Antibacterial Effect of Virgin and Refined Coconut Oils on Pathogenic Bacteria: A Review

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Abstract

Virgin coconut oil (VCO) is the most oldest edible oil, extracted from fresh and mature kernel using wet or dry methods, therefor the resulting oil is a pure, clear, and colorless with a scent of fresh coconut, these characteristics make VCO has the preferableness in medical and health applications, over refining coconut oil (RCO) that is extract from kernel of coconut after drying by methods makes the oil refining, bleaching and deodorizing. In spite of that, the chemical compositions particularly the fatty acids in both VCO and RCO are the same with no significant difference. MCFAs which are classified as MCTs, are the basic components in both VCO and RCO, these MCFAs particularly lauric acid (LA) following by capric and caprylic acids playing a great role in antimicrobial activity of coconut oil, therefor the extraction of these fatty acids are show more antibacterial activity on pathogenic bacteria more than lipolyzed VCO or VCO itself that may not show inhibition effect. Gram positive bacteria is more sensitive than gram negative one towards LA and other fatty acids, therefor these fatty acids at high concentrations showed inhibition effect on gram negative bacteria, while at low concentration showed resistance. This study attempts to review the chemical components in both VCO and RCO based on their extraction methods, also the antibacterial activity and the mechanism of action, also suggests that RCO has the same effect as antibacterial as VCO based on their chemical compositions.

Keywords: *Virgin coconut oil, Refined coconut oil, Medium chain fatty acids, Antibacterial activity.*

Introduction

Coconut nucifera commonly known as Coconut, is a member of the Arecaceae family, coastal tropical countries like Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam are considered the native of coconut tree cultivation [1,2], "tree of life" referred to the tree of coconut and all parts of this tree could be consumed by humans or animal and transformed into many products like brushes, ladle, spoon and house furniture [3]. The oval rough coconut fruit consist of the outer hard thin skin (exocarp), fibrous thick layer (mesocarp), hard core (endocarp), white kernel (endosperm), and a big cavity suspended with a thick, sweet albumen liquid called coconut water, the development of endosperm layer will give arise the flesh meat edible coconut or kernel, after drying of flesh coconut it would be called copra, which is a source of coconut oil extraction. Coconut oil is an oldest edible oil that was used in tropical countries for thousands years ago, which is extract from the fresh kernel or meat of coconut after maturation, that make coconut oil can be easily homemade that would be give natural oil and chemical free treatment, and with its low oxidation point making coconut oil stable for two years of storage without any oxidation process could be occur as the presence of saturated fat also it has long validity, stable in high heat and melting point from 23º to 26ºC, that makes coconut oil very healthy for backing and deep-fry [4-8].

The natural creamy and soft texture of VCO is well known for skin and hair care using [9], and also used in cosmetics industry such as prepare natural shampoo, scents making, soaps, massage oils, aromatherapy and many other beauty and cosmetic products [10,11]. VCO

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has very strong benefits in health and medical fields that make it very useful in weight loss, digestion, healing and infection, aid in prevention liver disease, dissolve stone of kidney, pancreatitis treatment, diabetes treatment and the most important fields include antibacterial, antiviral, antiparasitic, antifungal, anticancer, antidermatophytic, antioxidant, anticaries and disinfectant activities [12,13].

Coconut oil

Coconut oil can be classified into VCO and RCO. According to Philippine National Standard VCO the definition of VCO is the oil that obtained from fresh and mature kernel of the coconut, either by natural or mechanical methods in the presence of heat or not, without chemical refining, bleaching and deodorizing, and which does not lead to the changing the oil nature [14]. VCO is pure oil, clear and colorless, with a scent of fresh coconut, which depends on the method of production oil. Two mains procedures can be used to extract VCO, which are wet and dry procedures, in wet procedure VCO is obtained by pressing fresh and mature coconut by manual or mechanical methods with water addition or without, that forming the milky fluid coconut mixture from this coconut milk VCO can be obtained, in wet method it should be avoiding dry of coconut kernel, after that VCO is produced by three mains methods; modified kitchen, modified natural fermentation and fresh-wet centrifuge methods. In dry method VCO is obtained immediately from fresh coconut kernel, after dried the kernel partially under controlled heat for reaching the moisture to 10-13% and then mechanically pressed the kernel for obtaining the oil, dry method including; low pressure oil extraction, high pressure expeller and fresh-dry centrifuge methods [15-18], these methods that is used in VCO extraction makes it very useful without losing the nature of VCO or the active natural components like vitamins especially vitamin E, polyphenols and antioxidants [17,19]. On the other hand RCO is extracted from dried coconut kernel ''copra'', the drying process could be by using sun, smoke, or hot air, the obtained oil should be purified to make it appropriate for consumption, therefor the oil is must be chemical refined, deodorized and bleached, the heat is using for deodorizing the oil and for bleaching and the oil is filtered by clays to separate impurities, while using of sodium hydroxide to separate free fatty acids that make coconut oil has long shelf life, these processes will remove some characteristics of the oil [20], and that makes the resulting RCO is yellow color, no odor and no taste [21], whereas VCO which has not any refining, deodorizing or bleaching processes, makes it is the unique form and more useful which can be used in many applications in health and medical fields as compared with RCO that has traditional use [17,22].

Composition of VCO and RCO

One tablespoon of coconut oil supply 121 kilocalories, 13.7 gram fat, no protein, no carbohydrate, and very few amount of vitamins or minerals, that was reported by the National Nutrient Database published by the United States Department of Agriculture. About 99.9% of coconut oil is fatty acids (FA) and 91.9% of these fatty acids are saturated fatty acids (SFA), followed by 6.4% for monounsaturated fatty acid (MUFA) acids and 1.5% for polyunsaturated fatty acids (PUFA), and there is no dietary cholesterol [23]. The most predominate (SFA) is Lauric Acid (LA) about 50% and could be reached 56% depending on the variety of the coconut [17], this is followed by other fatty acids [12,24,25]. The standard quality of FAs compositions for coconut oil was reported by Codex Alimentarius [26], while for VCO was reported by Asian and Pacific Coconut Community (APCC) [27], it was also reported the value of iodine, percentage of free fatty acid (FFA), moisture, volatile matter and the value of peroxide as shows in Table 1.

VCO cannot be differentiated from RCO by the compositions of FAs as reported by, even the VCO was obtained from different methods for extraction, their no significant differences in fatty acid profile for various types of coconut oil when compared with the results of the Codex standards for coconut oil and the APCC standards for VCO [28,29],that means, the processing methods does not affect the profile of Fas[30], while the deferens are being that VCO has higher FFA, volatile matter, moisture, and lower peroxide value compared to RCO, which also comes with the Codex and APCC standards[29], these values determine the quality of VCO in addition to the color, odor and taste[17,31], FFA is the most crucial and important characteristic in the VCO producing and sales of products [32].

The saturation degree and fatty acid carbon chain length in any oil or fat will assist in determination of its characteristics, uses and impacts on human health, and VCO contains about 91.9% of SFAs 50% of it is LA as mention previously in this study, LA is a medium chain free fatty acids (MCFAs), and classified as medium chain triglycerides (MCTs), with 12 carbons chain (C12), followed by other MCFAs such as like caproic

(C6), caprylic (C8), capric (C10), including lauric acid (C12), and long chain fatty acids (LCFAs) myristic (C14), palmitic (C16), palmitoleic (C16:1), stearic (C18), oleic (C18:1), linoleic (C18:2), and linolenic (C18:3) [33,34]. About two thirds of fatty acids in coconut oil is a saturated MCFAs, while LCFAs which is also saturated comprise fewer than the third and about tenth for the unsaturated one [35]. Coconut oil is the unique oil from other vegetable oils because it's the one that 50% of fatty acids in it is LA [24,25].

Table 1: Standard parameters of quality of Codex Alimentarius for coconut oil and APCC for VCO compared with VCO and RCO values.

Parameters	Codex standard for coconut oil	APCC standard for VCO	VCO products (Dayrit et al, 2007)	RCO products (Dayrit et al, 2007)
% C6:0 Caproic acid	ND–0.7	0.4–0.6	0.24–0.56 (0.40)	0.32–0.59 (0.41)
% C8:0 Caprylic acid	4.6–10.0	5.0–10.0	4.15–9.23 (7.23)	5.32–8.83 (6.61)
% C10:0 Capric acid	5.0–8.0	4.5–8.0	4.27–6.08 (5.21)	4.56–6.03 (5.00)
% C12:0 Lauric acid	45.1–53.2	43.0–53.0	46.0–52.6 (48.66)	46.7–49.4 (48.14)
% C14:0 Myristic acid	16.8–21.0	16.0–21.0	16.0–19.7 (17.82)	16.2–19.6 (17.88)
% C16:0 Palmitic acid	7.5–10.2	7.5–10.0	7.65–10.1 (8.51)	7.80–9.73 (8.88)
% C18:0 Stearic acid	2.0–4.0	2.0–4.0	2.73–4.63 (3.50)	2.94–3.69 (3.26)
% C18:1 Linoleic acid	5.0–10.0	5.0–10.0	5.93–8.53 (7.16)	7.24–8.04 (7.63)
% C18:2 Linolenic acid	1.0–2.5	1.0–2.5	1.00–2.03 (1.52)	1.82–2.36 (2.19)
Iodine value	6.3–10.6	4.1–11.0	5.6–10.3 (7.28)	6.81–8.91 (8.00)
% FFA, as lauric acid	No standard	≤0.5	0.047–0.337 (0.131)	0.008–0.076 (0.021)
% Moisture	No standard	0.1–0.5	0.05–0.11a (0.08)	0.01–0.10a (0.05)
% Volatile matter	0.2	0.2	0.07–0.18c (0.13)	0.00–0.08c (0.03)
Peroxide value, meq/kg oil	<15	<3	0.00–1.86 (0.56)	0.27–3.39 (0.98)

a By Karl–Fisher titration.

b Mass loss at 105 °C.

c Mass loss at 120 °C.

Antibacterial activity of VCO

MCFAs that are found in coconut oil make this oil has potential role as antibacterial, antiviral, and antifungal activities [36], particularly LA and its other derivatives of MCFAs with carbon chains C6 to C12 gave the coconut oil its antimicrobial activity [37] against gram positive, therefor many studies showed the antibacterial effect of LA on *Staphylococcus aureus* and *Bacillus cereus*, while the activity of MCFAs and LCFAs with various carbon chain length (C8-C18) could not show inhibition effect against a number of gram negative bacteria [38-40] on the other hand studies reported the antibacterial effect of LA against gram negative bacteria such as *Neisseria gonorrhoeae*, *Chlamydia trachomatis, Helicobacter pylori* [41-44]. But still antibacterial activity of LA has great effect against gram positive bacteria when compare with gram negative bacteria, that is reported by a study performed by Abbas *et al*., 2017[45] that the esterified LA from coconut oil at different dilutions showed the antibacterial activity at highest dilution with largest inhibition zone for *Staphylococcus aureus* and *Streptococcus pneumoniae* followed by lowest inhibition zone for *Salmonella spp.*, *Mycobacterium tuberculosis* and *Escherichia coli*, while at lowest concentration, *Staphylococcus aureus* and *Streptococcus pneumonia* showed lowest inhibition zone compared with *Mycobacterium tuberculosis*, *Escherichia coli* and *Salmonella spp.*, that are showed resistance at the same lowest concentration, other study also reported the antibacterial the largest inhibition zone of extracted LA at different concentration for *Staphylococcus aureus*, *Streptococcus spp*. and Lactobacillus and the lowest inhibition for *Escherichia coli* which is also showed the resistance at the lower concentration of LA, in this study the same species showed resistance towards the coconut oil, which mean the extracted LA is more effect than coconut oil as antibacterial agent [46].

Antibacterial mechanism of VCO

The specific mechanism for the VCO as antibacterial agent is not detected and stilled unknown, the suggestion was that the metabolizing of the VCO makes it release its component of MCFAs, like caprylic, capric, and lauric acids, which are have the antimicrobial action [47], and LA is the most effected one, the integration of MCFAs of VCO into the bacterial cell membrane induce the solubilization lipids of the membrane which lead to disintegrate the bacteria cell wall [47,48], the disruption of bacterial cell membrane was indicated by the studies of electron microscope, which demonstrated the lysis of *Streptococcus agalactiae, S. aureus Clostridium albicans, C. perfringens,* and *C. trachomatis* when are exposed to the fatty acids of VCO [49,50]. VCO and its fatty acids showed the antibacterial effect on *Clostridium difficile* and the most action was belong to LA (C12) which is the predominant one, and followed by capric (C10) and caprylic (C8) acids, which are represented about 9% and 6% for each respectively according to Codex and APCC, these two fatty acids (Capric and caprylic acid) were showed less antibacterial action, while the activity of VCO towards *C. difficile* was abcent, but when coconut oil was lipolyzed showed the inhibition action on *C. difficile* [51]. The lipolyzing of MCTs by lipase and water leading to glycerol, diglycerides, monoglycerides and FFAs forming [52], the antimicrobial action belongs to monoglycerides and free fatty acids [49,50,53] and the less activity belongs to triglycerides, diglycerides and glycerol [48], therefor when VCO is lipolyzing by lipase to release its fatty acids and exposed the cells of *C. difficile* to this lipolyzing VCO had the inhibitory effect on the growth of bacteria at 0.15–1.2% of lioplyzing VCO while no effect for non-lioplyzing one, there were inhibitory effect of lauric, capric and caprylic acids individually for each, the most effect was for LA at concentration 1000 μM, these fatty acids integrate with lipid bacterial membrane works on disruption of bacterial cell membrane [48,51].

Conclusion

Many studies were reported the chemical components of in VCO and RCO with no significant difference in both, whatever the extraction methods were used. In the other hand the antimicrobial activity was also reported of the extracted fatty acids from VCO especially LA and followed by capric acid and caprylic show while no activity for caproic acid because it comprise about 0.5%, this low content of it makes it shows no antimicrobial activity. Coconut oil fatty acids were showed the antibacterial activity particularly on gram positive bacteria and in low effect for gram negative in specific concentrations for several species, that indicate using fatty acids in high concentration shows antibacterial activity on gram negative bacteria, which makes the antibacterial action was no longer for gram positive but also for gram negative bacteria, and as the both types of VCO and RCO have the same

chemical compositions with no significant difference as mentioned previously, that suggests the RCO has the same mechanism as antibacterial activity as VCO.

Conflict of Interest: we declare that there is conflict of interest

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