

REVIEW ON PRODUCTION AND POTENTIAL APPLICATIONS OF VIRGIN COCONUT OIL

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Abstract

Oils and fats are playing major role in human diet and health applications, coconut oil which is widely used as food source and in the manufacture of soaps, hair oil, cosmetics and other industrial products. Coconut oil is the major oil producing more than 93 countries in the world and serving to the human in different ways. Virgin Coconut Oil (VCO) differs from the commercial coconut oil in the way of its processing, normally extracted from fresh coconut kernel without any chemical processes, it is abundant in vitamins, minerals and anti-oxidants, thus making it the 'mother of all oils'. VCO is a edible grade value added product from coconut with numerous applications for mankind. VCO has its remarkable role in the different fields like food, Medicine, Cosmetics and Nanotechnology. Due to these applications it is considered as valuable oil. Ample researchers published different production methods and application of VCO in different fields of science. In the production of VCO there are different process were reported, in the process different solid and liquid products are producing as the byproducts. In this review production methods and their applications in food, medicine, nano-technological, cosmetic applications and physical and chemical characters were reviewed. Finally different by-products from the VCO production and their reported potential applications are also included.

Key words: Food applications, Medicinal applications, Nano-technological applications, Value added product, Virgin Coconut Oil.

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1. INTRODUCTION

Coconut (*Cocos nucifera* L.) is a tropical palm tree, which is widely distributed throughout Asia, Africa, Latin America and in Pacific regions. It can thrive as long as 100 years and its internationally traded major products are tender nuts, fresh coconuts, desiccated coconut, cup copra, coconut oil, oil cake (poonac), and copra meal (Prasad NBL et al. 1991).

The Coconut palm bestows multiple benefits to human beings. It serves as the major source of food, energy and cash income to multitudes of farm houses holds spreading over 93 countries where it is presently cultivated (Chan E et al. 2006). Several methods are reported traditionally for removing oil from coconuts has been commercially successful. In solvent extraction, though oil recovery is high, the process is rarely applied owing its high risk and high investment cost. So far, wet process technique has not been commercially successful because of poor oil recovery, high

moisture content, dark color, short shelf life and the process consumes more time and energy (Manisha DebMandal et al. 2011).

In recent years, new value-added products (VAP) from coconuts are becoming more popular among the consumers. Among the newly emerging value added products from coconut, newest high value product is the VCO, which is gaining popularity in the western world, USA and other developed countries. Various literatures available on VCO today, considered it as healthy and nutritive oil having qualities for using in therapeutic applications. The present demand for VCO is for use as a food supplement, nutraceutical, body moisturizer, carrier for aroma therapy etc. VCO is extracted from the fresh coconut, closest to its natural form without subjecting to any chemical or physical changes. VCO extracted by wet or dry process is developed very little of free fatty acids (<0.1%) and has sweet natural coconut flavour. VCO has great appeal to health conscious consumers.

Therefore, there is a large potential to develop VCO as an important product in functional health food sector in the world market (Dayrit CS, 2005).

This review paper presents an overview of the current status and recent trend of ongoing research in VCO. Brief explanations were given on the reported methods used to produce VCO are described. The results of published works on VCO were further reviewed which focused on physicochemical properties, their clinical, food and other applications.

1. Concept of virgin coconut oil

An emerging product of economically importance obtained from the coconut, both in the domestic and international market was the VCO (Corpuz P, 2004). The Philippine National Standards (PNS), Bureau of Product Standards (BPS) defines VCO as 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 deodorizing and which doesn't lose any of its natural properties (Blanca J. Villarino, et al. 2007). Other than Lauric acid (C12:0), VCO contains considerable amounts of short-chain fatty acids such as C6:0, C8:0 and C10:0 acids which were also investigated to have antimicrobial and antiviral effects (German. JB et al. 2009; Van Immerseel F et al. 2004 and Delmo GC, 2004). VCO has been claimed to have numerous beneficial health effects (Villariba C, 2003; Villariba C, 2004).

2. Production of VCO

Production of VCO was reported by different researchers in both dry and wet methods. In dry methods ball copra was used for the VCO production, in wet methods fully matured coconut was used.

2.1. Dry methods

Silveria MJS et al. (2004) were reported that the VCO production by employing small equipments like hydraulic press and table expellers where maintaining low temperature and pressures. In Sri Lanka, hydraulic press was used for the production of VCO. In such process testa was removed for ball copra and pressed for the oil extraction by using different

equipments. Further extracted oil was filtered to obtain pure VCO. Finally the efficiencies of such methods were not satisfied due to the application of low pressure and temperature, which not allows extraction of much oil from copra. In this method residual coconut meal is contain more amount oil content.

Neela Satheesh, NBL Prasad (2012a) was published a paper on the production of VCO by wet and dry methods and characterization of produced VCO. In this study authors are produced VCO from the three methods like Rotary ghani (power ghani), hydraulic press and table expeller where low temperature and heat is produced. From these three processes they reported the yields are around 36% and finally concluded that dry methods also suitable for the production of VCO.

In the dry methods, the yield of the process was reported very less and it is a laborious process to production of VCO in dry process so further researchers were concentrated on the wet methods for the production of VCO.

2.2 Wet methods

Different parameters were involved in the production of VCO by wet methods.

2.2.1. Use of enzymes: Raghavendhra SN et al. (2011) produced VCO by using of enzymes. In this reported process coconut milk was extracted, treated with an enzyme (protease) at different concentrations and centrifuged in order to separate it into coconut cream and aqueous phases. Subsequently, coconut cream was subjected to chilling (different temperatures) and thawing to ambient temperature ($29 \pm 2^{\circ}\text{C}$) followed by centrifugation to obtain a clear VCO. Physicochemical properties and fatty acid compositions were evaluated and compared with existed APCC standards and concluded that the VCO produced in this process showed good quality.

2.2.2. Low temperature methods

Nevin KG et al. (2008) to produce VCO, solid endosperm of the matured coconut was crushed, made into viscous slurry and squeezed through cheese cloth to obtain coconut milk which was refrigerated for 48 h. After 48 h the milk was subjected to mild heating (50°C) in a

thermostat oven and VCO obtained was filtered through cheese cloth.

Hamid MM et al. (2011) were reported that during the production of VCO by wet process, fresh coconut meat was collected and mechanically pressed to obtain coconut milk. Milk obtained was kept at 10⁰C for separation of coconut butter and water. Later, it was heated at 45⁰C, oil was centrifuged, separated and it was reported that 30-40% oil was obtained.

2.2.3. Fermentation methods

Neela Satheesh et al. (2012b) reported a study on production of VCO by fermentation. In the study extracted coconut milk was fermented with the probiotic *Lactobacillus sp.*, after specific fermentation time VCO was separated by the centrifugation. They were also studied the effect of different fermentation conditions on the yield of VCO.

2.2.4. Other traditional methods

Regulation of heating and natural fermentation of extracted coconut milk was the other two traditional methods used in the household and industrial levels were reported by Divina D. Bawalan (2002). Extracted coconut milk is subjected to low temperature to separate oil from emulsion. In natural fermentation process extracted coconut milk was allowed to ferment naturally for 2-5 days, and then separated VCO was collected and filtered.

3. Applications of VCO

VCO has different applications for food, Nano technological, therapeutic use. The following potential applications were reported.

3.1. Application of VCO as food ingredient

Choo SY et al. (2010) reported a research on substitution of milk fat with VCO to produce nutritious ice cream with pleasant coconut flavor and aroma. Finally concluded from the study that formulations with VCO were more popular in terms of appearance, aroma, texture, flavor and overall acceptability.

Submersed chicken in VCO was showed the high storage stability at room temperatures (Aritonang S N et al. 2009). In the study, such stored chicken was reported in reduced moisture content and microbial number. Mike Foale (2003) reported in his publication that,

VCO is acting as a major ingredient in the high quality cooking lotions, drinks etc., due to its special flavor and aroma properties.

Marikkar JMN et al. (2007) reported a paper on Assessment of the stability of virgin coconut oil during deep-frying. In the study VCO taken in an electrically operated open fat fryer and heated at 180⁰C for a period of 8 h. During frying, samples were withdrawn from the fryer at specified time intervals to monitor the changes in free fatty acid (FFA) content, peroxide value (PV), total polar compound (TPC) and anisidine value (AnV) using standard test methods. Experimental results reported that there was a tendency for the increase of FFA, PV, TPC, and AnV of all three oils. However, the values of these parameters corresponding to VCO were found to be lowest throughout the 8 h frying operation.

3.2. Applications in nano particle preparation

Reza Zamiri et al. (2011) reported that a laser ablation of a silver plate immersed in VCO was used for the fabrication of silver nano-particles. A Nd: YAG laser at wavelength of 1064 nm was used for ablation of the plate at different timings. VCO was allowed for formation of nano-particles with well-dispersed, uniform particle diameters which were stable for a reasonable length of time. Finally, concluded that preparation of silver nano particles by using VCO was an environmental friendly process.

VCO has recently become a more popular new raw material in the cosmetic industries (Sarmad A Edresi et al. 2009) since VCO-in-water, a nano-emulsion in the form of cream stabilized by an emulsifier, was prepared by using the Emulsion Inversion Point method.

3.3. Medicinal Applications of VCO

Administration of VCO has showed significant antithrombotic effect when compared to coconut oil. The antioxidant and vitamin levels were found to be higher in VCO fed laboratory animals than the animals fed with the sunflower oil. Dietary administration of VCO reduced the cholesterol and triglyceride levels and maintained the blood coagulation factor

levels. These properties of VCO may be attributed to the presence of biologically active unsaponifiable components, they are, vitamin E, pro-vitamin A, polyphenols and phytosterols in it (Nevin G et al. 2006).

An open-label pilot study was reported by Kai Ming Liau et al. (2011) for the investigation on VCO efficacy in weight reduction and its safe use in 20 obese but healthy Malay volunteers. By the utilization of VCO only waist circumference (WC) was significantly reduced with a mean reduction of 2.86 cm or 0.97% from initial measurement. Conclusion was drawn from the study that VCO was efficient for WC reduction and it is safe to use in humans.

VCO fed to the laboratory animals for 45 days along with a semi-synthetic diet and compared to coconut oil as control to determine Influence of virgin coconut oil on blood coagulation factors, lipid levels and LDL oxidation in cholesterol fed Sprague Dawley rats. After the experimental period, results have shown that polyphenol fraction from VCO was found to have more inhibitory effect on microsomal lipid peroxidation when compared to other oils. VCO with more unsaponifiable components viz. vitamin E and polyphenols than coconut oil exhibited increased levels of antioxidant enzymes and prevented the peroxidation of lipids in both in vitro and in vivo conditions (Nevin KG et al. 2008).

Hery winarsi et al. (2008) noted that, disturbance on the immune system and deficiencies of Zinc were the two factors which often trigger vaginal candidiasis in patient. Zn enriched VCO served to the patients group with two tablespoon per day resulted in enhance of different immune cells concentrations.

The anti-inflammatory, analgesic and antipyretic effects of VCO were assessed by acute inflammatory models; VCO showed moderate anti-inflammatory effects on ethylphenyl propiolate induced ear edema in rats and carrageenin and arachidonic acid induced paw edema. VCO exhibited an inhibitory effect on chronic inflammation by reducing the transudative weight, granuloma

formation, and serum alkaline phosphatase activity. VCO also showed a moderate analgesic effect on the acetic acid-induced writhing response as well as an antipyretic effect in yeast induced hyperthermia (Intahphuak S et al. 2010).

Nevin KG et al. (2010) evaluated healing property of VCO by monitoring the time taken for complete epithelization. In this study VCO-treated wounds healed much faster, as indicated by a decreased time of complete epithelization and higher levels of various skin components. A histopathological study showed an increase in fibroblast proliferation and neovascularization in VCO-treated wounds compared to controls.

A randomized double-blind controlled clinical trial was reported by Agero AL et al., (2004) on mild to moderate xerosis. The patients were randomized to apply both VCO and mineral oil on the legs twice a day for two weeks. VCO was proved to be effective and safe than mineral oil when used as a moisturizer.

Zakaria ZA et al. (2011) determined the hepatoprotective effect of MARDI-produced virgin coconut oils, prepared by dried or fermented-processed methods. In this study, paracetamol-induced liver damage in rats was developed. Liver injury induced by 3 g/kg paracetamol increased the liver weight per 100 g bodyweight indicating liver damage. Histological observation also done to confirms liver damage. Interestingly, pretreatment of the rats with 10, but not 1 and 5, mL/kg of both VCOs significantly reduced the liver damage caused by the administration of paracetamol, also it is further confirmed by the histological findings. In finally concluded, VCO possessed hepatoprotective effect, proposed that requires further in-depth study.

Olufunke O. Dosumu et al. (2012) carried an experiment to evaluate the possible protective effects of virgin coconut oil on alcohol-induced oxidative stress and serum lipid values in rats. In this experiment, animals were provided with 30% ethanol (7 ml/kg body weight/day) while 6.67 ml/kg body weight/day of VCO was administered for 4 weeks using a cannulated syringe. Results were reported that

administration of VCO improved the antioxidant status by decreasing the levels of malondialdehyde (MDA) and altering lipid profile levels to near normal. Sperm count, motility and serum testosterone levels were also significantly increased when compared with the alcohol-only treated group.

Zil Hayatullina et al. (2012) determined that oxidative stress and free radicals have been implicated in the pathogenesis of osteoporosis. Therefore, antioxidant compounds have the potential to be used in the prevention and treatment of the disease. In this study, investigated the effects of VCO on bone microarchitecture in a postmenopausal osteoporosis rat model, three-month-old female rats were randomly grouped into baseline, sham-operated, ovariectomized control (Ovx), and ovariectomized rats fed with 8% VCO in their diet for six weeks (Ovx+VCO). Results were obtained as rats supplemented with VCO had a significantly greater bone volume and trabecular number while trabecular separation was lower than the Ovx group. In conclusion, VCO was effective in maintaining bone structure and preventing bone loss in estrogen-deficient rat model.

Mahadevappa Siddalingaswamy et al. (2011) pointed that VCO has been shown to possess insulinotropic effects shown in isolated perfused mouse islet with hypolipidemic effects. VCO possess better antioxidant properties and these properties were exploited to study the anti-diabetic effects of VCO diabetic rats. Four groups of 8 rats each, first group served as non-diabetic control remaining groups were made diabetic and force fed with 2 ml alcoholic extracts of commercial coconut oil and VCO for 21 days. Blood glucose once in 5 days, body weight gain, food intake once in a week and water intake and urine output daily, were monitored. Animals were sacrificed at the end of 21 days examined. The results indicated that VCO reduced blood glucose and lipids viz total cholesterol (TC), tri- glycerides (TG), Low and Very Low Density Li- poprotein (LDL + VLDL) and thiobarbutyric acid reactive substances (TBARS) increased the antioxidant status by elevating activities of

anti- oxidant enzymes such as superoxide dismutase (SOD), catalase, glutathione peroxidase (GSH- Px), glutathione (GSH) concentration and de-creased lipid peroxidation in liver. These beneficial effects may be attributed to increased polyphenolic and other antioxidants content present in VCO.

Kusmandar Anggadiredja et al. (2011) reported that Nicotine is an addictive substance with detrimental effects on health. Several measures have been developed to help addicts quit smoking, yet the rate of increase in number of smokers does not seem to have slow down. In this current study investigated the effect of VCO on nicotine dependence and relapse using Conditioned Place Preference paradigm in rats. Finally results were showed that VCO and diclofence significantly decreases the preference to nicotine-paired compartments to those of preconditioning level in both preference tests. Finally, concluded that VCO prevents nicotine dependence as well as relapse. These results further lay foundation for development of potent agents for nicotine dependence.

Virgin coconut oil was administrated at 6.7 ml/kg body weight, while alcohol was given orally at 7 ml/kg body weight to determine the Influence of virgin coconut oil (VCNO) on oxidative stress, serum testosterone and gonadotropic hormones (FSH, LH) in chronic ethanol ingestion. Finally from the study concluded that the VCO effectively lowered alcohol-induced oxidative stress by reducing testicular malondialdehyde levels and ameliorated the deleterious effect of alcohol on serum testosterone level, but showed no effect on serum FSH and LH levels (Dosumu, O. O et al. 2010)

4. VCO as Massage Oil

It was reported that a blend of different essential oils (lemon oil, eucalyptus oil and lavender oil) and VCO was used to prepare massage oils. Physical and chemical properties as well as microbial analysis of the massage oil properties were assessed to evaluate quality characteristics of the preparation. Finally concluded that, VCO and its massage oil products were considered safe for customers

since they were free from microbial contamination (Sarunyoo Songkro et al. 2010).

3.5. Antimicrobial Property of VCO

VCO used in the fusion method, oil in water (o/w) creams were formulated at concentrations of 5 to 40% w/w of oil. Some investigations has reported by Oyi AR et al. (2010) that the release of active ingredients from creams using cream challenge and skin inoculation tests, thereby the creams were exposed to various spots on skin inoculated with *P. aeruginosa*, *E. coli*, *P. vulgaris*, *B. subtilis* and *C. albicans*. In addition *A.niger* and *S. aureus* were used for antimicrobial screening. The creams were also found to be stable and have the ability to withstand shock and to maintain their physical characteristics.

Inhibition property of VCO against *Candida sp.* obtained from clinical specimens was reported by Ogbolu DO et al. (2009). *C. albicans* was the most common isolate from clinical specimens and others were *C. glabrata*, *C. tropicalis*, *C. parapsilosis*, *C. stellatoidea* and *C. krusei*. Among all, *C. albicans* had the highest susceptibility (100%) to VCO and use of VCO in fungal infections is much beneficial in view of emerging drug-resistant *Candida sp.* Catap ES et al. (2013) reported *Oreochromis niloticus* is the most important aquaculture species in the Philippines. High demands of fish products and intensification of pond cultures have subjected these fishes to various environmental stress that lead to infectious pathogens, such as *Aeromonas hydrophila*. Hence, immunomodulators such as *Ganoderma lucidum* and VCO were considered as means to control infection and prevent fish mortality. Two separate controlled experiments had conducted to assess the effects of powdered *G. lucidum* and VCO in *O. niloticus* injected with *A. hydrophila*. Fish were infected with *A. hydrophila* after 30 days of feeding with either VCO or *G. lucidum*. Blood samples, head kidneys phagocytes and splenic lymphocytes were harvested at days 8 and 15 post-infection and were used to assay phagocytosis activity, lysozyme levels, and reactive oxygen species (ROS) production and lymphocyte proliferation were measured at day 15. Finally the results

showed that oral feeding of either powdered *G. lucidum* or VCO enhanced some nonspecific immune responses.

Yuniwart EYW et al. (2012) aimed to find preventing alternative of avian influenza (AI) disease in broiler chicken by increasing body immunity. Fatty acid in virgin coconut oil was potential as immunostimulant, which therefore could increase chicken immunity through the increase of lymphocyte T and Th-CD4. In such study used 40 one-day-old broiler chickens. Four levels of VCO namely 0, 5, 10, 15 mL/kg feed. Feed and water were given for four weeks. The result showed that the number of lymphocyte and Th-CD4 in chickens given 10 mL per kg feed and vaccinated with AI was higher than that in chickens given VCO without AI vaccine.

4. Characterization of VCO

A study was reported on VCO available in the Malaysia and Indonesia analyzed for its chemical characteristics and fatty acid composition. Significant difference was present in the C12:0 content (46.64-48.03%) among VCO samples. The major triacylglycerols obtained from the oils were LaLaLa, LaLaM, CLaLa, LaMM and CCLa (La, Lauric; C, Capric; M, myristic). All the chemical compositions were within the standards for VCO. Total phenolic content of VCO samples (12.18 mg GAE/100 g oil) were significantly reported (Marina AM et al. 2009a) higher than RBD CNO (6.14 mg GAE/100 g oil). VCO was as good as RBD CNO in chemical properties with the added benefit of being higher in phenolic content.

It was reported that VCO has gained wide attraction among the public and scientific community as functional food oil (Marina AM et al. 2009 b). From the health point of view, VCO has been documented as oil with more beneficial effects in clinical trials such as more antioxidant potential when compared to refined CNO. The underlying justification was based on the fact that VCO did not undergo RBD process, which destroys some of the biologically active components such as phenolic compounds. Also attention was made by the investigators to develop the methods

used for the detection of adulteration in VCO (Fabian M. Dayrit et al. 2007).

Virgin coconut oil currently holds a higher price than refined coconut oil. Because of its value, virgin coconut oil is prone to be adulterated by oils of less value. Thus, a rapid and efficient method for the detection of adulteration needs to be developed for virgin coconut oil. Methods for monitoring adulteration in virgin coconut oil using Fourier transform infrared (FTIR) spectroscopy (Marina AM et al. 2007) and Differential Scanning Calorimetry (DSC) (Marina AM et al. 2009c) have been developed recently. Marina AM et al. (2010) had demonstrated the prospect of using zNose™ electronic nose as a tool to detect adulteration of virgin coconut oil. Excellent results were reported for the differentiation between pure and adulterated samples down to the 1% detection limit.

Finally concluded from the study, these techniques have the potential to be implemented in routine quality control because it allows rapid sample differentiation without having to acquire detailed knowledge on the compositions of the headspace of the analyzed samples. Moreover, the method is convenient, nondestructive and requires no usage of toxic chemicals. To avoid the fraud from the manufactures different standardization organizations like Codex Alimentarius, APCC and Philippine National standards given the specification for VCO, these specifications are presented in table 1.

5. Waste and By-products in VCO Production

The following major waste and by-products were obtained in the VCO production process.

5.1 Coconut Water

Coconut water (coconut liquid endosperm) was one of the world's most versatile natural products which have wide applications (Olurin EO et al. 1972; Goldsmith HS, 1962; Eiseman B, 1954). This refreshing beverage was consumed worldwide as it has nutritious and beneficial effects on human health. There was increasing scientific evidences (Pradera ES et al. 1942; Anurag P et al. 2003 & Alleyne T et

al. 2005) that support the role of coconut water in health and medicinal applications. Coconut water was traditionally used as a growth supplement in plant tissue culture micro-propagation. There were wide range of reported applications (Jean WH Yong et al. 2009) of coconut water which can be justified by its unique chemical composition of sugars, vitamins, minerals, amino acids and phyto-hormones.

5.1.1 Composition of Coconut Water

It was reported that tender coconut water was sterile and used as a short term intravenous hydration fluid in remote areas during armed conflicts. It was also conceivable to use tender coconut water for Total Parenteral Nutrition (TPN) under similar circumstances. Patients on TPN need elemental supplementation. Although data analyses on the major elements (calcium, magnesium, potassium, sodium, and phosphorus) in tender coconut water were found to be abundant (Georg A. Petroianu et al. 2004).

Mandal SM et al. (2009) reported that three novel antimicrobial peptides of >3KDa weight were identified, isolated and purified from tender coconut water by using reverse-phase HPLC. Isolated peptides were extremely efficient against both pathogenic Gram-positive and Gram-negative bacteria (*E. coli*, *B. subtilis*, *P. aeruginosa*, *S. aureus*) and the three dimensional structures were also determined for these isolated protein and there is no similarity with any existed protein structures.

5.1.2 Applications of Coconut Water

Medical resources routinely used coconut water for intravenous hydration and resuscitation of critically ill patients which were limited only to remote areas of the world. It was reported (Jean WH Yong et al. 2009) that the successful use of coconut water as a short-term intravenous hydration fluid for a Solomon Island patient was done.

Nneli RO et al. 2008 reported that the coconut water effectively reduces the ulcers. The results showed that coconut milk and water via macroscopic observation had protective effects on the ulcerated gastric mucosa.

The effect of coconut water with paracetamol toxicity on some liver enzyme markers Aspartate Amino Transferase (AST), Alanine Amino Transferase (ALT) and Alkaline phosphatase (ALP), and total protein, urea total bilirubin and conjugated bilirubin were reported (Nwodo OFC et al. 2010). The accepted food yeast *Saccharornlices fragilis* grown in batch and chemostat culture using simulated coconut-water medium containing glucose, fructose, sucrose and sorbitol was reported (Smith ME et al. 1976) and

supplementation of coconut water with biotin and nicotinic acid increased the biomass yield in chemostat cultures.

It was reported (Joelia Marques de Carvalho, et al. 2007) that a blended beverage consisting of coconut water and cashew apple juice containing caffeine showed good acceptability, but the formulation with 12.5% cashew apple juice and 87.5% coconut water reached the highest hedonic scores and all formulations showed good microbiological quality.

Table1. Different Standards for Virgin Coconut oil

S. No	Parameter	APCC*	Codex Alimentarius	Philippine National Standards
1.	Fatty Acid Composition (%)			
	C6:0	0.4-0.6	ND-0.7	ND-0.7
	C8:0	5.0-10.0	4.6-10	4.6-10
	C10:0	4.5-8.0	5.0-8.0	5.8.0
	C12:0	43.0-53.0	45.1-53.2	45.1-53.2
	C14:0	16.0-21.0	16.8-21.0	16.8-21
	C16:0	7.5-10.0	7.5-10.2	7.5-10.2
	C18:0	2.0-4.0	2.0-4.0	2.0-4.0
	C18:1	5.0-10.0	5.0-10.0	5.0-10.0
	C18:2	1.0-2.5	1.0-2.0	1.0-2.5
	C18:3	< 0.5	ND-0.2	ND-0.2
	C20:0	< 0.5	ND-0.2	ND-0.2
	C20:1	< 0.5	ND-0.2	ND
C20:2-C24:1	< 0.5	ND	ND	
2	Identity characteristics			
	Relative density at 30°C	0.915-0.920	0.908-0.921	NA
	Refractive index at 40°C	1.4480-1.4492	1.448-1.450	NA
	Moisture Wt % max	0.1-0.5	0.2	0.20
	Insoluble impurities %	0.05	0.005	NA
	Saponification value	250-260(min)	248-265	NA
	Iodine value	4.1-11.0	6.3-10.6	NA
	Unsaponifiable matter%	0.2-0.5	<1.5	NA
	Specific gravity at 30°C	0.5	NA	NA
	Acid value	NA	10	NA
	Polenske value	13	NA	NA
3	Quality characteristics			
	Color	Water clean	NA	NA
	Free fatty acids	0.5%	NA	0.20
	Peroxide value	≤ 3meq/kg	NA	3.0
	Total plate Count	< 10 cfu	NA	NA
4	Contaminants			
	Matter volatile% at 105°C	0.2	0.2	0.20
	Iron (mg/kg)	5	5.0	5.0
	Copper (mg/kg)	0.4	0.4	0.40
	Lead (mg/kg)	0.1	NA	0.10
	Arsenic (mg/kg)	0.1	NA	0.10

NA= Not Available, ND=Not detectable.

*=Asian Pacific Coconut Community

Results have shown that the great difference among the formulations of cashew apple juice has occurred due to the vitamin C content variability (Pummer S et al. 2001) have shown that the coconut water was not only used as a short-term intravenous hydration and resuscitation fluid, it was investigated that it can also show influence on plasma coagulation in vitro.

5.2 Coconut Deoiled Meal

Boceta NB et al. (2000) reported that coconut flour was rich source of amino acids. Marketing research showed (Masa DM, 1996) that coconut flour could be marketed to manufacturers of noodles, biscuits, breads, cakes, and snack items. This may be due to its good quality and functional properties. The respondents found (Trinidad P. Trinidad et al. 2006) that coconut flour can be used as a basic ingredient or as a base material.

Crude protein content of Extracted Coconut Meal (ECM) was reported (Moorthy M. et al. 2009) to be 22.75%. Ether extract (2.89 %) in coconut meal was rich in short and medium chain fatty acids. These short and medium chain fatty acids were found to have remarkable physiological nutraceutical benefits such as anti-histamines, antiseptics and promoters of immunity. Cows fed with coconut meal have shown more chances to have these fatty acids in their milk (Nutraceutical milk). The glutamic acid and arginine contents were high in coconut meal in which arginine react with lysine and reduces its availability. When extracted coconut meal was included in compounded cattle feed there was a necessity to supplement lysine and methionine for yield of more milk.

5.3 Application of Whey Generated in the Production of VCO by Fermentation

During the production of VCO by fermentation, large amounts of whey i.e., waste water containing little coconut cream and coconut pulp was generated. This could be effectively employed along with other types of bio-wastes such as fish waste and fruit peel for the production of bio-extract (Sudarut Tripetchkul et al. 2010).

6. CONCLUSION

VCO has acquired wide appeal among the public and scientific community as functional food oil. From the health point of view, VCO has been documented as having more beneficial effects in clinical applications such as having more antioxidant potential compared to refined coconut oil. The fundamental explanation was based on the fact that VCO did not undergo the RBD process, which destroys some of the biologically active components such as phenolic compounds. People in different countries using the VCO as the part of their food. VCO have their immense role in the cosmetic industry, part of massage oils. VCO is also taking part in the advance technology like nano technologies for formation of nano particles and nano emulsion creams. A number of studies confirmed the higher content of phenolic contents, which correlated with higher antioxidant activity in VCO, compared with refined coconut oil. Focus was also addressed by investigators in developing methods for detection of adulteration in VCO. The overall knowledge improvement allowed the identification of suitable new techniques to better differentiate VCO from other vegetable oils, especially from refined coconut oil. From the VCO industry different by-products were producing but, they really have beneficial applications. Finally, VCO has wide choice to do research on production and their potential applications in different fields.

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