VCO for health and improving livelihoods of smallholder coconut processors.

However, one major concern is that unless VCO is produced correctly under well-managed, hygienic conditions, the poor quality oil produced will not meet prescribed standards, and may not be suitable for human consumption. A number of products currently on the market claiming to be VCO, do not meet prescribed standards. The FAO Regional Office for Asia and the Pacific has been involved with improving and developing VCO technologies over the previous four years with a view to establishing safe, hygienic methods for production.

The FAO research and development work with Thai institutions has resulted in this manual — a guideline for producing safe, hygienic VCO for micro- and village-scale processing systems. It is part of the FAO/Thailand TCP/THA3002 Project on Improvement of Coffee Quality and Improvement of Ochratoxin A on Robusta coffee, implemented with the Thailand Horticulture Research Institute, Department of Agriculture, Chumphon, Horticultural Research Centre (HRC). Chumphon HRC has the mandate for all coconut and Robusta coffee research and development in Thailand. The Robusta coffee industry of South Thailand is to a significant extent, integrated with coconut production and Robusta coffee is frequently planted under the shade of coconut trees. A part of this TCP coffee project examined socio-economic aspects of the coffee farm system. In addition to improving agricultural practices, processing and quality of the coffee, developing the complete farm system is very important for significantly increasing farm incomes and improving livelihoods.

Divina Bawalan, formerly of the Philippine Coconut Authority, is an international coconut processing specialist and food engineer and has worked with the development of virgin coconut oil and other coconut products for more than 20 years. Divina and co-author Keith Chapman, collaborated with the Thailand Institute of Scientific and Technological Research (TISTR) and the Chumphon HRC of the Department of Agriculture, to bring VCO technologies to Thailand through a complementary FAO supported initiative.
Divina’s work in Thailand has assisted the essential virgin coconut oil research and development and product development, and by way of her training, TISTR and Chumphon HRC have provided key technical information for the manual. VCO production and product technologies at farm level via outreach support by FAO to coconut communities have contributed valuable practical skills for documentation.

The manual is intended as a primary source of practical knowledge on good management practices (GMP). It will assist Asian Pacific Coconut Community (APCC) member country farmers and their families, entrepreneurs, processors, researchers, extension agents and technicians with the practical information on VCO and related products in this manual.

FAO sincerely thanks the authors and staff of TISTR, Chumphon HRC, Horticulture Research Institute of DOA, the Thailand Department of Agriculture Extension, and participating villages for VCO production, for their assistance in establishing the technologies that help make the preparation of this manual possible.

Keith Chapman, Industrial Crops Officer
FAO REgional Office for Asia and the Pacific, Bangkok, Thailand.

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and the manually operated horizontal screw type coconut milk press currently being used in the province of Leyte, Central Philippines; Mrs Charita Puentespina of Malagos Garden Resort, Davao City, Southern Philippines for allowing photos to be taken of their VCO processing facility; Dr Bruce Fife, author of The Healing Miracles of Coconut Oil and other books pertaining to the health benefits obtained from coconut for granting the permission to reproduce pertinent tables and to quote appropriate information.

We are very much indebted to Loraine Chapman, Australia, who has generously provided the English editing, indexing, design and electronic layout of the book for publication.

**Acronyms and abbreviations**

- AO: Administrative Order
- APCC: Asian Pacific Coconut Community, Jakarta
- BAFPS: Bureau of Agricultural and Fisheries Product Standard
- CRI: Coconut Research Institute of Sri Lanka
- DOA: Department of Agriculture, Thailand
- HRC: Horticulture Research Centre
- HRI: Horticulture Research Institute
- NRI: Natural Resources Institute
- PCA: Philippine Coconut Authority
- TISTR: Thailand Institute of Scientific and Technological Research
- UCAP: United Coconut Association of the Philippines
- DME: Direct micro expelling
- Foots: Sediment
- FFA: Free fatty acid
- GLC: Gas liquid chromatography
- GMP: Good Management Practices
- HACCP: Hazard Analysis Critical Control Points
- M.C.: Moisture content
- MCFA: Medium chain fatty acid
- Meat: Coconut kernel
- Php: Philippine peso
- Psi: Pounds per square inch
- RBD: Refined, Bleached and De-odourised
- ROI: Return on Investment
- VCO: Virgin Coconut Oil
- Water-clear: Clear, white VCO
Virgin coconut oil: production manual for micro- and village-scale production

Contents

CHAPTER 1
Micro- and village-scale processing ........................................... 9

Introduction ................................................................. 10
Product definition ............................................................ 12
  Product characteristics and uses ........................................ 12
Identity characteristics ....................................................... 15
  Colour, odour and taste .................................................. 16
  Specifications ............................................................. 16
Quality assurance in processing VCO ....................................... 16
Socio-economic significance of VCO processing ......................... 17

CHAPTER 2
Processing technology ......................................................... 19

Processing virgin coconut oil .................................................. 20
Critical Control Points in processing VCO .................................. 23
  Common processing Critical Control Points .......................... 23
    Receipt and inspection of nuts .......................................... 23
    Handling of coconut water .............................................. 24
    Drying and handling of VCO ........................................... 24
    Handling of coconut milk .............................................. 25

Modified Kitchen Method ..................................................... 27
Extraction and preparation .................................................... 27
  Processing of VCO ....................................................... 29
    Critical Control Points specific to Modified Kitchen Method ... 29
  Equipment and accessories .............................................. 31
  Quality control .......................................................... 32

Modified Natural Fermentation Method .................................... 35
Extraction and preparation .................................................... 35
  Processing of VCO ....................................................... 35
  Critical Control Points specific to Modified Natural Fermentation Method .................................................. 37
  Equipment and accessories .............................................. 38
  Quality control .......................................................... 40

Low Pressure Oil Extraction Method ....................................... 41
Extraction and preparation .................................................... 43
  Processing of VCO ....................................................... 43
  Critical Control Points specific to Low Pressure Oil Extraction Method .................................................. 44
  Equipment and accessories .............................................. 45
    1) Equipment for particle size reduction .............................. 45
    2) Dryers .......................................................... 45
    3) Equipment for oil extraction ...................................... 48
4) Filtration equipment.  
Quality control.  

**High Pressure Expeller Method.**  
Fresh-dry process  
Extraction and preparation  
Processing of VCO  
Critical Control Points specific to the High Pressure Expeller Method  
Oil extraction  
Equipment and accessories.  
Quality control.  

**CHAPTER 3**  
**General operation requirements.**  
Site requirements  
Plant requirement  

**CHAPTER 4**  
**Operation and maintenance procedures.**  
Good manufacturing practices in VCO processing  
Sanitation in the processing area.  
Sanitation with processing equipment.  
Personnel hygiene.  
Record keeping and production data.  

**CHAPTER 5**  
**By-products and downstream products.**  
Coconut milk residue (sapal)  
Residual or Class B oil  
Making other products  
Coconut husk, fibre and shell.  

**CHAPTER 6**  
**Economic analysis.**  
Cost and return analysis — VCO production  
Scenarios  
Summary of calculations  
Results and discussion  
Sensitivity analysis  
Equipment costs.  

**CHAPTER 7**  
**References.**  
References  
Further reading  
Continued …
Chapter 1

Micro- and village-scale processing
Introduction

Coconut (Cocos nucifera L.) has been part of peoples’ diet and livelihoods in the tropical countries of Asia, the Pacific, South and Central America and Africa for thousands of years. In these areas, native meals are cooked with either coconut milk or coconut oil. In the Cook Islands in the South Pacific, particularly Rarotonga Island, slices of fresh, mature coconut kernel are served with fruits every after meal. In India, the use of coconut for food and its applications in the Ayurvedic medicine, were documented in Sanskrit 4000 years ago (Kabara, 2000). Records show that in the United States, coconut oil was one of the major sources of dietary fats, aside from dairy and animal fats, prior to the advent of the American edible oil (soybean and corn) industry in the mid 1940s (Dayrit, 2005).

The long history of usage and the diverse studies done to characterise and define the composition of the various components of the coconut tree, its fruit and the related products derived from it, established the coconut’s uniqueness and superiority among agricultural crops. Every part of the coconut tree and its fruit can be either consumed by humans or animals or converted into other valuable products. If properly utilised, the coconut has the highest economic value among the palm family. This is why the coconut is normally referred to as the Tree of Life, Man’s Most Useful Tree, King of the Tropical Flora, Tree of Abundance.

Desiccated coconut, coconut milk/cream in liquid and powder form, and coconut oil are the most popular edible commercial products derived from fresh coconut meat (kernel). The meat is very nutritious as it contains dietary fat, dietary fibre, protein, carbohydrates, microminerals such as potassium and phosphorus, and vitamins such as niacin and riboflavin. See Tables 1 to 5 in Annex 1 for the composition and nutritional values of coconut meat, desiccated coconut and coconut milk. Coconut water, which is the liquid inside the coconut fruit, has also been shown to contain microminerals and nutrients which are essential to human health. Because of health benefits and special flavour of young coconut water, domestic sales and export of young coconuts are major income-generating activities for coconut farmers and traders in Thailand. See Tables 6 to 9 in Annex 1 for the composition of coconut water at various stages of maturity, and the electrolyte composition that is a first-rate oral rehydration agent for diarrhea patients (Anzaldo et al 1985).

The newest high value coconut product, which is becoming a by-word in coconut producing countries, the United States and other developed countries, is Virgin Coconut Oil (VCO). The growing demand for VCO can be attributed to the increasing number of published books, literature, results of medical research, anecdotal reports and internet information extolling the beneficial effects of coconut oil on the human
body. Most people generally believe that the demand for VCO as a functional food was generated by the publication of the book, *The Healing Miracles of Coconut Oil* — later revised and updated as *The Coconut Oil Miracles*. Written by American certified nutritionist and naturopathic doctor, Bruce Fife, the book discusses in layman’s terms, the results of medical research and anecdotal reports on the health benefits obtained from coconut oil. Dr Fife also stated, “Coconut oil is the healthiest oil on earth”.

Dr Fife has since written *Eat Fat, Look Thin* and *Coconut Cures*. Another book, *Rx Coconut (Perfect Health Nut)*, was written by Dr Vermen Verallo Rowell, Chief Dermatologist, Makati Medical Center in Metro Manila, Philippines and founder of VMV hypoallergenics line of cosmetics. The latest book on VCO, *The Truth About Coconut Oil (The Drugstore in a Bottle)*, by Dr Conrado Dayrit, Professor Emeritus of the Department of Pharmacology, University of the Philippines College of Medicine, who at 86 yrs old, is Director of Victor Potenciano Medical Center in Metro Manila, Philippines and a practicing cardiologist. These latest books are expected to finally persuade unconvinced doctors and consumers to look at the health benefits that can be derived from coconut oil.

The fast developing niche and high value markets for VCO as a food supplement, as a body moisturiser and carrier oil for aromatherapy, as a hair conditioner and as other applications, is generating a great deal of interest among coconut farmers and landowners, businessmen and entrepreneurs. The attraction is in the different processes for producing VCO with the goal being a possible source for improving livelihoods and incomes.

This manual provides basic information on VCO and small-scale VCO processing technologies for trainers, potential processors, businessmen and anyone interested in producing VCO for home consumption or in micro- and small-scale enterprises. For purposes of clarification and discussion, the terms micro-scale and village-scale coconut processing enterprises will have the following meaning as defined by Bawalan (2003).

**Micro-scale enterprises** include all those with coconut processing capacities below 1,000 nuts per day. Process operation is either completely manual or semi-mechanised, normally using not more than three simple, single-phase motorised machines. In the Philippines, micro-scale enterprises, which also include cottage level operations, normally produce coconut food products. Capitalisation normally ranges from Php50,000 to Php 500,000 (approximately USD1,000 to USD10,000).

**Village-scale enterprises** include all those with coconut processing capacities of 1,000 to 5,000 nuts per day. Process operation is semi-mechanised and uses a combination of single-
phase and three-phase motorised machines. Capitalisation normally ranges from Php 500,000 to Php 5,000,000 (approximately USD10,000 to USD100,000).

**Product definition**

The Philippine National Standard for VCO (PNS/BAFPS 22:2004/ ICS 67.2000.10) officially defines VCO (Figure 1) as:

- Oil obtained from the fresh, mature kernel (meat) of the coconut by mechanical or natural means, with or without the use of heat, without undergoing chemical refining, bleaching or de-odourising, and which does not lead to the alteration of the nature of the oil. Virgin coconut oil is suitable for human consumption without the need for further processing.
- VCO consists mainly of medium-chain triglycerides, which are resistant to peroxidation. The saturated fatty acids in VCO are distinct from animal fats, the latter consisting mainly of long-chain saturated fatty acids.
- VCO is the purest form of coconut oil, essentially water-clear or colourless. It contains natural Vitamin E and has not undergone any hydrolytic and atmospheric oxidation as demonstrated by its very low, free fatty acid (FFA) content (even without refining) and low peroxide value. It has a fresh coconut aroma that can be mild to intense depending on the oil extraction process used.
- VCO differs greatly from traditionally produced, copra-derived coconut oil, which must undergo chemical refining, bleaching and de-odourisation processes to make it suitable for human consumption. RBD (refined, bleached and de-odourised) coconut oil made from copra, is yellow in colour, odourless, tasteless and does not contain natural Vitamin E, since this is removed when the oil is subjected to high temperature and various chemical processes.

**Product characteristics and uses**

The degree of saturation and length of the carbon chain of the fatty acids comprising a particular fat or oil determines its properties, corresponding uses and its effects on human health. The more saturated the fat and the longer the chain, the harder the fat and the higher the melting point (Fife, 2001). Coconut oil is unique amid fats and oils, as it contains the highest percentage of medium-chain fatty acids (MCFA) with a carbon-chain length of 8 to 12 carbon atoms. VCO behaves and metabolises differently in the human body to other saturated and unsaturated fats or oils. MCFA in coconut oil is about 64%, with lauric fatty acid (C12) as the highest ranging from 47 to 53% depending on the coconut variety.

The most significant physical property of coconut oil is that unlike most fats, it does not exhibit gradual softening with increasing temperature, but passes rather abruptly from a brittle
solid to a liquid within a narrow temperature range. In this respect, it resembles cocoa butter (Spectrum of Coconut Products, Philippine Coconut Authority, undated). Coconut oil is liquid at about 27°C or higher and solidifies at about 22°C when it has the consistency of butter in temperate countries. The comparative fatty acid profile of common fats and oils is shown in Figure 2.

Copra-derived coconut oil has been produced and used commercially for almost a century. As such, its use for edible and inedible applications has already been well established.

For edible purposes, coconut oil is generally used as a frying and cooking oil because of its excellent resistance to rancidity development. It is also used as a substitute for expensive butterfat in filled milk, filled cheese and ice cream making these products cheaper without changing their palatability. When hydrogenated, coconut oil is used as margarine, shortening and baking fat. Other edible applications of coconut oil are:

- as a source of fat in infant formulas and baby foods because of its easy digestibility and absorbability;
- as a spray oil for crackers, cookies and cereals to enhance flavour, increase shelf-life and impart a glossy appearance;
- as an ingredient in confectionaries such as candy bars, toffee, caramels, etc.

The Spectrum of Coconut Products states that in food preparations and in diet, coconut oil performs the following functions.

- It serves as an important source of energy in the diet.
- It supplies specific nutritional requirements.
- It provides a lubricating action in dressings or leavening effect in baked items.
- It acts as carrier and protective agent for fat-soluble vitamins.
- It enhances the flavour of food.

The major inedible use of coconut oil is as a raw material in the manufacture of laundry and bath soaps; as coconut chemicals for production of biodegradable detergents, shampoos, shower gels and other cleaning agents; for cosmetics and toiletries; for foam boosting of non-coconut oil based soaps; for the production of synthetic resins and plasticisers for plastic etc.

With the advent of energy crisis in the 1970s, the use of coconut oil and coconut oil-derived coco methyl ester have been successfully used as a diesel fuel substitute. At present, coco methyl ester is

![Figure 2. Comparative fatty acid profile of common fats and oils](image-url)
Virgin coconut oil: production manual for micro- and village-scale production

being used in the Philippines as a fuel additive or fuel enhancer for diesel (up to 5% blend) to support the Clean Air Act of the country. It has been proven by several studies that the addition of coco methyl ester in diesel fuel substantially reduces smoke emission and nitrous oxide formation.

In Thailand, coconut oil is mixed with 10 to 20% kerosene, settled to remove free fats, filtered and used as a diesel fuel substitute. In Vanuatu and other Pacific Islands, coconut oil is used directly as a substitute for diesel.

VCO can also be used in all applications where crude, cochin and refined, bleached, de-odourised (RBD) coconut oils are normally used, and would be a much better alternative if it could be made available in large volumes at affordable prices.

In the manufacture of oleochemicals reserved for cosmetic applications, the use of VCO instead of copra-derived oil will enhance the quality of the final product because of its hypoallergenic properties. One interesting development to note, is that VCO is being focused on specific applications distinct from the traditional uses of coconut oil listed above.

The current emerging major uses of VCO are as:

- a hair and skin conditioner;
- an oil base for various cosmetic and skin care products;
- a carrier oil for aromatherapy and massage oils;
- a nutraceutical and functional food.

Mr. Arthur Bautista of the Splash Research Institute defines nutraceutical as

Natural food components that provide health benefits or reduce the risk of chronic disease, above and beyond their basic nutritional function.

Simply put, nutraceuticals are substances that not only nourish but also heal. Virgin coconut oil is considered a nutraceutical because studies have shown the following facts.

- The medium chain (C8 – C12) fats in coconut oil are similar in structure to the fats in mother’s milk that gives babies immunity to disease. There are also similar beneficial effects in adults, (Kabara, 2000).
- VCO possesses anti-inflammatory, anti-microbial and antioxidant properties which work together to protect arteries from atherosclerosis and the human heart from cardiovascular disease, (Fife, 2004).
- VCO boosts the immune system.
- VCO protects against heart disease by increasing high-density lipoprotein (HDL) that collects the excess or unused cholesterol in the body for excretion by the liver.
- VCO provides protection from infectious diseases not easily cured by known antibiotics.
Micro- and village-scale processing

- VCO is digested easily without the need for bile and goes directly to the liver for conversion into energy, (Dayrit, 2003).
- VCO stimulates metabolism, boosts energy and prevents deposition of fats thereby preventing obesity, (Dayrit, 2003).
- VCO improves the nutritional value of food by increasing absorption of vitamins, minerals and amino acids, (Fife, 2004).
- VCO is the world’s only natural, low-calorie fat, (Fife, 2004).
- VCO inhibits the action of cancer-forming substances (Clara Lim Syliangco, 1987).

For further information on the health benefits of coconut oil, see Annex 2: Frequently Asked Questions on Virgin Coconut Oil.

Identity characteristics

Gas Liquid Chromatography (GLC) range of fatty acids composition of VCO shall be in accordance with Table 1.

**Table 1. Gas Liquid Chromatography range of fatty acid composition of VCO**

<table>
<thead>
<tr>
<th>Common name</th>
<th>Composition</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caproic acid</td>
<td>C 6:0</td>
<td>ND – 0.7</td>
</tr>
<tr>
<td>Caprylic acid</td>
<td>C 8:0</td>
<td>4.6 – 10.0</td>
</tr>
<tr>
<td>Capric acid</td>
<td>C 10:0</td>
<td>5.0 – 8.0</td>
</tr>
<tr>
<td>Lauric acid</td>
<td>C 12:0</td>
<td>45.1 and above</td>
</tr>
<tr>
<td>Myristic acid</td>
<td>C 14:0</td>
<td>16.8 – 21</td>
</tr>
<tr>
<td>Palmitic acid</td>
<td>C 16:0</td>
<td>7.5 – 10.2</td>
</tr>
<tr>
<td>Palmitoleic acid</td>
<td>C 16:1</td>
<td>ND*</td>
</tr>
<tr>
<td>Stearic acid</td>
<td>C 18:0</td>
<td>2.0 – 4.0</td>
</tr>
<tr>
<td>Oleic acid</td>
<td>C 18:1</td>
<td>5.0 – 10.0</td>
</tr>
<tr>
<td>Linoleic acid</td>
<td>C 18:2</td>
<td>1.0 – 2.5</td>
</tr>
<tr>
<td>Linolenic acid</td>
<td>C 18:3, C 24:1</td>
<td>ND – 0.2</td>
</tr>
</tbody>
</table>

* ND= non-detectable

The fatty acid profile of virgin coconut oil is greatly dependent on the coconut variety. Studies done by the Philippine Coconut Authority (PCA) Zamboanga Research Centre, revealed that coconut hybrid varieties have a higher lauric fatty acid content (above 50%) than local tall varieties.

Thai village group at an FAO sponsored training session with TISTR in Prachap Khiri Khan, Thailand. The people are trained in all areas of producing virgin coconut oil and improving their farm incomes.
Colour, odour and taste

Virgin coconut oil shall be colourless, sediment free, with natural fresh coconut aroma and free from rancid odours or tastes.

Specifications

Virgin coconut oil shall conform to the requirements specified in the table below.

Table 2. Virgin coconut oil property requirements

<table>
<thead>
<tr>
<th>Properties</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture and volatile content</td>
<td>0.20% max.</td>
</tr>
<tr>
<td>Free fatty acids (expressed as lauric acid)</td>
<td>0.20% max.</td>
</tr>
<tr>
<td>Peroxide value</td>
<td>3.0 meq/kg oil max.</td>
</tr>
<tr>
<td>Food additives</td>
<td>None permitted</td>
</tr>
<tr>
<td>Contaminants</td>
<td></td>
</tr>
<tr>
<td>Matter volatile at 105°C</td>
<td>0.20% max.</td>
</tr>
<tr>
<td>Heavy metal</td>
<td>mg/kg max.</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>5.0</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>0.40</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>0.10</td>
</tr>
<tr>
<td>Arsenic (As)</td>
<td>0.10</td>
</tr>
</tbody>
</table>

In the absence of a laboratory analysis report, the quality of VCO can be assessed through sensory evaluation by testing the following attributes:

Colour. Virgin coconut oil has a clear water appearance. Based on the studies done under the Philippines/UK Aflatoxin Reduction in Copra Project, the colour of the oil is either brought about by contaminants in the oil (as in tapahan drying of copra), or by high temperature processing and microbial contamination of the coconut meat prior to oil extraction. Depending on the type of micro-organisms that cause the contamination, the oil colour can appear yellow or pink or red-orange (Figure 3).

Aroma. A good quality VCO does not have any rancid smell. It has a sweet coconut aroma which may range from mild to intense depending on the process used for extraction.

Taste. A good quality VCO should not have off-flavours or a sour taste. It should not cause any itchiness in the throat when ingested as this is an indication that the free fatty acid content is already higher than the prescribed standard.

Quality assurance in processing VCO

Quality assurance in the context of any industry should be viewed in two ways.

1. Ensure that the product produced by any processor conforms to domestic and internationally accepted product standards. The Philippines is the largest producer and exporter of coconut, so quality assurance is essential in VCO processing as the oil is becoming a highly lucrative export commodity. The market for VCO, whether local or international, has to
be protected and sustained by ensuring that only VCO of the highest quality is produced.

2. Quality assurance should be strictly implemented to protect the consumer. The VCO on sale must be of the highest quality since there is no way for a consumer to check the quality when it is bought in a packaged container. At present, VCO is generally bought as a food supplement or nutraceutical because of the increasing quantity of literature indicating its beneficial effect on human health. In this instance, quality is of paramount importance since the product is being ingested directly and not as a food ingredient or a cooking medium.

The *Philippine National Standard for VCO* (PNS/BAFPS 22:2004) promulgated for adoption by all producers, processors, traders and exporters of virgin coconut oil in the Philippines under PCA Administrative Order 01 Series of 2005, has the following specifications.

**Socio-economic significance of VCO processing**

Since 2001, when VCO was first shipped by a herbal company from the Philippines to the United States, demand for the product has been steadily growing in there and in other developed countries (Canada, Australia, United Kingdom). VCO is the latest addition in the line of coconut products that the Philippines has introduced to the world. Other coconut producing countries like India, Indonesia, Fiji, Papua New Guinea are now exporting VCO products because its average value is about 400 to 500% higher than the export value of copra-derived coconut oil. At present, demand for VCO is still higher than the supply since most production is from small-scale operations.

The fast developing and high value niche market for VCO, offers good prospects of increased living standards for the farmer. Virgin coconut oil can be produced in homes and by micro- and village-scale operations, creating a situation where coconut farmers can directly participate in a larger share of the industry profit instead of being mere producers of copra. In addition to normal work routine, a husband and wife team using home utensils, can process 50 nuts per day to produce three to five litres of VCO. Scraping of coconuts is done by hand.

Generally speaking, coconut meat from 15 fully mature coconuts is required to produce one litre VCO if done in a home or micro-scale operation. Fifteen coconuts are roughly equivalent to 3.3 kg of copra. Using the average domestic price of copra for 14 years in the Philippines at Php 10.70 (USD0.19) per kilo, 15 coconuts will generate an income of USD0.63. However, if the 15 coconuts are processed into VCO, the income generated will be Php 130.00 (about USD2.40), which is the current bulk buying price per litre for VCO traders in

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**VCO must meet prescribed quality standards.**

Meat and oil contact with metals other than stainless steel must be avoided at all costs to stop heavy metal contamination.

Coconut meat from 15 fully mature coconuts is usually required to produce 1 L VCO if done in a home or micro-scale operation.
the Philippines. The income obtained will be even higher if the VCO is sold locally in retail markets. In areas where VCO is produced, farmers are benefiting from an increased price per nut from Php 3.00 (USD0.05) to Php 5.50 (USD0.10). However, there are instances when copra prices fall to very low levels so it is no longer viable for farmers to harvest and process coconuts. Under these conditions, processing of coconut into VCO instead of copra is a much more profitable option.

On the macro-economic level, the value addition in terms of foreign exchange earnings of the Philippines on the export of coconut oil is also very high. The average international price for copra-derived coconut oil (1994 to 2004) is USD582/MT (UCAP statistics), while the recorded export price for VCO in December 2004 was USD3,134/MT (PCA). This means a value addition of about 500%. With this export price, VCO is now the highest valued coconut product in the world market.
Chapter 2

Processing technology
Virgin coconut oil can be produced directly from the fresh comminuted (grated, chopped, granulated) coconut meat, or from coconut milk, or from coconut milk residue (Figure 4). The choice of the technology to be adopted, depends to a great extent on the scale of operation, the degree of mechanisation desired, the amount of investment available and the demands of the prospective buyer. The scale of operation to be implemented is significantly dependant on the available coconut supply base. Coconut supply base can be estimated by using Table 3 that shows specific processing capacities.

Table 3. Required coconut supply base (ha) for specific processing capacities at different tree productivity rates (nuts/tree/year)*

<table>
<thead>
<tr>
<th>Desired processing capacity (nuts/day)</th>
<th>Productivity: Nuts/tree/year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>35</td>
</tr>
<tr>
<td>100</td>
<td>8.57</td>
</tr>
<tr>
<td>200</td>
<td>17.14</td>
</tr>
<tr>
<td>400</td>
<td>34.29</td>
</tr>
<tr>
<td>500</td>
<td>42.86</td>
</tr>
<tr>
<td>600</td>
<td>51.43</td>
</tr>
<tr>
<td>800</td>
<td>68.57</td>
</tr>
<tr>
<td>1000</td>
<td>85.71</td>
</tr>
<tr>
<td>2000</td>
<td>171.43</td>
</tr>
<tr>
<td>3000</td>
<td>257.14</td>
</tr>
<tr>
<td>4000</td>
<td>342.86</td>
</tr>
<tr>
<td>5000</td>
<td>428.57</td>
</tr>
</tbody>
</table>

* Calculations are based on 300 days per year of operation of the intended processing plant and the assumption that there are 100 productive coconut trees per hectare. Productivity rate is given in terms of number of nuts produced per tree per year.

Source: Bawalan (2003)
VCO produced by each process exhibits different organoleptic characteristics, so the process used for producing VCO can be identified by sensory evaluation. Coconut milk is an emulsion of oil and water that is stabilized by protein. To recover the oil from coconut milk, the protein bond has to be broken either by heat or by enzymes or some other mechanical means. For example, the different methods of the fresh-dry process 1 to 3 shown in Figure 4 and Table 4, use water-cooled, high-pressure expellers. Methods 1 to 8 in Table 4, differ only by the manner in which the fresh meat is prepared prior to oil extraction.

The export market at present provides a lower price for VCO produced from expellers than VCO produced from coconut milk.

<table>
<thead>
<tr>
<th>Type of process</th>
<th>Quality of oil and recovery</th>
<th>Advantages and limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Fresh-dry process</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Wet milling route)</td>
<td>FFA: 0.05 – 0.08%</td>
<td>Produces full protein, medium fat coconut flour as a co-product.</td>
</tr>
<tr>
<td>(High Pressure Expeller Method)</td>
<td>M.C.: 0.07 – 0.1%</td>
<td>Long shelf-life of oil: 1 yr and more.</td>
</tr>
<tr>
<td>M.C. of meat for extraction should be 3 – 4%</td>
<td>Colour: water-clear</td>
<td>Uses mechanical type of equipment to produce the oil.</td>
</tr>
<tr>
<td></td>
<td>Oil recovery: 31 kg/100 kg of fresh milled coconut meat (Based on 50 % initial M.C. of fresh meat)</td>
<td>Can be produced in a village-scale plant operation.</td>
</tr>
<tr>
<td><strong>2. Fresh-dry process</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Dessicated coconut route)</td>
<td>FFA: 0.05 – 0.08%</td>
<td>Produces full protein, medium fat coconut flour without testa as a co-product.</td>
</tr>
<tr>
<td>(High Pressure Expeller Method)</td>
<td>M.C.: 0.07 – 0.1%</td>
<td>Long shelf-life of oil: 1 yr and more.</td>
</tr>
<tr>
<td>M.C. of meat for extraction should be 3 – 4%</td>
<td>Colour: water-clear</td>
<td>Uses mechanical type of equipment to produce the oil.</td>
</tr>
<tr>
<td></td>
<td>Oil recovery: 30 kg/100 kg of fresh pared, ground meat (Based on 50 % initial M.C. of fresh meat)</td>
<td>High investment cost, suited only to medium scale plant operation (10,000 nuts/day and above).</td>
</tr>
<tr>
<td><strong>3. Fresh-dry process</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Grated coconut route)</td>
<td>FFA: 0.05 – 0.08%</td>
<td>Produces full protein, medium fat coconut flour without testa as a co-product.</td>
</tr>
<tr>
<td>(High Pressure Expeller Method)</td>
<td>M.C.: 0.07 – 0.1%</td>
<td>Long shelf-life of oil: 1 yr and more.</td>
</tr>
<tr>
<td>M.C. of meat for extraction should be 3 – 4%</td>
<td>Colour: water-clear</td>
<td>Uses mechanical type of equipment to produce the oil.</td>
</tr>
<tr>
<td></td>
<td>Oil recovery: 30 kg/100 kg of fresh grated meat (Based on 50 % initial M.C. of fresh meat)</td>
<td>Can be done in a micro-scale plant operation.</td>
</tr>
<tr>
<td><strong>4. Low Pressure Method</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.C. of meat for extraction should be 10 – 12% for bridge press and DME expeller, and 7 – 10% for Thai S. Steel Expeller</td>
<td>FFA: 0.1 – 0.2%</td>
<td>Uses manually operated equipment to produce the oil.</td>
</tr>
<tr>
<td></td>
<td>M.C.: 0.17% and above</td>
<td>Produces a semi-dry coconut residue that has to be further dried or processed to have market value.</td>
</tr>
<tr>
<td></td>
<td>Colour: water-clear</td>
<td>Shell-life of oil is very short if not immediately dried by gentle heating after extraction to remove water.</td>
</tr>
<tr>
<td></td>
<td>Oil recovery: 24.5 kg/100 kg of fresh grated coconut meat (Based on 50 % initial M.C. of fresh meat)</td>
<td></td>
</tr>
</tbody>
</table>

1 Thai expeller costs about USD3500, while Bridge Press costs USD500 to USD600. The Thai Expeller can process 200 to 250 kg/hr of fresh meat to give coconut milk or about 30 kg/hr of 7% M.C. meat to give VCO.
<table>
<thead>
<tr>
<th>Type of process</th>
<th>Quality of oil and recovery</th>
<th>Advantages and limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5. Traditional Wet or Modified Kitchen Method</strong>&lt;br&gt;M.C. of fresh meat for extraction is approx. 50%&lt;br&gt;Coconut milk is starting point for VCO extraction</td>
<td>FFA: 0.06 – 0.2%&lt;br&gt;M.C.: 0.07 – 0.14%&lt;br&gt;Colour: water-clear to pale yellow depending on the heating process (max temp 90°C).&lt;br&gt;Oil recovery: 19 kg/100 kg of fresh grated coconut meat (Based on 50 % initial M.C. of fresh meat)&lt;br&gt;Milk extraction done using manually operated press or Thai wet-market type hydraulic coconut cream milk press or Thai S. steel VCO/cream expeller</td>
<td>Very low investment cost.&lt;br&gt;Can be produced in a home-scale operation using ordinary kitchen utensils.&lt;br&gt;Produces a wet coconut residue that must be further dried or processed to have market value.&lt;br&gt;Produces a by-product (proteinaceous residue) with no commercial value at present.&lt;br&gt;After 5 days, oil becomes rancid if it is not properly heated to dryness after extraction to remove water.&lt;br&gt;Class B oil can be recovered from residue after Class A oil is skimmed off. This will give 19 kg of total oil recovery (Class A + Class B).</td>
</tr>
<tr>
<td><strong>6. Modified Natural Fermentation Method</strong>&lt;br&gt;M.C. of fresh meat for extraction is approx. 50%&lt;br&gt;Coconut milk is starting point for VCO extraction</td>
<td>FFA: 0.1%&lt;br&gt;M.C.: 0.12% &amp; below&lt;br&gt;Colour: water-clear&lt;br&gt;Oil recovery: 19.8 kg/100 kg fresh grated meat (Based on 50 % initial M.C. of fresh meat)&lt;br&gt;Milk extraction done using manually operated press or Thai wet-market type hydraulic coconut cream milk press or Thai S. steel VCO/cream expeller</td>
<td>Can be produced in a home-scale operation using ordinary kitchen utensils or in a micro-scale operation using semi-mechanised equipment.&lt;br&gt;Disposal of fermented skim milk could be a problem if carried out at capacities above 2,000 nuts/day. Skim milk must be diluted with water before disposal to waste.&lt;br&gt;Oil produced could turn sour if fermentation period is prolonged. Oil must be properly heated to dryness after extraction to remove water and prevent rancidity development.&lt;br&gt;Class B oil can be recovered from residue after Class A oil is skimmed off. This will give 19 kg of total oil recovery (Class A + Class B).</td>
</tr>
<tr>
<td><strong>7. Centrifuge Process</strong>&lt;br&gt;M.C. of fresh meat for extraction is approx. 50%&lt;br&gt;Coconut milk is starting point for VCO extraction</td>
<td>FFA: 0.04 – 0.08%&lt;br&gt;M.C.: 0.1% and below&lt;br&gt;Colour: water-clear&lt;br&gt;Oil recovery: 17 kg/100 kg fresh ground coconut meat (Based on 50 % initial M.C. of fresh meat)&lt;br&gt;Note: Reported oil recovery value here was calculated from information provided by a VCO processor in the Philippines using the two-stage centrifuge process. Single stage centrifuge process operation may have a different oil recovery rate.&lt;br&gt;Milk extraction is done using a motorised milk extractor.</td>
<td>Produces the best quality coconut oil with sweet coconut aroma if done in a two-stage centrifuge process.&lt;br&gt;Can only be produced in a medium to large-scale operation (above 10,000 nuts/day), as investment cost is very high.&lt;br&gt;Further processing of skim milk into a health beverage and the meat residue into coconut flour can improve profitability.&lt;br&gt;Tables 10 and 11 in Annex 1 give details on nutritional composition and amino acids in coconut skim milk.</td>
</tr>
</tbody>
</table>

There are eight different technologies available for producing VCO – only the processes which are applicable in micro- and village-scale operations are discussed in this manual.
8. Bawalan-Masa Process
The process uses coconut milk residue as raw material. The residue is blanched and dried at a specific moisture content and defatted under controlled conditions. Specially designed equipment produces VCO and low fat, high fibre coconut flakes. The flakes are ground to produce coconut flour with high dietary fibre.

<table>
<thead>
<tr>
<th>Type of process</th>
<th>Quality of oil and recovery</th>
<th>Advantages and limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Bawalan-Masa Process</td>
<td>FFA: 0.05 – 0.08% M.C.: 0.07 – 0.12% Colour: water-clear Oil recovery: 17 kg/100 kg of wet residue. From 100 kg of grated fresh meat generated 46.7 kg of wet residue which can be further processed to give 7.94 kg extra oil.</td>
<td>Further recovery of high value oil from residue makes coconut milk processing more profitable. Long shelf-life of oil: 1 yr and more. Produces low fat, high fibre coconut flour as a co-product. Requires mechanical type of equipment to produce the oil. Production process has to be attached or integrated into an existing coconut milk processing plant.</td>
</tr>
</tbody>
</table>


Critical Control Points in processing VCO

Common processing Critical Control Points

To ensure that only high quality VCO will be produced, the following Critical Control measures should be applied in all of the processes discussed in this VCO manual. Critical Control Points for individual processes are given later in manual.

Receipt and inspection of nuts

All de-husked nuts are inspected to segregate and reject immature, germinated or spoiled nuts when delivered to the plant. Only fully mature nuts, 12 to 13 months old, should be used for VCO production. As an indicator of maturity of the nut, the husk and shell is brown in colour and the nut makes a sloshing sound when shaken.

Always ensure that the nut, while fully mature, does not have a haustorium (Figure 5) because the oil content of the kernel starts to decline once the haustorium is formed and the quality deteriorates as the haustorium grows bigger.

Proper procedures must be adopted so that nuts do not break while unloading. Likewise, exposure to sunlight of the de-husked nuts during delivery, weighing and unloading should be avoided to prevent cracking of the shell that will cause spoilage. Nuts will crack and begin to decay after one hour in the sun.

Storage

De-husked nuts should be kept in clean storage areas with cement floors, good ventilation and adequate rain/sun cover. Avoid sun exposure of the de-husked nuts. Storage bins should be designed and partitioned so that the principle of first-in-first-out can be easily implemented. The pile of de-husked nuts should not be placed directly on the cement floor but on an elevated platform (pallet) with slats so that the coconut water can flow away if breakages occur. Maximum height for the storage pile of fresh nuts should not exceed 1.8 metres.


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De-husked, fresh coconuts should be processed within seven days from the time of harvest. Therefore the VCO processing facility should be placed within the coconut producing areas to ensure freshness of raw material and to lower transport costs of the nuts.

**Handling of coconut water**

Coconut water spoils and ferments very rapidly once the nut is opened. When the nut is split, coconut water should be collected in a container and properly disposed of in one of two ways. As another source of income it can be converted into vinegar — or other products including nata de coco and electrolyte drinks, or diluted with water and flushed into soakage pits or the sewage system.

Coconut water should not be left on the floor as it will attract flies and become a source of contamination. Undiluted coconut water becomes very acidic and will destroy the cement surface of the floor if it is not tiled. It also generates a foul smell once fermentation has started.

**Drying and handling of VCO**

Water in oil causes it to go rancid thus shortening its shelf-life. To ensure the VCO will have a long shelf-life, it should be subjected to an oil-drying process after recovery from coconut milk or extraction from dry grated or granulated coconut meat. Removal of residual moisture is critical in the VCO produced from the Modified Kitchen Method and the Modified Natural Fermentation Method. Because both are wet extraction processes, that is, recovery is from meat with an intermediate moisture content, the end product will contain more moisture than with high pressure expelling. Drying of the oil can be achieved using one of the following methods.

- Place the extracted oil in a double boiler and heat for about fifteen minutes or until the oil has changed from turbid to water-clear colour. Oil temperature should not exceed 65°C.
- Incubate or air-heat the oil in the container at 50°C for 12 hours or until the oil has changed from turbid to water-clear colour.
- Vacuum dry using a commercial vacuum dryer at 50°C.

Vacuum drying is the most effective way of drying oil without the risk of the colour turning yellow but the investment cost is high, so it is not a viable option for micro-scale processing.

A double boiler can be made by placing a stainless steel mixing bowl or basin in a larger pan that is half filled with water. Pour the oil into the smaller container. Once the water in the pan starts to boil, reduce the heat to the lowest possible setting so that the hot water remains at a simmer point.

Do not allow oil to boil or the container to boil dry!
Handling of coconut milk

**Modified Kitchen and Natural Fermentation Critical Control Points**

Coconut milk contains protein and other nutrients, is low in acid and has a high moisture and nutrient content making it very susceptible to microbial contamination and rapid spoilage. Because of these characteristics, grating or milling of fresh coconut meat and subsequent extraction of the milk should be done in a clean environment and under very strict sanitary conditions. The following critical control measures must be applied at all times:

- Always ensure that grating or scraping of coconut meat and subsequent milk extraction is done under sanitary conditions by observing good personal hygiene. Wash hands with soap and water before doing any preparation work, wear the necessary protective clothing with hair cover. Do not wear jewellery on the hands or arms.

- Ensure that all materials, utensils or equipment used in extracting and holding coconut meat and milk are thoroughly cleaned and rinsed with hot water. Utensils should be free from any soap residues.

- High quality clean water should be used for the diluent or re-hydrating agent for the second milk extraction. It should be free from microbial contamination and low in mineral content. Filtered, purified or demineralized water is preferable. Coconut water can also be used as a diluent, but a specific handling procedure must be observed to avoid microbial contamination. The coconut water must be filtered and immediately placed in a refrigerator or ice box while waiting for the grating and first milk extraction to be completed.

**NEVER HEAT VCO oil directly in a pot or pan as this will cause the oil to turn yellow. Drying the oil by heating will ensure that the water content of the oil is less than 0.2% and preferably less than 0.1%. Processing containers and packaging material used for VCO storage must be thoroughly cleaned and dry before filling with the VCO.**
Low Pressure Extraction and High Pressure Expeller Critical Control Points

The low pressure extraction methods and the high pressure expeller methods belong to the general category of Fresh-dry processing of VCO where the VCO is obtained by first drying the fresh, grated or comminuted coconut meat and then pressing the dried meat to separate the oil. Hence, in both processes, the most critical step is the drying of the meat. The following critical control measures must be observed when preparing the coconut meat for subsequent oil extraction.

- Dry the coconut meat within four hours of opening the nut. Delay in drying will allow bacterial contamination of the fresh meat and will result in an unacceptable yellow oil.
- Dry the grated or granulated coconut meat at a temperature of 70 to 75°C using an indirect, hot-air dryer, either steam heated or biomass fired. If the drying temperature is too low, bacterial contamination will occur resulting in an unacceptable yellow oil. On the other hand, if the drying temperature is too high, the grated meat will burn, also resulting in a yellow oil.
- Under conditions of low humidity and clear, hot days, the grated meat can be solar dried. A well-designed solar dryer can normally generate a drying temperature of about 70°C that is sufficient for the intended purpose. However, additional heat may be needed to ensure this temperature is reached on cloudy, rainy days. Open sun-drying is not recommended as grated meat can become contaminated with dust and insects and temperatures are too low to prevent bacterial breakdown of the meat.
- If using a direct contact dryer similar to the one being used in the South Pacific for the Direct Micro Expelling (DME) process, constant attention and turning of the grated meat is required to prevent it from becoming scorched or burnt, which will result in an unacceptable yellow oil.
Modified Kitchen Method

For decades, people in coconut producing areas like the Philippines and India have boiled coconut milk extracted from freshly grated or comminuted coconut meat with or without the addition of water, to produce coconut oil for hair and massage applications. However, the oil produced from this process is dark yellow in colour with a very short shelf-life — it normally becomes rancid within three to five days. The Modified Kitchen Method for producing VCO follows this principle except that the heating is controlled to prevent the oil from turning yellow, and the recovered oil is further dried to ensure that the moisture content is kept at less than 0.2 % to prolong its shelf-life and prevent rancidity.

The Modified Kitchen Method produces VCO with an intense coconut aroma but it has the lowest VCO recovery of the available technologies because a large proportion of oil remains entrapped in the proteinaceous residue (latik). This method requires precise temperature control and timing during the heating process to prevent the oil from turning yellow. However, Class B oil can be recovered by further heating or toasting the latik after the Class A VCO is recovered at a lower temperature with a maximum of 90°C.

Extraction and preparation

The Modified Kitchen Method comprises two distinct parts — extraction/preparation of coconut milk and processing of the VCO from the milk. Figures 6 and 7 and Table 5 demonstrate the work-flow from de-husking of coconuts to the extraction of the coconut milk.

Read and follow the Critical Control Points in Chapter 1, before starting production of VCO using the Modified Kitchen Method.

Figure 6. Flow chart for the extraction and preparation of coconut milk

Making VCO by this method is tedious and requires precise temperature control. Generally, the process is not recommended except when the fermentation process fails.
### Table 5. Process for the extraction and preparation of coconut milk

<table>
<thead>
<tr>
<th>Process</th>
<th>Action to take</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selecting nuts</td>
<td>Select fully matured nuts (12 to 13 months old) and de-husk; the husk should be turning brown — not green.</td>
</tr>
<tr>
<td>1) Splitting and grating</td>
<td>Split the de-husked nut into two and grate the meat either manually or through the use of motorised grater. Another method is to manually de-shell the coconut and feed the meat with testa into a Thai motorised coconut shredder.</td>
</tr>
<tr>
<td>2) First milk extraction</td>
<td>Extract the milk from the grated coconut meat either by hand or by manually operated or motorised coconut milk press. This can be the hydraulic type, vertical screw or horizontal screw type press, manually operated or motorised. Set aside the milk obtained. Prepare the coconut milk residue (sapal) for second extraction.</td>
</tr>
<tr>
<td>3) Second milk extraction</td>
<td>Do a second milk extraction by mixing water with the sapal obtained from the first milk extraction using a ratio 2 sapal:1 water. Press the residue again.</td>
</tr>
<tr>
<td>4) Mixing of first and second milk extracts</td>
<td>Mix thoroughly the first and second milk extracts by stirring vigorously for about 10 minutes.</td>
</tr>
</tbody>
</table>


![Figure 7. Major steps for preparation and extraction of coconut milk](image)

Scraping coconuts using a hand rotary scraper machine in Sri Lanka

Preparing coconuts for scraping at the village processing facility in Thailand. The meat is then pressed to extract virgin coconut oil.
Processing of VCO

Figures 8 and 9 and Table 6 demonstrate the Modified Kitchen Method for processing of coconut milk to produce VCO.

Table 6. The Modified Kitchen Method for processing of coconut milk to produce VCO

<table>
<thead>
<tr>
<th>Process Description</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Setting of the coconut milk mixture</td>
<td>Allow the coconut milk mixture to stand for a maximum of three (3) hours. Note 1: If the settling is done in the refrigerator or in an ice box, coco skim milk which is a very nutritious beverage that contains protein and micronutrients such as calcium, potassium, phosphorus, niacin, thiamine and riboflavin, can be recovered for human consumption (see Tables 10 and 11 in Annex 1 for the nutritional value of coconut skim milk). Likewise, the proteinaceous residue (latik) can be eaten with rice cakes or used in cooking as a meat extender. Skim milk is a very perishable food item so it has to be consumed immediately after separation or, to prolong its shelf for a day, it must be pasteurised at 67°C for 20 minutes in a double boiler. Heating it to higher temperature will destroy the flavour Note 2: Settling the coconut milk at ambient temperature (not in the refrigerator) will cause the skim milk and resulting latik to turn sour — it is unsuitable for human consumption. Note 3: Settling of coconut milk can be bypassed by going directly to slow heating step 3. However, it will take a much longer heating time to recover the oil.</td>
</tr>
<tr>
<td>2) Separation of coconut cream and coco skim milk</td>
<td>Separate the cream (oily part) from the coco skim milk (watery part) by scooping the cream from the top. Note 4: Coco skim milk can be kept in the freezer for processing later into beverage or properly discarded if it has no further use.</td>
</tr>
<tr>
<td>3) Slow heating of the coco cream</td>
<td>Place the coco cream in a double boiler and heat very slowly to coagulate the protein and release the oil. After slow heating for about 2 to 2.5 hours, coconut protein (latik) will coagulate and the oil will separate out (Class A VCO). For the first hour of heating, temperature can be allowed to reach 90°C. After this time, the temperature should not exceed 80°C until the protein begins to coagulate. When the oil starts to separate from the coagulated protein, lower the temperature to 60°C.</td>
</tr>
<tr>
<td>4) Separation of oil and latik</td>
<td>Separate the oil from the latik by straining the mixture through a muslin cloth or in a stainless steel screen with fine mesh placed over a stainless steel pot. Set aside the latik. Note 5: If the settling of milk (Step 1) is done in a refrigerator or in an ice-box, the recovered latik can be eaten or used as meat extender in some food formulations.</td>
</tr>
<tr>
<td>5) Oil drying</td>
<td>This is required to ensure that all residual moisture is removed to prolong the shelf-life of the VCO. See Drying and handling VCO product for the Critical Control Points that must be observed.</td>
</tr>
<tr>
<td>6) Final filtration of oil</td>
<td>Oil is filtered to remove adhering fine particles of latik that passed through the muslin cloth. Note 6: One practical and simple way of filtering the oil is by pouring the oil over sterilized cotton wool placed in the hole of a big funnel, and allowing it to trickle down. For a large-scale operation, a fabricated pressure filter with filter cloth is recommended to increase filtration rate.</td>
</tr>
<tr>
<td>7) Packaging and storage</td>
<td>VCO may be stored in stainless steel containers and poly-lined drums. Pour oil into very dry bottles for marketing. Note 7: The recommended packaging material for VCO is glass. PET bottles (plastic bottles normally used for mineral water) can be used in cases where the VCO is immediately consumed. Glass is recommended if the VCO is sold in stores where it may remain on the shelf for several weeks.</td>
</tr>
</tbody>
</table>


Critical Control Points specific to Modified Kitchen Method

Aside from the critical control points discussed previously, heating of the coconut milk or cream is the major critical step in the Modified Kitchen Method as this will determine whether the oil recovered will be water-clear (Class A) VCO, or yellow (Class B) oil which will preclude it from being classified as ‘virgin’.

VCO must be water-clear
The following control measures should be observed at all times to ensure that only water-clear oil will be recovered.

- Begin by heating the coco cream in the double boiler at medium heat until it is almost boiling; then reduce the heat to low until the latik coagulates and the coconut oil separates out. Stir the coco cream to disperse the heat.
- Heating should be done in such a way that the coconut cream in the pan will just simmer and not boil (max temperature 90°C).
- Do not allow the proteinaceous latik to turn brown as this will give a yellow coloured coconut oil. Once the Class A VCO separates from the latik (Figure 9), remove it from the pan. The remaining latik can be further heated to recover more oil. However, this type of Class B oil will already be yellow and only suitable for skin care or massage products.
Equipment and accessories

The Modified Kitchen Method is often carried out in a home-scale operation. Hence, manual grating and manual squeezing of coconut milk is not uncommon. The following equipment list is applicable at micro- and village-scale operation.

1) Motorised coconut grater. Processing capacity of 50 to 80 nuts per hour depending on the skill of the operator, stainless steel blade and housing of the 1/2 HP electric motor, direct drive units. Fabricated in the Philippines and Thailand.

2) Coconut milk presses

Bridge press. Manually operated, vertical screw type press, with perforated holding basket and receptacle trough. All materials in contact with the coconut meat are made of stainless steel; 9 kg grated meat (20 nuts) per load; 15 to 20 minutes pressing cycle per load; process capacity about 60 to 80 nuts per hour. Fabricated in the Philippines; original design from the Agro Processing Division, Natural Resources Institute, Chatham, Kent, United Kingdom. Thai version is manufactured by Ngow Huat Yoo, Bangkok, Thailand.

Horizontal screw press. Manually operated; continuous feed without the need for a holding bag; 47 kg grated meat (100 nuts) per hour for a two-pass extraction. The first and second extraction requires mixing grated meat with water; all materials in contact with coconut meat are made of stainless steel. Designed and fabricated in Cavite, Philippines.

Hydraulic jack. Manually operated with fixed head; perforated holding basket and circular receptacle with downspout; 10 tons capacity hydraulic jack; all materials in contact with the coconut meat made of stainless steel; 2.5 kg grated meat per load (4 to 5 nuts); 5 minutes pressing cycle per load; process capacity of about 48 to 60 nuts per hour. Designed and fabricated by PCDR Metalwerke, Caloocan City, Philippines. Similar presses are available in Sri Lanka.

In Thailand, coconut milk is produced in wet markets using a coconut shredder to chop up the meat of the whole coconut after it is removed from the shell. The meat is then put into a triple layered material bag and the milk is extracted by a stainless steel motorised hydraulic press (Figure 11). This unit is suited to micro- and village-scale operations. Capacity of the press is 30 to 40 kg/hour (double-pressed) of fresh grated meat. Alternatively, a Thai motorised horizontal screw expeller can double press 200 to 250 kg/hr of fresh meat to produce coconut milk. This unit can produce VCO directly if moisture content of meat is 7 to 10%. All units are supplied by Ngow Huat Yoo, Bangkok, Thailand.

3) Wok, cast iron. Diameter 68 cm, 20 L capacity. Converts into an improvised double boiler with the addition of stainless steel basin; fabricated metal support (stainless steel) with stainless...
32

4) **Stove** with appropriate housing to fit a wok. Coconut husk, shell, coconut shell-charcoal or gas fired stove.

5) **Manual filtering device.** Gravity type, 18 L capacity per batch; designed by Divina D. Bawalan.

**Quality control**

Laboratory analysis of a VCO sample should be done to make certain it meets the domestic and international standard approved for the product. However, for micro- and village-scale operation, submitting a sample for laboratory analysis for every production batch is not economically viable. In addition, properly equipped, quality control laboratories that can do the analysis of VCO samples are not always located close to the production areas. The practical approach to this problem then,
is to have the processors standardise their methods, and strictly adhere to the instructions and recommendations in this manual of the Critical Control Points that should be observed for every step.

This manual is a foundation for the establishment of the Good Management Practices (GMP) and HACCP systems that should be the goal in every VCO processing facility. The need for regular laboratory analysis on VCO production batch samples can be greatly reduced once the process has been standardised. The procedure in this manual, Critical Control Points, GMP and HACCP systems must be established and strictly adhered to by the processor who then develops confidence in the process and the quality of the products.

While standardising a particular process, the VCO processor is required to submit samples for laboratory analysis for benchmark data. The processor will be confident that a high quality product is being produced after the quality control systems have been set in place, and four laboratory analysis reports of samples from different production batches reveal the same results that pass the prescribed standard for VCO. The processor can limit the submission of samples for analysis to four times per year or when a buyer requests an analysis. In the meantime, a sensory evaluation and visual examination are routine quality checks.

**IMPORTANT**
Coconut oil is not entitled to the label 'Virgin' if there is any other substance added to it.

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**Figure 12.** Equipment for heating of cream and oil drying. Coco shell fired stove (top), improvised re-boiler (below)

**Figure 13.** Small gravity type filtering device (top) and storage container for VCO (lower)
On a bulk basis, the expeller-pressed process is being considered ‘cold-pressed’ and is currently priced lower than VCO produced from the Modified Fermentation Process. However, if the VCO is already packed in small bottles for retail, then the price is almost the same. Some producers are also putting the term ‘cold pressed’ on their labels and large re-packers are buying expeller-pressed VCO.

The issue on heat or no heat process for VCO production is still being debated, but the VCO Association and concerned government agencies are now more vigilant in checking misleading labels and advertising. Any company or producer with misleading advertising will be asked to change this under the VCO standard which states that no additive is permitted, that is, the coconut oil is no longer entitled to the label ‘Virgin’ once there is any other substance added to it.
Modified Natural Fermentation Method

Fermentation generally means the addition of yeast or enzyme or suitable micro-organism to a feedstock to obtain a desired product. However, in the case of the Natural Fermentation Method for producing VCO, no other substance is added. It has been observed that when a coconut milk mixture is allowed to stand for more than 10 hours under favourable conditions, the oil naturally separates from the water and the protein. The mechanism for this natural separation without the addition of any fermentation agent is unexplained. One theory is that the natural enzyme in coconut meat, which is subsequently transferred to the coconut milk, is being activated at some point. Another theory is that airborne lactic acid bacteria, which have the capability to break the protein bonds, act on the coconut milk causing VCO separation. It can be surmised that the term, Natural Fermentation Method, was coined because the water and the curd that separate out from the oil, smell and taste sour. It is ‘natural’ because no other substance is added to achieve the fermentation.

Of all the VCO processing technologies, the Modified Natural Fermentation Method has the lowest labour requirement and the least energy input. However, if the fermentation process is not properly controlled, then it produces oil with a sour smell and relatively higher free fatty acid content nullifying the saving in labour costs as the oil cannot be classed as VCO. Precise controls for the maturity of coconuts and the ambient conditions for the fermentation room are necessary to obtain good, high quality oil recovery.

The Modified Natural Fermentation Method comprises two distinct parts – extraction/preparation of coconut milk and processing of the VCO from the milk.

Extraction and preparation

Production of coconut milk for Modified Natural Fermentation Method is the same as for the Modified Kitchen Method. Read and follow the Common Critical Control Points in Chapter 1 before starting production of VCO using the Natural Fermentation Method.

Processing of VCO

Figure 14 and Table 7 demonstrate the Modified Natural Fermentation Method of processing coconut milk to produce VCO. Pictorial photographs of major process steps for the Natural Fermentation Method are the same as those in Figure 8.

In the traditional Natural Fermentation Method, settling and subsequent fermentation of coconut milk is done for 36 to 48 hours. However, laboratory analyses of VCO produced using
Figure 14. Natural Fermentation Method of processing coconut milk to produce VCO

Table 7. The Modified Natural Fermentation Method of processing coconut milk to produce VCO

<table>
<thead>
<tr>
<th>Process</th>
<th>Action</th>
</tr>
</thead>
</table>
| 1) Setting of the coconut milk mixture | Allow the coconut milk mixture to stand for 16 – 24 hours in a place where the temperature can be maintained at 35 – 40°C.  
Note 1: If the intention is to recover coco skim milk for further use as a beverage, then two-stage settling has to be carried out (the first stage settling is done in the refrigerator or ice box for 3 hours (see Table 5 step 1). After separating the cream from coco skim milk, the cream is again allowed to settle (second stage settling at 35 – 40°C) for 13 – 21 hours. |
| 2) Separation of the oil and fermented curd layers | Separate the oil from the fermented curd by using a ladle to scoop the oil off the top.  
Note 2: Dispose of the water phase (fermented skim milk) and gummy portions by diluting with water before draining into a grease trap and then into the sewage system or soakage pit. Put the fermented curd and the oil in separate containers. |
| 3) Oil drying | Drying is required to ensure that all residual moisture is removed to prolong the shelf-life of the VCO. See Drying and handling for the options and the Critical Control Points that must be observed in oil drying.  
Note 3: Apart from removing the residual oil, heating the VCO in a double boiler or vacuum dryer will ensure that fermentation will be stopped. It will also remove the faint sour smell in the oil.  
Note 4: If the oil is subjected to incubation (air-drying) or vacuum drying, then it needs to be filtered first (Step 4). |
| 4) Filtration of oil | Filter the VCO to remove adhering particles of fermented curd.  
Note 5: Filtration of the VCO produced from the Modified Natural Fermentation Method does not require special filtration equipment as only relatively large particles of curd near the surface of the oil need to be separated. Any filtering medium that can trap the curd will be appropriate.  
Note 6: One practical and simple way of filtering the oil is by pouring the oil over sterilized cotton wool placed in the hole of a big funnel, and allowing it to trickle down. For a large-scale operation, a fabricated pressure filter with filter cloth is recommended to increase filtration rate. See also the Bawalan Gravity Filter, Figure 13. |
5) Heating of fermented curd

After VCO separation, the fermented curd is heated to recover the residual Class B oil that can be used for making skin care products and herbal soaps. The oil is separated from the heated curd by following the procedure in the Modified Kitchen Method (see Table 5 step 3). The temperatures are not as strictly controlled but should not exceed 90°C or the oil will become dark yellow.

Note 7: After the Class B oil is recovered, the toasted curd can be mixed with other compost material and use as organic fertiliser.

Note 8: The Class B oil recovered by heating should be dried in a double boiler. Do NOT MIX with the Class A VCO.

6) Packaging and storage

VCO may be stored in stainless steel containers and poly-lined drums. Pour oil into very dry bottles for marketing.

Note 9: The recommended packaging material for virgin coconut oil (VCO) is glass. PET bottles (plastic bottles normally used for mineral water) can be used in cases where the VCO is immediately consumed. Glass is recommended if the VCO is sold in stores where it may remain on the shelf for several weeks.

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**Figure 15. Different Stages in the Natural Fermentation of Coconut Milk. Initial stage (a), transition stage (b), final stage (c)**

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**Critical Control Points specific to Modified Natural Fermentation Method**

Aside from the general critical points discussed previously, settling and subsequent fermentation of coconut milk is the most critical step in the Modified Natural Fermentation Method. While the process appears very simple, it requires proper control of operating conditions and observance of strict sanitary measures and critical control procedures for good quality Class A VCO to be produced. Sometimes no oil is separated at all, even after 24 hours. Occasionally the coconut milk mixture that is left to settle for 16 to 24 hours will generate big bubbles and overflow the fermenting container with no oil being separated.

To ensure that good quality VCO is produced, the following measures must be observed.

- Maintain a fermentation temperature of 35° to 40°C in the area where the fermenting container will be placed. Relative humidity within the area should also be maintained at a maximum of 75%. A properly designed fermentation cabinet with electric, incandescent bulbs strategically placed to help raise the inside temperature when needed is an ideal way to do this. A small electric heater with built-in thermostat control can also be installed in the fermentation cabinet.

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**Fermentation temperature is critical — 35° to 40°C is ideal.**
Under these conditions, a fermentation time of 16 hours results in a relatively high yield of fine quality VCO. At lower temperatures, less oil is recovered.

- The major cause of the bubbling problem mentioned above, is contamination, either through soap residues in the fermenting container or invasion of micro-organisms. Hence, strict sanitary measures must be observed at all times.

Note: If this bubbling problem occurs, immediately put the mixture in the evaporating pan and apply the Modified Kitchen Method so that oil can be still recovered. However, this oil that will be considered Class B oil and should only be used for making herbal soap and skin care products. It is not suitable for human consumption.

- After the coconut milk is placed in the settling/fermentation container, it must be covered with either a loose fitting lid or cloth to stop aerial contamination by yeast, moulds or bacteria.

- The Modified Natural Fermentation Method is very sensitive to the maturity and freshness of the nuts. Immature nuts contain a higher percentage of protein which makes the protein bonding in coconut milk much more difficult to break and release the oil. Likewise, the longer coconuts are stored, the higher the risk of spoilage and the higher the risk of contamination. To ensure that the oil will naturally separate from the coconut milk upon settling for 16 to 24 hours, only newly harvested, fully mature coconuts should be processed by this method.

If proper operating conditions and sanitary precautions are strictly followed, five distinct layers can be seen in the fermenting container after settling for 16 hours (Figure 16). The bottom layer is made up of gummy sediment. The next layer is the watery, fermented skim milk that is no longer fit for human consumption and has to be properly discarded. The next layer is a solid layer of spent, fermented curd. Above this is the separated oil for recovery as VCO. The top layer is floating fermented curd. Note that fermented curd still contains a considerable amount of trapped oil.

**Equipment and accessories**

In the Philippines, most of the micro- and village-scale processors of VCO use versions of the Modified Natural Fermentation Method. There is a standard design for coconut graters as shown in Figure 10 but different types of coconut milk presses are used, such as the table-top versions of the manually operated vertical and horizontal screw and hydraulic...
jack type presses or motorised presses etc., described previously. All the equipment listed in the Modified Kitchen Method is also applicable to the micro- and village-scale production of VCO using the Natural Fermentation Method. In addition, the following equipment is used.

1) **Motorised horizontal screw type coconut milk press.** 300 to 350 nuts per hour (100 to 110 kg/hr) of freshly grated or shredded coconut meat; 2 HP electric motor, single phase; stainless steel screw, built-in filter and housing. Designed and fabricated by Princena's Machine Shop, San Pablo City, Laguna, Philippines (Figure 17).

2) **Stainless steel horizontal screw expeller.** Used in Thailand to make coconut milk or VCO, depending on moisture content or grated coconut meat; capacity 200 to 250 kg/hr of fresh meat (two passes), 3 HP electric motor, single or three phase. Designed and supplied by Ngow Yuat Yoo, Bangkok, Thailand (Figure 17).

3) **Stock pots.** Stainless steel, assorted sizes; ladles and other accessories.

4) **Fermenting container.** Made of food-grade, transparent plastic. It should be wide-mouthed for easy removal of fermented curd and separated VCO. Capacity optional (Figure 18).

Note: The ideal fermentation equipment for the Modified Natural Fermentation Method is a fabricated stainless steel cylindrical tank (maximum capacity 100 L) with a conical bottom and equipped with various outlet points at specified levels and a sight glass to see the different layers as the oil separates. Oil can then be withdrawn from the outlet points based on the levels shown in the sight glass. However, this type of equipment is quite expensive for micro- and village-scale operation so most processors use transparent plastic containers of 1 to 10 L or more.

Figure 18. Fermentation containers
Other appropriate equipment for comminuting coconut meat (instead of grating) is the Thai coconut shredder where the coconut meat is first removed from the shell using manual de-shelling tools or a de-shelling machine and then fed to the shredder. This has the following advantages (Figure 19).

- Much safer to use. The operator’s hands are not near the rotating blade as is the case of standard motorised graters.
- Higher processing capacity. Makes it suitable for large-scale operations when coupled with a de-shelling machine.
- Higher oil recoveries. Recover more meat from the shell to process into VCO.

**Quality control**

Quality control required for VCO produced by the Modified Natural Fermentation Method, is the same as for the Modified Kitchen Method (See page 32).

High quality VCO is always water-clear.
Low Pressure Oil Extraction Method

In the early 1990s, oilseeds specialists in Britain conducted a series of studies on the effect of moisture content on the extraction of oil from various oilseeds. They found that low pressures of 460 psi (32 kg/cm²) and lower could be used for extracting oil when the moisture content of the material is within the range of 10 to 13%. The traditional process of oil extraction from oilseeds is through the use of high pressure expellers (above 1600 psi), at a feed moisture content of 3 to 4%. National Resources Institute (NRI) made available the design of the prototype bridge press appropriate for low pressure VCO extraction. However, the technology was not promoted in the Philippines because the difference in price with copra-produced oil for micro-scale production made it uneconomical at that time. Currently, an upgraded version of the bridge press is being used by several producers in the Philippines using the Modified Natural Fermentation Method to produce VCO (Figure 20).

The Direct Micro Expeller (DME) process for VCO production developed by Kokopacific, Australia, functions on the same principle as the Low Pressure Oil Extraction Method. The hand ratchet driven DME unit is used in tandem with a contact/conduction type dryer (Figure 21). This process is operating in Fiji, Western Samoa, Timor Leste and other countries for producing VCO.

One VCO producer in the Philippines set up the DME dryer and DME expeller for VCO production, but the equipment is now used intermittently as the company is producing VCO using the Natural Fermentation Method.

- The DME process is labour intensive. It takes more people to do the drying, turning and moving of small batches of grated coconut meat being dried in the contact dryer. This is necessary to prevent the grated meat from burning, which will make the oil yellow. The dryer is the standard DME contact stainless steel plate dryer design except that it is gas fired (instead of using coconut shell and husks as fuel). In addition to the drying team, two people are required to load the DME cylinders with partially dried grated meat (1.5 to 2.0 kg per load), do the pressing and remove the defatted meat afterwards.
- The DME process requires skill to dislodge the defatted meat from the loading cylinder after oil extraction. The length of time required to dislodge the material depends on the skill of the operator in manipulating the ratchet mechanism pushing...
Another advantage of placing the partially dried grated meat in fine muslin bag when pressing the oil as in bridge press operation, is that the muslin bag acts as a pre-filter which considerably reduces the number of fine particles of meat being transferred to the oil during extraction.

The piston inside the cylinder. This results in downtime during operation thereby reducing process capacity. Normally, only 6 to 8 pressings can be handled in one hour. (Note: The main reason for this residue dislodging problem is that partially dried grated meat is being placed directly in the loading cylinder so when it is pressed, the particles form a hard solid mass inside the cylinder. With the Bridge press developed by NRI, partially dried grated meat is placed in fine muslin bag which is then positioned in the perforated cylindrical cage for pressing. The muslin bag then easily slides out of the cage after pressing. However, this practice could not be applied in the DME press because the diameter of the loading cylinder or tube is too small).

- Based on the information obtained from the Philippino owner, it takes a minimum of seven days to settle and clarify the DME oil to remove fine particles of meat. After filtration, the oil is allowed to stand for another seven days (total 14 days) before bottling or shipment to ensure that all fine particles trapped in the oil are removed.

Essentially, two to three DME press machines, depending on the operators, are needed to match the capacity of one bridge press in terms of throughput per hour for making VCO from coconut meat dried to 10 to 12% moisture content (Figure 21).

The Engineering Department of the Coconut Research Institute (CRI), Sri Lanka, has also developed low pressure oil extraction equipment for VCO production. Two types of presses are available — a small vertical screw type with the screw mounted on the cover of the holding cylinder where the partially grated coconut meat is placed, and a hydraulic jack type press (Figure 22).

Difficulty in dislodging the defatted coconut meat after oil extraction is encountered because partially dried grated meat is also directly loaded and pressed in the cylinder instead of

Figure 21. (a) Contact dryer, Siquijor Island, Philippines. (b) DME press in Timor Leste. (c) Drying grated coconut meat on contact dryer Timor Leste
putting it in fine muslin bags as in bridge press operation. (Note: Unlike the DME press, the practice of placing the partially dried grated coconut meat in muslin bags and positioning it in the cylinder for pressing, can be easily adopted using the two types of Sri Lankan presses since the diameter of the cylinders are large enough for proper positioning of the bags).

**Extraction and preparation**

Figure 23 and Table 8 describe the Low Pressure Oil Extraction Method for producing VCO.

**Processing of VCO**

Read and follow the Common Critical Control Points before starting production of VCO by the Low Pressure Oil Extraction Method.

![Figure 22. Sri Lankan vertical screw type (a) and hydraulic jack (b) type oil presses; small Thai stainless steel hydraulic jack micro expeller at Chumphon HRC (c)](image)

![Figure 23. Process flow chart, Low Pressure Oil Extraction Method](image)

Oil recovery is 24.5 kg/ 100 kg or fresh coconut meat.
Virgin coconut oil: production manual for micro- and village-scale production

**Table 8. The Low Pressure Oil Extraction Method of processing**

<table>
<thead>
<tr>
<th>Process</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Selection of nuts</td>
<td>Select only fully matured nuts with no haustoria (12 – 13 months old)</td>
</tr>
<tr>
<td>2) Splitting and grating or shelling and shredding</td>
<td>Split the de-husked nut in halves and grate the meat, either manually or with a motorised grater. Note 1: Another option (similar to a desiccating plant process) is to de-shell the nuts and put the meat through a Thai coconut shredder or a knife mill.</td>
</tr>
<tr>
<td>3) Drying</td>
<td>Dry the grated or shredded coconut meat to a moisture content of 10 – 12% at a temperature of 70 – 75°C using an indirect type of hot air dryer, modified copra dryer, contact dryer or solar dryer. Note 2: Thai S. Steel Expeller works optimally for VCO extraction at 7% M.C. of shredded or grated coconut meat. Note 3: See previous sections for important considerations in drying the coconut meat to the prescribed moisture content.</td>
</tr>
<tr>
<td>4) Oil extraction</td>
<td>Extract the oil using a manually operated vertical screw type press (Bridge press), a DME press, a Sri Lankan press or Thai low pressure stainless steel expeller.</td>
</tr>
<tr>
<td>5) Oil drying</td>
<td>As oil extraction is done when the moisture content of the material is relatively high, drying of the oil is required to ensure that all residual moisture is removed to prolong the shelf-life of the VCO. See previous sections for the options and the Critical Control Points in oil drying. Note 4: Oil drying by double boiling before filtration is recommended to ensure that moisture remaining after extraction is removed immediately. If done by gravity, settling of the oil and subsequent filtration to remove fine particles of meat, takes longer. Unlike the latik in Modified Kitchen Method and the curd in Natural Fermentation Method that only adheres to the surface of the oil and can be easily removed, the Low Pressure Oil Extraction Method causes very fine particles of dried meat sediment (foots) to be trapped in the oil so it has to be settled first before filtration. If the moisture content of the oil is too high after extraction, then there is the risk that the oil may start to go rancid during settling. Note 5: The original technology on the Low Pressure Oil Extraction Method does not include an oil drying step (NRI), and neither does the DME process. However, it is deemed necessary to include this step as there is a strong probability that water in partially dried meat will remain in the oil during extraction causing the oil to rapidly turn rancid.</td>
</tr>
<tr>
<td>6) Setting of the oil</td>
<td>The oil is left for a minimum of 3 days to allow sufficient time for the trapped foots to settle.</td>
</tr>
<tr>
<td>7) Filtration of the oil</td>
<td>Filtration of the oil is done using a three-layered filter cloth bag. Note 6: Sometimes even after filtration, there will still be foots settling at the bottom of the container after long standing. Simply decant the oil to a clean container leaving the foots. Larger operations may use filter pad plate filters with pressurising pumps.</td>
</tr>
<tr>
<td>8) Packaging and storage</td>
<td>Pack the oil in a very dry bottle or container for storage. Note 7: The recommended packaging material for VCO is glass. PET bottles (plastic bottles normally used for mineral water) can be used in cases where the VCO is immediately consumed. Glass is recommended if the VCO is to sold in stores where it may remain on the shelf for several weeks.</td>
</tr>
</tbody>
</table>

### Critical Control Points specific to Low Pressure Oil Extraction Method

Aside from the critical points discussed previously, the most critical step in Low Pressure Oil Extraction Method is getting the grated or ground coconut meat dried to the optimum range of 10 to 12% M.C. for good oil recovery and quality. If the moisture content of the meat is too low, no oil will be extracted as the Bridge press can only generate about 400 psi. If the moisture content is too high, the press or expeller will produce a turbid oil — a mixture of oil and coconut milk. Note that the moisture content of coconut meat varies according to maturity of the nut when harvested, the variety, and the length of time that the nut has been stored before processing. The performance of
To obtain a possible drying time, dry a batch of grated coconut meat to the lowest moisture content possible under the prevailing humidity conditions and store in a tightly sealed container.

**Equipment and accessories**

1) **Equipment for particle size reduction**

See pages ? for the description of coconut graters and the Thai coconut shredder.

2) **Dryers**

The type of dryer used will depend on the scale of production, availability of construction materials (if it needs to be constructed on-site), preference of operators in terms of ease of operation, the price and drying efficiency of the dryer.

   a) **Modified copra dryer.** An indirect, natural draught, coconut shell/husks fired tray type dryer constructed on-site. The dryer was developed by Divina Bawalan at the PCA Davao Research Centre, Philippines, where suitable frames to hold a series of trays with screens were made in lieu of the loading bed for copra. Drying is essentially a batch type operation.

   The dryer comprises a furnace and a metal cylindrical heat exchanger with baffles attached to a chimney for emission of hot combustion gases generated after heating the metal heat exchanger. The furnace and heat exchanger are enclosed in a dryer body (2.44 m x 3.05 m x 1.82 m) with concrete or brick walls and air intake ports on the sides. As the air is heated through contact with the metal heat exchanger and the surface of
the furnace, it rises to heat the grated coconut in trays above. There are 30 drying trays, and each can be loaded with 1.5 to 2.0 kg freshly grated coconut meat. Temperature in the dryer is controlled by regulating the fuel feed and air intake but must not exceed 70 to 75°C (Figure 25).

**Table 9. Advantages and disadvantages of the modified copra dryer**

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Uses the generated by-products, coconut shell and husks for fuel.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prevents the drying grated material from being scorched or burnt since only hot air is in contact with the meat.</td>
</tr>
<tr>
<td></td>
<td>After the grated meat is loaded into the trays, only one operator is required to feed fuel and regularly change the position of trays.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disadvantages</th>
<th>Drying efficiency is highly dependent on the prevailing ambient conditions and wind velocity.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Relatively lower process capacity since it is a batch type operation and the dryer must be covered by a roof for protection from rain.</td>
</tr>
</tbody>
</table>

A similar type of modified copra dryer has been developed at Chumphon HRC in Thailand, using insulation on the sides of the heat exchanger and plywood walls instead of brick or concrete (Figure 26a).

**b) DME dryer.** This is essentially a direct contact type where heat is transferred by conduction through the surface of the S. steel sheet to the grated coconut meat to be dried. It is constructed on-site, based on the design specifications. The dryer comprises a long, stainless steel sheet mounted on a concrete base with heating stones underneath. A burner/furnace made of used, galvanized iron petroleum drums, is mounted on the front end and a chimney is attached to the other end. Drying is done by loading the fresh grated meat in thin layers onto the surface at one end of the sheet and continuously moving the meat with wooden paddles towards the other end of the dryer where it is then removed and loaded into the DME cylinder for pressing (See Figure 21 for a photo of the DME dryer).
Table 10. Advantages and disadvantages of the direct contact DME dryer

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Uses generated by-products, coconut shell and husks for fuel.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disadvantages</td>
<td>Relatively fast drying rate as it is done in a continuous manner.</td>
</tr>
<tr>
<td></td>
<td>Labour-intensive since it requires a number of people to constantly feed the fresh grated meat onto the metal surface, fast turn and move it along to the end, and to regularly feed in fuel.</td>
</tr>
<tr>
<td></td>
<td>High risk of meat getting scorched or burnt since there is a tendency for the wet grated meat to stick to the surface of the metal. The resulting oil will be pale yellow and is no longer entitled to the label 'Virgin'.</td>
</tr>
</tbody>
</table>

c) Electric or gas heated Forced-draught tray type dryer. This is a standard dryer with different capacities and sizes that can be bought easily from known manufacturers. It is generally equipped with a thermostat control that allows the operator to set the desired drying temperature and a blower to circulate hot air through and over the surface of the meat dryer trays (Figure 26b).

Table 11. Advantages and disadvantages of the Forced-draught tray type dryer

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Drying of the meat is done under highest of sanitary conditions.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Loaded grated meat for drying can be safely left without the risk of it being scorched or burned.</td>
</tr>
<tr>
<td></td>
<td>Thermostat control allows for a constant temperature drying.</td>
</tr>
<tr>
<td>Disadvantages</td>
<td>Uses electric power or gas for heating so drying cost is much higher.</td>
</tr>
<tr>
<td></td>
<td>Higher initial investment cost.</td>
</tr>
</tbody>
</table>

d) Solar dryer. In areas where there is a regular long duration of daily sunshine, solar drying of grated meat may be the cheapest option for producing VCO from the Low Pressure Oil Extraction Method under a micro-scale operation. There are various designs available of solar dryers that can be constructed on-site using polyethylene transparent plastic sheets and wood. Solar heat collectors can

Figure 26b. Gas heated, forced-draught tray type dryer at Chumphon HRC, Thailand. Close-up of meat on trays (left)
also be incorporated to make the solar dryer to achieve higher drying temperatures. Electricity or gas ancillary heaters with blowers will be needed for cloudy, rainy conditions.

3) Equipment for oil extraction

   a) Manually operated vertical screw type (Bridge press). Perforated holding basket and receptacle trough (Figure 11a); all materials in contact with the coconut meat made of stainless steel; 9 kg partially dried grated coconut meat per load (about 45 nuts); 15 to 20 minutes cycle per load (loading, pressing and unloading); process capacity of about 135 to 180 nuts per hour (30 to 35 kg meat/hr). Fabricated in the Philippines; upscale model of the original design from the Agro Processing Division, Natural Resources Institute, Chatham, Kent, United Kingdom. The Thai Bridge press has the same dimensions and capacity; manufactured by Ngow Yuat Yoo, Bangkok, Thailand.

   b) DME press (Figure 21b). Comprises piston and cylinder assembly with ratchet mechanism to push or release the piston; 1.5 to 2.0 kg partially dried grated meat per load; 8 pressings per hour; manufactured by Kokonut Pacific, Australia.

   c) Sri Lankan Coconut Oil Expeller (Figure 22). Vertical screw type; medium scale batch operation, 0.75 kg grated dried meat per load; stainless steel holding cylinder and head; mild steel stand (height 60 cm); total weight 13 kg.

   d) Sri Lankan Hydraulic Jack Operated Oil Expeller. Batch operation; 2.5 kg grated dried meat per load; stainless steel holding cylinder and head; cylinder diameter 150 mm; total weight 80 kg (Figure 22b).

   e) Thai S. Steel Expeller. Suitable for oil extraction from ground dried meat 7 to 11% M.C.; capacity 20 kg per hour of meat producing 10 kg of VCO; manufactured by Ngow Yuat Yoo, Bangkok, Thailand (Figure 24).

4) Filtration equipment

A gravity or pressurised filtering device should be used with a fine cotton canvas cloth or filter paper as filtering medium. At present, a prototype pressurised filtering device made of stainless steel is being tested by a fabricator in the Philippines. We make no recommendation on this device until the work performance has been carried out. If pressurised, filter paper of 0.95 micron can be used. For gravity filtration, use 2.5 micron filter paper (TISTR, 2005). Filter paper presses quickly become blocked so it is better to settle, decant and use a canvas filter plate press (Figure 29).

Quality control

See quality control on page ?
High Pressure Expeller Method

The traditional process of extracting oil from coconut is by the use of high pressure expellers. The coconut is converted into copra either in half-cup form or finger pieces, then it is milled, conditioned at the right moisture content and the oil extracted using a horizontal screw type expeller or a combination of vertical and horizontal screw expellers.

Cora is produced by small holders either by sun-drying, smoke drying or a combination of both, and to a small extent by indirect drying. Prior to milling and expelling, cora is generally stored in a warehouse from two to eight weeks depending on the price speculations of cora traders. Because of this, cora has already undergone some deterioration resulting in low quality extracted oil. VCO cannot be produced from cora.

An expeller press is a screw type machine, which continuously moves the ground, dried meat to the other end of the expeller, forcing it into a very narrow clearance (choke) thereby creating high pressure to compress the material and subsequently release the oil. The extracted oil flows down through the slats and sieves of a barrel cage surrounding the screw (wormshaft). The defatted residue material forms into a hardened cake, and is released from the expeller. The thickness of the cake can be altered by adjustments made to the choke.

Fresh-dry process

The major difference between the traditional coconut oil extraction process and the High Pressure Expeller Method for VCO production, is that fresh coconut meat is quickly dried in a grated, ground or milled form and immediately expelled so that no deterioration of the meat can occur, thereby producing a very high quality oil fit for human consumption. The High Pressure Expeller method is generally referred to as the Fresh-dry process of VCO manufacture. There are several versions of this fresh-dry processing, mainly in the manner that the coconut meat is prepared prior to drying and expelling. High pressure expellers used for VCO production must be made of stainless steel and must have a built-in cooling system in the wormshaft to prevent the temperature increasing to a point where it will cause the oil to turn yellow.

Brown skin removal (testa)

With a suitably designed high pressure expeller and the correct operating conditions, the highest oil extraction efficiency is obtained, especially if the fresh coconut meat is milled and dried without removing the brown skin (testa) from the meat. Most processors of VCO remove this brown skin because there is a general belief that if this is included, it will cause discolouration of the oil. However, this is not true as proven by various production trial runs conducted since 1990 at the PCA.
Davao Research Centre, Philippines, when virgin coconut oil was unknown in the commercial market. Providing the fresh meat is properly handled, and processed immediately under the correct operating conditions, the oil that is recovered will be water-clear VCO.

**Extraction and preparation**

Figure 27 and Table 12 demonstrate the High Pressure Expeller Method for production of VCO.

**Processing of VCO**

Read and follow the **Common Critical Control Points** before starting production of VCO using the High Pressure Expeller Method.

---

**Table 12. High Pressure Expeller Method for VCO production**

<table>
<thead>
<tr>
<th>Process</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Selection of nuts</td>
<td>Select fully mature nuts free from haustoria (12 – 13 months old).</td>
</tr>
</tbody>
</table>
| 2) De-shelling                 | The shell is removed manually using a hand tool or with a de-shelling machine.  
Note 1: An experienced person in the Philippines can manually de-shell 1,000 nuts per 8 hour day. A de-shelling machine can process 200 – 250 nuts per hour depending on the skill of the operator. |
| 3) Splitting and grinding or wet milling | Split the de-shelled fresh coconut to remove water and put the meat through a grinder or a knife mill.  
Note 2: Experienced de-shellers normally remove the shell from the nut without breaking the kernel.  
Note 3: Higher yield in oil extraction is obtained if the particles of dried meat fed into the expeller are in granular form. Hence it is better to grind or mill the fresh coconut meat instead of grating it. |
3) Drying
Dry the meat to 3 – 4% M.C., at a temperature of 70 – 75°C using an indirect type hot air dryer. Follow the common Critical Control measures to be observed in drying coconut meat (Page ?).

Note 4: The conveyor type dryer, similar to those in desiccated coconut plants where drying is done continuously at a fast rate without scorching or burning the meat, is the best dryer to use for drying granulated fresh meat to 3 – 4% M.C. The output end of the dryer can be directly coupled to the feed hopper of the expeller. However, investment cost for this type of dryer is quite high so it is more suited to medium scale operation. Fluidised bed dryers are also ideal for drying granulated, fresh coconut meat.

4) Oil extraction
Extract the oil using a High Pressure Expellers with a built-in cooling system.

5) Settling of the oil
The oil is allowed to settle for a minimum of 7 days, which is sufficient time for the trapped foots to settle to the bottom before filtering.

Note 5: Usually, oil extracted through well-designed High Pressure Expellers already has very low moisture content so there is no need to subject the oil to an oil drying step. However, the process traps a higher percentage of foots (10 – 15%).

Note 6: Commercial oil milling plants processing copra have built-in settling tanks fitted with moveable screens and mechanical scrapers to continuously remove foots before the oil is filtered.

6) Filtration of the oil
Filtration of the oil is carried out using pressurised filtering devices.

Note 7: The standard equipment used for filtration in commercial oil milling plants is the pressurised plate and frame filter press to ensure that all foots is removed.

Note 8: When filtration is done using gravity filters, foots can still settle on the bottom of the container after long standing. Simply decant the VCO to another container leaving the foots behind.

8) Packaging and storage
Pack the oil in a very dry bottle or container for storage.

Note 9: The recommended packaging material for VCO is glass. PET bottles (plastic bottles normally used for mineral water) can be used in cases where the VCO is immediately consumed. Glass is recommended if the VCO is sold in stores where it may remain on the shelf for several weeks.

**Critical Control Points specific to the High Pressure Expeller Method**

Aside from the common Critical Control Points, special attention should be given to the oil extraction step as this is the most critical part of the High Pressure Expeller Method in terms of extraction efficiency and product quality.

**Oil extraction**

Oil extraction efficiency in high pressure expellers is determined by the following factors:

- moisture content of the feed material;
- temperature of the feed material;
- choke clearance;
- particle size.

Well-designed coconut oil expellers, generally work efficiently when the moisture content of the feed material is at 3 to 4%. The dried granulated meat is heated, dried and fed while still warm so the oil flows out easily during the extraction process. This is why the standard Anderson expeller, generally used in the coconut oil milling industry in the Philippines, has a built-in conditioner — cookers adjust the moisture content and temperature of the milled copra. Adjustments in the choke generally high pressure expelling needs close control and very careful supervision to produce high quality VCO.
clearance are made to extract the maximum oil yield possible. Experienced operators know whether the oil extraction rate is at the optimum level by the thickness of the pressed cake emerging from the expeller. Corresponding adjustments in the choke clearance are made if the pressed cake is greater than 1 mm. Granulate the coconut meat to a particle size of 3 mm diameter since very thin, flat particles as in grated, sliced or shredded coconut meat tend to slide out of the choke, thereby reducing the amount of oil extracted.

**Cooling system**

As mentioned previously, high pressure expellers for VCO production require a built-in cooling system for the wormshaft to control the increase in temperature at high pressure during the extraction operation. This cooling is to prevent the oil from turning yellow. For expellers without a cooling system, adjust the choke to a wider clearance and have the feed material at a higher moisture content. However, as with the Thai expeller, this method sacrifices the oil extraction efficiency.

**Equipment and accessories**

1) **Manually operated de-shelling machine.** 1/2 HP gear motor, 3 phase, 220 volts, 40 rpm output (200 to 250 nuts per hour based on the skill of the operator). Designed and fabricated by Princena’s Machine Shop, San Pablo City Philippines.

2) **Multi-purpose power grinder** complete with accessories and 1-unit induction motor. 3 phase, 220 volts, 1750 rpm for spindle drive, 1-unit 1 HP gear motor, 3 phase 220 volt for screw feeder; food grade stainless steel for all parts in contact with fresh coconut meat. The equipment is available in process capacities of 550 and 300 nuts per hour. Designed and fabricated by Princena’s Machine Shop, San Pablo City, Philippines.

3) **Knife mill.** 2 HP, 3 phase, 220 volts motor, process capacity 100 kg per hour, food grade stainless steel for all parts in contact with fresh coconut meat. Same design as the knife mill used for copra except that food grade stainless steel is used instead of mild steel. Designed and fabricated by Princena’s Machine Shop, San Pablo City, Philippines.

4) **Continuous conveyor dryer** (Apron type). Coconut shell fired heat exchanger, 9 m long; 4 blowers of 1.5 HP each, single phase 220 volts, dryer drive 1 HP single phase, 220 volts; 30 to 50 kg per hour dried meat depending on moisture content. Output moisture content can be adjusted by adjusting the speed of the conveyor. Fabricated by Princena’s Machine Shop, San Pablo City, Philippines. A bigger capacity dryer is also available.

5) **Simplextractor expeller.** Process capacity of 50 to 75 kg per hour, 5 HP motor, 3 phase, 220 volts (Figure 28a), with built-in cooling system for wormshaft. Designed and fabricated by VR & E Enterprises, Caloocan City, Philippines. Also available
in process capacity of up to 100 kg per hour with 7.5 HP 3 phase motor.

Plate and frame filter press is standard equipment used for filtration in commercial oil milling plants to ensure that all foots is removed quickly. The foots is trapped in the canvas cloth between each plate as the oil is pushed through it under pressure. A conventional plate and frame filter press for commercial oil milling operation can have as many as 18 plates with each frame measuring 40 cm by 40 cm. Shown in Figure 29 is a mini plate and frame filter press in which the parts in contact with oil are fabricated in stainless steel to make it suitable for filtration of VCO produced from High Pressure Expellers. Stainless steel ‘Mono’ type pumps with a capacity of 300 L/hr used for wine and alcohol production, are suitable for linking to filter presses.

**Quality control**

See quality control, page ?

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**Figure 28.** Thai expeller for VCO or coconut milk production. Close-up of expeller with cover removed. (bottom photo)

**Figure 29.** Mini plate and frame filter press.

All VCO produced by high pressure and low pressure expelling requires settling or filtration to produce water-clear VCO.
Burnt coconut meat in Thai expeller. This is caused by the meat being too dry (less than 7% M.C. for VCO).

TISTR FAO project virgin coconut oil products — soap, hand lotion, massage oil

VCO from a bridge press (left group) and an expeller (right group), before and after filtering

Coconut meat flakes after passing through the Thai expeller to make VCO

TISTR staff training DOA staff in using a Thai expeller at Chumphon Research Centre, Thailand
Site requirements

In choosing the site for setting up a VCO processing facility, the following points should be considered.

- Availability of an abundant potable water supply. This is critical in VCO plants employing the Modified Kitchen and Natural Fermentation Methods.
- Abundant raw material supply base close by. Fresh coconuts can be easily delivered to the plant within one day after dehusking.
- Processing plants location. Should be located away from materials or facilities where strong odours can arise (e.g. piggery, poultry or chemical plants).
- Availability of electric power. For the High Pressure Expellers Method, a three phase electrical line is required.
- Availability of good drainage system. This is important for waste disposal.

Plant requirement

The major use of VCO at present is as a food supplement (it is being ingested as is and not just an ingredient or a medium for cooking), so all the requirements applicable to a food processing facility must also apply to a VCO plant.

Presidential Decree No. 856, otherwise known as the Sanitation Code of the Philippines, states the following requirements in constructing a food processing building:

- screened windows and doors;
- painted walls and ceiling;
- well-planned piping and closed drainage systems;
- concrete or tiled floor;
- well ventilated rooms;
- lights with metal guards;
- toilet and bathroom located in a separate section outside the processing area.

In designing the floor plan and machinery lay-out, the following should be considered.

- Process flow should follow the continuous processing steps to eliminate contamination.
- For maintaining sanitation, plant and equipment lay-out must be designed so that there is easy access for cleaning specific areas and sanitisation for assigned personnel.
- Entrance to the processing area should be separate from the entrance to the general access area for non-plant personnel (office and display room, pantry etc).
• A washing area should be provided near the entrance to the processing area so that production personnel can easily wash their hands on entering and whenever necessary.

A suggested ideal floor plan building and perspective to minimize risk of contamination in a village-scale VCO plant using the Natural Fermentation Method and for VCO plant using the Low Pressure Oil Extraction Method and High Pressure Expeller Method are shown in Figures 30 and 31. The suggested floor plan for the VCO plant using the Natural Fermentation Method can also be used for the Modified Kitchen Method, except that the allocated area for the fermentation room will be used for the settling of milk and heating of the cream. Note that the main entrance to the processing plant should only be opened once a day in the morning when bringing in enough nuts to be processed for the day. Processing personnel should enter only through the personnel entrance near the change room and wash room.

Simpler more open plan buildings may be utilised if they are screened and located away from dusty areas. Sometimes the nut cracking, scraping and pressing or expelling may be done at one location and the fermentation etc and oil separation and drying done in an allocated area in an enclosed building.

Figure 30. Suggested floor plan and building perspective for village-scale VCO plant using the Natural Fermentation Method

Figure 31. Suggested floor plan and building perspective for village-scale VCO plant using the Low Pressure or High Pressure Expeller Method
Training a village group in VCO technology, Thailand

Villagers have been trained in VCO technology by TISTR staff through the FAO project in Thailand

Trying the VCO product produced by TISTR, Thailand
Chapter 4

Operation and maintenance procedures
Good manufacturing practices in VCO processing

Good Manufacturing Practice (GMP) is a set of guidelines and procedures that must be followed to ensure that the food products manufactured in a particular plant, are free from rubbish, dirt, contaminants and pathogenic micro-organisms so as to be safe for human consumption. The emerging major use of VCO is as a food supplement, so all the guidelines for a food processing facility must be applied. If appropriate care is not taken, contamination of the product may occur during production, packaging, handling and storage.

Fresh coconut meat and coconut milk are low in acid, high in moisture and nutrients and are very susceptible to microbial contamination. Thus, strict sanitation in the plant area and equipment and strict personal hygiene must be practiced at all times to minimize the risk of contamination.

Sanitation in the processing area

Cleanliness in the VCO plant is maintained by frequent and continuous cleaning and washing down of various process areas and machines as well as a general cleanup at the end of each working shift. The purpose of continuous cleaning is to keep waste from accumulating during the operating day, which not only improves sanitation, but also reduces the time needed for end-of-shift cleaning. Each weekend, every process area must be scrubbed with soap and water, flushed with clean water again and a bactericidal agent applied. To prevent and eliminate insect and rodent infestation, rooves are sprayed with an insecticide twice a week. Cleaning and disinfection of processing area should not be underestimated because this can reduce the risk of VCO not meeting consumer and government standards.

The Natural Fermentation Method for VCO production is very susceptible to microbial contamination which normally results in off-quality VCO or no VCO being separated from the residue.

In business terms, strict adherence to sanitary procedure will mean zero or fewer rejection/retention/complaints and no involvement in outbreaks of food poisoning.

Coconut shells should be regularly removed from the grating area to prevent contamination and foul odours occurring. When a plant produces VCO from coconut milk, the residue (sapal) generated after milk extraction, should be regularly transferred to the drying area or the area where it will be further processed. Sun-drying on a smooth-finish concrete patio is ideal for preparing a coconut meal for animal feed. Wet coconut milk residue left unattended for more than four hours will deteriorate causing foul odours and will develop microbial contamination.
Likewise, the grating and milk extraction area (in the Modified Kitchen and Natural Fermentation Methods), and the de-shelling, washing and meat grinding area should be regularly cleaned during and after every eight-hour shift to prevent micro-organisms from multiplying to high levels. This is done by pressure hosing away of all coconut meat and coconut water. As mentioned before, immediate flushing away of coconut water is necessary whenever it is spilled on the floor.

The fermentation room (in the VCO facility using the Natural Fermentation Method) should be equipped with an exhaust fan which should operate for at least 30 minutes at the end of every fermentation cycle to remove stale air and carbon dioxide and should be designed in such a way that there is regular entry of fresh outside air.

Packaging areas should be equipped with white formica, tiled or stainless steel tables and should be cleaned after every use. Any spillage of oil on the floor should be immediately cleaned with soap and water.

**Sanitation with processing equipment**

Food grade stainless steel is recommended for construction of all parts of VCO process equipment that will come in contact with coconut meat, milk or oil. Listed below are some sanitation points that must be observed.

1. All equipment, where fresh coconut meat is being handled/processed, must be cleaned after every four hours of use. Equipment must not be left un-cleaned at the end of a production day. Cleaned equipment should be free of grease and adhering product particles, detergent residue, brush bristles, etc.

2. Hot water should be used for the final rinse of the equipment. If hot water is not available, chlorinated water should be used followed by thorough rinsing with clean cold water.

3. Special attention should be given to the insides of coconut milk presses to ensure that not a single particle of coconut meat is left adhering to the surface of the filter, the perforated cage or loading cylinders at the end of a production day. Presses should be flushed with pressurised water.

4. The blades and housing of the grater, should be thoroughly cleaned with water every four hours, and with soap and water at the end of the production day. Use hot water in the final rinse to prevent bacterial contamination. If hot water is not available, chlorinated water should be used followed by thorough rinsing with clean cold water.

5. The feed, inside and discharge points of the grinder or shredder should be cleaned with cold water and rinsed with hot water every four hours, and should be thoroughly cleaned free of any adhering particles of meat at the end of a production day. If hot water is not available, chlorinated
6. Where the VCO plant uses the Low Pressure Oil Extraction Method and the High Pressure Expeller Method, coconut meat dryers should be cleaned every eight hours. Cleaning includes complete removal of coconut particles, especially the yellow scorched crumbs adhering to the dryer surface which trap the coconut meat particles being dried, e.g. the tray for tray type dryer, apron for conveyor type dryer, metal surface for DME contact dryer. Coconut particles should not remain in the area for more than 24 hours.

7. All tools and equipment accessories should be thoroughly cleaned before and after use.

**Personnel hygiene**

Much contamination can also come by way of the personnel and operators who are actually involved in the processing of VCO. For this reason, personal hygiene must be given equal consideration to the building and processing equipment sanitation. Washing facilities must be located near the entry point so that workers can wash their hands with soap and water before dipping their hands in the anti-bacteria solution and commencing work.

A high standard of personal hygiene must be maintained at all times. It is vital that only healthy personnel should enter and work in the process area. Healthy condition means that the person is free from the following sickness or disorders:

- respiratory tract infections such as common cold, sore throat, pneumonia, tuberculosis and others;
- intestinal disorders such as diarrhea, dysentery, typhoid fever and Hepatitis B and C;
- skin disorders such as sores, abrasions and lesions, infected ears, boils, scabies and severe rashes;
- plant personnel who are sick with any of the above diseases must stay away from the processing area until they are well.

High standards of personal hygiene also means dressing in appropriate work attire before entering the processing area (Figure 32). Suitable attire consists of hair cover, facial mask (if required), uniform, apron and boots or appropriate footwear. Work attire should be white so that dirt can be easily seen.

Street clothes and shoes should never be worn inside the processing area. Occasional visitors or inspectors in the production area are also required to dress in sanitary garments before entering.

*Figure 32. Proper work attire in a VCO processing plant*
Each of the abovementioned work attire components has the following functions.

<table>
<thead>
<tr>
<th>Component</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hair cover (Figure 33)</td>
<td>Hair restraint is necessary to prevent hair from falling into the VCO products. Any packaged food product contaminated by hair is unacceptable to customers! A clean hair cover also acts as a barrier preventing microbial contamination of hands after touching the hair.</td>
</tr>
<tr>
<td>Facial mask (Figure 33)</td>
<td>Masks must cover the nose and mouth while handling coconut milk, harvesting the separated oil from the fermentation process and during packaging. A mask serves as a barrier to workers touching their nose and mouth so preventing microbial contamination.</td>
</tr>
<tr>
<td>Apron and uniform</td>
<td>Wearing an apron and uniform has a psychological effect on plant personnel about being conscious of maintaining cleanliness at all times in the processing area. Aprons and uniforms should be white or light coloured so that dirt can easily be seen.</td>
</tr>
<tr>
<td>Footwear</td>
<td>Specific footwear should be worn only inside the processing area. Plant personnel should change footwear when going outside the production area, and again when re-entering. Street shoes should never be worn inside the processing area.</td>
</tr>
<tr>
<td>Latex or plastic gloves</td>
<td>Gloves should be worn when handling coconut water and vinegar to prevent future contamination of the oil and burning of the skin.</td>
</tr>
</tbody>
</table>

High standards of personal hygiene also means maintaining clean hands at all times since this is one of the major sources of contamination. A wash area is provided near the entrance to processing plants so that plant personnel are reminded about regular washing of hands. The hands should be washed with soap and water under the following circumstances:

- before starting work;
- after touching or scratching head, hair, mouth, nose, ears, or any uncovered part of the body;
- after using the toilet;
- after breaktime, smoking, eating or drinking;
- after touching dirty dishes, equipment and utensils;
- after coughing, sneezing or blowing the nose;
- after chewing gum or using toothpicks;
- after touching trash, floors, soiled objects etc.;
- after using cleaners or chemicals;
- after cleaning, taking out the trash or putting away supplies.

*Figure 33. Illustration of hair cover and facial masks*
Record keeping and production data

A daily record of production and other data should be kept and maintained in the VCO plant. These records are necessary to compute production costs and to ascertain if efficiency and productivity is improving. Each batch of product should be given a coded identification number to make it easier for management to trace back any customer complaints about a particular consignment. Sample production data sheets and other relevant forms are available for photocopying in Annex 3.
Chapter 5

By-products and downstream products
Coconut milk residue (sapal)

Coconut residue is a by-product of coconut milk, nata de coco and coconut jam processing and also of the VCO process based on coconut milk. The residue represents approximately 25 to 50% of the weight of freshly grated meat on a wet basis, depending on the coconut milk extraction process used. The residue usually retains about 35 to 40% of the original oil content of the fresh coconut meat and has a low market value if not further processed. The residue is dried and sold as animal feed, discarded as waste or used to make compost.

Analyses by the Food and Nutrition Research Institute (FNRI), Philippines, of dried coconut residue show it is very rich in dietary fibre with the following composition.

- Protein: 5.1%
- Fat: 38.3%
- Moisture: 4.0%
- Ash: 1.8%
- Carbohydrates: 50.8%
- Dietary Fibre: 31.9%

Coconut milk residue that can be utilised in various ways. These are shown in Figure 34 and Table 13.
Table 13. Ways of utilising coconut milk residue

<table>
<thead>
<tr>
<th>Utilisation options</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) As an ingredient and extender for various home recipes to enhance nutritional value of food.</td>
<td>The use of residue (sapal) as an ingredient and extender in various home recipes to enhance nutritional value of food, provides additional income and improves the health of people using sapal regularly. Adding sapal to recipes fortifies the food products with dietary fibre and fat (oil) essential for good nutrition. In the coco burger recipe, the residue acts as a meat extender in addition to the health benefits, thus making the product cost effective for large families. Note: Coconut dietary fat (oil) mainly comprises medium chain fatty acids which have been shown in several studies to have antibiotic, anti-obesity, anti-cancer and other beneficial effects on the human body and coconut dietary fibre has been shown to have cholesterol-lowering effects. Food recipes incorporating sapal and developed by the Philippine Coconut Authority are given in Annex 4.</td>
</tr>
<tr>
<td>2) Processing into macaroons and cookies as a source of income</td>
<td>Macaroons are cookies (biscuits) with desiccated coconut as the major ingredient. By substituting desiccated coconut in a recipe with sapal, the cost of the product is greatly reduced without sacrificing the taste and nutritional value. When using sapal for cookies by partially substituting wheat flour, the cost is reduced and the nutritional value of the product is enhanced by way of dietary fat and fibre. Processing of sapal into macaroons and cookies can be a livelihood improvement activity. The baked products can be sold in schools, shops or included in feeding programs of local government. Recipes for making macaroons and cookies using sepal developed by the Philippine Coconut Authority are provided in Annex 4. Semi-commercial production of macaroons using sapal is shown in Figure 35.</td>
</tr>
<tr>
<td>3) Drying coconut meat to sell to oil mills for further extraction of oil</td>
<td>Based on the analysis of dried sapal as reported by FNRI, sapal contains 38% oil on a dry basis, which is still appropriate for High Pressure Expellers pressing. If oil millers are informed of this, then it is certain that they will buy sapal for further extraction of oil.</td>
</tr>
<tr>
<td>4) Processing into another type of VCO and coconut flour, or high quality animal feed ingredient</td>
<td>If processing is carried out under very strict sanitary conditions, the co-product of VCO can be sold as coconut flour, or as a high quality animal feed ingredient. The process for producing coconut flour and white coconut oil from sapal was developed at the PCA and the technology was commercially adopted in 2002 by a coconut milk manufacturing company in Davao City. The process is only viable with a minimum processing capacity of 1,000 kg wet sapal per day. Application of Bawalan-Masa process to produce another type of VCO and coconut flour from sapal requires a higher investment and higher volume of sapal as raw material, and is not suited for micro- and village-scale operation.</td>
</tr>
<tr>
<td>5) Processing into organic fertiliser</td>
<td>The process involves decomposition of the sapal mixed with other agricultural residues and the addition of enzymes or other decomposition agents to make organic fertiliser/compost.</td>
</tr>
</tbody>
</table>

Residual or Class B oil

When producing VCO using the Modified Kitchen and Natural Fermentation Methods, it is always possible to recover some residual (Class B) coconut oil after the premium grade or Class A VCO is removed. Residual oil is recovered by further heating of the latik in the case of Modified Kitchen Method or the fermented curd if using the Natural Fermentation Method, to release the trapped oil. This residual oil, about 10 to 15% of the harvested Class A VCO, is yellow and has a strong coconut aroma because of the high heating required to fully release the trapped oil. Recovering the residual oil and processing it into downstream products will further enhance profitability in VCO operations.

Where there are lapses in strict critical control procedures or sanitary conditions, the quality of VCO produced may not pass the Class A VCO standard. If this is the case, further processing of the oil into other products is necessary to recoup production costs and possibly acquire additional income. There are several ways of utilising the residual oil so that additional income can be generated (see Figure 35 and Table 14).

Making other products

Downstream products include soap and biodiesel. When the odour further removed, other products such as cooking oil, skin lotions and skin care products and massage and carrier oils for the spa and aromatherapy industry.

Figure 35 indicates a typical flowchart for processing Class B oil.
### Table 14. Other products produced from residual oil (Class B)

<table>
<thead>
<tr>
<th>Downstream product</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Culinary oil</td>
<td>Further processing of the oil is required to remove the odour and taste for consumers who do not like the coconut flavour that it imparts to food cooked in it or when used on salads etc. Based on information obtained from VCO traders in the Philippines and an owner of a health food company in Canada, there are now a growing number of people demanding odourless, chemical-free white coconut oil for culinary purposes and as a substitute for using the traditional RBD copra-derived coconut oil. Details on removal of odour are given in Annex 5.</td>
</tr>
<tr>
<td>2) Oil for hair and scalp care</td>
<td>Coconut oil has been used in coconut-producing countries for decades to maintain healthy hair and scalp. In the Philippines, older women in the rural areas regularly use coconut oil in their hair but young people should be encouraged to adopt the practice. One potential export market for this type of oil is Bangladesh. Based on the data gathered, both adult Bangla males and females use coconut oil in their hair. In Bangladesh supermarkets, coconut oil is found in the hair care section — a well-packaged copra-derived oil is being sold at an equivalent price of USD1.00 per 400 ml. The addition of natural essential oils of rosemary or patchouli will enhance the therapeutic value of coconut oil as a hair and scalp conditioner and will camouflage the coconut odour.</td>
</tr>
<tr>
<td>3) Carrier oil for aromatherapy and massage oils</td>
<td>The growing popularity of spas and health resorts worldwide will prove an excellent market for the promotion of the Class B VCO as a carrier oil. The oil massages evenly, eventually soaking into the skin and does not leave a heavy, sticky residue.</td>
</tr>
<tr>
<td>4) Base oil for moisturising oil, body butter, cream and other skin care products</td>
<td>VCO has been proven to have hypoallergenic properties and is specially suited to sensitive skin in moisturising body oil and other skin care products. The re-processed residual oil can be sold in bulk to major cosmetic companies. Alternatively, the VCO processors can convert Class B oil into a moisturising body oil that is an easy, risk-free product to make at home or village level. Because of the presence of water in creams and lotions, preservatives are needed to prolong the product shelf-life. Sometimes, these may be difficult to obtain.</td>
</tr>
<tr>
<td>5) Herbal soap</td>
<td>Coconut oil is an excellent raw material for making soaps as it provides the lathering and active cleaning properties that other oils cannot. In the last five years, the use of herbal soaps has gained worldwide popularity, so conversion of the residual oil into herbal soaps offers good marketing prospects. Philippine-made herbal soap prices range in price from USD0.80 to $2.00 per 135 g bar depending its therapeutic effect. Pacific and Thai herbal soaps are often sold at higher prices.</td>
</tr>
<tr>
<td>6) Raw material for biodiesel production</td>
<td>Biodiesel is gaining popularity as a fuel additive and fuel enhancer to support the Clean Air Act of the Philippines. As the quality of Class B oil is still much higher than that of copra-derived crude coconut oil, it is an excellent raw material for small-scale processing into biodiesel. However, the economics of using this oil for biodiesel production has to be studied and compared with the income obtained.</td>
</tr>
</tbody>
</table>


Simple methods for preparing coconut oil-based aromatherapy and massage oils are given in Annex 5 while adapted formulations for some skin care products that do not need chemical preservatives are found in Annex 5. Both are excerpts from Bawalan, D., 2005. *Final Mission Report on Coconut Processing*. Thailand.
Coconut husk, fibre and shell

Coconut fibre, husk and shells may be used in many ways to produce value-added, for example, coir, rope, mats, coco-peat for potting mixtures, shells for charcoal and ornaments. Shells may also be used to fire coconut dryers and husks can be returned to the field as organic mulch to supply nutrients around trees.
### Chapter 6

#### Economic Analysis

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Units</th>
<th>Unit cost (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorised grater (1/2 HP)</td>
<td>1</td>
<td>154.55</td>
</tr>
<tr>
<td>Bridge press</td>
<td>1</td>
<td>608.91</td>
</tr>
<tr>
<td>Gravity type filter assembly</td>
<td>2</td>
<td>12.13</td>
</tr>
<tr>
<td>Flexible reboiler assembly</td>
<td>1</td>
<td>108.99</td>
</tr>
</tbody>
</table>

**Fermenting plastic container:**

- **18** units at **1.82 USD** per unit.

**Questions:**

- Do I have enough money to buy this equipment?
- How long before I get my money back?
Economic analysis

To provide indicative data on the profitability of micro-scale VCO processing, a cost and return analysis was done using the Modified Natural Fermentation Method based on a 350 nuts/day processing capacity in a coconut producing community in the Philippines.

Cost and return analysis — VCO production

The 350 nuts/day capacity used in the calculation, is the maximum capacity in an eight-hour day that can be processed with a bridge press fabricated in the Philippines, if coconut milk extraction is done in two passes. There is a limit to upsizing the size of a bridge press since a balance has to be made between capacity and milk extraction efficiency. Other data used in the calculation were gathered on a mission for the German Development Cooperation Agency (GTZ) in July 2005.

Oil recovery is increased by about 17% if the grated meat is double-pressed before extracting the milk. However, double-pressing also halves the processing capacity of the bridge press. If a higher processing capacity is desired, the processor can do a single pressing of the grated meat in two eight-hour shifts per day or add another set of equipment.

Under the current marketing structure for VCO in the Philippines, a micro- or a village-scale VCO processor has the following options to sell the product.

• Sell in bulk to traders.
• Sell in bulk to repackers.
• Pack in small package sizes and wholesale to retail outlets, or direct sell.
• A combination of these options is possible.

For purposes of clarification, the following definitions are applied.

Trader — a person or a company who buys in bulk from producers, exports the VCO or supplies the VCO to retailers.

Repacker — a person or a company who buys in bulk from producers, repacks the product in small sizes under their own brand name, and sells to retailers.

The profitability of any processing venture is highly dependent on the country, the location of the VCO operation and availability of equipment and raw materials.
Scenarios

Three case scenarios are considered.

- Case 1: All Class A VCO products sold in bulk at the current traders buying price of USD2.40/L (PhP 132/L).
- Case 2: All Class A VCO products sold in bulk to re-packers at USD3.50 (PhP 192.50 /L).
- Case 3: Half of Class A VCO sold in bulk to traders at USD2.40/L and half sold in the retail market at USD8.00/L.

In all cases, it is assumed that the residual oil (Class B) is sold in bulk at USD1.70/L. As well as the prices mentioned above, the following basic assumptions are used.

<table>
<thead>
<tr>
<th>Table 15. Basic assumptions for selling residual oil (Class B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exchange rate</td>
</tr>
<tr>
<td>Wages for equipment operators</td>
</tr>
<tr>
<td>Wages for unskilled workers</td>
</tr>
<tr>
<td>Salary of production supervisor</td>
</tr>
<tr>
<td>Cost of electricity</td>
</tr>
<tr>
<td>Pre-operating expense</td>
</tr>
<tr>
<td>Quality control expenditure</td>
</tr>
<tr>
<td>Admin &amp; marketing cost</td>
</tr>
<tr>
<td>Fringe benefits</td>
</tr>
<tr>
<td>Number of plant workers</td>
</tr>
</tbody>
</table>

The working capital is calculated based on a seven-day inventory of raw material at a buying price of USD0.09 per nut; a 90 day inventory of packaging material and labels as applicable, one month direct labour cost and a seven-day finished goods inventory.

Sensitivity analyses on the specified processing capacity defined three case scenarios at different prices for coconuts. The Return on Investment (ROI) under conditions of with and without taxes are calculated and used as a basis of comparison and a measure of profitability. Income tax is assumed to be 35% of the net profit. Under Philippine conditions, a business enterprise is considered profitable if the ROI is above 28%, which is the current interest rate on commercial loans.

The Modified Natural Fermentation Method, using listed equipment, has the lowest labour requirement with the least energy input.
Summary of calculations
Cost (in USDollars)
350 nuts/day processing capacity; processed by Natural Fermentation Method

<table>
<thead>
<tr>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk sale to trader</td>
<td>Bulk sale to repacker</td>
<td>50% Bulk sale to trader, 50% Retail</td>
</tr>
</tbody>
</table>

No. of nuts processed/day 350 350 350
Operating days/year 300 300 300
Effective production days/year 250 250 250
Raw material cost $/nut 0.09 0.09 0.09
Production cost
Class A VCO ($/L) 2.60 2.60 2.84
Class B VCO (assumed by-product; no cost)
Assumed selling price $/L
Class A bulk 2.40 3.50 2.40
retail 8.00
Class B bulk 1.70 1.70 1.70
Building cost (80 m²) 5,091 5,091 5,091
Fixed capital investment 6,373 6,373 6,373
Working capital and pre-op. 2,158 2,375 3,323
Total investment 18,727 26,486 38,477
Total revenue 5,429 5,429 5,429
Raw material 7,875 7,875 7,875
Packaging 369 369 2,068
Direct labour 4,455 4,455 4,455
Light and power 179 179 179
TOTAL variable cost 12,877 12,877 14,576
TOTAL production cost 18,306 18,306 20,006
GROSS profit 421 8,180 18,471
Admin & marketing cost (2% of gross sales) 375 530 770

WITHOUT TAX

| NET PROFIT | 46 | 7,650 | 17,702 |
| RETURN ON INVESTMENT (ROI) % | 54% | 87% | 182% |

WITH TAX

Income Tax (35% of net profit before tax) 16 2,677 6,196

| NET PROFIT (after tax) | 30 | 4,972 | 11,506 |
| RETURN ON INVESTMENT (after tax) | 35% | 56% | 118% |

Higher profits from pre-packaged retail products involve additional risk. However, returns on investment are very attractive with a short payback period of about one year.

Remember
Quality, Price and Continuity of Supply are essential in marketing VCO.
Sensitivity analysis

350 nuts/day processing capacity, double-pressing

<table>
<thead>
<tr>
<th>Price of nut USD/100 pieces</th>
<th>5.00</th>
<th>6.00</th>
<th>7.00</th>
<th>9.00</th>
<th>11.00</th>
</tr>
</thead>
</table>

| PRODUCTION COST | Case 1: bulk sale $2.40/L (trader) | 2.10 | 2.22 | 2.35 | 2.60 |
| Case 2: bulk sale $3.50/L (repacker) | 2.35 | 2.60 | 2.84 |
| Case 3: 50% to trader; 50% retail $8.00/L | 2.34 | 2.46 | 2.59 | 2.84 | 3.08 |

| GROSS PROFIT | Case 1: bulk sale $2.40/L (trader) | 3,921 | 3,046 | 2,171 | 421 |
| Case 2: bulk sale $3.50/L (repacker) | 9,930 | 8,180 | 6,430 |
| Case 3: 50% to trader; 50% retail $8.00/L | 21,971 | 21,096 | 20,221 | 18,471 | 16,721 |

| RETURN ON INVESTMENT (without tax) | Case 1: bulk sale $2.40/litre (trader) | % | % | % | % |
| Case 2: bulk sale $3.50/L (repacker) | % | 108 | 87 | 67 |
| Case 3: 50% to trader; 50% retail $8.00/L | % | 221 | 211 | 202 | 183 | 164 |

| RETURN ON INVESTMENT (with tax) | % | % | % | % | % |
| Case 1: bulk sale $2.40/L (trader) | % | 27 | 21 | 14 | 0.35 |
| Case 2: bulk sale at $3.50/L (repacker) | % | 70 | 57 | 44 |
| Case 3: 50% to trader; 50% retail $8.00/L | % | 144 | 137 | 131 | 119 | 106 |

| PAYBACK PERIOD (years) | Case 1: bulk sale $2.40/L (trader) | 3.71 | 11.84 |
| Case 2: bulk sale $3.50/L (repacker) | 0.93 | 1.13 |
| Case 3: 50% to trader; 50% retail $8.00/L | 0.51 | 0.56 |

Results and discussion

Results of analysis revealed the following.

a) The operation will not be profitable at the specified processing capacity of 350 nuts/8 hr day if the price is USD0.09/nut and if the VCO is sold in bulk to traders at USD2.40/L. In Case 1 (350 nuts per day capacity), the operation can only be profitable when the price/nut is reduced to USD0.06 if no tax is paid, or USD0.05/nut if tax is paid (tax rate 35% of profit).

b) The operation is very profitable even if the price is increased to USD0.11/nut and 35% tax is paid, if the Class A VCO is sold in bulk to repackers at USD3.50/L.

The most profitable operation is Case 3 where 50% of Class A VCO is sold in bulk to traders at USD2.40/L and 50% sold to retailers at USD8.00/L. However, this involves higher working capital because of higher packaging cost, higher marketing costs and higher risks in cash flow since the turn-over is not as fast as selling in bulk. In most cases, retail selling means selling the product on consignment. If the turn-over is low then the cash...
flow and working capital of the operation are compromised. Payback period at a processing capacity of 350 nuts/day, price of nuts at USD0.09/nut and a VCO selling price of USD3.50/L (Case 2) is 1.13 years.

Selling in bulk to traders at USD2.40/L can also be profitable if VCO is produced by individual farmers at home, processing their own coconuts and using family labour where there are no overhead costs as in an established VCO processing facility. This model is common in Luzon, Philippines, where traders have their own group of farmer producers. However, this system has a higher risk in terms of maintaining the quality of the product. The risk can be greatly reduced if the farmer-producer follows a strict, standardised procedure manual where all Critical Control Points in VCO processing are observed.

**Equipment costs**

Below is a list of approximate prices of the necessary equipment for setting up a 350 nut/day unit for VCO processing.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Units</th>
<th>Unit cost USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorised grater (1/2 HP)</td>
<td>1</td>
<td>154.55</td>
</tr>
<tr>
<td>Bridge press</td>
<td>1</td>
<td>690.91</td>
</tr>
<tr>
<td>Gravity type filter assembly</td>
<td>2</td>
<td>72.73</td>
</tr>
<tr>
<td>Flexible reboiler assembly</td>
<td>1</td>
<td>109.09</td>
</tr>
<tr>
<td>Fermenting plastic container</td>
<td>18</td>
<td>1.82</td>
</tr>
<tr>
<td>Stainless steel stock pot (4 sets at 4 assorted sizes per set)</td>
<td>4</td>
<td>18.18</td>
</tr>
<tr>
<td>Charcoal stove with housing</td>
<td>1</td>
<td>63.64</td>
</tr>
<tr>
<td>Assorted stainless steel strainer</td>
<td></td>
<td>72.73</td>
</tr>
<tr>
<td>Ladles and other accessories</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastic pails (24 L)</td>
<td>6</td>
<td>5.45</td>
</tr>
<tr>
<td>Plastic container with cover (400 L)</td>
<td>2</td>
<td>10.00</td>
</tr>
<tr>
<td>Stainless steel basin (60 cm dia)</td>
<td>2</td>
<td>13.64</td>
</tr>
</tbody>
</table>

In Thailand, graters are about one-third of the prices quoted here and stainless steel containers, strainers etc., are about half the price quoted here.
References

Anonymous, Undated. Spectrum of Coconut Products, Philippine Coconut Authority.

Anon. 1979. Technical Data Handbook on the Coconut, Its Products and By-Products, Research Coordination and Documentation Center, Corporate Planning and Information Office, Philippine Coconut Authority, Quezon City Philippines.


WWW.eaudrey.com
Further reading


### Table 1: Nutrient Composition

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Moisture</th>
<th>Fats and oils</th>
<th>Natural sugar</th>
<th>Protein</th>
<th>Carbohydrates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.5 – 3.5</td>
<td>58.0 – 62.0</td>
<td>5.9</td>
<td>8.0</td>
<td>18.0 – 20.0</td>
</tr>
</tbody>
</table>

#### Type of Essential Amino Acid

<table>
<thead>
<tr>
<th>Type of Essential Amino Acid</th>
<th>Amount (g/100 g protein)</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isoleucine</td>
<td>5.1</td>
<td>2.5 – 3.5</td>
</tr>
<tr>
<td>Leucine</td>
<td>4.1</td>
<td>58.0 – 62.0</td>
</tr>
<tr>
<td>Lysine</td>
<td>3.6</td>
<td>5.9</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>2.7</td>
<td>8.0</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>Cysteine/Cystine</td>
<td>1.8</td>
<td>18.0 – 20.0</td>
</tr>
</tbody>
</table>
Virgin coconut oil: production manual for micro- and village-scale production

Table 1. Changes in the texture of coconut meat and its composition at different stages of maturity *

<table>
<thead>
<tr>
<th>Age (month)</th>
<th>Texture of meat</th>
<th>Moisture (%)</th>
<th>Ash (%)</th>
<th>Protein (%)</th>
<th>Oil (%)</th>
<th>Total CHO ** (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>soft &amp; watery</td>
<td>89.0</td>
<td>0.6</td>
<td>2.4</td>
<td>3.8</td>
<td>4.2</td>
</tr>
<tr>
<td>9</td>
<td>soft &amp; watery</td>
<td>86.4</td>
<td>0.8</td>
<td>2.7</td>
<td>4.9</td>
<td>5.2</td>
</tr>
<tr>
<td>10</td>
<td>moist &amp; crunchy</td>
<td>58.5</td>
<td>2.0</td>
<td>6.3</td>
<td>24.7</td>
<td>8.5</td>
</tr>
<tr>
<td>11</td>
<td>dry &amp; crunchy</td>
<td>46.4</td>
<td>2.2</td>
<td>6.2</td>
<td>33.6</td>
<td>11.6</td>
</tr>
<tr>
<td>12</td>
<td>dry &amp; crunchy</td>
<td>43.3</td>
<td>2.2</td>
<td>5.5</td>
<td>35.8</td>
<td>13.2</td>
</tr>
</tbody>
</table>

* Analysis was conducted on pared coconut meat (no testa). ** Assessed by difference

Table 2. Composition of Philippine desiccated coconut*

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>2.5 – 3.5</td>
</tr>
<tr>
<td>Fats and oils</td>
<td>58.0 – 62.0</td>
</tr>
<tr>
<td>Natural sugar</td>
<td>5.9</td>
</tr>
<tr>
<td>Protein</td>
<td>8.0</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>18.0 – 20.0</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>2.0 – 4.0</td>
</tr>
<tr>
<td>Ash</td>
<td>1.5 – 2.0</td>
</tr>
</tbody>
</table>

* Desiccated coconut is the pure white, particulated or shredded dehydrated product obtained from fresh, pared coconut meat processed under very strict sanitary conditions.
Source: Philippine Coconut Authority

Table 3. Micromineral content of Philippine desiccated coconut*

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Amount (mg/100 g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium (K)</td>
<td>565</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>174</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>20</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>95</td>
</tr>
</tbody>
</table>

* Moisture Content of 4.6 %

Table 4. Amino acid composition of desiccated coconut

<table>
<thead>
<tr>
<th>Essential amino acids</th>
<th>% N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arginine</td>
<td>0.78</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>0.28</td>
</tr>
<tr>
<td>Leucine</td>
<td>0.45</td>
</tr>
<tr>
<td>Lysine</td>
<td>0.22</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>0.26</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>0.19</td>
</tr>
<tr>
<td>Cystine</td>
<td>0.11</td>
</tr>
<tr>
<td>Methionine</td>
<td>0.11</td>
</tr>
<tr>
<td>Threonine</td>
<td>0.19</td>
</tr>
<tr>
<td>Histidine</td>
<td>0.13</td>
</tr>
<tr>
<td>Valine</td>
<td>0.35</td>
</tr>
</tbody>
</table>

### Table 5. Nutritional composition of coconut milk as compared to dairy milk (per 100 g basis)

<table>
<thead>
<tr>
<th></th>
<th>Coco milk</th>
<th>Cow’s milk</th>
<th>Carabao’s milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food energy, calories</td>
<td>318</td>
<td>65</td>
<td>123</td>
</tr>
<tr>
<td>Protein, g</td>
<td>5.5</td>
<td>3.3</td>
<td>5.4</td>
</tr>
<tr>
<td>Fat, g</td>
<td>34.8</td>
<td>3.6</td>
<td>9.5</td>
</tr>
<tr>
<td>Total carbohydrate, g</td>
<td>1.9</td>
<td>5.0</td>
<td>4.2</td>
</tr>
<tr>
<td>Calcium, mg</td>
<td>15</td>
<td>137</td>
<td>216</td>
</tr>
<tr>
<td>Phosphorus, mg</td>
<td>100</td>
<td>74</td>
<td>101</td>
</tr>
<tr>
<td>Iron, mg</td>
<td>1.6</td>
<td>0.6</td>
<td>0.2</td>
</tr>
<tr>
<td>Potassium, mg</td>
<td>324</td>
<td>141</td>
<td>146</td>
</tr>
<tr>
<td>Vitamin A, I.U.</td>
<td>-</td>
<td>130</td>
<td>160</td>
</tr>
<tr>
<td>Thiamine, mg</td>
<td>0.02</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Riboflavin, mg</td>
<td>0.01</td>
<td>0.18</td>
<td>0.18</td>
</tr>
<tr>
<td>Niacin, mg</td>
<td>0.3</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Ascorbic Acid, mg</td>
<td>trace</td>
<td>2.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Source: Food and Nutrition Research Centre, Philippines, 1968

### Table 6. Composition of coconut water at different growth stages

<table>
<thead>
<tr>
<th>Composition</th>
<th>Without kernel</th>
<th>With soft kernel (0 – 4 mm)</th>
<th>With semi-hard kernel (2 – 6 mm)</th>
<th>With hard kernel (10 – 12 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>4.8</td>
<td>4.9</td>
<td>4.9</td>
<td>5.3</td>
</tr>
<tr>
<td>NaCl %</td>
<td>0.280</td>
<td>0.252</td>
<td>0.268</td>
<td>0.383</td>
</tr>
<tr>
<td>Reducing sugar %</td>
<td>3.95</td>
<td>5.25</td>
<td>5.26</td>
<td>5.24</td>
</tr>
<tr>
<td>Sucrose %</td>
<td>0.148</td>
<td>0.329</td>
<td>0.484</td>
<td>0.160</td>
</tr>
<tr>
<td>Vitamin C mg/ml water</td>
<td>2.5</td>
<td>3.71</td>
<td>3.44</td>
<td>2.24</td>
</tr>
<tr>
<td>Volume water ml</td>
<td>295</td>
<td>230</td>
<td>235</td>
<td>210</td>
</tr>
</tbody>
</table>

* Average of 48 samples of each variety


### Table 7. Average analysis of coconut water

<table>
<thead>
<tr>
<th>Solute</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugars (levulose and dextrose)</td>
<td>2.6%</td>
</tr>
<tr>
<td>Chlorides</td>
<td>0.17%</td>
</tr>
<tr>
<td>Protein</td>
<td>0.55%</td>
</tr>
<tr>
<td>Oil</td>
<td>0.74%</td>
</tr>
<tr>
<td>Total solids</td>
<td>4.71%</td>
</tr>
<tr>
<td>Ash</td>
<td>0.46%</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>1.02</td>
</tr>
<tr>
<td>pH</td>
<td>5.6</td>
</tr>
</tbody>
</table>

Source: Anzaldo et al, 1985

### Table 8. Total reducing sugar and protein content of coconut water from nuts of various ages

<table>
<thead>
<tr>
<th>Age (months)</th>
<th>Total reducing sugars (g/100 ml)</th>
<th>Protein (g/100 ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>2.20</td>
<td>0.104</td>
</tr>
<tr>
<td>5</td>
<td>2.25</td>
<td>0.210</td>
</tr>
<tr>
<td>6</td>
<td>2.39</td>
<td>0.262</td>
</tr>
<tr>
<td>7</td>
<td>2.56</td>
<td>0.356</td>
</tr>
<tr>
<td>8</td>
<td>2.63</td>
<td>0.504</td>
</tr>
<tr>
<td>9</td>
<td>2.89</td>
<td>0.512</td>
</tr>
<tr>
<td>10</td>
<td>2.79</td>
<td>0.512</td>
</tr>
</tbody>
</table>

Source: Anzaldo et al, 1985
### Table 9. Electrolyte composition of coconut water from coconuts of various ages

<table>
<thead>
<tr>
<th>Age (months)</th>
<th>Potassium (meq/L)</th>
<th>Sodium (meq/L)</th>
<th>Calcium (meq/L)</th>
<th>Magnesium (meq/L)</th>
<th>Chlorine (meq/L)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>43.86</td>
<td>1.11</td>
<td>13.23</td>
<td>6.46</td>
<td>44.00</td>
<td>4.90</td>
</tr>
<tr>
<td>5</td>
<td>40.13</td>
<td>1.68</td>
<td>10.20</td>
<td>5.87</td>
<td>38.16</td>
<td>4.87</td>
</tr>
<tr>
<td>6</td>
<td>35.53</td>
<td>1.58</td>
<td>9.60</td>
<td>4.27</td>
<td>33.00</td>
<td>4.92</td>
</tr>
<tr>
<td>7</td>
<td>36.40</td>
<td>2.06</td>
<td>10.67</td>
<td>4.27</td>
<td>35.83</td>
<td>4.92</td>
</tr>
<tr>
<td>8</td>
<td>36.73</td>
<td>2.20</td>
<td>10.80</td>
<td>5.14</td>
<td>45.67</td>
<td>5.17</td>
</tr>
<tr>
<td>9</td>
<td>42.67</td>
<td>2.47</td>
<td>11.20</td>
<td>5.34</td>
<td>30.34</td>
<td>5.40</td>
</tr>
<tr>
<td>10</td>
<td>44.26</td>
<td>3.05</td>
<td>17.07</td>
<td>6.13</td>
<td>37.67</td>
<td>5.40</td>
</tr>
</tbody>
</table>

Source: Anzaldo, 1987

### Table 10. Nutritional composition of coconut skim milk and other milk sources

<table>
<thead>
<tr>
<th></th>
<th>Coco skim milk*</th>
<th>Soybean milk**</th>
<th>Cow’s milk**</th>
<th>Human milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food energy, calories</td>
<td>27</td>
<td>33</td>
<td>65</td>
<td>77</td>
</tr>
<tr>
<td>Protein, g</td>
<td>1.6</td>
<td>3.4</td>
<td>3.5</td>
<td>1.1</td>
</tr>
<tr>
<td>Fat, g</td>
<td>0.4</td>
<td>1.5</td>
<td>3.5</td>
<td>4.0</td>
</tr>
<tr>
<td>Carbohydrate, g</td>
<td>4.5</td>
<td>2.2</td>
<td>4.9</td>
<td>9.5</td>
</tr>
<tr>
<td>Calcium, mg</td>
<td>26</td>
<td>21</td>
<td>118</td>
<td>33.0</td>
</tr>
<tr>
<td>Phosphorus, mg</td>
<td>36.0</td>
<td>48</td>
<td>93</td>
<td>14.0</td>
</tr>
<tr>
<td>Iron, mg</td>
<td>0.7</td>
<td>0.8</td>
<td>trace</td>
<td>0.1</td>
</tr>
<tr>
<td>Vitamin A, I.U.</td>
<td>-</td>
<td>40</td>
<td>140</td>
<td>240</td>
</tr>
<tr>
<td>Thiamine, mg</td>
<td>0.01</td>
<td>0.08</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>Riboflavin, mg</td>
<td>0.01</td>
<td>0.03</td>
<td>0.17</td>
<td>0.04</td>
</tr>
<tr>
<td>Niacin, mg</td>
<td>0.4</td>
<td>0.2</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Ascorbic Acid, mg</td>
<td>2.0</td>
<td>0.0</td>
<td>1.0</td>
<td>5.0</td>
</tr>
</tbody>
</table>


### Table 11. Amino acid content of coconut skim milk

<table>
<thead>
<tr>
<th>Type of essential amino acid</th>
<th>Amount (g/100 g protein)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isoleucine</td>
<td>2.5</td>
</tr>
<tr>
<td>Leucine</td>
<td>5.1</td>
</tr>
<tr>
<td>Lysine</td>
<td>4.1</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>3.6</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>2.1</td>
</tr>
<tr>
<td>Cysteine/Cystine</td>
<td>1.8</td>
</tr>
<tr>
<td>Methionine</td>
<td>1.2</td>
</tr>
<tr>
<td>Threonine</td>
<td>2.4</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>0.9</td>
</tr>
<tr>
<td>Valine</td>
<td>4.1</td>
</tr>
</tbody>
</table>

*Equivalent to g/16 g nitrogen
Source: Hagenmaier, 1980
Frequently asked questions

What is VCO?

Why are MCFAs important?

Why is some oil yellow?

What are MCFAs anyway?

What are they anyway?
Frequently asked questions

1. What is virgin coconut oil?

Virgin coconut oil (VCO) is obtained from the fresh and mature kernel (meat) of coconut by mechanical or natural means with or without the application of heat that does not lead to alteration of the oil. VCO is suitable for human consumption in its natural form.

It is the purest form of coconut oil, water-clear in colour, contains natural Vitamin E and has not undergone hydrolytic or atmospheric oxidation as shown by its very low, free fatty acid content and peroxide value. It has a mild to intense fresh coconut aroma depending on the type of process used for production.

2. What is copra-derived oil?

Copra-derived coconut oil has to undergo chemical refining, bleaching and de-odourisation processes to make it suitable for human consumption. This type of coconut oil is commonly referred to as RBD (Refined, Beached, De-odourised) oil. It is yellow or pale yellow in colour and does not contain Vitamin E since this is removed when the oil is subjected to high temperature and various chemical processes. It is odourless and tasteless.

3. What are the ideal quality characteristics of VCO?

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Ideal Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>Water-clear; 1 Yellow, 0.1 Red using Lovibond Tintometer</td>
</tr>
<tr>
<td>Free fatty acid (as lauric)</td>
<td>0.1% max</td>
</tr>
<tr>
<td>Moisture</td>
<td>0.1% max</td>
</tr>
<tr>
<td>Peroxide value</td>
<td>1 max</td>
</tr>
<tr>
<td>Lauric fatty acid content</td>
<td>47 to 55%</td>
</tr>
<tr>
<td>Aroma</td>
<td>fresh coconut scent, mild to intense</td>
</tr>
</tbody>
</table>

4. What is the Philippine national standard for VCO?

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Standard Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>Water-white (water-clear)</td>
</tr>
<tr>
<td>Free fatty acid (as lauric)</td>
<td>0.2% max</td>
</tr>
<tr>
<td>Moisture</td>
<td>0.2% max</td>
</tr>
<tr>
<td>(Matter volatile at 105°C)</td>
<td>3 max</td>
</tr>
<tr>
<td>Peroxide value</td>
<td>&lt; 10 cfu</td>
</tr>
<tr>
<td>Total plate count</td>
<td>None permitted</td>
</tr>
<tr>
<td>Food additive</td>
<td>None permitted</td>
</tr>
<tr>
<td>Contaminants (Maximum)</td>
<td>Iron – 5 mg/kg</td>
</tr>
<tr>
<td></td>
<td>Copper – 0.4 mg/kg</td>
</tr>
<tr>
<td></td>
<td>Lead – 0.1 mg/kg</td>
</tr>
<tr>
<td></td>
<td>Arsenic – 0.1 mg/kg</td>
</tr>
</tbody>
</table>

5. What causes the yellow colour in coconut oil?

- Bacterial contamination of the coconut meat before oil extraction.
- High processing or drying temperatures.
6. What is the simplest and cheapest method of producing VCO?
The Modified Modified Natural Fermentation Method.

7. How many coconuts are required to produce one litre of VCO?
Depending on the size and the process used, 10 to 15 fully mature (12 to 13 months), de-husked coconuts.

8. What is the effect of high temperature processing on VCO?
Vitamin E and sterol content are removed and the colour becomes yellow. In the presence of high moisture, the triglycerides may break into free fatty acid and glycerol. In this case, it will give a false free fatty acid reading — this measures the degree of hydrolytic rancidity that the oil has undergone.

9. Does VCO need to be kept in the refrigerator and how long does it last?
VCO does not need to be kept in the refrigerator (see Q. 20). Coconut oil is the most stable of plant-derived oils being traded in the world. If properly processed, its natural anti-oxidants give it a longer shelf-life than other oils. Samples of VCO produced in December 1998 and stored in transparent, open glass bottles at the processing laboratory of the Philippine Coconut Authority, Davao Research Center, still smelt fresh in February 2003.

10. What are the current major uses of VCO?
• As a nutraceutical and functional food used in cooking.
• As a hair conditioner.
• As a body oil or a substitute for moisturising lotion.
• As carrier oil for aromatherapy and massage oils.

11. Why is VCO being considered a nutraceutical?
As well as the instant energy it provides for the human body, it also has medicinal properties. It has been found that the medium chain (C₈ – C₁₂) fats in coconut oil have similar effects to the fats in mother’s milk that gives babies immunity to disease.

12. What are the distinguishing characteristics of coconut oil compared to other oils traded in the world market?
• High percentage of lauric (C₁₂) fatty acid, ranging from 48 to 55% depending on the coconut variety.
• High percentage of medium chain fatty acids (MCFA) (C₈ – C₁₂), generally about 64%.

13. What is the importance of medium chain fatty acids and lauric fatty acid?
• Since 1984, there have been an increasing number of publications regarding the antiviral, antimicrobial, antifungal and antiprotozoal properties of medium chain fatty acids (C₆ – C₁₃), with lauric acid (C₁₂) and its monoglyceride form monolaurin, being mentioned as the most potent against lipid coated micro-organisms such as
HIV, measles virus, herpes simplex virus, Helicobacter pylori and others, which are not normally cured by ordinary antibiotics.

- Studies have also shown that MCFAs are directly converted into energy in the liver and increase the metabolic rate of an individual. This in turn provides energy for the body, promotes weight loss and reduces the deposit of fats in the body.

14. What do the experts say regarding coconut oil-derived lauric fatty acid and its monoglyceride form, monolaurin?

According to Professor Jon Kabara (2000), Professor Emeritus, Department of Pharmacology, Michigan State University who pioneered research on monolaurin:

- Monolaurin, as a dietary supplement has shown very good results as an antibiotic and antiviral agent, particularly in its potency against lipid-coated/enveloped viruses.
- Monolaurin does not cause resistant organisms to appear and can, in fact, reduce the resistance of germs to antibiotics.
- When coconut oil is consumed, the body makes the disease-fighting monolaurin.

According to Dr Mary Enig (2001), a noted nutritional biochemist, formerly with the University of Maryland, now with the Nutrition Department, Enig Associates:

- Recently published research has shown that natural coconut fat in the diet leads to a normalisation of body lipids, protects against alcohol damage to the liver and improves the immune system’s anti-inflammatory response.
- The antimicrobial fatty acids and their derivatives are essentially nontoxic to man and they are produced in vivo by humans when they ingest those commonly available foods that contain adequate levels of medium chain fatty acids like coconut oil.
- The medicinal properties of lauric acid and monolaurin have been recognised by a small number of researchers for nearly four decades and this knowledge has resulted in more than 20 research papers and several U.S. patents.

15. What are lipid coated viruses and bacteria?

Lipid is the medical term for fats. Lipid coated microorganisms such as viruses and bacteria, have an envelope of fat covering the basic life structure, called nucleotides (DNA and RNA). The lipid coat is the reason that ordinary antibiotics cannot easily penetrate and kill these types of micro-organisms. However, several researchers have reported that MCFAs, particularly lauric fatty acids that are predominantly present in coconut oil, can penetrate and dissolve the lipid coating.

The information provided here is not in anyway meant to encourage readers to substitute VCO for the drugs or antibiotics being prescribed by their doctor in treating illnesses. VIRGIN COCONUT OIL IS NOT A DRUG, but a functional food and should only be used as such. Always remember that anything in excess is not good for you, so do not take more than 3½ tablespoons of VCO per day.
16. What are the lipid-coated micro-organisms which have been reported to be inactivated by lauric fatty acid and its monoglyceride, monolaurin?

**LIPID COATED VIRUSES**

- Human immunodeficiency virus (HIV)
- Measles virus
- Herpes simplex virus
- Herpes viridae
- Sarcoma virus
- Synctial virus
- Human lymphotropic virus (Type II)
- Vesicular stomatitis virus
- Visna virus
- Cytomegalovirus
- Epstein-Barr virus
- Influenza virus
- Leukemia virus
- Pneumonovirus
- Hepatitis C virus

**LIPID COATED BACTERIA**

- Listeria monocytogenes
- Helicobacter pylori
- Hemophilus influenza
- Staphylococcus aureus
- Streptococcus agalactiae
- Groups A, B, F & G Streptococci
- Gram-positive organisms
- Gram-negative organisms (if pre-treated with chelator)


Note: Monolaurin can be synthesized in the laboratory by reacting pure lauric fatty acid and pharmaceutical grade glycerol in definite proportion to produce a mixture of tri, di and monoglycerides of lauric fatty acid. Monolaurin or the monoglyceride of lauric fatty acid is separated from the said mixture by molecular distillation. Monolaurin is now being sold as food supplement in the United States in capsules of 300 mg/capsule. It has a GRAS ( Generally Regarded As Safe) rating from the US Food and Drug Administration.

17. Which bacteria have been reported to be inactivated by MCFAs and its monoglycerides like monocaprin and monolaurin?

<table>
<thead>
<tr>
<th>Bacterium</th>
<th>Diseases caused</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Streptococcus</em></td>
<td>throat infections, pneumonia, sinusitis, ear ache, rheumatic fever, dental cavities</td>
</tr>
<tr>
<td><em>Staphylococcus</em></td>
<td>staph infection, food poisoning, urinary tract infections, toxic shock syndrome</td>
</tr>
<tr>
<td><em>Neisseria</em></td>
<td>meningitis, gonorrhea, pelvic inflammatory disease</td>
</tr>
<tr>
<td>Chlamydia</td>
<td>genital infections, lymphogranuloma venereum, conjunctivitis, parrot fever, pneumonia, periodontitis</td>
</tr>
<tr>
<td><em>Helicobacter pylori</em></td>
<td>stomach ulcers</td>
</tr>
<tr>
<td>Gram positive organisms</td>
<td>anthrax, gastroenteritis, botulism, tetanus</td>
</tr>
</tbody>
</table>

18. What is the link between coconut oil and Severe Acute Respiratory Syndrome (SARS)?

According to Dr. Conrado Dayrit, Professor Emeritus, Department of Pharmacology, University of the Philippines who was involved in the first clinical trial on the use of coconut oil and monolaurin to treat HIV+ patients, the coronavirus which has been identified as the virus causing the SARS, is also lipid coated which means that lauric fatty acid and monolaurin could possibly have an inactivating effect on the SARS virus.

The pathogenic organisms causing influenza and pneumonia are both on the list of lipid-coated viruses and bacteria which are found to be inactivated by lauric fatty acid and monolaurin which in turn is manufactured by the human body from coconut oil. It should be noted that the symptoms exhibited by SARS-infected patients are similar to symptoms of pneumonia and influenza.

Therefore, it can be said that lauric fatty acid and monolaurin which are created by the body from coconut oil, could be a future potential cure for SARS.

19. Is the lauric fatty acid in VCO reduced if it is processed using a high temperature?

No. The lauric fatty acid content of coconut oil is highly dependent on the variety of coconut and not on the process used. In a study done by the PCA, Zamboanga Research Centre, Philippines, it was found that hybrid coconuts contain a higher content of lauric fatty acids than local tall varieties.

20. Is VCO that solidifies in an air-conditioned room or in the refrigerator still usable as a nutraceutical or functional food, or food supplement?

Yes. It is natural for VCO or RBD oil, to solidify when placed in the refrigerator or in a cool air-conditioned room because it solidifies at 22°C. Coconut oil that does not solidify at this temperature is not pure coconut oil and has been mixed with other oils.

21. What is the maximum recommended daily dose to obtain health benefits from VCO?

- 50 ml or 3½ tablespoons of VCO, or
- eating the meat of half a mature coconut, or
- eating 66 g desiccated coconut.

22. What is the best time to take virgin coconut oil?

It depends on what benefit from the VCO you want to achieve.

a. If you want to use it for controlling weight, take half the dose 30 minutes before lunch and dinner.

b. If you are using it as treatment for constipation, take it as a full dose before bedtime.

c. If you want to boost your immune system, take it anytime of the day in single or divided doses.
<table>
<thead>
<tr>
<th>Date</th>
<th>Batch No.</th>
<th>No. of nuts processed</th>
<th>No. of nuts rejected</th>
<th>Weight of VCO recovered, kg</th>
<th>Lot identification No. for VCO</th>
</tr>
</thead>
</table>

**Annex 3**

Daily production data sheets and summaries
### Modified Kitchen Method data sheet

**Date of production**

A. Selection of nuts

<table>
<thead>
<tr>
<th>No. of nuts selected</th>
<th>No. of nuts rejected (if any)</th>
<th>No. of nuts actually processed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B. Grating

<table>
<thead>
<tr>
<th>Time started</th>
<th>Time finished</th>
<th>Total grating time, hours/minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Weight of grated nut _______ kg

C. Milk extraction

<table>
<thead>
<tr>
<th></th>
<th>Time started</th>
<th>Time finished</th>
<th>Total extraction time hours/minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; extraction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; extraction</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Weight of first milk extract ________ kg
Weight of water added _____________ kg
Weight of second milk extract ________ kg
Weight of wet coconut milk residue ______ kg

D. Settling for 3 hours

<table>
<thead>
<tr>
<th>Weight of cream, kg</th>
<th>Weight of skim milk, kg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

E. Heating of cream

<table>
<thead>
<tr>
<th>Time started</th>
<th>Time finished</th>
<th>Total heating time, hours/minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Weight of wet proteinaceous residue (latik) _________ kg

<table>
<thead>
<tr>
<th>Wt. of premium oil, unfiltered</th>
<th>Wt. of premium oil, filtered</th>
<th>Wt. of residual oil, unfiltered</th>
<th>Wt. of residual oil, unfiltered</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Weight of toasted latik ________ kg
Modified Natural Fermentation Method data sheet

Date of production __________________________

A. Selection of nuts

<table>
<thead>
<tr>
<th>No. of nuts selected</th>
<th>No. of nuts rejected (if any)</th>
<th>No. of nuts actually processed</th>
</tr>
</thead>
</table>

B. Grating

<table>
<thead>
<tr>
<th>Time started</th>
<th>Time finished</th>
<th>Total grating time, hours/minutes</th>
</tr>
</thead>
</table>

Weight of grated meat __________ kg

C. Milk extraction

<table>
<thead>
<tr>
<th></th>
<th>Time started</th>
<th>Time finished</th>
<th>total extraction time hours/ minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; extraction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; extraction</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Weight of first milk extract __________ kg
Weight of water added __________ kg
Weight of second milk extract __________ kg
Weight of wet coconut milk residue ________ kg

D. Settling/fermentation of coconut milk

Time started | Time finished | Total fermentation time, ours/minutes

E. Harvesting of separated oil

Time started | Time finished | Total harvesting time, ours/minutes

Weight of wet fermented curd ________ kg

<table>
<thead>
<tr>
<th>Wt. of premium oil, unfiltered</th>
<th>Wt. of premium oil, filtered</th>
<th>Wt. of residual oil, unfiltered</th>
<th>Wt. of residual oil, unfiltered</th>
</tr>
</thead>
</table>

Weight of toasted curd ________ kg
Low Pressure Extraction Method data sheet

Date of production __________________________

A. Selection of nuts

<table>
<thead>
<tr>
<th>No. of nuts selected</th>
<th>No. of nuts rejected (if any)</th>
<th>No. of nuts actually processed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B. Grating

<table>
<thead>
<tr>
<th>Time started</th>
<th>Time finished</th>
<th>Total grating time, hours/minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Weight of grated meat ___________ kg

C. Drying of grated meat

<table>
<thead>
<tr>
<th>Time started</th>
<th>Time finished</th>
<th>Total drying time, hours/minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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</tbody>
</table>

Weight of dried meat ________ kg

D. Extraction of oil

<table>
<thead>
<tr>
<th>Time started</th>
<th>Time finished</th>
<th>Total extraction time, hours/minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Weight of extracted oil, unfiltered ________ kg
Weight of coconut meal _____ kg

E. Settling of oil

<table>
<thead>
<tr>
<th>Date/Time started</th>
<th>Date/Time finished</th>
<th>Total settling time, hours/minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F. Filtration of oil

<table>
<thead>
<tr>
<th>Time started</th>
<th>Time finished</th>
<th>Total filtration time, hours/minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Weight of filtered oil _________ kg
Weight of foots __________ g
High Pressure Expeller Process data sheet

Date of production __________________________

A. Selection of nuts

<table>
<thead>
<tr>
<th>No. of nuts selected</th>
<th>No. of nuts rejected (if any)</th>
<th>No. of nuts actually processed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

B. De-shelling of coconut meat

<table>
<thead>
<tr>
<th>Time started</th>
<th>Time finished</th>
<th>Total de-shelling time, hours/minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Weight of coconut meat ________ kg

C. Grinding of coconut meat

<table>
<thead>
<tr>
<th>Time started</th>
<th>Time finished</th>
<th>Total grinding time, hours/minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Weight of ground/granulated meat ________ kg

D. Drying of granulated meat

<table>
<thead>
<tr>
<th>Time started</th>
<th>Time finished</th>
<th>Total drying time, hours/minutes</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

Weight of dried granulated meat ________ kg

E. Extraction of oil

<table>
<thead>
<tr>
<th>Time started</th>
<th>Time finished</th>
<th>Total extraction time, hours/minutes</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

Weight of extracted oil, unfiltered ________ kg

Weight of coconut meal ________ kg

F. Settling of oil

<table>
<thead>
<tr>
<th>Date/Time started</th>
<th>Date/Time finished</th>
<th>Total settling time, hours/minutes</th>
</tr>
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</table>

G. Filtration of oil

<table>
<thead>
<tr>
<th>Time started</th>
<th>Time finished</th>
<th>Total filtration time, hours/minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Weight of filtered oil ________ kg

Weight of foots ________ g
<table>
<thead>
<tr>
<th>Production date</th>
<th>Batch No.</th>
<th>No. of nuts processed</th>
<th>No. of nuts rejected</th>
<th>Weight of VCO recovered, kg</th>
<th>Lot identification No. for VCO</th>
<th>Weight of wet residue, kg</th>
<th>Weight of wet latik or curd, kg</th>
<th>Weight of residual oil, kg</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
</tr>
<tr>
<td>Production date</td>
<td>Batch No.</td>
<td>No. of nuts processed</td>
<td>No. of nuts rejected</td>
<td>Weight of VCO recovered, kg</td>
<td>Weight of coco meal, kg</td>
<td>Weight of foots, kg</td>
<td>Lot identification No. for VCO</td>
<td>Weight of VCO, kg</td>
</tr>
<tr>
<td>----------------</td>
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<td>---------------------</td>
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</tr>
</tbody>
</table>
From coco milk to oil, cookies, hamburgers and soap!
Annex 4

Recipes
Recipes for VCO-based products

Coconut solid residue recipes

Coconut burger

Ingredients

1 cup fresh coconut milk residue
1 cup ground beef, or other meat
2 eggs, well beaten
¼ cup onions, chopped
1 tbsp garlic, minced
½ tsp ground pepper plus other spices to suit taste
3 tbsp soy sauce
2 tbsp cornstarch
½ tsp salt

cooking oil for frying

tomato sauce/catsup for serving

Procedure

Beat eggs. Completely dissolve cornstarch in the beaten eggs. Set aside.

Mix thoroughly fresh coconut residue, ground beef, onions, garlic, ground pepper, soy sauce, salt, chopped fresh green chili (if desired).

Add the beaten eggs with cornstarch to the mixture and mix thoroughly. Form into thin patties (2 tablespoons per patty).

Heat cooking oil in frying pan. Fry the patties until done. Drain off excess oil.

Serve with sauce/catsup while hot.

Note: The addition of fresh coconut residue (from coconut milk extraction) to the usual beef burger recipe provides dietary fibre which aids in preventing constipation and lowering of cholesterol. Coconut dietary fat has been shown to have antimicrobial properties and boosts the immune system as well as providing food energy. Using coconut residue for food is more economical than throwing it away or using for animal feed.

Source: Product Development Department, PCA, Diliman, Quezon City

Coconut okoy

Ingredients

½ cup all purpose wheat flour
½ tsp baking powder
½ cup matured pumpkin/squash, grated together with skin
1 cup fresh coconut milk residue
1 cup shrimps or ground chicken
1 egg, well beaten
½ cup onions, chopped
½ tbsp ground pepper plus other spices to suit taste
½ tsp salt
oil for frying

Procedure
Mixed together all ingredients and form into patties. Deep fry in oil until golden brown.
Serve hot with vinegar seasoned with salt and garlic as sauce.
Source: Philippine Coconut Authority, Region IV-A (Lucena)

Coco Shanghai
Ingredients
2 cups coconut milk residue
½ cup ground chicken or pork (optional)
1 carrot, chopped into small pieces
¼ cup soy sauce
1 egg
1 pc onion, chopped
3 strands green onion leaves, chopped
½ tsp salt
½ tsp ground pepper plus other spices to suit taste
spring roll (lumpia) wrapper
cooking oil for frying

Procedure
Mix all ingredients. Wrap 2 tablespoons of mixture in spring roll wrapper. Heat cooking oil in frying pan and fry until done.
Drain excess oil. Serve while hot.
Source: Philippine Coconut Authority, Region IV-A (Lucena)

Macaroons
Ingredients
1 can condensed milk (large)
3 eggs, well beaten
½ cup butter
¼ cup sugar
½ cup all-purpose flour
2 cups dried/toasted coconut milk residue (sapal)
1 tsp vanilla
2 tsp baking powder
Baking pan: 2 baking sheets or trays or 2 muffin pans

Procedure
Mix together all ingredients and beat well. Put mixture into paper cups. Fill only to one-half of the cup to avoid overflow of mixture during baking. Place on the baking sheet or tray and bake in a pre-heated oven (350ºF or 200ºC) 15 to 20 mins.
Source: Product Development Department, PCA
Peanut sapal thumbprints

Ingredients

$\frac{3}{4}$ cup sifted all purpose wheat flour  
1 cup toasted coconut residue  
$\frac{1}{2}$ tsp baking powder  
$\frac{1}{2}$ tsp baking soda  
$\frac{1}{4}$ tsp salt  
$\frac{1}{2}$ cup margarine or butter  
$\frac{3}{4}$ cup sugar  
$\frac{1}{4}$ cup peanut butter  
1 egg  
$\frac{1}{2}$ cup finely chopped peanuts

Procedure

Pre-heat oven to 350°F or 200°C. Sift together flour, baking soda, baking powder and salt. Set aside. Cream butter, peanut butter, sugar and egg. Blend in the dry ingredients and sapal. Cover and chill. Shape dough into 1-inch balls. Roll in peanuts. Place 3 inches apart on slightly greased baking sheet. Press thumb in centre of each cookie. Bake for 15 minutes or until set but not hard.

Source: Product Development Department, PCA

Coco oatmeal drop cookies

Ingredients

$\frac{1}{2}$ cup margarine or butter  
$\frac{1}{2}$ cup brown sugar, firmly packed  
$\frac{1}{2}$ cup granulated sugar  
2 eggs  
$\frac{1}{2}$ tsp vanilla  
$\frac{3}{4}$ cup sifted all-purpose flour  
$\frac{1}{2}$ tsp fine salt  
$\frac{1}{2}$ tsp baking soda  
1 cup oatmeal  
$\frac{1}{2}$ cup toasted coconut milk residue (sapal)  
$\frac{1}{4}$ cup cashew nuts, chopped

Procedure

Cream margarine/butter till light and fluffy. Add the brown and granulated sugar gradually. Mix in eggs and vanilla. Set aside. Sift flour, salt and baking soda together. Add to creamed mixture. Stir the oatmeal, sapal and cashew nuts into the above mixture. Mix until well blended. Drop by heaping teaspoonfuls into greased cookie sheets. Bake in pre-heated oven at 350°F (200°C) for about 15 minutes or until done.

Source: Product Development Department, PCA, Diliman, Quezon City
Preparation of massage and aromatherapy oils

Aromatherapy and massage oils can be prepared using two methods.

1. Addition of essential oils to suitable carrier oils. Virgin coconut oil is a suitable carrier oil because it is hypoallergenic and easily absorbed by the skin.

   Normally, 20 drops (almost 1 ml) of essential oil is added per 30 ml of carrier oil. For very strongly scented essential oils like patchouli, add 2 ml patchouli oil to 98 ml VCO to make a 2% solution. Essential oils can be blended for various therapeutic effects.

   Only pure 100% natural essential oils should be used. Oils diluted with alcohol or other solvents do not mix with VCO and should not be used.

2. Oil infusion of aromatic herbs and leaves. A simple way of doing this is to place the ground, dried herbs in heat resistant glass container or double boiler, cover and heat gently for one hour (for leaves like rosemary) or 2 hours (for roots like ginger). Use the ratio of 60 g dried aromatic herbs or leaves to 480 ml carrier oil (VCO).

   A longer method is to place a glass container with oil and herbs or leaves in the sun everyday for 10 days then discard the leaves.

Only pure, 100% natural essential oils should be used. Oils diluted with alcohol or other solvents do not mix with VCO and should not be used.

Massage oil for muscle pain

Grate or chop finely, 42 g fresh ginger root and place in a double boiler with 240 ml VCO.

Gently heat for two hours or until the oil turns clear. Initially, the oil will appear turbid because of the water in the fresh ginger. Allow the oil-ginger mixture to cool then filter it. A yellow-coloured, clear oil should result. For every 99 ml of ginger-infused VCO, add 1 ml eucalyptus essential oil.

Store in a dry, tightly sealed amber bottle.

Note: This is a formulation developed by Divina Bawalan.
Virgin coconut oil: production manual for micro- and village-scale production

Coco oil-based body/skin care products

Coconut moisturising jelly

120 ml VCO
30 g beeswax
2 ml essential oil of choice (peppermint, lavender, ylang ylang, lemon grass, etc.)

Melt the beeswax slowly over a double boiler. Heat the coconut oil in a separate container in a pan with heated water. Mix the oil and melted beeswax until well blended. Cool to 50°C. Add essential oil and stir thoroughly. Pour into cosmetic jars and let cool.

Note: Coconut oil and the melted beeswax should be the same temperature when mixed together otherwise a lumpy product will result.

Moisturising body butter

30 g beeswax
90 g cocoa butter
90 g VCO
10 ml honey
3 ml essential oil of choice

Melt beeswax slowly in a double boiler. Add cocoa butter and blend. Add VCO and blend. Remove from heat and add honey. Blend using a stick blender. Cool to about 50°C. Add essential oil and blend again. Transfer to a clean dry container.

Lip balm

20 g cocoa butter
20 g grated beeswax
40 g VCO

Melt the cocoa butter and beeswax slowly in a double boiler. Add VCO. Stir well using a glass stirrer. Continue stirring until the mixture starts to thicken. Alternatively, the mixture can be poured into a blender and pulsed until it thickens. Pour into sterilised containers.

Add peppermint or orange flavours if desired after cooling and before the mixture starts to thicken.

Note: This is a formulation following the guidelines in making lip balms provided on the website: www.eaudrey.com

TISTR staff training in soap making
Making VCO soap

Under a Thai/FAO project grant, the Thailand Institute of Science & Technological Research (TISTR) produced a range of herbal soaps from both RBD coconut oil and VCO, and packaging to suit the products.

**Base formula**

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCO</td>
<td>60 g</td>
<td></td>
</tr>
<tr>
<td>Sodium hydroxide</td>
<td>10 g</td>
<td></td>
</tr>
<tr>
<td>De-ionised water</td>
<td>28 g</td>
<td></td>
</tr>
<tr>
<td>Sodium benzoate</td>
<td>0.5 g</td>
<td>(preservative)</td>
</tr>
<tr>
<td>Essential oil</td>
<td>1–2 g</td>
<td>(pure, undiluted)</td>
</tr>
</tbody>
</table>

**Method**

Dissolve sodium hydroxide and sodium benzoate in water; leave until the temperature of the mixture cools to about 37°C.

Pour the mixture into the VCO; stir constantly with a stick blender or stirring rod, about 10 to 15 minutes until the mixture begins to thicken (trace). Add the essential oil (see below for quantity), and stir in.

Pour the mixture into the 50 mm PVC pipe lined with polythene film (other soap moulds can be used instead of the pipe). Cure for two days then push the soap from the pipe and cut into 100 g bars.

Leave to mature on an open shelf at room temperature for two to four weeks. Wrap the soap in waxed paper and place in packaging.

**Essential oils**

TISTR made five different soap bars using these essential oils: lemongrass (1.5%), citronella (1.5%), lime (1.5%), turmeric (1.0%) and vetiver (1.0%).
To make soap bars, pour the soap into cylinder molds to cure for two days, then remove from the cylinders and cut into bars. Use a guide to make sure every bar is the same size! Cure on an open shelf at room temperature for two to four weeks. Package for sale.
Quality control
The TISTR soap bars have a firm texture with good lathering and are mild on the skin. After curing, all soaps were subjected to invivo skin irritation tests; no irritation was found with either RBD oil or VCO based soap. Bars made with lemongrass, citronella and tumeric oils have anti-microbial properties that meet international specifications. All soaps meet toilet soap quality standards.

Physio-chemical properties of VCO soap

<table>
<thead>
<tr>
<th>Specification</th>
<th>Unit</th>
<th>Virgin coconut oil (TISTR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific gravity</td>
<td>-</td>
<td>0.914</td>
</tr>
<tr>
<td>Refractive index</td>
<td>-</td>
<td>1.453</td>
</tr>
<tr>
<td>Saponification value</td>
<td>mg KOH/g oil</td>
<td>259</td>
</tr>
<tr>
<td>Iodine number</td>
<td>Wijs</td>
<td>7.36</td>
</tr>
<tr>
<td>Unsaponified matter</td>
<td>g/kg</td>
<td>-</td>
</tr>
<tr>
<td>Acid value</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Free fatty acid (as lauric)</td>
<td>%</td>
<td>0.12</td>
</tr>
<tr>
<td>Water and volatile matter</td>
<td>%</td>
<td>0.19</td>
</tr>
<tr>
<td>Colour platinum-cobalt scale</td>
<td>-</td>
<td>0.9 Y, 0.3 R</td>
</tr>
<tr>
<td>Fatty acid composition</td>
<td>C8:0</td>
<td>7.2</td>
</tr>
<tr>
<td></td>
<td>C10:0</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td>C12:0</td>
<td>47.9</td>
</tr>
<tr>
<td></td>
<td>C14:0</td>
<td>19.0</td>
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<tr>
<td></td>
<td>C16:0</td>
<td>9.1</td>
</tr>
<tr>
<td></td>
<td>C18:0</td>
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<tr>
<td></td>
<td>C18:1</td>
<td>5.7</td>
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<tr>
<td></td>
<td>C18:2</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>other</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Many formulations exist for soaps, including pure VCO soaps and those made from a mixture of oils. An internet search will provide hundreds of recipes. A useful spreadsheet program for developing soap formulae is ‘SoapCalc’. By entering the desired oil mixture, the program calculates the amount of sodium hydroxide, preservative, essential oil and water to add.

Liquid soap
To make liquid soaps, substitute Potassium Hydroxide for the Sodium Hydroxide.
Removing odour and taste from CLASS B oil

The commercial process for removing odour and taste from coconut oil (generally termed de-odourisation), involves putting the coconut oil through high pressure (150 psi) steam in a vacuum. De-odourisation equipment is a standard feature in commercial oil mills producing RBD oil.

However, the investment and operating cost is too high even for a village-scale operation. The procedure given below will remove the odour and taste of Class B oil but not as completely as commercial steam de-odourisation. This procedure is for coconut oil produced from fresh mature coconut meat and is not applicable to coconut oil derived from copra.

1. Using a measuring jug, place the oil and water in a double boiler at a ratio of 2:1. Do not stir. Note that when the water is heated, the water vapour will rise to the surface of the oil carrying with it aromatic components which provide the odour and taste in the oil. Cover with a loose fitting lid or use a cover with built-in pressure vent.
2. Simmer for about three hours at a temperature not exceeding 85°C.
3. Scoop the top portion (oil) and transfer to a stainless steel pot while still hot. Be careful not to scoop out any water.
4. Keep the oil at a temperature of 50°C for 12 hours.
5. Transfer to a dry storage container leaving behind a one-inch layer at the bottom which can be mixed with the next batch for re-processing.

Coconut water vinegar

Ingredients

- 5 L coconut water
- 5 L three-day old coconut toddy (tuba)
- ½ teaspoon Fleischmann dry yeast
- ½ kg white sugar

Procedure

Alcoholic fermentation

Collect fresh coconut water and strain through cheese cloth. Dissolve the sugar in the coconut water. Pasteurise by heating at 65°C for 20 minutes or boil for 5 minutes. Allow to cool to 40°C.

Dissolve the yeast in 1 cup of this sterilised coconut water and pour into the mixture.

• IMPORTANT: Make sure that the yeast is still active — indicated by bubbles while being dissolved and continuing after the yeast has completely dissolved.
Pour the mixture into a sterilised narrow-mouth jar (preferably glass). Cover with clean brown paper or newsprint and seal with a rubber band.

- NOTE: Do not use cellophane. Keep the cover slightly loose not tight.

Allow the mixture to ferment for four to seven days or until there are no more bubbles of carbon dioxide being formed. Transfer into a wide-mouthed jar by using rubber tubing to siphon out the solution.

- NOTE: Be careful not to disturb the sediment.

**Acetic acid fermentation**

To the alcoholic solution prepared in procedure above, add 2.5 L of mother vinegar or 5 L three-day old coconut toddy. Loosely cover with clean brown paper or newsprint and sealed with rubber band. Set aside for at least 30 days or until maximum sourness is obtained. Filter the vinegar with cheese-cloth and then pasteurise at 65 to 80°C before bottling.

Make a clear vinegar by clarifying. Stir a well-beaten white egg into the vinegar and heat until the egg white coagulates. Filter to obtain clear vinegar.

- NOTE: Pasteurisation is necessary at the correct time to kill micro-organisms responsible for fermentation, otherwise fermentation will continue and vinegar will be converted into water and carbon dioxide.

Source: Product Development Department, PCA

---

Mother vinegar contains cultured strains of *Acetobacter aceti* or other suitable fermenting micro-organism. Coconut toddy is obtained by tapping the unopened flowers of coconut which ferments naturally (i.e. without adding fermenting micro-organisms). In the Philippines, coconut toddy is either processed into coconut liquor locally known as lambanog, or into a special type of coconut vinegar or into coconut sugar.
Index

A
antibiotic 67
antimicrobial fatty acids 88
antimicrobial properties 100
apron type dryer 52
aroma 12
aromatherapy 69, 87
recipe 103
Ayurvedic medicine 10

B
bacteria 89
Bawalan-Masa process 67
biodiesel production 69
bridge press 45

C
cancer 67
carrier oil 69
recipe 103
Chlamydia 89
cholesterol 67, 100
Class B oil
uses 69
Clean Air Act of the Philippines 69
cocnut, dessicated 82
cocnut flour 67
cocnut jam 66
cocnut meat 10
composition 82
critical control points 44
drying 67
finding moisture content 45
grinders 52
high pressure expellers 52
pared 82
sanitation 61
yellow colour 86
cocnut milk 10, 93
composition 83
recipes 100
residue 66
skim - composition 84
using residue 67
cocnut shells
during processing 60
cocnut skim milk
amino acid content 84
cocnut tree - consumable parts

10
cocnut water 10
analysis 83

composition 83

sugar/protein content 83
sanitation 61
coconut water electrolyte composition 84
Cocos nucifera L. 10
coco milk
composition 83
cocnut milk
continuous cleaning 60
continuous conveyor dryer 52
copra 69
knife mill 52
derived cooking oil 86
copra-derived oil
hair 69
copra dryer
modified 45
coronavirus 90
costs 74
cost and return analysis 72

D
Dayrit, Dr Conrado 11
de-odourisation 86, 108
de-shelling 50
sanitation 61
de-shelling machine 52
desiccated coconut 10
amino acid composition 82
composition 82
DME press 48
dryer
cocnut shell fired type 46
driers
apron type 52
cleaning 62
continuous 52
direct contact 46
forced draught tray 47
solar 48
type of 45
drying 51

E
economics 72
essential oils 103, 105
expeller
high pressure 49
expellers 48
high pressure 51

F
face masks 63
fatty acids 67, 87, 88, 90
fermentation
sanitation of room 61
fermentation room 57
Fife, Dr 11
filter paper 48
filtration 51
filtration equipment 48
Food and Nutrition Research Institute 66
food poisoning 60
foots 94
filtering 51
settling 51
forced-draught tray type dryer 46, 47
frame filter press 53
free fatty acid 12, 86
soap 107
Fresh-dry process 49

G
German Development Cooperation Agency 72
Good Manufacturing Practice 60
GRAS 89
graters
cleaning 61
grinders 52
hair conditioner 87
haustoria 50
health benefits 11
rehydration 10
Helicobacter pylori 88, 89
Hepatitis B and C 62
herbal soap 69
recipe 105
herpes simplex virus 88
High Pressure Expellers
drying 67
high pressure expellers 51
cooling system 52
High Pressure Expeller Method 49
cleaning 62
Critical Control Points 51
extraction/preparation 50
floor plan 57
High Pressure Expeller Process
data sheet 95
High Pressure Expeller process
data summary 97
HIV 89, 90
Hydraulic Jack Operated Oil Expeller 48
hydrolytic rancidity 87
I
income from residual oil 68

K

knife mill 52

L

lauric acid 86, 87, 88, 89, 90
soap 107
lipid-coated viruses 89
lipid coated viruses 88
liver 88
Low Pressure Expeller Method
floor plan 57
Low Pressure Extraction Method
data sheet 94
Low Pressure Oil Extraction
data summary 97
Low Pressure Oil Extraction Method

cleaning 62
Critical Control Points 44
filtering 48

M

macaroons 67
Makati Medical Center 11
marketing 72
massage oil 69, 87, 103
recipe 103
MCFA 87, 88
measles 88
medium chain fatty acid 67
medium chain fatty acids 87, 88
micro-organisms 60, 61, 87, 88, 89
micro-scale
definition 11
microbial contamination 60
Modified Kitchen Method
data sheet 92
data summary 91, 96
floor plan 57
residual oil 68
sanitation 61
moisturising lotion 87
monoglyceride 87, 89
monoglycerides 89
monolaurin 87, 88, 89, 90

N

nata de coco 66
Natural Fermentation Method
cleaning 60
data sheet 93
data summary 91, 96
fermentation room 61
fermented curd 68
floor plan 57
residual oil 68
sanitation 61
simplest method 87
Neisseria 89
nutraceutical 87

O

obesity 67
odour
removing from oil 108
oil for cooking 69
oil extraction 51
high pressure 51
oil extraction equipment 48
organic fertiliser 67

P

packaging 51, 73
soaps 105
peroxide value 12, 86
personal hygiene 62

clothing 62
PET bottles 51
Philippine National Standard 12
Plant requirement 56
presses

cleaning 61
processing
sanitation in 60
processing equipment
sanitation 61

Q

quality control
Philippine National Standard 12

R

RBD oil 86
recipes 100
record keeping 64
Repacker 72
residual oil
income from 69
processing 69
residue
composition 66
utilising coconut milk 67
Return on Investment 73
Rowell, Dr Vermen Verallo 11
S

S. Steel Expeller 45, 48
Sanitation Code of the Philippines 56
sanitisation 56
sapal 66
processing 60
recipes 101
SARS 90
shelf-life 87
simplextractor expeller 52
skin care products 104
smoke drying
high pressure expeller 49
soap 69
liquid 107
properties of 107
quality control 107
recipe for making 105
SoapCalc 107
solar dryers 47
Sri Lankan Coconut Oil Expeller 48
Staphylococcus 89
sterol content 87
storage 51
Streptococcus 89
sun-drying
high pressure expeller 49
sanitation 60

T

testa 82
removal for high pressure expeller 49
Thai coconut shredder 45
Thai Stainless Steel Expeller 45, 48
Trader 72
turbid oil 44

V

VCO

aroma 12
characteristics 12, 86
composition 86
current major uses 87
demand for 10
peroxidation 12
processing facility 56
recommended dosage 90
standards 12
Victor Potenciano Medical Center 11
village-scale
definition 11
vinegar
recipe for 108
Vitamin E 12, 86
effect of high temperature  87

W
wash room  57
water-clear  86
water supply  56
wet milling  50
wormshaft  49
  cooling system  49
  high pressure expellers  52