Profitability in VCO production can be enhanced by processing some of the VCO into downstream products such as hand-made bath soaps (ordinary and herbal), massage oils, moisturising body oil, body butter and other skin care products, and hair conditioner. This was demonstrated in the Philippines, where small scale producers of VCO survived the competition with big processing plants by going into VCO-based downstream products. The VCO industry in the Philippines started with farmer producers linked to traders/exporters and with small producers. However, when the world demand for the product became bigger, big manufacturers of coconut milk and desiccated coconut added VCO to their product lines. These plants, which have been in the coconut manufacturing business for decades, hold all quality certifications (ISO, HACCP etc.) with some also having organic certification. Hence, the majority of small scale producers, who were producing only VCO, had to cease operations because institutional buyers preferred the VCO produced by the larger, better accredited companies.

In Fiji, there are several companies, including Pure Fiji Ltd, Fiji Mana/Origins Pacific Ltd, Natural Oils of Fiji Ltd, Organic Earth Fiji, Mokosoi Products Fiji Ltd, that are processing soaps and skin care products using VCO or high quality coconut oil. The Pure Fiji brand of soaps, creams, lotions and other skin care products is well advertised, reasonably priced and sold in duty-free shops in Fiji and Australia and on international flights of Air Pacific. Likewise, small VCO producers in Samoa under the auspices of the Women in Business Development Inc. are supplying VCO to The Body Shop International of the United Kingdom for processing into its coconut bath and body range of products. One company in Tahiti is also producing VCO-based body oil for tourists. In most of these cases, it is not the VCO producers producing the downstream products; it is the companies that buy their VCO. The profitability of the VCO operation is, therefore, dependent on maintaining the goodwill of the companies that buy it.

7.1 Moisturising toilet/bath soap

Soap is a household necessity, assuring manufacturers of a ready market. There are now several home-scale producers of VCO in the Marshall Islands, Fiji, Kiribati and Papua New Guinea who use this method. One former trainee in Papua New Guinea is producing VCO and converting it into soap. It was reported that miners in Papua New Guinea prefer the VCO-based soap that he produces because it lathers and cleans well, even in hard water. Another trainee in the Marshall Islands has, since 2006, been producing VCO and converting some of it into a fragrant body oil by infusion with aromatic leaves. In Fiji, a trainee from Vanua Levu is producing VCO which she converts into herbal soaps for tourist shops. There is now an association of small-scale VCO producers using the modified natural fermentation method in Fiji.
Soap (Figure 73) is the solid material obtained when an alkali reacts with the fatty acids in animal, vegetable and seed oils and fats under a process known as saponification. The type of oil or fat used defines the characteristics of the resulting soap, i.e. whether it is mild or drying to the skin, whether it will form good lather, whether it will have good detergency or cleaning properties, etc. Soap using coconut oil as a base oil has two advantages.

- It lathers, even in very hard (brackish) water.
- It has superior cleaning and detergent properties because of the predominant lauric fatty acid content.

Based on Philippine's export data, the demand for coconut oil-based soap has been steadily growing. The United Coconut Association of the Philippines (UCAP) newsletter reported that, as of February 2010, the export of toilet/bath soaps ranked second among the Philippine export of non-traditional coconut products, with an average price of USD 2.08/kg (www.ucap.org.ph). UCAP further reported that the export volume for bath soaps increased by around 200% since February 2009. This is even higher than VCO export performance, which ranked third in the Philippines export of non-traditional products.

One of the reasons for the increasing popularity of coconut oil-based bath soap is its inherent natural glycerine content, which moisturises the skin. Such types of soap are produced under cold process saponification, whereas bath soaps produced in large manufacturing plants are normally made from soap noodles using the hot process. Soap noodle is a semi-processed substance composed of fatty acids with carbon chains ranging from C<sub>12</sub> to C<sub>18</sub>. It is produced by removing the glycerol component and the fatty acids with carbon chains C<sub>6</sub>–C<sub>10</sub> of coconut oil through a steam hydrolysis and distillation process. Hence, cheaper varieties of commercial bath soaps that do not have added emollients tend to be drying on the skin since the natural glycerine component of coconut oil has been removed.

Herbal soap is a cold-processed soap with added natural plant material/extracts that are known to have therapeutic or beneficial effects on the skin. This type of soap has gained popularity because it is reputed to address specific skin problems. For example, ti-tree, lemon ti-tree and lemon soaps are said to be useful in preventing pimples and acne. One of the most popular herbal soaps is pawpaw (papaya) soap because of the general belief that it can lighten the dark patches of skin. Herbal soaps are priced much higher than ordinary toilet/bath soaps, and comprise a large proportion of the Philippine export of soaps.

Pawpaw, morinda and other types of herbal soaps can be produced easily in most PICTs because of the abundance of suitable plant resources. For instance, in Fiji, pawpaw trees grow by the roadside and in backyards, and the fruits are just eaten by birds and fruit bats. Guava, in many places an invasive woody weed, and morinda (noni or kura) grow in abundance throughout the Pacific Islands.

For soap formulations, soap making procedures and other related information, please refer to Annex 12.1.

Caustic soda is an ingredient of soap. It requires careful handling. To reduce the risk involved in handling caustic soda and to ensure that the amount of caustic soda to be used for specific formulation does not exceed the requirement for saponification, a stock caustic soda solution with known concentration is prepared first (i.e. mixing 1 kg of caustic soda flakes/crystals with a specific amount of water). It is much easier and safer to weigh caustic soda solution than small amounts of caustic soda/crystals.

Where there is a group of women producing soap, one person can be assigned to handle the preparation and weighing of the caustic soda solution for distribution to members of the group, who can then do the mixing and addition of desired herbal extracts to produce the soap. In this way, the risks associated with preparation of caustic soda solution are negated.
7.2 Aromatherapy/massage oils

Aromatherapy is the general term used for the application of essential oils from aromatic plants, shrubs and trees for the treatment of both medical and psychological conditions, and for wellness and beauty, as in cosmetic preparations. Essential oils are extracted from different parts of different plants, e.g. lavender and ylang-ylang from flowers; eucalyptus, lemon ti-tree, tea tree and patchouli from leaves; cinnamon from leaf and bark, etc. Each essential oil has specific therapeutic values and applications to address a particular human condition. For example, certain essential oils are believed to ease aching muscles and relax a tired body, and others to decongest stuffy noses and promote easier breathing.

Massage is the main method used by aromatherapists for the application of essential oils for various purposes. The oils are combined with specific plant oils, generally called carrier oils, to form the massage oil. This is done so that the aromatic scent from the essential oil can be dispersed to a wider skin area and because the use of pure essential oil for direct application to the skin is potentially dangerous, as it can irritate or even burn the skin.

Massage is an effective means of ensuring that the essential oils which have been diluted with carrier oils are penetrating a person’s skin. A proportion of the volatile oil vaporises with the heat generated by the hands on a person’s skin when a massage is performed and extra benefit is gained from inhaling it.

A carrier oil has to be hypoallergenic (i.e. it does not irritate even the most sensitive skin) and it must be easily absorbed by the skin.

Virgin coconut oil (VCO) has been shown to be an excellent carrier oil, and carrier of choice among expert masseurs and therapists, because it is hypoallergenic and easily absorbed, as well as having anti-microbial properties. Results of several researches done at the Dermatology Department of the Makati Medical Center in the Philippines as reported by Verallo-Rowell (2005) have confirmed VCO’s anti-microbial properties. It should be noted that VCO obtained from the fresh-wet process (coconut milk route) is better suited to aromatherapy application because it is very light in texture.

Except for the atoll islands in the Pacific, where agricultural resources are limited, PICTs abound with aromatic roots, flowers and leaves (Figure 74) which can easily be used for making aromatherapy oils with VCO. Many of them can be found in backyards or growing wild. Pacific Islanders are aware of the therapeutic applications of such aromatic plants but not in conjunction with aromatherapy.

Figure 74. Aromatic roots and leaves in Fiji
There are two methods of preparing massage oils using VCO.

**a. Addition of an appropriate essential oil to VCO** This can be done if pure, natural essential oils are available or can be purchased. It is the simplest method of making aromatherapy oil.

A single essential oil or a combination of two or more oils can be used to create the specific aroma and therapeutic value that are needed. For example, lavender and ylangylang essential oils are known for their relaxing/anti-stress properties, tea tree and lemongrass oil have antimicrobial properties, while cineole-rich eucalyptus oils are considered excellent for decongesting stuffy noses.

The mixing of essential oils should always be done in dark coloured bottles to prevent the therapeutic value of the essential oil from being destroyed by sunlight, and it should be done on a drop by drop basis (e.g. one drop of tea tree oil plus two drops lemon grass). When the scent is right, the percentage or proportion of each oil is noted. This oil blend can then be mixed with virgin coconut oil.

Normally, 20 drops (almost 1 ml) of essential oil or a blend of essential oils is added per 30 ml of carrier oil. For very strongly scented essential oils like patchouli, just 2 ml patchouli oil are added to 98 ml VCO to make a 2% solution. (Annex 12.2 has some formulations for aromatherapy oils.)

Only 100% pure essential oils should be used. Essential oils mixed with alcohol or any other substance should not be used at all because it will destroy the quality of the aromatherapy oil.

**b. Oil infusion of aromatic herbs, roots and leaves**

Oil infusion can be done using either dried or fresh herbs, roots, bark and leaves. It should be noted that flowers are not generally recommended for oil infusion. Essential oils from flowers have to be extracted by steam distillation or some other means so as not to destroy the scent.

A simple method of oil infusion is to simmer a mixture of VCO and the aromatic plant material in a double boiler (Figure 75). An improvised double boiler can be made by putting a stainless steel mixing bowl over a pot of water (Figure 43). The water level inside the pot should be touching the bottom of the mixing bowl. The procedure is described below.

1) Pound the dried or fresh herbs/aromatic materials in a mortar and pestle and put them in the stainless steel mixing bowl.
2) Add VCO. For every 60 grams of dry herbs, add 480 ml of VCO. For fresh herbs or aromatic materials, the ratio is 120 grams fresh materials for every 480 ml of VCO. A more concentrated oil infusion can be done by doubling the amount of herbs/aromatic leaves. However, the resulting concentrated oil infusion may need to be diluted with VCO prior to it being used as a massage oil.

3) Put the mixing bowl over the pot of water. Cover it loosely and put the improvised double boiler on the stove. Heat the mixture gently for at least one hour for dry leaves and two hours for dry roots and bark. It should be noted that, when fresh materials are used, the VCO turns cloudy at the start due to the water content of the fresh material. This moisture has to be completely removed, under low-moderate heat, to prevent the aromatic oil from turning rancid. Heat the mixture until it becomes clear.

4) Cool the mixture. Strain it and store it in dark coloured bottles away from direct sunlight and heat. A small amount of Vitamin E oil (1 capsule per 240 ml of infusion) will help preserve the quality of preparation.

Please refer to Annex 12.2 for the formulation of massage oil for rheumatism and muscle pain using VCO infused with ginger root as the base oil.

7.3 Skin care products

The use of coconut oil as skin moisturiser has been known in PICTs and other coconut-producing countries for hundreds, if not thousands, of years. VCO does not cause skin irritation and can be applied to even the most sensitive skin. Hence, one of the major applications of VCO is as a base oil for hypoallergenic cosmetics and skin care products. This end-use comprises the bulk of the VCO currently being exported from the Philippines.

Adding attractive or therapeutic fragrances to VCO either through the use of essential oils or by oil infusion will enhance its marketability as a skin conditioner. In addition, a VCO-based product which can be used as a natural substitute for petroleum jelly can be easily made in the kitchen.

Note: The skin care formulations (Annex 12.3) presented in this manual are those in which the ingredients are locally available. They do not require the addition of water and emulsifiers. Emulsifiers are substances that stabilise the oil and water mixtures, i.e. they prevent oil and water from separating. Creams and lotions where water is added as part of the formulation to give the product the desired consistency require chemical preservatives. This is to prevent the base oil from getting rancid and to retard the growth of microorganisms which might have adverse effects on the skin.

7.4 Hair care products

Coconut oil conditions the hair and scalp. Pacific Islanders, especially women, have been massaging coconut oil in their scalp and hair for thousands of years. In many countries, not only women, but men and children also put coconut oil in their hair. VCO is, however, much better than crude, copra-derived coconut oil for hair conditioning. The addition of essential oils like ti-tree, rosemary and patchouli, which are believed to have a good effect on the hair and scalp, enhance the efficacy of VCO as a hair conditioner. When using rosemary, the procedure for oil infusion should be followed (Section 7.2). It should be noted, however, that the concentration of the essential/herbal oils in scented oils for hair care should be lower than that used for massage oils. Hence, after infusion using the procedure described in Section 7.2, the infused oil is diluted with VCO on a 1:1 ratio and then it is packaged and sold as hair conditioner. Rosemary, patchouli and ti-tree can be easily cultivated in PICTs’ tropical weather. Rosemary is well known as a herb for cooking and can be bought in supermarkets.
7.5 **Utilisation of residual coconut oil and off-quality VCO for downstream products**

In producing VCO from the modified kitchen and natural fermentation methods, some residual oil or second-grade coconut oil can be recovered after the premium grade VCO is harvested (Bawalan and Chapman 2006). It is recovered by further heating the *sinusinu* (in the case of the modified kitchen method) or by allowing the curd to ferment for another 24 hours (in the modified natural fermentation method). The residual oil obtained by further heating the *sinusinu* is already yellow in colour and has a strong coconut aroma, since a high temperature is required to fully release the entrained oil from the *sinusinu*. However, the grade B residual oil obtained through further settling of curd from the fermentation process is still white (or in some cases a very pale yellow). This amounts to about 10–15% of the harvested class A VCO.

In cases where there are lapses in strictly following the critical control procedures and in maintaining the sanitary conditions, the quality of VCO produced may not pass the VCO standard. In these circumstances, further processing of the oil into downstream products is necessary to recoup production costs and obtain additional income.

The residual, second grade VCO can be processed into toilet/bath soap (ordinary and herbal) without the need to reprocess it. Likewise, it can also be used for making oil infusions for massage oils, and skin and hair conditioners. However, it may need to be further processed to remove unpleasant or strong coconut odours if it is to be mixed with pure essential oils or if it is to be used as cooking oil.

Based on information obtained by the author from VCO traders in the Philippines, North American health food traders and Australasian chefs, there is a growing number of people who demand an odourless, chemical-free, clear VCO for culinary purposes rather than the traditional refined, bleached and deodorised (RBD) copra-derived coconut oil.

The standard commercial process for removing odour and taste in a copra-derived coconut oil is by putting it in contact with high pressure (150 psig) steam under vacuum conditions. This process is called deodorisation. Equipment for deodorisation is a common feature in commercial oil mills which produce RBD coconut oil or cooking oil. However, application of this process is not economically viable in a village-scale operation because of the high process capacity of equipment, and the high investment and operating costs. It should be emphasised that the quality and nutritional value of second grade VCO from the modified kitchen and natural fermentation methods is still very much higher than the copra-derived, crude coconut oil. Hence, it can be converted into cooking oil without undergoing the standard refining and bleaching process.

Bawalan (GTZ Report 2005) and Bawalan and Chapman (2006) provide the following home-scale procedure for removing the odour and taste in a grade B VCO produced using the modified kitchen and modified natural fermentation process. **Note: This procedure is not suitable for removing odour and taste from copra-derived crude coconut oil.**

1. Place water in the mixing bowl of an improvised double boiler as described in the oil infusion section above. Add second grade VCO to the water in a ratio of two parts oil to one part water. Do not stir.
2. Simmer for about three hours. When the water at the bottom of the mixing bowl is hot, water vapour rises through the oil, carrying with it the aromatic components which give odour and taste to a particular substance.
3. After three hours, scoop out the top portion (oil) and transfer it to a stainless steel pot while still hot. Be careful not to scoop out the water as well.
4. Cool the oil to room temperature. Place it in an icebox or freezer to solidify for at least two hours.
5. Remove it from the ice box or freezer and allow it to liquefy at room temperature.
6. Transfer the oil to a dry storage container, leaving behind a 2 cm layer at the bottom. This layer can be mixed with the next batch for re-processing or can be mixed with the residual oil earmarked for soap.
Coconut oil, like most plant-derived oils, is composed of triglycerides of fatty acids of varying lengths.

For a layman to understand the chemical composition of coconut oil, the meaning of the terms triglycerides and fatty acids have to be understood first.

A triglyceride is a substance consisting of fatty acids, chemically bound to glycerol in a ratio of 3:1. The three fatty acids are held together through a special attachment to the glycerol and thus form a single molecular structure (Enig 2000). This is shown in the general chemical formula below:

![Chemical structure of triglyceride](attachment:image.png)

Fatty acids are essentially chains of carbon atoms with attached hydrogen atoms. These chains come in varying lengths (1 to 24 carbon atoms) with carboxyl (acid) group (-COOH) at one end (Enig 2000). They are represented by the chemical formula $RCOOH$ where $R$ represents the hydrocarbon chain with the methyl group (-CH$_3$) at the beginning of the chain. Thus, lauric fatty acid (with 12 carbon atoms) which is predominantly present in coconut oil, has the chemical formula:

$$\text{CH}_3\text{(CH}_2\text{)}_{10}\text{COOH}$$

Fatty acids are either saturated or unsaturated, depending on the type of bonds that connect their carbon atoms. Fatty acids that have only single bonds in their carbon chain are called saturated. Oils and fats that are predominantly composed of saturated fatty acids are more stable and more resistant to oxidation and rancidity. This is because all carbon atoms are filled up with attached hydrogen atoms and there are no open points where oxygen can react. Coconut oil is predominantly composed of saturated fatty acids (about 92%) so it is considered a saturated oil in tropical countries and a saturated fat in temperate countries. (This was actually the basis of the smear campaign levied on coconut oil by the American Soybean Association in the 1980s.)

Saturated fatty acids are further classified into short chain, medium chain and long chain, depending on the length of the carbon chain and the number of carbon atoms on it. Short chain fatty acids have 4–6 carbon atoms, medium chain acids have 8–12 and long chain fatty acids have 14 or more. The medium chain saturated fatty acids are metabolised differently from long chain saturated fatty acids. Coconut oil is unique in the sense that, among fats and oils, it contains the highest percentage, about 64%, of medium chain fatty acids (MCFA).

Fatty acids that have double bonds linking their carbon atoms are categorised as unsaturated. The presence of a double bond in fatty acids represents a point of instability because this point in between two carbon atoms is open and susceptible to reaction with oxygen and other substances. The more double bonds, the higher the instability. Oils and fats that contain predominantly unsaturated fatty acids, such as soybean oil (about 84% unsaturated) and corn oil (about 86% unsaturated), are unstable and prone to oxidation. These types of oil have to be partially hydrogenated to prolong their shelf-life.
Hydrogenation is a process where hydrogen gas is bubbled through unsaturated oil in the presence of nickel as a catalyst. The resulting reaction forces unsaturated fatty acids to accept additional hydrogen atoms and become partially saturated. Full hydrogenation converts liquid oil into solid fat. Partial hydrogenation limits the time exposure of the unsaturated vegetable oil to the stream of hydrogen gas, thereby converting it either into a semi-solid state similar to butter or retaining its liquid state.

Unsaturated fatty acids are further classified into **mono-unsaturated** and **poly-unsaturated**, depending on the number of double bonds they have. Mono-unsaturated fatty acids contain one double bond in their carbon chain and poly-unsaturated fatty acids contain two or more double bonds. It should be noted that all naturally occurring unsaturated fatty acids have long carbon chains. Olive oil is categorised as a mono-unsaturated oil while soybean oil falls into the poly-unsaturated class. The comparative fatty acid profile of common fats and oils is shown in Figure 76 while the classification of fats and oils is diagrammatically shown in Figure 77.

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**Figure 76. Comparative fatty acid profile of common fats and oils**

*Source: UCAP Brochure on Coconut Oil*

**Figure 77. Classification of fats and oils**

*Source: UCAP Brochure*
The degree of saturation and length of the carbon chain of fatty acids help to determine their properties, corresponding uses and effect 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).

The difference in structure between saturated, mono-unsaturated and poly-unsaturated fatty acids is shown in the diagrams below.

**SATURATED FATTY ACID**

```
O
H    H    H    H    H    H    H    H    H    H    H    H    H    H    H    H    H    O
H——C——C——C——C——C——C——C——C——C——C——C——C——C——C——C——C——C——OH
H    H    H    H    H    H    H    H    H    H    H    H    H    H    H    H    H    H
```

Stearic Fatty Acid (18 Carbon chain)

**MONO-UNSATURATED FATTY ACID**

```
O
H    H    H    H    H               H               H    H    H    H    H    H    H    O
H——C——C——C——C——C——C——C——C——C——C——C——C——C——C——C——C——C——OH
H    H    H    H    H    H    H    H    H    H    H    H    H    H    H    H    H    H
```

Oleic Fatty Acid (18 Carbon chain, 1 double bond)

**POLY-UNSATURATED FATTY ACID**

```
O
H    H    H    H    H               H               H    H    H    H    H    H    H    O
H——C——C——C——C——C——C——C——C——C——C——C——C——C——C——C——C——C——OH
H    H    H    H    H    H    H    H    H    H    H    H    H    H    H    H    H    H
```

Linoleic Fatty Acid (18 Carbon chain, 2 double bonds)

In subjecting unsaturated vegetable oils like soybean and corn oil to a partial hydrogenation process to prolong their shelf-life, another type of fatty acid is created. This is the so called **trans fatty acid**. With partial hydrogenation, most of the double bonds of the unsaturated oil remain but their hydrogen atoms change position and become trans, or across, from each other (Verallo-Rowell 2005). Hence, **trans fatty acids** are artificially altered unsaturated fatty acids in which hydrogen atoms attached to the carbon atoms linked with the double bonds have shifted position from the same side (cis) to the opposite side (trans). It should be emphasised that the cis position (same side) is the natural position and trans is the abnormal position. The partial hydrogenation process straightens the fatty acid molecules to enable them to be ‘packed’ in solid form like saturated fats, while remaining unsaturated (www.ucap.org.ph). Oils that have been partially hydrogenated increase their plasticity and substantially lengthen their shelf-life, unlike the original, highly unsaturated oils they were made from.

The composition, type and most common sources of fatty acids are shown in Table 10.
### Table 10. The composition, type and most common sources of fatty acids

<table>
<thead>
<tr>
<th>Common Name(^1)</th>
<th>Composition(^1)</th>
<th>Type(^1)</th>
<th>Remarks/Most Common Food Sources(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butyric acid</td>
<td>C 4:0</td>
<td>Saturated short chain</td>
<td>Butter (approx. 4%)</td>
</tr>
<tr>
<td>Caproic acid</td>
<td>C 6:0</td>
<td>Saturated short chain</td>
<td>Butter (approx. 2%); coconut and palm kernel oil (&lt; 1%)</td>
</tr>
<tr>
<td>Caprylic acid</td>
<td>C 8:0</td>
<td>Saturated medium chain</td>
<td>Coconut (8%) and palm kernel (4%) oils; butter (1%)</td>
</tr>
<tr>
<td>Capric acid</td>
<td>C 10:0</td>
<td>Saturated medium chain</td>
<td>Coconut and palm kernel oils (4–6%); butter (2%)</td>
</tr>
<tr>
<td>Lauric acid</td>
<td>C 12:0</td>
<td>Saturated medium chain</td>
<td>Coconut and palm kernel oils (45–53%); butter (3%)</td>
</tr>
<tr>
<td>Myristic acid</td>
<td>C 14:0</td>
<td>Saturated long chain</td>
<td>Nutmeg butter (87%); Coconut and palm kernel oils (16–18%); butter (12%); animal tallow (3–5%)</td>
</tr>
<tr>
<td>Palmitic acid</td>
<td>C 16:0</td>
<td>Saturated long chain</td>
<td>Palm oil (45%); cocoa butter (25%); chicken fat (23%); butterfat (26%); animal tallow (approx. 25%); cottonseed oil (25%); other temperate seed oils (approx 10–12%)</td>
</tr>
<tr>
<td>Palmitoleic acid</td>
<td>C 16:1</td>
<td>Mono-unsaturated long chain, omega 9</td>
<td>Marine animal oils; chicken fat; ruminant tallow; lard; butterfat; olive oil</td>
</tr>
<tr>
<td>Stearic acid</td>
<td>C 18:0</td>
<td>Saturated long chain</td>
<td>Cocoa butter (35%); chicken fat (6%); butterfat and lard (12.5%); animal tallow (20–25%); seed oils (2–5%)</td>
</tr>
<tr>
<td>Oleic acid</td>
<td>C 18:1</td>
<td>Mono-unsaturated long chain, omega 9</td>
<td>All animal and vegetable fats and oils; olive (approx. 70%); hybrid safflower and sunflower (approx. 80%); canola (approx. 64%); animal tallow and butterfat (30– 35%); peanut oil (approx. 50%); palm oil (40%); other temperate seed oils (15–30%)</td>
</tr>
<tr>
<td>Linoleic acid</td>
<td>C 18:2</td>
<td>Poly-unsaturated long chain Omega 6</td>
<td>All animal and vegetable fats and oils (2–8%); safflower oil (80%); sunflower oil (68%); corn oil (57%); soybean and cottonseed oil (53%); peanut oil (46%); lard, olive and palm oil (40%); animal tallow and butterfat (2–4%);</td>
</tr>
<tr>
<td>Gamma linolenic acid (GLA)</td>
<td>C 18:3</td>
<td>Poly-unsaturated long chain Omega 6</td>
<td>Evening primrose oil (9%); black currant seed oil (15–19%); borage oil (approx 20%)</td>
</tr>
<tr>
<td>Alpha linolenic acid</td>
<td>C 18:3</td>
<td>Poly-unsaturated long chain Omega 3</td>
<td>Soybean and rapeseed oils (7–10%); flaxseed oil; linseed oil(^1)</td>
</tr>
<tr>
<td>Arachidic acid</td>
<td>C 20:0</td>
<td>Saturated long chain</td>
<td>Peanut oil</td>
</tr>
<tr>
<td>Eicosa Pentanoic acid (EPA)</td>
<td>C 20:5</td>
<td>Saturated long chain Omega 3</td>
<td>Unhydrogenated fish oil</td>
</tr>
<tr>
<td>Behenic acid</td>
<td>C 22:0</td>
<td>Saturated long chain</td>
<td>Peanut oil</td>
</tr>
<tr>
<td>Erucic acid</td>
<td>C 22:1</td>
<td>Mono-unsaturated long chain Omega 9</td>
<td>Rapeseed oil Authors note: The high erucic acid content of rapeseed oil makes it inedible since erucic acid is toxic to humans</td>
</tr>
<tr>
<td>Docosa Hexaenoic acid (DHA)</td>
<td>C 22:6</td>
<td>Saturated long chain Omega 3</td>
<td>Fish oil</td>
</tr>
</tbody>
</table>

\(^1\) Source: Dayrit (2005)  
\(^2\) Source: Enig (2000)
Annex 2
Process description and quality standard RBD coconut oil

Process Description

Copra in the Philippines is generally produced by small coconut farmers using a wide variety of sun-drying or smoke-drying methods, or a combination of both and to a certain extent, natural-draught indirect (hot air) drying. From the farm, the copra goes to a series of traders before it is delivered to the mills to produce crude coconut oil. In contrast, the common practice in most PICTs is to cut the fresh kernel (green copra) and sell it to traders, who do the drying and subsequent delivery of copra to the oil mills.

At the mill, the copra undergoes the following steps shown in Figure 78.

![Figure 78. Process flow chart for the production of RBD coconut oil](image)

**Cleaning** – copra is transferred from the warehouse to the mill by a series of floor conveyors, rotor-lifts and overhead conveyors. The copra is cleaned of metal fragments, dirt and other foreign matter, manually or by the use of shaking or revolving screens, magnetic separators and other similar devices.

**Milling** – to facilitate oil extraction, copra is broken into fine particles by high speed vertical hammer mills. It is reduced to a particle size of about 1/16" to 1/8".
**Re-drying/Conditioning** – the milled copra, which has about 5–6% moisture content, is passed through a steam-heated cooker where the moisture content is reduced to about 4%. At the same time, the cooker brings the temperature of the copra to the conditioning temperature of about 104°C (220°F). At the conditioner, the copra is maintained at about 104°C–110°C (220°F–230°F) for about 30 minutes. This will ensure uniform heat penetration into the copra before oil extraction. Moderately high temperature facilitates the expelling action. Oil is able to flow out more easily due to the decrease in viscosity. Also, obstruction due to gums, proteins etc. in the copra becomes less because the heating dries and shrinks these substances. The moisture content of copra when it leaves the conditioner is about 3%.

**Oil extraction** – the milled copra is subjected to high pressure oil extraction using an expeller, first by a vertical screw, and finally by a horizontal main screw. The oil extraction efficiency and the thickness of the cake are controlled by a choking mechanism at the end of the discharge end of the main screw. The normal setting of the choke is for 3/8” to 1/2” cakes. With this setting, the oil content in the cake is kept at about 7%. To control the temperature during extraction, the main shaft is provided with water cooling and cooled oil is sprayed over the screw cage bars. The temperature of the oil should be kept at about 93°C–102°C (200°F–215°F) to produce light colored oil and effect good extraction.

**Screening** – the oil extracted in the expeller flows into the screening tanks to remove the entrained particles in the oil, generally referred to as ‘foots’. The foots settle at the bottom and are continuously scooped out by a series of chain-mounted scrapers, which lift them to the screen on top of the tank. While the foots are travelling across the screen, oil is drained out of them. The foots leaving the screen are conveyed back and mixed with the copra entering the expeller. Screening reduces the solid content of the oil to about 10%.

**Filtration** – the oil is passed through a plate and frame filter press to further remove the solids in the oil. Two filter presses are provided — one on duty while the other is being cleaned and dressed. Maximum filtering pressures reach about 60 psi. The filtered oil flows into a surge tank from where it is finally pumped to the coconut oil storage tank.

Crude coconut oil from the dry (copra) process is dark; turbid; high in free fatty acids (FFAs), phosphatides and gums; has an unpleasant odour; and may be contaminated by bacteria and moulds. To render this oil edible, it has to undergo further processing as shown below.

**Refining** – consists of neutralisation, bleaching and deodorising. Neutralisation reduces the FFAs to improve the taste and appearance of the oil. It is done by reacting sodium hydroxide with free fatty acids to form an oil-insoluble precipitate called soapstock. This is removed once it settles out. Phosphatides and gums are removed by spraying hot water on the oil. The oil is then dried under vacuum. Typically, 5% of the weight of the crude oil is lost in refining but the loss can be as high as 7.5% (Hagenmaier 1980)

**Bleaching** – takes out most of the dissolved or colloidal pigments responsible for the colour of crude oil. Either activated carbon or bleaching earths such as bentonite or a combination of both are added to the neutralised oil under vacuum while heating it to 95°C–100°C. The bleaching agents are removed afterwards by passing the oil through a filter press.

**Deodorisation** – removes volatile odours and flavours as well as peroxides that affect the stability of the oil. It is done by heating the oil to a temperature of 150°C while in contact with live steam under vacuum conditions (29 psi pressure).
It should be noted that most oil mills in PICTs do not undertake refining, bleaching and deodourisation processes. Instead, the copra-derived oil undergoes only physical refining, using phosphoric or citric acid to reduce the gums. The appearance of coconut oil sold in the supermarkets in Fiji is shown in Figure 79.

The power and utilities needed for the production of RBD coconut oil are roughly estimated as follows:

a. power consumption – 120 kWh per ton of copra
b. steam consumption – 100 to 120 kg per ton of copra at 100 psi
c. water consumption – 3 to 5 cubic metres per ton of copra

**Quality standard for RBD coconut oil**

The Philippine Standard for RBD coconut oil is shown in Table 11.

**Table 11. The Philippine Standard for RBD coconut oil**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture Content, %</td>
<td>0.1% max</td>
</tr>
<tr>
<td>Free Fatty Acid (as % oleic)</td>
<td>0.1% max</td>
</tr>
<tr>
<td>Colour*</td>
<td>10 Y (yellow), 1 R (red)</td>
</tr>
<tr>
<td>Saponification Value</td>
<td>250–264</td>
</tr>
<tr>
<td>Iodine Value **</td>
<td>7.5–10.5</td>
</tr>
<tr>
<td>Odour</td>
<td>Odourless</td>
</tr>
</tbody>
</table>

* Colour is measured in the laboratory with an analytical tool called the Lovibond Tintometer. It works on the principle of measuring the wavelength of light that passes through a sample of oil.

** The iodine value is a measure of the degree of saturation or unsaturation of the oil, the lower the iodine value, the more saturated the oil or fat is.
1. What is virgin coconut oil (VCO)?

The Philippine National Standard for VCO (PNS/BAFPS 22:2007/ ICS 67.200.10) officially defines VCO as an:

oil obtained from the fresh, mature kernel of the coconut by mechanical or natural means, with or without the use of heat, without undergoing chemical refining, bleaching or deodorizing, and which does not lead to the alteration of the nature of the oil. Virgin coconut oil is an oil which is suitable for consumption without the need for further processing.

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

2. What is RBD coconut oil?

RBD coconut oil refers to refined, bleached and deodorised oil that is generally used as edible/cooking oil in the Philippines. It is derived from copra and has to undergo chemical refining, bleaching and deodorisation processes after extraction to make it suitable for human consumption. 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 the various chemical processes. It is odourless and tasteless.

3. What are the ideal quality characteristics of VCO?

**Colour** – water-clear; reading of 1 yellow, 0.1 red using Lovibond Tintometer  
**Free fatty acid** (as lauric) – 0.1% max  
**Moisture** – 0.1 % max  
**Peroxide value** – 1 meq/kg and below  
**Lauric fatty acid content** – 45–56%  
**Scent** – fresh coconut scent, mild to intense

4. What is the Philippine National Standard for VCO?

**Colour** – water-clear  
**Free fatty acid** (as lauric) – 0.2% (maximum)  
**Moisture** – < 0.1 %  
**Matter volatile at 120 0C (w/w)** – 0.12% to 0.2 %  
**Peroxide value** – 3 (maximum)  
**Food additive** – none permitted  
**Contaminants:**  
- Iron – 5 mg/kg  
- Copper – 0.4 mg/kg  
- Lead – 0.1 mg/kg  
- Arsenic – 0.1 mg/kg

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1This is a reprinted and updated version of Bawalan D.D. 2004. Frequently asked questions on virgin coconut oil. Cocoinfo International11(2) Jakarta, Indonesia: Asian and Pacific Coconut Community.
5. What causes the yellow colour in coconut oil?
   • Bacterial contamination of the coconut kernel before oil extraction
   • High process temperature

Therefore, for the coconut oil to be categorised as virgin, its colour should be water-clear.

6. What is the simplest method of producing VCO?
   • The modified natural fermentation process

7. How many coconuts are required to produce one litre of VCO?
   • 10–15 mature, husked (12–13 months old) coconuts, depending on the size and the process used

8. What is the effect of high temperature processing on VCO?
   • The Vitamin E and sterol content are removed.
   • 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 which 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?

No, VCO does not need to be kept in the refrigerator. Coconut oil is the most stable among the plant-derived oils being traded in the world. If properly processed, its natural antioxidants give it a longer shelf-life compared to other oils. Samples of VCO which the author produced in 1998 and stored in transparent glass bottles at the processing laboratory in PCA Davao Research Center still smell fresh after five years.

10. What are the current major uses of VCO?
   • A hair conditioner
   • A body oil or a substitute for moisturising lotion
   • Carrier oil for aromatherapy and massage oils
   • A nutriceutical and functional food

11. Why is VCO considered a nutriceutical substance or a functional food?

A nutriceutical substance and a functional food are almost the same thing. Generally speaking, they both mean foods or food components that provide other health benefits aside from the nutritional function that they perform when ingested. In layman’s terms, nutraceuticals are substances which not only nourish but also heal. VCO is considered a nutriceutical substance and functional food because, apart from providing instant energy to the human body, it is said to prevent infections, boost immunity, reverse disease states and assist in the cure of many types of illnesses. Coconut oil is far superior to other functional foods because of its believed beneficial effect. Several studies indicate that the medium chain (C₈–C₁₃) fatty acids in coconut oil are similar to the fats in mother’s milk that gives babies immunity from disease.
12. What are the distinguishing characteristics of coconut oil compared to other oils traded in the world market?

- a high percentage of lauric (C_{12}) fatty acid, ranging from 45–56% depending on the coconut variety
- a high percentage of medium chain fatty acids (C_{8–12}), generally about 64%

13. What is the importance of medium chain fatty acids (MCFAs) and lauric fatty acid?

- Since 1984, increasing amount of literature has been published discussing the antiviral, antimicrobial, antifungal and antiprotozoal properties of medium chain fatty acids (C_{8}, C_{10}, C_{12}). Lauric acid (C_{12}) and its monoglyceride form, monolaurin, are mentioned as the most potent against lipid-coated microorganisms such as HIV, the measles virus, the herpes simplex virus, Helicobacter pylori and others that are not normally cured by ordinary antibiotics.
- Studies also indicate that MCFAs are directly converted into energy in the liver and increase the metabolic rate of an individual. This in turn 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, 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 viruses;
- it does not cause resistance organisms to appear and has also shown that it can reduce the resistance of germs to antibiotics;
- when coconut oil is consumed, the body makes the disease-fighting monolaurin.

According to Dr Mary Enig, 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 over nearly four decades and this knowledge has resulted in more than 20 research papers and several US patents.

15. What are lipid-coated viruses and bacteria?

Lipid is the medical term for fat. Lipid-coated micro-organisms such as viruses and bacteria have an envelope of fat covering their basic life structure called nucleotides (DNA and RNA). This is the reason for ordinary antibiotics not being able to penetrate easily and kill this type of pathogenic microorganism. However, several researchers have reported that MCFAs, particularly lauric acid that is predominately present in coconut oil, can penetrate and dissolve the lipid coating.
16. What are the lipid-coated microorganisms that have been reported to be inactivated by lauric fatty acid and its monoglyceride, monolaurin?

Table 12. Lipid-coated microorganisms reported to be inactivated by lauric fatty acid and monolaurin

<table>
<thead>
<tr>
<th>Lipid-coated viruses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human immunodeficiency virus (HIV)</td>
</tr>
<tr>
<td>Measles virus</td>
</tr>
<tr>
<td>Herpes simplex virus</td>
</tr>
<tr>
<td>Herpes viridae</td>
</tr>
<tr>
<td>Sarcoma virus</td>
</tr>
<tr>
<td>Syntial virus</td>
</tr>
<tr>
<td>Human lymphotropic virus (Type II)</td>
</tr>
<tr>
<td>Vesicular stomatitis virus</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lipid-coated bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listeria monocytogenes</td>
</tr>
<tr>
<td>Helicobacter pylori</td>
</tr>
<tr>
<td>Hemophilus influenza</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
</tr>
</tbody>
</table>

Source: Fife (2001)

17. What are the bacteria that have been reported to be inactivated by MCFAs and their monoglycerides, such as monocaprin and monolaurin?

Table 13. Bacteria reported to be inactivated by MCFAs and their monoglycerides

<table>
<thead>
<tr>
<th>Bacterium</th>
<th>Diseases caused</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streptococcus</td>
<td>throat infections, pneumonia, sinusitis, ear ache, rheumatic fever, dental cavities</td>
</tr>
<tr>
<td>Staphylococcus</td>
<td>staph infection, food poisoning, urinary tract infections, toxic shock syndrome</td>
</tr>
<tr>
<td>Neisseria</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>Helicobacter pylori</td>
<td>stomach ulcers</td>
</tr>
<tr>
<td>Gram positive organisms</td>
<td>anthrax, gastroenteritis, botulism, tetanus</td>
</tr>
</tbody>
</table>

Source: Fife (2001)
18. What is the link between coconut oil and severe acute respiratory syndrome (SARS)?

According to the late Dr Conrado Dayrit, former Professor Emeritus in the Department of Pharmacology at the University of the Philippines, the coronavirus, which has been identified as the virus causing SARS, is also lipid-coated, which means that lauric fatty acid and monolaurin could possibly have an inactivating effect on it.

The pathogenic organisms causing influenza and pneumonia are both on the list of lipid-coated viruses and bacteria that are found to be inactivated by lauric fatty acid and monolaurin. As mentioned by Kabara (2000), monolaurin is derived by the human body from coconut oil. It should be noted that the symptoms exhibited by SARS infected patients are similar to the symptoms of pneumonia and influenza.

Therefore, by inductive reasoning, it can be postulated that lauric fatty acid and monolaurin (which are derived by the body from coconut oil) could be potential cures for SARS.

19. What are trans fatty acids?

Trans fatty acids are artificially altered unsaturated fatty acids in which hydrogen atoms attached to the carbon atoms linked with the double bonds have shifted position from the same side (cis) to the opposite side (trans). This happens when unsaturated oils like soybean and corn oil are subjected to the partial hydrogenation process. This process straightens the fatty acids molecules to enable them to be ‘packed’ in solid form like saturated fats, while remaining unsaturated (www.ucap.org.ph). Oils that have been partially hydrogenated increase their plasticity and substantially lengthen their shelf life, unlike the original, highly unsaturated oils they were made from.

20. Why are trans fats bad for the health?

The body cannot metabolise trans fats for lack of proper enzymes, thus making these artificial fats unhealthy. The primary health risk identified with trans fat consumption is an elevated risk of coronary heart disease (CHD). A comprehensive review of studies of trans fats published in 2006 in the New England Journal of Medicine indicates a strong and reliable connection between trans fats consumption and CHD (www.ucap.org.ph). In addition, studies on both humans and animals have shown that trans fats lower the HDL (‘good’) cholesterol; raise the LDL (‘bad’) cholesterol; increase the risk of heart attack and diabetes; and may cause certain cancers.

21. Do RBD coconut oil and VCO contain trans fatty acids?

No, RBD coconut oil and VCO do not contain any trans fatty acids. As a very stable oil, coconut oil is never subjected to the partial hydrogenation process.

22. Is the lauric fatty acid in VCO reduced if it is processed using high temperatures?

No, the lauric fatty acid content of any coconut oil is highly dependent on the variety of coconut and not on the process used.

23. Is VCO that solidifies in an air-conditioned room or in a refrigerator still usable as a nutraceutical substance or functional food?

Yes, it is natural for coconut oil, virgin or RBD, to solidify when placed in the refrigerator or a cool air-conditioned room because coconut oil is solid at temperatures of 22°C and below and liquid at temperatures of 27°C and above. Coconut oil that does not solidify when placed inside the refrigerator is not pure coconut oil but is mixed with some other oils.

24. What is the maximum recommended dosage to obtain health benefits from VCO?

- 50 ml or 3.5 tbsp. of virgin coconut oil or
- the kernel of half a mature coconut or
- 66 grams of desiccated coconut (can be mixed with breakfast cereal).
25. What is the best time to take VCO?

It depends on what benefit you want to achieve.

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

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

c. If you want to boost your immune system, take it any time of the day, in single or divided doses.

26. IMPORTANT REMINDERS!!!

- The information provided in this annex is not in any way meant to encourage readers to substitute VCO for the drugs or antibiotics prescribed by their doctor for treating illnesses. Please note that VIRGIN COCONUT OIL IS NOT A DRUG but a functional food and should be used only as such.

- Further, always remember that anything in excess is bad, so do not take more than 3½ tablespoons of VCO a day.

The Philippine National Standard for VCO presented here is the revised version of PNS/BAFPS 22:2004/ICS 67.200.10 which was issued in 2004. This revised version took into consideration the results of several studies done to characterise VCO and validate some of the provisions stipulated in the 2004 standard.

1 Scope

This standard applies to virgin coconut oil in a state of human consumption.

2 References

The titles of the standards publications referred to in this standard are listed on the inside back cover.

3 Definitions

For the purpose of this standard, the following definitions apply:

3.1 General

3.1.1

free fatty acids (FFA)
a specified fatty acid liberated by hydrolysis from naturally occurring fats

3.1.2

glyceride
an ester formed by the combination of glycerol and fatty acid. Glycerides occur naturally in oils and fats

3.1.3

virgin coconut oil (VCO)
oil obtained from the fresh, mature kernel of the coconut by mechanical or natural means, with or without the use of heat, without undergoing chemical refining, bleaching or deodorizing, and which does not lead to the alteration of the nature of the oil. Virgin coconut oil is an oil which is suitable for consumption without the need for further processing

Virgin coconut oil (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 saturated fatty acids.

4 Essential composition and quality of factors

4.1 Identity characteristics
4.1.1 Gas liquid chromatography (GLC) ranges of fatty acids composition shall be in accordance with Table 1.

Table 1 – Gas liquid chromatography range of fatty acid composition

<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>0.1 – 07</td>
</tr>
<tr>
<td>Caprylic acid</td>
<td>C 8:0</td>
<td>4.0 – 10.0</td>
</tr>
<tr>
<td>Capric acid</td>
<td>C 10:0</td>
<td>4.0 – 8.0</td>
</tr>
<tr>
<td>Lauric acid</td>
<td>C 12:0</td>
<td>45.1 – 56.0</td>
</tr>
<tr>
<td>Myristic acid</td>
<td>C 14:0</td>
<td>16 – 21</td>
</tr>
<tr>
<td>Palmitic acid</td>
<td>C 16:0</td>
<td>7.5 – 10.2</td>
</tr>
<tr>
<td>Stearic acid</td>
<td>C 18:0</td>
<td>2.0 – 5.0</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>
</tbody>
</table>

4.2 Quality characteristics

4.2.1 Colour, odour and taste

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

4.2.2 Virgin coconut oil shall conform to the requirements specified in Table 2.

Table 2 – Virgin coconut oil property requirements

<table>
<thead>
<tr>
<th>Properties</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Moisture content</td>
<td>≤ 0.1</td>
</tr>
<tr>
<td>% Matter volatile at 120°C (w/w)</td>
<td>0.12 – 0.20</td>
</tr>
<tr>
<td>% Free fatty acids (expressed as lauric acid)</td>
<td>0.20</td>
</tr>
<tr>
<td>Peroxide value, meq/kg oil, max.</td>
<td>3.0</td>
</tr>
<tr>
<td>Food additives</td>
<td>None permitted</td>
</tr>
</tbody>
</table>

5. Contaminants

Table 3 – Allowable limits of contaminants in Virgin Coconut Oil (VCO)

<table>
<thead>
<tr>
<th>(Heavy metal, mg/kg, max.</th>
<th></th>
</tr>
</thead>
<tbody>
<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>
6. Hygiene

It is recommended that the product covered by the provisions of this standard shall be in accordance with the appropriate Sections of the General Principle of Food Hygiene recommended by the Codex Alimentarius Commission (CAC/RCP 1-1969, Rev.3-1997).

The total aerobic microbial count does not exceed 100 cfu per ml, the total combined molds and yeast count does not exceed 10 cfu per ml and it meets the requirements for the tests for the absence of Salmonella species and Escherichia coli.

7. Packaging

Virgin coconut oil (VCO) should be packed in any suitable food grade container that can withstand transportation, handling and storage conditions.

8. Labelling

The label of each package shall have the following information:

1. Name of product: “Virgin coconut oil”
2. Brand name or trade name
3. Net content
4. Lot identification
5. Name and address of the manufacturer and/or packer, or distributor
6. The phrase “Product of the Philippines”
7. Type of Process (See Annex)
8. Date manufactured and “Best Before”
9. BFAD registration number and bar code (Optional)

9. Methods of analysis and sampling

9.1 Determination of fatty acid composition
   According to IUPAC 2.301, 2.302 and 2.304 or ISO 5508:1999 or ISO 5509:1999.

9.2 Determination of Moisture Content
   According to AOAC 984.20 (Karl Fisher Method)

ANNEX

Type of Production Processes recognized by the Philippine Coconut Authority (PCA) on the production of Virgin Coconut Oil (VCO) as per PCA Administrative Order 01 Series of 2005

Implementing Rules and Regulations to Enforce Standards on the Production and Marketing of Virgin Coconut Oil

Section V: Production Processes

Producers/processors shall state in their product label sufficient information to identify the process used in the production of virgin coconut oil such as traditional process (latik), fermentation with heat, fermentation without heat, centrifuge process, expelling process (with or without cooling system), or equivalent process which insures that the product conforms with the definition and chemical and physical characteristics in the Philippine Virgin Coconut Oil Standards herein adopted.

B. APCC STANDARDS FOR VIRGIN COCONUT OIL

1. Scope

   This standard applies to virgin coconut oil.
2. Description

Coconut oil is derived from the kernel/kernel/copra of the coconut (Cocos nucifera L.). Virgin coconut oil is obtained from the fresh, mature kernel by mechanical or natural means with or without the application of heat. Virgin coconut oil is suitable for human consumption in its natural state.

3. Essential composition and quality factors

<table>
<thead>
<tr>
<th>Identity Characteristics</th>
<th>Interim APCC Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative density</td>
<td>0.915 – 0.920</td>
</tr>
<tr>
<td>Refractive index at 40 degree-C</td>
<td>1.4480 – 1.4492</td>
</tr>
<tr>
<td>Moisture % wt. max.</td>
<td>0.1 – 0.5</td>
</tr>
<tr>
<td>Insoluble impurities per cent by mass. max.</td>
<td>0.05</td>
</tr>
<tr>
<td>Saponification Value</td>
<td>250 – 260 min.</td>
</tr>
<tr>
<td>Iodine value</td>
<td>4.1 – 11.00</td>
</tr>
<tr>
<td>Unsaponifiable matter % by mass. max.</td>
<td>0.2 – 0.5</td>
</tr>
<tr>
<td>Specific gravity at 30 degree./30 degree-C</td>
<td>0.915 – 0.920</td>
</tr>
<tr>
<td>Acid Value max.</td>
<td>0.5</td>
</tr>
<tr>
<td>Polenske Value min.</td>
<td>13</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GLC Ranges of Fatty Acid Composition (%)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C 6:0</td>
<td>0.4 – 0.6</td>
</tr>
<tr>
<td>C 8:0</td>
<td>5.0 – 10.0</td>
</tr>
<tr>
<td>C 10:0</td>
<td>4.5 – 8.0</td>
</tr>
<tr>
<td>C 12:0</td>
<td>43.0 – 53.0</td>
</tr>
<tr>
<td>C 14:0</td>
<td>16.0 – 21.0</td>
</tr>
<tr>
<td>C 16:0</td>
<td>7.5 – 10.0</td>
</tr>
<tr>
<td>C 18:1</td>
<td>2.0 – 4.0</td>
</tr>
<tr>
<td>C 18:2</td>
<td>5.0 – 10.0</td>
</tr>
<tr>
<td>C 18:3 – C 24:1</td>
<td>1.0 – 2.5</td>
</tr>
<tr>
<td>&lt; 0.5</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quality Characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>Water clean</td>
</tr>
<tr>
<td>Free Fatty Acid</td>
<td>? 0.5%</td>
</tr>
<tr>
<td>Peroxide Value</td>
<td>?3 meq./kg oil</td>
</tr>
<tr>
<td>Total Plate Count</td>
<td>&lt; 10 cfu</td>
</tr>
<tr>
<td>Odour and Taste</td>
<td>Free from foreign and rancid odour and taste</td>
</tr>
<tr>
<td>Contaminants</td>
<td></td>
</tr>
<tr>
<td>Matter volatile at 105 degree C</td>
<td>0.2%</td>
</tr>
<tr>
<td>Iron: (Fe)</td>
<td>5 mg/kg.</td>
</tr>
<tr>
<td>Copper</td>
<td>0.4 mg/kg.</td>
</tr>
<tr>
<td>Lead</td>
<td>0.1 mg/kg.</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0.1 mg/kg.</td>
</tr>
</tbody>
</table>
4. **Food Additives**
   None permitted

5. **Hygiene**
   It is recommended that the product be prepared in accordance with the GMP and HACCP standards.

6. **Labelling**
   The name of the food on the label be “Virgin Coconut Oil”. The provisions of the General Standard for the labelling of Packaged Food (CODEX STAN 1 – 1985) (Rev. 1 – 1991) shall apply.

7. **Methods of analysis and sampling**
   Based on Codex Alimentarius (Volume 13).
Annex 5
Recommended procedure to indicate the moisture content of grated kernel in a DME dryer

Background information

The DME dryer is the most common dryer used by VCO processors in PICTs. It is a flat bed direct contact type dryer where the batch of fresh grated coconut kernel is spread thinly on the surface of the dryer. The load is regularly turned to prevent it from getting scorched. As a requirement of the DME process, the grated kernel has to have a moisture content within the range of 10–12%. A study done on the low pressure oil extraction process which works on the same principle as the DME revealed that optimum oil recovery can be obtained if the moisture content of the dried grated kernel is at 11% before extraction. Under the existing standard process for DME, the moisture content of the dried grated kernel before it is unloaded from the dryer is determined by feel by dryer operators. This subjective method of determining moisture content is the major reason why batches of VCO produced by the DME process have variable quality.

There is a science-based procedure that can be followed to ensure that the 10–12% range of moisture content will be reached. However, before implementing a more scientific approach, there is a need to first determine the average moisture content of the coconuts supplied to the VCO plant. This system is relatively simple to implement in PICTs because there is little variation in the moisture content of the coconuts. It is certain that coconuts supplied to VCO plants in PICTs are fully mature since they have fallen from the tree instead of being plucked.

Recommended procedure

The procedure is described as follows:

1. Using the previously determined average initial moisture content of the kernel as a basis, do a material balance computation to determine the final weight of the kernel when its moisture content is reduced to 11% for a specific weight of freshly grated kernel to be loaded in the dryer per batch.
   - For instance, using a standard 3.5 kg freshly grated kernel per batch and assuming an initial moisture content of 50%, the final weight of the dried kernel at a moisture content of 11% should be 1.97 kg or approximately 2 kg.
   - For an initial weight of 12 kg at the same initial moisture content, the final weight of the dried kernel at 11% moisture content should be 6.74 kg or roughly 6.75 kg (Note: In the modified DME process, the weight of fresh grated kernel loaded in the dryer is 12 kg per batch.)

2. Station a weighing scale near the dryer that can take the weight of the kernel per batch plus the weight of the basin. Designate at least three basins with the same weight as the weighing container. Tare the weighing scale with the weight of the basin by resetting the reading on the weighing scale to zero while the empty basin is still placed in the weighing scale.

3. Every time a batch of freshly grated kernel is loaded, weigh it. Make the weight of loaded fresh kernel the same for every batch (i.e. 12 kg for the modified DME process).

4.Unload the dried grated kernel in the designated weighing container. Weigh again.
   - If the weight of the dried kernel is still higher than the computed final weight (e.g. 6.75 kg if the initial moisture content of fresh kernel is 50%), return the batch to the dryer and dry further.
   - If the weight of the dried kernel is already lower than the computed weight, sprinkle a little water (while the basin of dried kernel is positioned on the weighing scale) until the computed weight is reached. Mix thoroughly after sprinkling with water.
A6.1 Husking equipment

- Manual husking tool – These are different variations of metal spike with a sharp tip standing vertically in the ground (Figure 80).

- Motorised coconut husking machine – Husking is done by bringing down a cutter to a positioned whole coconut that moves through a hydraulic mechanism (Figure 81). The machine has a husking capacity of 1800 nuts per eight-hour day using a 1.5 hp single-phase electric motor. It is currently used by Talleu Milk Products Ltd., Viti Levu, Fiji for their coconut product line. Fabricated by Method Machine Works Sdn Bhd (729390-M) 51-1, Jalan Puteri 5/16, Bandar Puteri, 47100 Puchong, Selangor, Malaysia. Tel: 603-8060-1925; Fax: 603-8060-1935; URL: www.coconutmachine.com
Shelling equipment

- Motorised shelling machine – a standard feature in coconut milk and desiccated coconut processing plants in Asia. It is composed of vertical tool with sharp tip mounted in front of a rotating gear where the shell of whole husked coconut is held and moved on top of the sharp tool. Untrained and inexperienced operators should not handle this machine as it might result in cut fingers.

The Philippine shelling machine (Figure 82) has a processing capacity of 200–250 nuts per hour based on the skill of the operator. It is run by a 1/2 hp gear motor, 3-phase, 220 volts, 40 rpm output. Designed and fabricated by Princena’s Machine Shop, 3rd St. Villa Antonio Subdivision, San Pablo City, Philippines. Tel. +6349-5624618; E-mail: pms.since1979@yahoo.com

The Malaysian shelling machine is currently used at Tailevu Milk Products Ltd, Viti Levu, Fiji (Figure 82). Shelling capacity is 180 nuts per hour depending on the skill of the operator. It is also run by a 1/2 hp gear motor, 3-phase, 220 volts, 40 rpm output.

The Philippine shelling machine differs from the Malaysian equipment in terms of the sharpened tip of the vertical tool as shown in the figures below. Likewise, it occupies a smaller space.

Figure 82. Motorised shelling machines from Philippines (left) and Malaysia (right)
A6.2 Comminution equipment: grating, shredding, cutting, scraping, grinding

Grating equipment

- Manual graters

Manual graters (Figure 83) are a standard feature in most Pacific households. They remove the fresh kernel from the coconut shell and reduce its particle size to fine pieces at the same time.

- Motorised graters

  The DME grater, the Fijian grater, the Thailand grater and the Philippine grater (Figure 84) all work on the same principle, differing only in the type of head. The Philippine grater has a stainless steel blade and housing, a ½ hp electric motor and direct drive. The Thai grater is considered the safest, but also the least durable. The Fijian grater is manufactured by On Time Engineering, G.P.O. Box 12437, Suva, Fiji. Tel. (679) 3385337/3384776; Fax: (679) 3385337.
The processing capacity of motorised coconut graters depends on the skill of the operator. Based on the Philippines experience, the grating capacity can go as high as 80 nuts per hour. However, the grating capacity is reduced as the hands of the operator get tired holding the half nut towards the rotating grater head.

- **Coconut Shredding/Cutting/Scraping/Grinding Machines**

  The Malaysian coconut grinding machine and the Thai coconut scraping machine (Figure 85) can be called coconut shredding equipment since both work on the same principle of shredding the coconut kernel into thin pieces. Both have a stainless steel drum with spikes and a stainless steel rod which rotate in opposite directions (Figure 86). The coconut kernel is first removed from the shell using either a manual shelling tool or a motorised shelling machine. The kernel is then dropped in between the rotating drum and the rod.

  ○ The Malaysian coconut grinding machine is currently being used at Tailevu Milk Products Ltd, Viti Levu, Fiji. It runs on a 3 hp electric motor and has a shredding capacity of 180 nuts per hour. It is manufactured by the same company that supplies the coconut husking and shelling machines.

  ○ The Thai coconut scraping machine runs on a 2 hp single-phase electric motor, 220 volts, 50 Hz. All parts are made of stainless steel. The processing capacity of kernel is equivalent to about 220 nuts per hour. It is designed and manufactured by Ngow Huat Yoo Machinery, 107 Verngnakom Kasem Lane New Road, Soi 10 Samphantawong, Bangkok 10100, Thailand. Tel: +66-2-2225571/2247648-9; Fax: +66-2-2247649.
The coconut shredding machine has several advantages.

- It is safe to use, inasmuch as the hands of the operator are remote from the rotating blade, in contrast to standard motorised graters.
- It has a higher process capacity than standard motorised graters and is well suited for larger scales of operation when coupled with a shelling machine.
- Higher oil recovery is achieved on a per nut basis inasmuch as there is no coconut kernel left on the shell.

- Multi-purpose power grinder complete with accessories and 1-unit induction motor, 3-phase, 220 volts, 1750 rpm for spindle drive, 1-unit 1hp gear motor, 3-phase 220 volts for screw feeder. Food-grade stainless steel for all parts in contact with the fresh coconut kernel. The equipment is available in process capacities of 550 and 300 nuts per hour (coconut kernel equivalent). Designed and manufactured by Princena’s Machine Shop, 3rd St. Villa Antonio Subdivision, San Pablo City, Philippines. E-mail: pms.since1979@yahoo.com; Tel: +6349-5624618.

The same advantages as mentioned for the Thai coconut shredder are obtained from this coconut kernel grinder. In addition, it has a high processing capacity. However, the grinder is considerably more expensive and uses a special type of motor

- Knife mill – 2 hp, 3-phase, 220 volts motor, process capacity of 100 kg per hour, food-grade stainless steel for all parts in contact with the fresh coconut kernel. It is exactly the same design as the knife mill used for copra except that food-grade stainless steel is used instead of mild steel.

- SIMPLEX granulator – Can be used for both fresh and dried kernel; has an input capacity of up to 80 kg per hour; is driven by a 1.5 hp single-phase TEFC electric motor with push button magnetic contactor with overload cut-off. Designed and manufactured by VFV Trinity Machine Works, 44E Rizal Avenue Ext. Grace Park, Caloocan City. Tel: +632-3648648; Fax: +632-3658742; E-mail: vfvtrinity@hotmail.com
A6.3 Coconut milk extraction

**Manually operated equipment**

- Manually operated vertical screw type (bridge press), with perforated holding basket and receptacle trough; all materials in contact with the coconut kernel are made of stainless steel; 9 kg grated coconut kernel per load (about 20 nuts equivalent); 15–20 minutes pressing cycle per load; process capacity of about 60–80 nuts per hour (Figure 87).

Manufactured in the Philippines by PCDR Metalwerke Enterprise, No. 11 Lourdes St., Marcela, Kalookan City, Metro Manila, Telefax: +632-2874834. Original design from the Agro Processing Division, Natural Resources Institute, Chatham, Kent, United Kingdom.

![Figure 87. Philippine Bridge press for coconut milk and oil extraction](source)

- Manually operated hydraulic jack (10 tonnes capacity); table model; all materials in contact with the coconut kernel are made of stainless steel; 2.5 kg grated kernel per load (about 4–5 coconuts equivalent); five minutes pressing cycle per load, process capacity of about 48–60 nuts per hour (Figure 88).
Motorised equipment

- Motorised horizontal screw type coconut milk press (Figure 89) – Equivalent to 300–350 nuts per hour process capacity (freshly grated or ground coconut kernel input); 2 hp electric motor, single phase, stainless steel screw, built-in filter and housing. A higher capacity model at 500 nuts per hour is also available. Designed and manufactured by Princena’s Machine Shop, 3rd St. Villa Antonio Subdivision, San Pablo City, Laguna, Philippines. E-mail: pms.since1979@ yahoo.com; Tel: +6349-5624618.

Figure 88. Manually operated hydraulic jack type coconut milk press from the Philippines, stand alone (left) and table (right) models

Figure 89. Two models of motorised horizontal screw type coconut milk extractors from the Philippines
- Motorised coconut squeezing machine (screw type) (Figure 90) – Equivalent to 250 nuts per hour process capacity (freshly grated or ground coconut kernel input); stainless steel worm shaft/screw and stainless steel cage and frame fitted with 3 hp single-phase 220 volts, 50 Hz. Designed and manufactured by Ngow Huat Yoo Machinery, No. 107 Verngnakom Kasem Lane New Road, Soi 10 Samphantawong, Bangkok 10100, Thailand, Tel: +66-2-2225571/2247648-9; Fax: +66-2-2247649.

![Figure 90. Motorised horizontal screw type coconut milk extractor from Thailand](image)

- Motorised hydraulic coconut milk press (Figure 91) – Designed and manufactured by Ngow Huat Yoo Machinery, Bangkok, Thailand. Contact numbers as above.

![Figure 91. Motorised hydraulic coconut milk press from Thailand](image)
A6.4 Coconut milk separation equipment

**Two-phase centrifuge/cream separators** (Figure 92) – This is actually designed for the separation of dairy milk from skim milk but is adapted for separation of coconut milk into coconut cream and skim milk where the cream is further processed into VCO. The centrifuge is manufactured in India and has a stainless steel separation bowl and disc; milk separation capacity of 300 litres per hour; 31 discs, 7500 rpm; separation temperature at 35°–40°C; 1/2 hp electric motor, 110/220 volts, 50 Hz; 25 litres holding capacity of milk reservoir.

![Figure 92. Two phase (liquid-liquid) centrifuge](image)

A6.5 Drying equipment

The choice of dryer depends on the scale of production, the availability of construction materials (if needed to be constructed on site), the operator’s preference in terms of ease of operation, and the price and drying efficiency of the dryer.

- **DME dryer** (Figure 93) – This is essentially a flat bed, direct contact type of dryer where heat is directly transferred by conduction to the grated coconut kernel through the surface of the metal sheet. It is constructed on site, based on the design specifications of the technology developer. The dryer is composed of a stainless steel sheet (1.21 m x 4.86 m) mounted over a concrete base with heating stones underneath. A burner/furnace made of used (mild steel) petroleum drums is mounted on the front end for burning coconut shells and a chimney is attached to the other end.

![Figure 93. DME flat bed direct contact dryer](image)
Advantages

- It uses the generated by-product, coconut shells, for fuel.
- It has a relatively fast drying rate because of the direct heating.

Disadvantages

- It is labour intensive since it requires a minimum of three persons: one on each side of the dryer to do the constant layering of the freshly grated kernel on the metal surface, turning and moving it fast, and another person to regularly feed fuel into the dryer.
- There is a high risk of the kernel getting scorched or burned, since there is a tendency for the wet grated kernel to stick to the surface of the metal. Once the kernel is scorched or burned, the resulting oil will be pale yellow and no longer entitled to the label ‘virgin’.

• **Electrically-heated or gas-fired forced draught tray dryer** (Figure 94) – This is a standard dryer that can be bought from known manufacturers. It comes in different capacities and sizes. It is generally equipped with a thermostat control that allows the operator to set the drying temperature as desired. It is also equipped with a blower that circulates hot air around and on the surface of the dryer trays.

![Figure 94. Electrically heated forced draught tray dryer at Food Processing Centre in Tarawa, Kiribati](image)

Advantages

- Drying of the kernel is assured to be under the highest sanitary conditions.
- With proper temperature setting, loaded grated kernel for drying can be safely left untended without the risk of it getting scorched or burned.
- The thermostat control allows for a constant temperature drying.

Disadvantages

- It uses electric power or gas for heating, so the drying cost is much greater, and so is the carbon footprint.
The investment cost is higher.
It is labour intensive in terms of loading the fresh kernel into trays and mixing it at regular intervals during the drying process.

- **Continuous conveyor (apron) dryer** (Figure 95) – Coconut shell or gas-fired heat exchanger, 9.3 m long, 4 blowers of 1.5 hp each, single-phase 220 volts, dryer drive, 1 hp single phase, 220 volts, 50–60 kg per hour dried kernel output depending on moisture content. Output moisture content can be adjusted by adjusting the speed of the conveyor; output end of the dryer can be connected to the feed hopper of the expeller. A large capacity dryer is also available. Manufactured by Princena’s Machine Shop, 3rd St. Villa Antonio Subdivision, San Pablo City, Philippines. E-mail: pms.since1979@yahoo.com; Tel: +6349-5624618.

![Mini conveyor dryer from the Philippines](image)

**Advantages**

- It uses the generated by-product, coconut shells, for fuel.
- It can be used continuously, thereby ensuring low downtime in production.
- It prevents the drying pieces of kernel from getting scorched or burned, since it is hot air that is in contact with the kernel.
- It offers more flexibility in operation, since the desired output moisture content of the kernel can be set by adjusting the speed of the conveyor.
- It requires only one dryer operator.
- It can be used for drying other products.

**Disadvantages**

- The investment cost is high.
- It requires a bigger space because of the length of the dryer.
- The electric power cost is relatively high because of the electric motors to run the conveyor and the air blowers.
• **Indirect, natural draught coconut shell/husk-fired tray dryer** (Figure 96) – This dryer is constructed on site and is a modified version of the indirect type of copra dryer developed by the author at the PCA Davao Research Center. Suitable frames to hold a series of trays with screens were made in lieu of the loading bed of copra. Drying is essentially a batch type operation. The dryer is composed of a furnace and a metal cylindrical heat exchanger with baffles (made of used metal drums) attached to a chimney, from which hot combustion gases generated from burning coconut husks or shells are released after transferring the heat to the air surrounding the metal exchanger. The furnace and heat exchanger are enclosed in a dryer body (2.44 x 3.05 x 1.82 m) with concrete or brick walls provided with air intake ports on the side. As the air is heated through contact with the metal heat exchanger and the surface of the furnace, it rises to surround the grated coconut in the trays. It has a total of 30 drying trays which can be loaded with 1.5–2.0 kg of freshly grated coconut kernel. The temperature in the dryer is controlled by regulating the fuel feed.

![Image of natural draught coconut shell/husk-fired tray dryer]

**Figure 96. Natural draught coconut shell/husk-fired tray dryer**

**Advantages**

- It uses the generated by-products, coconut shells and husks, for fuel.
- It prevents the grated kernel from getting scorched or burned since it is hot air that is in contact with the kernel.

**Disadvantages**

- The drying efficiency is highly dependent on the prevailing ambient conditions and wind velocity.
- It has a relatively lower process capacity since it is a batch type operation.
- It is labour intensive in terms of loading the fresh kernel in trays and the need for changing the position of the trays at regular intervals during the drying process.

• **Solar dryer** – In areas where there are long periods of sunshine, solar drying of grated kernel could be the cheapest option for producing VCO from the low pressure oil extraction method under a micro-scale operation. There are different designs of solar dryer that can be constructed on site using polyethylene transparent plastic sheets and wood. Some solar heat collectors can be incorporated to make the solar dryer achieve a higher drying temperature. Previous solar drying trials done by the author revealed that a temperature of 70°C, which is just right for coconut drying, can be easily achieved in a properly designed solar dryer.
A6.6 Coconut oil extraction equipment

- **Manually operated vertical screw type bridge press trough** (Figure 87) – Has a perforated holding basket and receptacle; all materials in contact with the coconut kernel are made of stainless steel, 9 kg partially dried grated coconut kernel per load (about 45 nuts equivalent); 15–20 minutes loading, pressing and unloading cycle per load; process capacity of about 135–180 nuts per hour. Manufactured in the Philippines by PCDR Metalwerke Enterprise, No. 11 Lourdes St., Marcela, Kalookan City, Metro Manila, Telefax: +632-2874834; upscale model of the original design from the Agro Processing Division, Natural Resources Institute, Chatham, Kent, United Kingdom.

- **DME press** (Figure 18) – Kokonut Pacific described this as a ‘robust rack and pinion SAM™ Press with its interchangeable stainless steel cylinders and pistons’. The press, is mounted on a wall, has a ratchet mechanism for bringing up and down a lever that pushes the piston positioned on top of the partially dried grated kernel inside the cylinder. It can press 1.5–2.0 kg partially dried grated kernel loaded in the cylinder to recover the oil at eight pressings per hour.

- **New Zealand Press** (Figure 19) – This is manufactured by the Axis Industrial Ltd of Auckland, New Zealand and is currently being used by Women in Business Development Inc. in Samoa and Origins Pacific Ltd. in Fiji for VCO production. The press is a combination manually operated vertical screw and hydraulic jack-type press. The average processing time per cycle per 7 kg dried kernel load is about 15 minutes.

- **SIMPLEXTRACTOR high pressure expeller** (Figure 97) – Process capacity of 50 kg dried kernel per hour, 5 hp motor, 3-phase, 220 volts with built-in cooling system for worm shaft. Also available in process capacity of up to 80 kg per hour with 7.5 hp 3-phase motor. Designed and manufactured by VFV Trinity Machine Works, 44E Rizal Avenue Ext. Grace Park, Caloocan City. Tel: +632-3648648; Fax: +632- 3658742; E-mail: vfvtrinity@hotmail.com.
A6.7 Filtration equipment

- **Gravity type filtering device** (Figure 98) – Designed by the author, this filtering device is suited for clarifying VCO produced using the modified kitchen and natural fermentation methods. It is composed of two 20-litre cylindrical water containers (normally used in water dispensers) with the bottom cut out. These are placed one on top of the other over a stainless steel pot receptacle and everything is held together by a manufactured mild steel frame. The filtering medium is sterilised cotton wool placed in the neck of the water container. It can filter 18 litres per batch. This gravity type filtering device cannot be used for filtering oil obtained from the low pressure oil extraction method or the high pressure expeller method.

- **Plate and frame filter press** – This is the standard equipment used for filtration in commercial oil milling plants to ensure that all foots are speedily removed. The foots are trapped in the canvas cloth positioned between each plate as the oil is pushed through. A conventional plate and frame filter press for a commercial oil milling operation can have as many as 18 plates with each frame measuring approx 40 x 40 cm. A mini plate and frame filter press is also available (Figure 99).

- **Vertical pressure filters** (Figure 100) – These are normally used for fine filtration of coconut oil from a high pressure expeller.

A6.8 Fermentation cabinet

One way of ensuring that the right temperature is maintained during the fermentation process is to make a properly designed fermentation cabinet with electric light bulbs placed in strategic positions that can raise the temperature inside as needed. A small electric heater with built-in thermostat control can also be installed in the fermentation cabinet. (Note: Use incandescent bulbs, not the energy-saving compact fluorescent lamp (CFL) for warming the air in the fermentation box or cabinet. CFL bulbs give more light but very little heat.)
Figure 99. Mini plate and frame filter press from Australia (left) and standard plate and frame filter press at Wainiyaku Estate Plantation, Fiji (right)

Figure 100. Vertical pressure filter at Wainiyaku Estate Plantation, Fiji
Annex 7
Production data sheet and other relevant record forms in a VCO processing facility

DAILY PRODUCTION DATA SHEET  
MODIFIED KITCHEN METHOD

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 nut ______________________ kgs

C. Milk extraction

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

1st extraction  
2nd extraction

Weight of first milk extract ______________________ kgs  
Weight of water added ______________________ kgs  
Weight of second milk extract ______________________ kgs  
Weight of wet coconut milk residue ______________________ kgs

D. Settling for two hours

<table>
<thead>
<tr>
<th>Weight of cream, kgs</th>
<th>Weight of skim milk, kgs</th>
</tr>
</thead>
</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>
</table>

Weight of wet proteinaceous residue ______________________ kgs

<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, filtered</th>
</tr>
</thead>
</table>

Weight of toasted residue ______________________ kgs

## DAILY PRODUCTION DATA SHEET
### MODIFIED NATURAL FERMENTATION METHOD

**Date of production:**

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

Weight of grated kernel _____________ kgs

**C. Milk extraction**

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

Weight of first milk extract ________________ kgs

Weight of water added ________________ kgs

Weight of second milk extract ____________ kgs

Weight of wet coconut milk residue __________ kgs

**D. Settling/fermentation of coconut milk**

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

**E. Harvesting of separated oil**

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

Weight of wet fermented curd ___________ kgs

<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, filtered</th>
</tr>
</thead>
</table>

Weight of toasted curd ___________ kgs

DAILY PRODUCTION DATA SHEET  
LOW PRESSURE EXTRACTION METHOD

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 kernel ______________________ kgs

C. Drying of grated kernel

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

Weight of dried kernel ______________________ kgs

D. Extraction of oil

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

Weight of extracted oil, unfiltered ______________________ kgs

Weight of coconut meal ______________________ kgs

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>
</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>
</table>

Weight of filtered oil ______________________ kgs

Weight of “foots” ______________________ kgs

# DAILY PRODUCTION DATA SHEET
## HIGH PRESSURE EXPPELLER PROCESS

### 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. Shelling of coconut kernel

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

Weight of coconut kernel _________________ kgs

#### C. Grinding of coconut kernel

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

Weight of ground/granulated kernel _________________ kgs

#### D. Drying of granulated kernel

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

Weight of dried granulated kernel _________________ kgs

#### E. Extraction of oil

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

Weight of extracted oil, unfiltered _________________ kgs

Weight of coconut meal _________________ kgs

#### 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>
</thead>
</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>
</table>

Weight of filtered oil _________________ kgs

Weight of “foots” _________________ kgs

PRODUCTION DATA SUMMARY
MODIFIED KITCHEN AND NATURAL FERMENTATION METHOD

<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, kgs</th>
<th>Lot Identification No. for VCO</th>
<th>Weight of Wet Residue, kgs</th>
<th>Weight of Wet Latik or Curd, kgs</th>
<th>Weight of Residual Oil, kgs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

### PRODUCTION DATA SUMMARY

**LOW PRESSURE OIL EXTRACTION AND HIGH PRESSURE EXPPELLER PROCESS**

<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, kgs</th>
<th>Lot Identification No. for VCO</th>
<th>Weight of Coconut Meal, kgs</th>
<th>Weight of Foots, kgs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

A8.1 Charcoal processing technologies

There are two methods that are generally used for small scale production of charcoal in the Philippines, the pit method and the kiln method.

A8.1.1 Pit method

Pits for charcoal making are made by digging holes in the ground to the desired size. Guarte (1993) mentions that circular or rectangular pits (Figure 101) are generally used. The size of the pit varies according to the availability of shells and the capacity desired. He adds that most rectangular pits in the Philippines are approximately one metre wide, two metres long and one metre deep, and circular pits are a minimum size of one metre in diameter and one and a quarter metres deep. Rectangular pits should have rounded sides on the bottom part to minimise the amount of air that might be trapped there which could cause over-burning of charcoal in that part.

The steps for making charcoal by the rectangular pit method are given below.

a. Place 100 coconut shell halves at three equidistant points in the pit leaving a space in between the groups of shells.

b. Start the burning of three or four shells outside the pit and drop them in the space at the bottom of the pit to initiate burning.

c. Once the other shells start burning, cover them with additional shells. The aim is to prevent the shells from breaking out into flame as this will turn the shell to ashes.

d. Additional shells are added progressively as the fire spreads upward until eventually the heap reaches the top of the pit. At this point, large volumes of dark smoke are generated.

e. Cover the pit with a metal sheet or any material that will not burn and allow the carbonisation to continue.

f. Once the smoke becomes clear and transparent, completely seal the cover of the pit by putting clay soil over the cover and sides. Ensure that the seal is airtight to prevent the charcoal from turning into ash.

g. Allow two or three days for the charcoal to completely cool.

h. Remove the charcoal and store it in bags.

Figure 101. A rectangular pit for charcoal making
The pit method has both advantages and disadvantages.

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero or very low capital investment</td>
<td>Fixed position</td>
</tr>
<tr>
<td>Low maintenance cost</td>
<td>Removing the charcoal from the pit is troublesome</td>
</tr>
<tr>
<td>Flexible size</td>
<td>Charcoal is normally contaminated with dirt</td>
</tr>
</tbody>
</table>

A8.1.2 Kiln method

There are three types of kiln that are currently being used in the Philippines, the drum kiln (Figure 102) which is the most popular for individual farmers, the fabricated metal kiln or Pag-Asa kiln (Figure 103) for a bigger scale of operation and the PCA brick kiln (Figure 104) for long term usage.

Drum method

A 200 litre, used petrol or steel drum is used as a kiln. The top is cut off and used as a cover during carbonisation. The drum is cleaned and washed thoroughly, especially if it was used as container for corrosive materials. The capacity of a drum is 450 to 500 whole shells (900 to 1000 half shells) depending on the size. The procedure takes six hours plus overnight cooling. A skilled worker can operate eight or nine drum kilns at the same time. Charcoal recovery is 27.5% of the total weight of shells, provided the shells are properly dried and come from fully mature nuts.

There are different versions of drum kiln: one type with four equidistant holes at the bottom, another type with several equidistant holes along the sides of the drum at different heights, and a very simple type that has no holes at all. Procedures vary depending on the type of drum kiln. The charcoal making steps for the drum without any holes are described below.

a. Place the drum on flat, clean ground.

b. Ignite two pieces of coconut husk or three or four pieces of coconut shell, and carefully drop them into the bottom of the drum. Arrange them evenly around the bottom by poking them with a stick, and allow them to burn vigorously.

c. When these husks or shells are burning vigorously, add about 20 half coconut shells. Loosely cover the drum with the top portion which was removed before. Allow the shells to carbonise. The start of carbonisation is signified by the release of heavy dark smoke.
d. Add more shells whenever the smoke becomes lighter or when you see flames. Replace the cover after each addition.

e. Continue putting in fresh batches of shells until the pile reaches the top of the drum.

f. When the smoke coming out of the loosely covered drum becomes clear, fit the cover on the lid of the drum.

g. Turn the covered drum upside down. (The bottom of the drum becomes cooler as the carbonisation moves towards the top, which allows the worker to hold the bottom portion.)

h. Seal the kiln by pressing relatively wet soil around the lid. The absence of smoke indicates that the drum is completely sealed.

It should be noted that some charcoal makers do not turn the drum kiln upside down. The lid is sealed with wet clay when the smoke becomes transparent and clear. Sealing of the lid is easier when the drum is turned upside down but it takes a lot of skill to turn the drum upside down without spilling the contents.

**Fabricated metal kiln (Pag-Asa kiln)**

The best known charcoal kiln designed in the Philippines is the Pag-Asa kiln (Figure 103), which is normally used by commercial charcoal producers. It is a fabricated metal kiln composed of two parts: a cylindrical base and a conical top part. Unlike the drum kiln with only the top open, the Pag-Asa kiln is open at the top and the bottom. The size of the kiln depends on the capacity that is desired and needed by the user. A kiln with a cylindrical base diameter of 46”, a height of 41” and a conical top with a diameter of 16” can take about 3000 half shells. The procedure takes 7 to 8 hours with a cooling time of 16 to 17 hours. A skilled worker can operate three Pag-Asa kilns at the same time. Charcoal recovery is 25–27 % based on the weight of input.

The steps for making charcoal using the Pag-Asa kiln are described below.

a. Pile on the ground about 50 shell halves, leaving a space in the middle.

b. Ignite two to three pieces of dry coconut shell or husk and place them in the central space.

c. Once the other shells in the pile are burning strongly, place the Pag-Asa kiln over the pile of shells, completely containing or enveloping them.

d. Add more shells whenever the smoke becomes lighter or when flames break out.

e. Continue adding shells until the kiln is full.

f. When the smoke coming out of the kiln becomes lighter and transparent, seal around the bottom of the kiln with soil, cover the top with a metal sheet and seal it with clay or any material that will make it airtight.

g. Allow the charcoal to cool for 16 to 17 hours.

h. Collect the charcoal after removing the soil and tilting the kiln to expose the charcoal inside.

i. If the charcoal is intended for delivery to a charcoal granulation or activated carbon plant, separate small particles by passing the charcoal through a mesh screen sieve.

j. If the charcoal is intended for delivery to the local market, pack it in sacks without screening it.

![Figure 103. Fabricated metal kiln (Pag-Asa kiln)](image-url)
PCA brick kiln

The PCA brick charcoal kiln (Figure 104) was developed by the Philippine-German Coconut Project (PGCP)\(^1\) and was evaluated and popularised by the Philippine-Korea Cooperation project to provide coconut farmers and charcoal manufacturers with an alternative device for charcoal making. The kiln is intended for a centralised type of operation since it is constructed on site and not moveable like the drum and Pag-Asa kilns. It is constructed using bricks which do not corrode and are resistant to heat so it is expected to have a longer service life than metal kilns. The capacity of the kiln is approximately 3,000 half shells. The kiln is mainly made of 2”x 4”x 8” standard rectangular fire bricks. It is dome-shaped to optimise the carbonisation process. The dimensions of the kiln are: base diameter (inside): 1.20 m., height (net): 1.10 m., volume: 0.73 cu. m. A total of 24 air inlet ports, each with a diameter of one inch, are placed in four rows around the circumference of the kiln. Each row has six air intake ports equidistant from each other. The first row is positioned at the base of the kiln. The distance between each row is equivalent to the height of five bricks (i.e. the succeeding rows of air intake ports are made after the addition of five layers of bricks during construction).

A skilled charcoal maker can operate four kilns at a time for an average of eight hours from ignition to covering. The operating time depends on the moisture content of the shells (using dry shells shortens carbonisation time and ultimately reduces cost) and on how well the procedures are followed. Proper operating procedures should be followed to produce good quality charcoal. The average charcoal recovery rate is 28.4% based on dry weight of input.

The procedure for making charcoal using the PCA brick kiln is described below.

a. Start by igniting about 50 dry coconut shells or husks and wait for about five minutes to allow them to burn strongly.

b. Close the brick door and then add another batch of dry coconut shells, usually about 500 shells.

c. Seal all joints of the brick door with wet ash.

d. Wait until the colour of the smoke changes from blackish to whitish and then add another batch of coconut shells. Repeat this procedure until the kiln is full.

e. Close the air inlet ports at the base with wet ash when embers are visible or on the level of the second row of air inlets. Repeat this procedure on the third row. The fourth row of air inlets is closed at the same time as the removable kiln cover (similar to a clay pot cover) is placed on top.

f. The number of coconut shells added in each batch decreases near the end of the operation.

g. Close the kiln after the last batch is fully burned. Seal the top cover first with dry pulverised ash or fine sand and finish with wet ash.

h. Check for any leaks.

i. Unload the charcoal on the following day by opening the top cover and brick door. Use a spade to transfer the charcoal from the kiln to the containers.

j. Check for live embers on the surface of the charcoal. Ignition sometimes happens due to the high charcoal temperature and sudden exposure to air.

k. Store the charcoal in a well-ventilated warehouse away from passageways to prevent and/or reduce fire risk.

\(^1\)The Philippine-German Coconut Project is a technology transfer and self-help type of project involving R and D on coconut post-harvest technologies and strengthening of farmers’ capabilities. It was co-funded by GTZ and was implemented by PCA from 1992–2000.
A8.2 Quality parameters and grading of coconut shell charcoal

Coconut shell charcoal contains the highest percentage of fixed carbon of all ligneous charcoal. Accordingly, a good charcoal has the following average composition: 3% moisture, 10% volatiles, 2% ash, and 85% fixed carbon. The following are the quality parameters of coconut shell charcoal when analysed quantitatively:

**Fixed carbon content** – is the amount of carbon contained in a particular type of charcoal. The fixed carbon content of charcoal ranges from a low of about 50% to a high of around 95%. Thus charcoal consists mainly of carbon. The carbon content is usually estimated as a ‘difference’, i.e. all the other constituents are deducted from 100 as percentages and the remainder is assumed to be the percentage of ‘pure’ or ‘fixed’ carbon.

**Ash** – is determined by heating a weighed sample to red heat to burn away all combustible matter. The residue is the ash. It consists of mineral matter, such as clay and silica, and calcium and magnesium oxides, which were present in the original wood and picked up as contaminants from the earth during processing.

**Moisture content** – is the water that is physically bound in the charcoal. Quality specifications for charcoal usually limit the moisture content to around 5–15% of the gross weight of the charcoal. Moisture content is determined by oven-drying a weighed sample of the charcoal. It is expressed as a percentage of the initial wet weight.

**Volatile combustible matter content** – is defined as the water and other organic matter that is released as a result of various chemical reactions that occur when biomass is heated in the presence of limited air. The volatile matter content in charcoal (other than water) is composed of all those liquid and tarry residues not fully driven off in the process of carbonisation. The amount can vary from a high of 40% to a of 5% or less. It is measured by heating away from air, a weighed sample of dry charcoal at 90°C to constant weight. The weight loss is the volatile matter. Volatile matter (VM) is usually specified free of the moisture content, i.e. volatile matter minus moisture content.

**Foreign matter content** – refers to any material mixed in the batch of charcoal, e.g. pebbles, stones, metals, bits of wood, husk, etc.

### A8.2.1 Grades and standards of charcoal

Good quality charcoal must conform to the standard grade set by the industry on export. Charcoal is classified into metallurgical grade A, and commercial grades A and B under the Philippine standard for shell charcoal. The limits for each parameter are shown in Table 14.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Metallurgical Grade A</th>
<th>Commercial Grade A</th>
<th>Commercial Grade B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed carbon</td>
<td>80% max.</td>
<td>75% max.</td>
<td>65% max.</td>
</tr>
<tr>
<td>Ash</td>
<td>3% max.</td>
<td>3% max.</td>
<td>3% max.</td>
</tr>
<tr>
<td>Moisture Volatile</td>
<td>10% max.</td>
<td>10% max.</td>
<td>10% max.</td>
</tr>
<tr>
<td>Combustible matter</td>
<td>10% max.</td>
<td>10% max.</td>
<td>20% max.</td>
</tr>
<tr>
<td>Sieve analysis</td>
<td>Not more than 5% shall pass a ¼ inch mesh sieve</td>
<td>Not more than 5% shall pass a ¼ inch mesh sieve</td>
<td>Not more than 5% shall pass a ¼ inch mesh sieve</td>
</tr>
</tbody>
</table>
A8.2.2 Physical grading

On a farm, quantitative analysis of charcoal can never be done, simply because it is not practical to do so. However, farmer producers may conduct their own quality assessment based on the physical attributes of their produce. The following quality assessment guide can be used (Table 15).

Table 15. Charcoal quality assessment guide

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Attributes of good quality charcoal</th>
<th>What to do</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>Uniformly bluish-black colour. Glistens in sunlight.</td>
<td>Get a piece of charcoal and allow the sunlight to touch the surface. Observe the colour.</td>
</tr>
<tr>
<td>Appearance</td>
<td>Clean, shining fracture and free of fibres.</td>
<td>Get a piece of charcoal and observe it under light. Tap it on top of a piece of paper and observe the amount of dust/fibres that fall out.</td>
</tr>
<tr>
<td>Sound</td>
<td>Produces a high, metallic sound when snapped or dropped on a hard surface.</td>
<td>Drop a piece of charcoal on a hard surface and listen to the sound of the fracture.</td>
</tr>
<tr>
<td>Foreign matter</td>
<td>Should be free of dust, fibres, pebbles and other materials.</td>
<td>Screen the charcoal using a ¼ inch mesh screen.</td>
</tr>
</tbody>
</table>

Under-burnt shells do not give a metallic sound when snapped, while over-burnt shells are friable and a fracture sounds dull.

Source of Information: Engr. Evelyn T. Caro
Agriculturist 1 and Technology Transfer Specialist
PCA Region XI, Davao City, Philippines.

A8.3 Processing of coconut shell charcoal briquettes

Equipment

Binder cooker This is used for binder preparation. The size and type of cooker largely depends on the plant capacity and mode of operation. A biomass-fired (coconut husk or shell) cooker is necessary to have a continuous supply of boiling water during operation.

Mixer This is used to evenly distribute the binder with the charcoal fines. Good mixers are characterised by their ability to achieve a homogenous mixture in the shortest time possible.

Briquettor (Figure 105) This equipment converts the charcoal fine-binder mixture into a solid substance with defined shape. Briquettes can be made into various shapes (egg-shaped, oblong, hexagonal, cylindrical, circular and pillow-shaped) depending on the type of mould and briquetting machine used. The pillow-shaped briquette is commonly produced. For home scale production and use, a manually operated briquetting machine can be used.

Dryer This is necessary to immediately dry and harden newly formed briquettes. Tray type mechanical and natural draught indirect dryers can be used for drying. Sundrying can be done but, due to unpredictable weather condition, it is not recommended for large scale production.
Charcoal fines

The best raw material for making charcoal briquettes is coconut shell charcoal fines due to their high heating value compared to charcoal fines from other biomass materials. Charcoal fines are generated as a waste product in granulating charcoal intended for activated carbon production. Another way of obtaining charcoal fines is by segregating and grinding small particles of shell charcoal from carbonisation operation.

Binder

Cassava starch is commonly used as binder because this is the cheapest and most readily available material.

Water

This is used for dissolving starch prior to cooking it. Any clean and chemical-free water can be used.

**Steps in charcoal briquette making**

1. Weigh exact amounts of charcoal fines, water and binder — just enough for one mixing. The recommended ratio is 1:10:20 (starch:water:charcoal fines).

2. Dissolve the starch in a small amount of water until the solution is homogenous. Pour in boiling water. Stir until cooked or gelatinised.

3. Place charcoal fines in the mixer and pour in the binder while still hot. Stir until all particles are coated by the binder.

4. Pour freshly prepared mixture into the briquettor mould and press or feed it into a motorised briquetting machine (Figure 105).

5. Arrange freshly moulded briquettes in the drying trays to allow circulation of air and operate the dryer when all the trays are full.

6. Remove deformed and cracked briquettes. Pack good briquettes in plastic bags and seal.

*Source of Information: Engr. Evelyn T. Caro*

*Agriculturist 1 and Technology Transfer Specialist*

*PCA Region XI, Davao City, Philippines.*
Annex 9
Simple processing technologies for coconut water utilisation

A9.1 Coconut water vinegar

Vinegar is generally defined as an alcoholic liquid that has been allowed to sour. It is considered one of the oldest fermentation products known to man (Banzon et al, 1990).

Coconut water vinegar uses coconut water as starting material. Coconut water is the liquid endosperm found inside a coconut. It is one of the by-products generated during the processing of coconut kernel. In its natural form, coconut water contains micro minerals which are beneficial to human health, as shown in Tables 16 and 17.

<table>
<thead>
<tr>
<th>AGE (months)</th>
<th>Potassium (mEq/litre)</th>
<th>Sodium (mEq/litre)</th>
<th>Calcium (mEq/litre)</th>
<th>Magnesium (mEq/litre)</th>
<th>Chlorine (mEq/litre)</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>
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<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 et al. (1987)

The composition of coconut water vinegar as analysed by the Philippine Food and Nutrition Research Institute and reported by Banzon et al. (1990) is shown below:

- Food energy value: 3 calories/gram
- Moisture: 98%
- Fat: 0.1%
- Total carbohydrates: 1.4%
- Ash: 0.3%
- Calcium: 24 mg/100 grams
- Phosphorous: 34 mg/100 grams
- Iron: 0.1 mg/100 grams
- Riboflavin: 0.01 mg/100 grams
- Protein: trace
- Thiamine: trace
- Niacin: trace

Source: Banzon et al, 1990

Table 16. Average composition of coconut water

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</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)
Vinegar is primarily used to flavour and preserve foods and as an ingredient in salad dressings and marinades. It has also been used as a medicine and a preservative. A dilute solution of vinegar has been found to be an effective rinse for fresh salad vegetables to remove traces of pesticide.

In the Philippines, coconut water vinegar is used as a table condiment and sauce for some Filipino dishes. It is used as a seasoning for meat, fish and vegetables during cooking; as an ingredient in the manufacture of vegetable pickles, catsup and other tomato products, mayonnaise, mustard, dressing and sauces; and as additive in many manufactured foods to enhance flavour (Banzon et al, 1990). In addition, it is used as a cleaning agent.

There are two methods for making coconut water vinegar on a home and micro scale production. These are:

- by using yeast and microbial culture (e.g. acetobacter acetii) as fermenting medium (Table 18)
- by using three-day-old coconut toddy as a starter (Table 19).

### The yeast and microbial culture process

**Table 18. The yeast and microbial culture process for coconut water vinegar production**

<table>
<thead>
<tr>
<th>Process Steps</th>
<th>Critical Control Points/Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Part A: Alcoholic Fermentation</strong></td>
<td></td>
</tr>
<tr>
<td>1) Collect three litres fresh coconut water. Strain through cheese cloth.</td>
<td>Coconut water should come from ungerminated, unspoiled and newly opened nuts.</td>
</tr>
<tr>
<td>2) Dissolve 1/4 kg sugar in the coconut water.</td>
<td>This is to increase sugar concentration of the coconut water.</td>
</tr>
<tr>
<td>3) Pasteurise by heating at 65°C for 20 minutes or boil for five minutes. Cool at 40°C.</td>
<td>Avoid overheating as this may spoil the flavour.</td>
</tr>
<tr>
<td>4) Dissolve half a teaspoon Fleischmann dry yeast in one cup of sterilised coconut water and pour into the mixture.</td>
<td>IMPORTANT: Make sure that the yeast is still active. This is indicated by bubbles while the yeast is being dissolved and after it is dissolved.</td>
</tr>
<tr>
<td>5) Pour the mixture into a sterilised narrow-mouth jar (preferably glass).</td>
<td></td>
</tr>
<tr>
<td>6) Cover the narrow mouth with clean brown paper or newsprint and seal it with a rubber band.</td>
<td>IMPORTANT: Do not use cellophane or plastic. Keep the cover slightly loose, not tight.</td>
</tr>
<tr>
<td>7) Allow the mixture to ferment for four to seven days or until there are no more bubbles of carbon dioxide formed.</td>
<td></td>
</tr>
<tr>
<td>8) Transfer into wide-mouthed jar using rubber tubing to siphon out the solution.</td>
<td>IMPORTANT: Be careful not to disturb the sediments.</td>
</tr>
<tr>
<td><strong>Part B: Acetic Acid Fermentation</strong></td>
<td></td>
</tr>
<tr>
<td>1) To the alcoholic solution prepared in procedure A above, add 1.5 litres of mother vinegar. Mix thoroughly.</td>
<td>Mother vinegar is started from a microbial culture of selected fermenting micro organisms, e.g. Acetobacter acetii, and is generated for every batch of coconut water vinegar produced. In the Philippines, there are government agencies producing mother vinegar for sale to would-be producers of coconut water vinegar.</td>
</tr>
<tr>
<td>2) Loosely cover the container with clean brown paper or newsprint and seal with a rubber band.</td>
<td>IMPORTANT: Do not use cellophane or plastic.</td>
</tr>
<tr>
<td>3) Allow to ferment for 30 days or until maximum sourness is obtained.</td>
<td></td>
</tr>
</tbody>
</table>
4) Set aside 1.5 litres to be used as mother vinegar for the next batch.

5) Pasteurise at 65°C–80°C to kill the fermenting micro-organism before bottling the product. IMPORTANT: Pasteurisation is needed at the right time to kill the micro-organisms responsible for fermentation. Otherwise, fermentation will continue and the vinegar will be converted into water and carbon dioxide. Use a stainless steel vessel during pasteurisation. Do not use aluminum, copper or brass containers.

6) Cool and pack in sterilised bottles.

Considering the situation where PICTs will start from zero base in coconut water vinegar processing, it is recommended to use the simple process where three-day-old coconut toddy is used as starter and will be mixed with coconut water. The other process for making coconut water vinegar requires the addition of sugar and yeast to coconut water to ferment it into alcohol, then a suitable microbial culture is added to the alcoholic mixture to ferment it into vinegar. It should be noted that coconut toddy contains a natural fermenting enzyme. Three-day-old coconut toddy is actually an alcoholic mixture already and if it is distilled off, it will yield coconut liquor. Mixing three-day-old toddy with coconut water as the fermenting medium actually shortens the fermentation time into vinegar since there is no longer any need to ferment the coconut water into alcohol. Processing of coconut water into vinegar using three-day-old toddy as starter can be easily done in Cook islands, Rabi Island (Fiji), Kiribati, Marshall Islands, Solomon Islands and Tuvalu, where coconut toddy collection is regularly done.

Table 19. Processing of coconut water vinegar using three-day-old coconut toddy

<table>
<thead>
<tr>
<th>Process Steps</th>
<th>Critical Control Points/ Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Collect five litres of fresh coconut water. Strain through cheese cloth.</td>
<td>The coconut water should come from ungerminated, unspoiled, newly opened nuts.</td>
</tr>
<tr>
<td>2) Pasteurise by heating at 65°C for 20 minutes or boil for five minutes.</td>
<td>Avoid overheating as this may spoil the flavour of the product. Use stainless steel container during pasteurisation. Do not use aluminum, copper or brass containers.</td>
</tr>
<tr>
<td>3) Pour into fermenting containers.</td>
<td>Food grade plastic containers can be used. They should be washed properly with soap and water and rinsed with hot water before use.</td>
</tr>
<tr>
<td>4) Add five litres of the three-day-old coconut toddy.</td>
<td>The sugar content of the toddy has already been naturally converted to alcohol. Note: Three-day old coconut toddy is the toddy which is left to stand for 72 hours after collection from the coconut tree.</td>
</tr>
<tr>
<td>5) Loosely cover the mouth of the container with cheesecloth or muslin. A cloth diaper for babies can also be used.</td>
<td>IMPORTANT: Do not use cellophane. Keep the cover slightly loose.</td>
</tr>
<tr>
<td>6) Allow the mixture to ferment for seven days.</td>
<td>IMPORTANT: Be careful not to disturb the sediment.</td>
</tr>
<tr>
<td>7) Collect by siphoning.</td>
<td></td>
</tr>
</tbody>
</table>

Table 19. Processing of coconut water vinegar using three-day-old coconut toddy
A9.2 Coconut sauce

Ingredients

- 2 cups coconut water
- ½ cup brown sugar
- ½ cup salt
- MSG (optional)

Procedure

1. Heat pan
2. Heat sugar until dark brown. Adjust stove flame to medium.
3. Add coconut water, salt and MSG if desired.
4. Stir and boil for 15 minutes
5. Remove from heat and strain.

Source: Philippine Coconut Authority
Region VIII (Davao City), Philippines

8) Pasteurise at 65°–80°C to kill the fermenting micro-organisms before bottling

Important: pasteurisation is needed at the right time to kill micro-organisms responsible for fermentation. Otherwise, fermentation will continue and the vinegar will be converted into water and carbon dioxide. Use a stainless steel container during pasteurisation. Do not use aluminum, copper or brass containers.

9) Cool and pack in sterilised bottles.
Annex 10
Food products from coconut milk residue

These recipes were selected from the coconut recipes developed by staff of the Philippine Coconut Authority and tested by the author.

Coconut Burger

Ingredients

- 1 cup fresh coconut milk residue
- 1 cup minced beef or minced chicken or canned tuna flakes
- 2 eggs, well beaten
- ¼ cup onions, chopped
- 1 tbsp garlic, minced
- ½ tsp ground pepper plus other spices to taste
- fresh green chilli, chopped (optional)
- 3 tbsp soy sauce
- 6 tbsp corn starch
- 1/2 tsp salt
- cooking oil for frying
- tomato catsup for garnish

Procedure

1. Beat the eggs. Completely dissolve the cornstarch in the beaten eggs. Set aside.
2. Mix the fresh coconut residue thoroughly with the minced beef/chicken or tuna flakes, onions, garlic, ground pepper, soy sauce, salt, chopped fresh green chili (if desired).
3. Add the egg mixture and mix thoroughly.
4. Shape into thin patties (two tablespoons per patty).
6. Drain off excess oil. Serve with catsup while hot.

Note: The addition of fresh coconut residue (from coconut milk extraction) to the usual burger recipe provides dietary fibre which helps to prevent constipation, lowers cholesterol. It also provides coconut dietary fat, which has been shown to have antimicrobial properties and boosts the immune system, aside from providing food energy. It also utilises coconut residue (which is normally thrown away or used as animal feed) thereby reducing the cost of the food as well.

Source of basic recipe: Product Development Department
Philippine Coconut Authority
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 minced chicken
- 1 egg, well beaten
- ½ cup onions, chopped
- ½ tbsp ground pepper plus other spices to taste
- ½ tsp salt
- MSG to taste (optional)
- Cooking oil for frying
- Vinegar seasoned with salt and garlic

Procedure

1. Mix all ingredients.
2. Shape into patties.
3. Deep fry in oil until golden brown.
4. Serve hot with vinegar seasoned with salt and garlic.

Source of basic recipe: Philippine Coconut Authority
Region IV-A (Lucena)

Macaroons

Ingredients

- 1 can (big) condensed milk
- 3 eggs, well beaten
- 1/2 cup butter
- 1/4 cup sugar
- ½ cup all-purpose flour
- 2 cups dried/toasted coconut milk residue
- 1 tsp vanilla
- 2 tsp baking powder

Procedure

1. Preheat the oven to 350°F.
2. Mix all ingredients well.
3. Spoon mixture into paper cups. Fill the cups only half full to avoid overflow of mixture during baking.
4. Place on baking sheets or muffin pans and bake at 350°F for 15–20 mins.

Source: Product Development Department
Philippine Coconut Authority
**Peanut Sapal Cookies**

**Ingredients**
- 3/4 cup sifted all purpose wheat flour
- 1 cup toasted coconut residue
- 1/2 tsp baking powder
- 1/2 tsp baking soda
- 1/4 tsp salt
- 1/2 cup margarine or butter
- 3/4 cup sugar
- 1/4 cup peanut butter
- 1 egg
- 1/2 cup finely chopped peanuts

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

*Source: Product Development Department
Philippine Coconut Authority*

**Cinnamon Sapal Cookies**

**Ingredients**
- ½ cup shortening or butter
- 1 cup sugar
- 1 egg, well beaten
- ½ cup evaporated milk
- 1 cup toasted coconut residue
- 1½ cups sifted flour
- ½ tsp salt
- 1 tsp cinnamon powder
- 2½ tsp baking powder

**Procedure**
1. Cream the butter or shortening and sugar together until light and fluffy.
2. Add the egg, then stir in the milk.
3. Add the toasted coconut residue.
4. Sift the flour, salt, cinnamon and baking powder and add to the mixture. Mix well.
5. Drop by teaspoonful onto a greased baking sheet.
6. Bake in a moderate oven 375°F until brown, about 15 minutes.

*Source: Product Development Department
Philippine Coconut Authority*
Figure 106. Coconut burgers (left) and macaroons (right)
Annex 11
Production of coconut flour and VCO from coconut milk residue using the Bawalan-Masa process

The Bawalan-Masa Process (Figure 43) has the following major steps:

**Blanching** – blanching coconut milk residue is done through the injection of live steam using a blanching machine at a minimum temperature of 85°C for about seven minutes or immersion in boiling water for 1½ minutes in order to kill harmful micro-organisms which might have contaminated the milk residue during handling. Blanching is a necessary step in coconut flour production, although it increases the moisture content of the coconut milk residue.

**Drying** – the wet coconut residue is dried using a tray type mechanical dryer to a specified moisture content. The dryer could be gas fired, electrically heated or steam heated. For large scale operation, the conveyor type dryer, similar to the one used in a desiccated coconut plant, is more practical to use.

**Defatting** – the dried coconut residue is passed through a high pressure screw press with a cooling system under a specified expeller setting to reduce oil content of the flour to 9% or less. A co-product of this process is another type of VCO with very mild coconut scent, easily absorbed by the skin. It is important to reduce the oil content of the coconut flakes to the lowest possible level to prolong the shelf-life of the coconut flour.

It should be noted that conventional designs of oil expellers as used in the coconut industry are not suitable for VCO and coconut flour production. Conventional expellers generate too much heat during operation, which destroys the nutritive value and affects the colour of the flakes.

**Re-drying** – the defatted coconut flakes are re-dried to reduce their moisture content to 2.5–3.0%.

**Grinding** – the dried coconut flakes are then ground to reduce particle size to a fine mesh (at least 100 mesh) as required in food product formulation.

**Filtration of Oil** – the VCO produced when it leaves the defatting equipment has entrained very fine particles of dried coconut milk residue which should be removed to clarify the oil. This is done through the use of a plate and frame filter press similar to what is done in copra oil milling operations.

The Bawalan-Masa Process is patented under the Philippine Patent Office in the name of the Philippine Coconut Authority. The process was developed by the author while working as Senior Science Research Specialist and Ms Dina B. Masa, Manager, Product Development Department, Philippine Coconut Authority.
A12.1 Toilet/bath soap

Figure 161. Soap-making tools and equipment

Weighing scale
Stick blender
SS wire whisk
Heat resistant plastic container
Eye goggles, gloves and mask
Plastic basin
Soap moulds
Notes on soap-making tools and equipment

1. All equipment should be stainless steel, plastic or glass. Never use aluminium as this will react with caustic soda.

2. Soap moulds can be a fabricated wood with formica lamination or heat-resistant plastic. If non-heat resistant plastic is used, the desired shape of the soap plastic mould will not be retained.

Additives in soap-making

Additives are substances that not only alter the overall appearance of a given soap but which also lend their own special qualities to it (hollydeyo@millenium-ark.net, 2004).

Additives include:

Colouring materials – can be food grade dyes, spices (such as turmeric) that have the pigment for a specific colour, or any non-allergy-causing substance that provides colour to the soap. The author found that children’s crayons are a cheap alternative to commercial dyes for home-scale soap-making.

Essential oils or fragrance oils – give the soap the desired scent; they should not contain any alcohol.

Chelating agent – this is either citric acid or ethylene diamine tetra acetic acid (EDTA), which acts as a sort of metal scavenger or water softener, preventing the formation of bathtub rings when the soap is used in hard water.

Mineral oil or glycerine – this is added to enhance the emollient properties of soap and prevents its skin-drying effect. For special moisturising effect, cocoa butter or avocado oil or jojoba oil can be added instead of mineral oil.

Basic formulation for moisturising herbal bath soap are shown in Table 20.

Table 20. Basic formulation for moisturising herbal bath soap

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coconut oil</td>
<td>1,000 grams</td>
</tr>
<tr>
<td>Caustic soda solution, 35°Be</td>
<td>578 grams</td>
</tr>
<tr>
<td>OR</td>
<td></td>
</tr>
<tr>
<td>Coconut oil</td>
<td>550 grams</td>
</tr>
<tr>
<td>Palm oil</td>
<td>300 grams</td>
</tr>
<tr>
<td>Sunflower oil</td>
<td>200 grams</td>
</tr>
<tr>
<td>Caustic soda solution, 35°Be</td>
<td>550 grams</td>
</tr>
<tr>
<td>OR</td>
<td></td>
</tr>
<tr>
<td>Coconut oil</td>
<td>800 grams</td>
</tr>
<tr>
<td>Canola oil</td>
<td>200 grams</td>
</tr>
<tr>
<td>Caustic soda solution, 35°Be</td>
<td>548 grams</td>
</tr>
<tr>
<td>OR</td>
<td></td>
</tr>
<tr>
<td>Coconut oil</td>
<td>800 grams</td>
</tr>
<tr>
<td>Sunflower oil</td>
<td>200 grams</td>
</tr>
<tr>
<td>Caustic Soda Solution, 35°Be</td>
<td>548 grams</td>
</tr>
<tr>
<td>Essential oil (optional)</td>
<td>20 grams</td>
</tr>
<tr>
<td>Colour (optional)</td>
<td>children’s crayon or oil soluble dye, amount depends on desired intensity of colour</td>
</tr>
</tbody>
</table>
For special effects to convert formula into herbal soap

<table>
<thead>
<tr>
<th>Add at trace:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Aloe vera extract</td>
<td>50 grams</td>
</tr>
<tr>
<td>or lemon extract</td>
<td>50 grams</td>
</tr>
<tr>
<td>or green papaya extract</td>
<td>50 grams</td>
</tr>
</tbody>
</table>

**Soap-making procedure**

The preparation of caustic soda is shown in Table 21 and the preparation of soap is shown in Table 22.

*Table 21. Processing steps and safety measures for the preparation of caustic soda solution*

<table>
<thead>
<tr>
<th>Process Steps</th>
<th>Safety Measures/Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Put on rubber gloves.</td>
<td>Caustic soda flakes should be of high purity and free from metal content. Buy them from chemical suppliers. Do not use caustic soda for cleaning drains. Use rubber gloves when handling caustic soda flakes. Special care should be taken in handling caustic soda flakes as they are highly irritating to the skin.</td>
</tr>
<tr>
<td>b. Weigh 1 kg caustic soda flakes.</td>
<td></td>
</tr>
<tr>
<td>c. Using a graduated cylinder, measure 2.3 litres of water and place in a heat-resistant plastic or stainless steel container.</td>
<td>The water should be as pure as possible. Distilled or filtered rain water is best.</td>
</tr>
<tr>
<td>d. Place the container of purified water over a basin of cold water.</td>
<td>When caustic soda flakes are dissolved in water, they generate a lot of heat so this reaction should be counteracted by the basin of cold water.</td>
</tr>
<tr>
<td>e. Put on eye goggles, gas mask and rubber gloves before mixing the caustic soda solution.</td>
<td>Caustic soda solution is a very corrosive substance and can burn the skin and irritate the eyes. It also emits a lot of fumes in the initial stage of dissolving.</td>
</tr>
<tr>
<td>f. Place vinegar and water nearby to neutralise caustic soda in case of an accidental spill or if the solution comes in contact with the skin.</td>
<td></td>
</tr>
<tr>
<td>g. <strong>ADD CAUSTIC SODA FLAKES TO WATER — NOT WATER TO CAUSTIC SODA FLAKES —</strong> and mix thoroughly until all the crystals or flakes are dissolved.</td>
<td>The mixing of the caustic soda solution should be done in a well-ventilated, open area.</td>
</tr>
<tr>
<td>h. When cool, store the solution in a plastic container. Label it properly.</td>
<td>Lye flakes or crystals and lye solution can be fatal if swallowed so put them out of reach and sight of small children and animals. Keep containers of lye properly labelled and sealed.</td>
</tr>
</tbody>
</table>
Table 22. Processing steps and critical control points for soap-making

<table>
<thead>
<tr>
<th>Process Steps</th>
<th>Critical Control Points/Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Weigh the required amount of oil or fat and place in a mixing bowl.</td>
<td>The oil or fat can be one kind only (e.g. coconut oil, palm oil, beef tallow) or a mixture of different kinds.</td>
</tr>
<tr>
<td></td>
<td>The fatty acid composition of oil determines the quality of soap with regard to cleaning efficiency, lathering properties and moisturising effect. Hence, it is best to mix oils to get the special properties one wants in a soap.</td>
</tr>
<tr>
<td></td>
<td>Always remember that in making soap, weight and not volume is used as a unit of measure.</td>
</tr>
<tr>
<td>b. Weigh the required amount of caustic soda solution prepared as described above.</td>
<td><strong>Please remember all the safety precautions mentioned above when handling caustic soda solution.</strong></td>
</tr>
<tr>
<td>c. Slowly add the caustic soda solution to the oil in the mixing bowl and stir in one direction using a large stainless steel egg whisk or an electric stick blender or an electric hand mixer. Set the speed to 1 or low.</td>
<td>This is done to ensure that the oil and caustic soda solution are mixed properly to undergo the saponification reaction.</td>
</tr>
</tbody>
</table>
| d. Stir continuously for 15 minutes, then stop for 5 minutes. Stir for 5 minutes then stop for 5 minutes. Do this sequence of alternate stirring and resting until the mixture reaches a ‘light trace’ consistency. It is like the consistency of condensed milk. Mixing should be done in one direction only. | The amount of time required for the soap mixture to reach the ‘trace’ stage depends on the fatty acid composition of the oil. Saturated oils like coconut and palm oil reach the ‘trace’ stage more quickly than polyunsaturated oils like soybean and sunflower oils, which take longer to ‘trace’. Coconut oil takes about 45 minutes.  
‘Trace’ is a term in soap-making to describe the consistency (thickness) of soap when it is ready to pour into moulds. When caustic soda solution and fat/oil first combine, the mixture is thin and watery. Gradually, the caustic soda and fat/oil react to form soap. The mixture thickens to a trace consistency and turns opaque.                                                                 |
| e. Add colour to the desired intensity. (The colour can come from crayons melted in oil over a water bath or from oil-soluble dye dissolved in oil. Stir for 5 minutes. | The oil used for dissolving dye or melting with crayons should be taken from the previously weighed oil for making the soap.                                                                                                                                                       |
| f. Add the desired additives (emollients and scents) and stir.                | Fragrance oils or essential oils used as scents should be added at a time when the soap mixture is very near the ‘full trace’ stage to prevent the caustic soda from destroying the scent. |
|                                                                               | If synthetic fragrance is used to scent the soap, please make certain that the fragrance is oil-based and has no alcohol content. The addition of alcohol-based fragrance to the soap mixture will cause it to curdle.                                    |

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**g. Test the soap mixture to see if it has reached the ‘full trace’ stage.**

Drip some soap mixture from a spoon across the surface of the mixture. It should leave a ‘trace’ or a small mound.

Draw a line in the surface of the soap mixture with a spoon or rubber spatula. If a ‘trace’ of the line remains for a few seconds, the soap has traced (Figure 162).

**Figure 162. Appearance of soap mixture at ‘full trace’**

| h. Pour the soap mixture into the soap mould, cover the surface of the soap with plastic or wax paper and allow to stand at room temperature for 24 hrs. | Covering the surface of the soap mixture will prevent it from having white spots on the surface when the soap solidifies.  
24 hours is needed for complete saponification and solidification. |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>i. Remove the soap from the mould and cut into desired sizes.</td>
<td>For smoothly-cut soap, a fabricated soap cutter using guitar chords as the cutting medium can be used (Figure 163).</td>
</tr>
<tr>
<td>j. Stamp, dry and age the soap for at least two weeks.</td>
<td></td>
</tr>
<tr>
<td>k. Pack the soap in desired packaging material and label.</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 163. Soap cutter for rectangular (left) and for circular (right) shaped soaps**

Source: Bawalan and Chapman (2006)
Quality control in soap-making

Soap cannot be made without any alkali solution. The two most common alkali solutions in use for soap making today are caustic soda, or sodium hydroxide (NaOH), and potassium hydroxide (KOH). For bar soap, it is always sodium hydroxide that is used. Potassium hydroxide is mostly used for liquid soap because it produces very soft soap and is slow to trace. Caustic soda is a chemical classified as a strong base; it is highly corrosive and burns the skin. Hence, the amount of caustic soda solution added to oil to form soap should be computed and measured accurately, as any amount in excess will result in soap that has an irritating effect on the skin. The main reason a cold-processed soap is allowed to age for at least two weeks is to make certain that all caustic soda in the soap has reacted completely with the oil.

Based on the foregoing, quality control of soap is always made by measuring its pH value. In layman’s term, pH is defined as a measure of the degree of acidity or alkalinity of a substance where the values are measured on a range of one to fourteen. A neutral substance (neither acidic nor basic), such as water, is given a value of seven. A pH below seven means the substance is an acid and pH above seven means the substance is a base (alkaline). The greater the pH difference from seven, the stronger the acidity or alkalinity of the substance. The strength of an acid or base can be measured by means of a pH meter or (and more quickly) by litmus paper, special paper with chemicals in it that change the colour of the paper depending on the pH of the substance being tested.

To test a bar of soap’s pH, wet the bar in running water and rub the bar with your hands until you get some bubbles or a thin film of liquid soap on the outside of the bar. Wet the litmus paper on it, observe the change in the colour of the paper and compare it to the colour chart that is provided by the manufacturer to determine the pH value. Soap as a general rule is alkaline in nature. However, the pH should not be more than ten. A pH of nine or less is better. If the pH of the soap is more than ten, it will probably cause a burning sensation on the skin. As the soap ages, the pH drops, so it is better to test the pH at the end of the two weeks’ ageing period (for cold processed soap).

A12.2 Aromatherapy/massage oils

This section deals with some formulations for aromatherapy oil that were prepared and tested by the author. All prepared aromatherapy and massage oils should be stored in dark coloured bottles. Thoroughly cleaned and dried cough syrup bottles can be used.

a. Massage oils for relaxation or to relieve stress

<table>
<thead>
<tr>
<th>Formulation a1</th>
<th>Formulation a2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lavender oil – 3 ml</td>
<td>Ylang Ylang Oil – 2 ml</td>
</tr>
<tr>
<td>Virgin coconut oil – 97 ml</td>
<td>Virgin Coconut Oil – 98 ml</td>
</tr>
</tbody>
</table>

b. Deodorising body oil

Lemongrass oil – 2.5 ml
Virgin Coconut oil – 97.5 ml

Author’s Note: The same formulation has also been tested for the prevention of smelly feet; the oil is massaged into the foot and in between the toes before putting on socks.

c. Massage oil for respiration (easy breathing in case of colds)

Eucalyptus oil – 1.5 ml (about 30 drops)
Peppermint oil – 1.0 ml (about 20 drops)
Virgin coconut oil – 97.5 ml

d. Massage oil for rheumatism and muscle pain

Eucalyptus oil – 1 ml
Ginger oil infused virgin coconut oil – 99 ml

Note: Do the oil infusion with ginger by following the procedure discussed in Section 7.2 of the manual.
A12.3 Skin care products

In all of the formulations listed below, it is advisable to do the mixing in thoroughly cleaned and dried heat-resistant glass beakers.

Coconut moisturising jelly (substitute for petroleum jelly)

**Ingredients**
- Virgin coconut oil: 1/2 cup (120 ml)
- Grated beeswax: 30 grams
- Essential oil of choice: 2 ml or depending on desired intensity of scent

**Procedure**
Melt the beeswax slowly in a double boiler or put the container of beeswax in a pan with heated water. Heat the VCO in the same way as the beeswax. Mix the oil and melted beeswax together. Cool to 50°C while stirring constantly. Add the essential oil and stir thoroughly. Put into cosmetic jars and allow to cool.

*Note: Wait for the VCO-beeswax mixture to cool to at least 50°C (warm feel) before adding the essential oil. Otherwise, the scent will be destroyed by heat.*

Lip balm

**Ingredients**
- Cocoa butter: 15 grams
- Grated beeswax: 15 grams
- Virgin coconut oil: 30 grams

**Procedure**
Melt the beeswax slowly in a double boiler or put the container of beeswax in a pan with heated water. Heat the VCO and cocoa butter in the same way as the beeswax. Mix the oil cocoa butter and melted beeswax together. Cool to 50°C while stirring constantly. Add a few drops of peppermint flavouring oil. Put into cosmetic jars and let cool. If you want a softer balm, add more VCO. If you want a harder balm, add more beeswax.

Moisturising body butter

**Ingredients**
- Beeswax: 20 grams
- Cocoa butter: 60 grams
- Sesame oil (deodorised): 20 grams
- Virgin coconut oil: 30 grams
- Olive oil: 10 grams
- Essential oil of choice: 2 ml or depending on the preferred intensity of the scent

*Note: Use deodorised or odourless sesame oil. Virgin sesame oil has a very strong odour which will destroy the scent of the product. Remove from the formulation if you cannot find an odourless sesame oil.*

**Procedure**
Melt the beeswax slowly in a double boiler or put the container of beeswax in a pan with heated water. Add the cocoa butter and blend with the beeswax without removing from the heat. Slowly blend in the oils, one at a time. Let the mixture cool to 50°C and add the essential oil. Blend well. Pour into moulds and cool to solidify.
Glossary

**Alkali** – is a primary ingredient in soap making. This is either caustic soda (sodium hydroxide) or caustic potash (potassium hydroxide). Soap produced using caustic soda is much harder than soap produced using potassium hydroxide. This is why potassium hydroxide is normally used when making liquid soap. Alkali used for soap making should be pure and free from any metal content.

**Ash** – is the residue that remains when a substance is subjected to high heat in the presence of air and all combustible matter is burned.

**Ball copra** – is a dehydrated whole kernel, an edible copra unique to India and certain parts of Sri Lanka. Fully mature, unhusked coconuts are placed in specially constructed ball copra stores or on a wooden platform above the kitchen fire-place just below the roof and allowed to dry for eight to twelve months (Ranasinghe et al. 1980).

**Biochemical oxygen demand (BOD)** – is the quantity of oxygen used by aerobic microorganisms and reducing compounds in the stabilisation of decomposable matter during a selected time at a certain temperature (Frazier and Westhoff 1988). A period of five days at 20°C is generally used and results are expressed in five-day BOD (BOD$_5$). It is the amount of dissolved oxygen needed to decompose the organic matter in waste water; a high BOD indicates heavy pollution with little oxygen remaining for fish (Webster’s New World College Dictionary, 2010).

**Charcoal briquette** – also called patent fuel - is a compacted mass of fuel material made from a mixture of very small charcoal pieces (fines) and a binder and moulded under pressure (FPRDI 1992).

**Chelating agents** – include citric acid, or ethylene diamine tetra acetic acid (EDTA), and are used as soap-making additives. They act as metal scavengers or water softeners, preventing the formation of tub rings when soap is used in hard water.

**Choke** – is the very small opening at the end section of a high pressure expeller which the dried, milled kernel is forced to pass through to effect the extraction of oil. The dried kernel is pushed to this opening through the rotation/movement of a worm shaft, or screw. Adjustment in the choke clearance determines the oil extraction efficiency and the thickness of the coconut flakes.

**Cochin oil** – the coconut oil industry term for semi-refined, copra-derived coconut oil which is generally used for inedible or industrial applications (e.g. raw material for the production of coconut chemicals).

**Coconut flour** – is the ground, solid residue/flakes obtained after extraction of virgin coconut oil from dried, comminuted coconut kernel, or coconut milk residue that is processed under sanitary conditions.

**Coconut milk** – is the white opaque fluid, an emulsion of oil and water, obtained when freshly grated or comminuted coconut kernel is pressed either by manual or mechanical means with or without the addition of water.

**Coconut milk residue** – is the solid material that is left behind when coconut milk is extracted from fresh grated or shredded coconut kernel. It represents approximately 40–52% of the weight of freshly grated kernel on a wet basis, depending on the coconut milk extraction process that is used.

**Coconut shell** – or endocarp - is the hard, stony, dark brown, thin layer between the coconut husk (mesocarp) and the kernel of the mature coconut. It is soft and dark cream in colour when the nut is immature. This is where the coconut kernel is attached.

**Coconut shell charcoal** – is the product derived from carbonisation of coconut shell from fully matured nuts under a limited or controlled amount of air. It contains the highest percentage of fixed carbon of all ligneous charcoal.
Coconut skim milk— is the watery phase which separates out from the coconut cream when coconut milk is allowed to stand for two hours or when it is passed through a two-phase (liquid-liquid) centrifuge. In the centrifuge process of VCO production, coconut skim milk is generated as a by-product, since it is only the separated cream that is processed into VCO. Coconut skim milk has a sweetish flavour characteristic of young coconut. It can be pasteurised, frozen or packed in cans or tetrabrik or passed through a spray dryer to produce coconut skim milk powder.

Coconut water— is the liquid endosperm contained in a central almost spherical hollow of the coconut fruit. This is one of the by-products generated during the processing of coconut kernels. In its natural form, coconut water contains micro minerals and vitamins which are beneficial to human health.

Copa— is the dehydrated/dried coconut kernel, the primary product known in all coconut growing countries of the world. It is the oldest known coconut product and the principal commodity by which farmers normally convert their coconuts into income. Copa-making prevents the spoilage of fresh coconut kernel by greatly reducing its moisture content.

Cup copra— is dehydrated kernel halves, the most common type of copra available in the market. It is produced by drying coconut kernels in their shell (husked or unhusked) by sun drying, kiln drying or a combination of both, and removing them from the shell either after the kernel has partially dried or at the end of the drying operation.

Desiccated coconut— is the pure white, shredded, dehydrated food product obtained from fresh, pared coconut kernel which is processed under very strict sanitary conditions.

Fatty acid— is a term given to substances in which the chemical formula is represented by RCOOH where R is essentially chains of carbon and hydrogen of varying length (e.g. CH₃CH₂COOH). For a detailed discussion on fatty acids, please refer to Annex 1.

Filled Milk— also known as evaporated or reconstituted milk, a liquid milk formulation in which the butterfat in dairy milk is removed and substituted with coconut oil to make the product cheaper, i.e. it is dairy skim milk that is homogenised with coconut oil. It is normally available in Asian supermarkets as canned liquid milk.

Finger copra— is dried kernel in small pieces; the fresh kernel is removed from split unhusked coconuts and dried by kiln drying (direct or indirect) and by sun drying.

Fixed carbon content— the amount of carbon contained in a particular type of charcoal.

FOB— stands for freight on board. A commercial term, it is used in exporting products and means that the quoted price is based on the place of origin, and does not include shipping and insurance costs.

Food safety— is the assurance that food will not cause any harm to the consumer when it is prepared and/or eaten according to it is intended use. It is the achievement of all conditions and the implementation of all measures that are necessary during production, processing, storage, distribution and preparation of food so that it does not present an appreciable risk to health when consumed.

Free fatty acid— is the amount of fatty acid in oil which is not bonded to glycerol. It exists in an uncombined state as a definable chemical unit. The acid content in an edible fat or oil is given by the quantity of free fatty acids derived from the hydrolytic breakdown of the triglycerides which gives the oil the rancid smell. In most vegetable oils, free fatty acids are expressed as percentage acidity calculated as oleic acid (a mono-unsaturated fat). The uncombined fatty acid comes from the breakdown of fat (as triglycerides) into a unit of fatty acid and glyceride. However, for virgin coconut oil, it is expressed in terms of its predominant fatty acid, i.e. lauric acid. The higher the free fatty acid content, the lower the quality of oil.

Foreign matter content— refers to any materials mixed in a batch of specific products which by properties and characteristics of the substance should not be there.

Functional food— refers to any edible substance which provides health benefits aside from the nutrients that it gives to the human body.
Good manufacturing practices – 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 microorganisms so as to be safe for human consumption.

Green copra – refers to the fresh coconut kernel in PICTs in finger-size pieces which are normally taken out from split coconuts by means of a knife or a special tool.

Haustorium – is the creamy/light yellow spongy structure that grows inside the coconut kernel when germination starts (known as vara in Fiji). The longer the germination growth, the bigger the haustorium. The coconut kernel becomes thinner, slimy and rancid as the haustorium grows.

Herbal soap – is a cold-processed soap with added natural plant material/extracts that are known to have a therapeutic or beneficial effect on the skin.

Hot air dryer – is the general term for dryers in which the medium that picks up the moisture from the wet material to be dried is hot air with blower (forced draught) or without blower (natural draught). The technical term is convection type dryers. Heating of the air is done either through steam or a biomass-fired or gas-fired burner attached to a heat exchanger. On the other hand, the DME dryer is an example of a conduction or direct type dryer where heat is directly transferred from the hot metal surface to the wet material.

Hydrogenation – is a process in which hydrogen gas is bubbled through unsaturated oil in the presence of nickel as a catalyst. The resulting reaction forces unsaturated fatty acids to accept additional hydrogen atoms and become partially saturated. Full hydrogenation converts liquid oil into solid fat. Partial hydrogenation limits the time exposure of the unsaturated vegetable oil to the stream of hydrogen gas, thereby converting it either into a semi-solid state similar to butter or retaining its liquid state.

Low fat desiccated coconut – is actually coconut milk residue which is dried under strict sanitary condition. Its protein, fat and sugar content are much lower than the traditionally known full fat desiccated coconut. Its selling value is its lower fat and high dietary fibre content.

Moisture content – is a measure of the amount of water that is physically bound in a particular solid or substance and that can be removed to a certain extent by directly or indirectly heating the substance.

Moisture content in coconut oil – is a measure of the amount of water expressed as a percentage that is left adhering or entrained in the oil molecules after extraction and post processing of oil. It has to be kept at the lowest level possible and preferably totally removed because it causes deterioration in the shelf-life or keeping quality of the oil.

Monolaurin – the monoglyceride of lauric fatty acid (i.e. lauric acid linked glycerol on a 1:1 ratio). It is available commercially in pellets and capsule form in the United States. It is produced by reacting lauric fatty acid crystals with glycerol under specified conditions. The resulting product is then purified using a molecular distillation process.

Nutraceuticals – are natural food components that provide health benefits or reduce the risk of chronic disease above and beyond their basic nutritional function. In layman’s term, nutraceuticals are substances which not only nourish but also heal.

Peroxide value – is a measure of the extent of oxidative absorption and entrainment of oxygen in a fat or oil. The peroxide content present in an edible fat or oil indicates its state of primary oxidation and its tendency to go rancid. The lower the peroxide value, the higher the quality of the oil.

pH – is defined as a measure of the degree of acidity or alkalinity of a substance where the values are measured on a range of 1–14. A neutral substance (neither acidic nor basic), like water, is given a value of 7. A pH below 7 means the substance is an acid and a pH above 7 means the substance is a base. The greater the pH difference from 7, the stronger is the acidity or alkalinity of the substance.
**RBD coconut oil** – refers to refined, bleached and deodorised coconut oil derived from copra. The crude coconut oil is subjected to chemical refining, bleaching and deodorisation processes after oil extraction to make it fit for human consumption. RBD coconut oil is generally used as cooking oil in the Philippines.

**Sanitation Standard Operating Procedures** – is a set of activities related to the sanitary handling of raw materials, food products, work areas and equipment. It ascertains that conditions prescribed by GMPs are met by plant facilities and operations.

**Sinusinu** – is the Fijian term for the proteinaceous residue or coagulated coconut protein that forms when coconut milk is boiled. It is a by-product of the traditional process of producing coconut oil, and currently does not have market value but is used as toppings for rice cakes and as an extender for meat-based food recipes.

**Soap** – is the solid material obtained when an alkali reacts with the fatty acids in animal, vegetable and seed oils and fats under a process known as saponification. The type of oil or fats used defines the characteristics of the resulting soap, i.e. whether it is mild or drying to the skin, whether it will form good lather, whether it will have good detergency or cleaning properties, etc.

**Soap noodle** – is a semi-processed substance composed of fatty acids with carbon chains ranging from C_{12}–C_{18}. It is produced by removing the glycerol component and the fatty acids with carbon chains C_{6}–C_{10} of coconut oil through a steam hydrolysis and distillation process.

**Trace** – is a soap-making term that describes the consistency (thickness) of soap when it is ready to pour into moulds.

**Trans fatty acids** – are artificially altered, unsaturated, fatty acids in which hydrogen atoms attached to the carbon atoms linked with the double bonds have shifted position from the same side (cis) to the opposite side (trans). This happens when unsaturated oils like soybean and corn are subjected to the partial hydrogenation process. This process straightens the fatty acid molecules to enable them to be ‘packed’ in solid form like saturated fats, while remaining unsaturated (www.ucap.org.ph).

**Vinegar** – is generally defined as an alcoholic liquid that has been allowed to sour. It is considered one of the oldest fermentation products known to man (Banzon et al. 1990). Coconut water vinegar is one type of vinegar that uses coconut water as starting material.

**Virgin coconut oil (VCO)** – is the oil obtained from the fresh, mature kernel of the coconut by mechanical or natural means, with or without the use of heat, without undergoing chemical refining, bleaching or deodorising, and which does not lead to the alteration of the nature of the oil. VCO is suitable for consumption without the need for further processing. VCO is the purest form of coconut oil, water white in colour, containing natural Vitamin E and not having undergone atmospheric or hydrolytic oxidation, as attested by its low peroxide value and low free fatty acid content.

**Volatile combustible matter content** – is defined as the water and other organic matter that are released as a result of various chemical reactions which occur when biomass is heated in the presence of limited air. The volatile matter in charcoal (other than water) is composed of all those liquid and tarry residues not fully driven off in the process of carbonisation.
In addition to the stock knowledge of the author, the following publications were valuable resources.


Carbonell, M.D. (ed.). 1979. Technical data handbook on the coconut, its products and by-products, a compilation. Philippine Coconut Authority, Quezon City: Research Coordination and Documentation Center, Corporate Planning and Information Office. 324 p.


PCA (Philippine Coconut Authority). nd. Spectrum of coconut products. Philippine Coconut Authority.


Websites visited

eAudrey’s Luxuriant Soap and Homemaking: www.eaudrey.com (10 February 2005)

The Asia and Pacific Coconut Community: www.apccsec.org (13August 2010)

The APCC member countries include: Federated States of Micronesia, Fiji, India, Indonesia, Kiribati, Malaysia, Marshall Islands, Papua New Guinea, Philippines, Samoa, Solomon Islands, Sri Lanka, Thailand, Vanuatu and Vietnam. Jamaica is an associate member of the APCC.

Organic Certification Center of the Philippines: www.occpphils.org/organic-agriculture.htm (16 August 2010)

The United Coconut Associations of the Philippines: www.ucap.org.ph (20 August 2010)

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Engr. Divina D. Bawalan is a Chemical Engineer by profession and is a free lance international consultant on coconut processing and utilisation since September 2004 to the present. She has more than 20 years’ accumulated knowledge of the coconut industry in the Asia-Pacific Region. She has been in the forefront of VCO technology development and transfer since 2001 when the Philippines introduced VCO onto the world market. As early as 1990, when VCO was still an unknown commodity, she was conducting production trials using different processes to produce white coconut oil while still a senior science research specialist of the Philippine Coconut Authority.