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Review Article

Extraction process, Chemical properties, molecular mechanism of *Cocos nucifera* – an overview

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ABSTRACT

Coconut is having highly importance due to its versatile uses. For food its ball copra, coconut oil is used, which is having high quantity of in medium chain fatty acids. Extraction process of Virgin coconut oil (VCO) is diverse globally. This virgin coconut oil is significant in various pharmacological activities viz. anticancer, anti-diabetic, anti-inflammatory, anti-microbial, anti-oxidant, hypocholesterolemic, moisturizing properties etc. as per safety concern it has been long used food supplement with no recorded side effect or adverse event. But still coconut oil consumption is undervalued, although all of its health benefits, due to a scarcity of scientific data. This review throws light on health benefits, extraction process, Chemical properties, and molecular mechanism.

Background

In India coconut tree (*Cocos nucifera Linn*) known as the *Kalpavriksha* (a wish-fulfilling divine tree), may be so as each part of the tree is valuable in terms of food, medicinal properties, household uses. [01] To promote the integrated development of coconut and coconut related products, the Indian government set uped Coconut Development Board, in Kerala. Virgin coconut oil (VCO) is the naturally processed, chemically free and additive free product from fresh copra/ khobra (coconut's white, inside karnel) or its derivatives (coconut milk and coconut milk residue), which has not undergone any chemical processing after extraction. VCO is an oil with colorless, sediment-free, having natural coconut fragrance, free from unpleasant rancid taste or odor properties. [02] Ready to consume without further processing. The VCO contains medium-chain triglycerides which are resistant to peroxidation, also lauric acid (45-55%) as main fatty acid. Along with lauric acid monolaurin are significantly effective against a variety of viruses, gram-positive bacteria, and fungi. [03-08] Some major pharmacological activities of VCO are anti-cancer, anti-convulsing, anti-diabetic, anti-histaminic, anti-inflammatory, anti-microbial, and anti-oxidant. VCO is safe for long term consumption as food or supplementary. [09, 10]

Search Methodology

The literature review is done by using *PubMed*, Scopus and Google scholar, and other internet search engines up to of June 30, 2021. The keywords were used for data extraction and retrieval as following in combination with virgin coconut oil - LD50, cancer, sources, extraction process, cancer targets, formulations, cardiac arrest, organ protective agent, PPAR, oxidative stress, hepatoprotection, tumour proliferation, anti-inflammatory, hypertension, anti-microbial, brain, neuropathy pain, gastroenterological, kidney, renal, nephrotoxicity, nephropathy, heart, toxicity, toxic dose, clinical trial, covid 19, corona virus, Mucormycosis, dermatitis, chemical constituents etc. Nearly all the associated and cross-reference articles were screened and pertinent data was extracted.

Discussion

Extraction Process of VCO-

There are a variety of methods reporting in various articles as follows -

Dry methods

In mill employed process testa was removed for ball copra; sun dried for four

days then pressed for oil extraction using mill. 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 contains more amount oil content. Neela Satheesh and NBL Prasad published a paper on the extraction of VCO using both wet and dry methods, as well as the characterization of the VCO that was made. The authors of this study produced VCO using three methods: Rotary *Ghani* (power *Ghani*), hydraulic press, and table expeller, all of which generate low temperature and heat. They recorded yields of around 36% from these three processes and concluded that dry methods are also suitable for the production of VCO. The yield of the dry methods was stated to be very low, and it is a laborious process to produce VCO in the dry system, so further research was focused on the wet methods for the production of VCO. [11]

Wet methods

Wet methods generated VCO using a variety of parameters.

Use of enzymes

Raghavendhra SN et al. used enzymes to make VCO. Coconut milk was collected, treated with an enzyme (protease) at various concentrations, and centrifuged to isolate the coconut cream and aqueous phases in this process. After that, the coconut cream was chilled (at various temperatures) and then thawed to room temperature (29°C), accompany by centrifugation to achieve a transparent VCO. The physicochemical properties and fatty acid compositions of the VCO produced in this process were evaluated and compared to existing APCC requirements, resulting in the conclusion that the VCO produced in this process were of good quality. [12]

Low-temperature methods

To make VCO, crushed the matured coconut's strong endosperm, made viscous slurry, and squeezed it through cheesecloth to obtain coconut milk, which was then refrigerated for 48 hours. After 48 hours, the milk was heated to 50°C in a thermostat oven, and the VCO was filtered via cheesecloth. [13] Fresh coconut meat was collected and mechanically pressed to obtain coconut milk, during the development of VCO by wet process. [14] To separate the coconut butter from the water, the milk was held at 10°C. It was then heated to 45°C, the oil was centrifuged and separated, and 30-40% oil was collected, according to reports.

Fermentation methods

In processing of VCO by fermentation, extracted coconut milk was fermented with the probiotic Lactobacillus sp., and VCO was separated by centrifugation after a particular fermentation period. They also looked into the impact of different fermentation conditions on VCO yield. [15]

Other traditional methods

VCO is also extracted by subjecting the coconut milk to heat or by allowing the extracted milk to ferment naturally for 2 to 5 days and then separate the oil which gets separated from water. [16]

Chemical Properties and Chemistry

Gas Liquid Chromatography (GLC) ranges of Fatty Acid Component of virgin coconut oil shown in Table.1 are as per the International coconut community. [02] Coconut oil differs from other fats and oils in that it is composed predominantly of medium-chain triglycerides. The composition of Fatty acids in VCO as determined by Gas Liquid Chromatography include Saturated fats: Lauric acid (45% to 56%), Myristic acid (16% to 21%), Palmitic acid (7.5% to 10.2%), Caprylic acid (4% to 10%), Capric acid (4% to 8%), Stearic acid (2% to 4%), Caproic acid (0.10% to 0.95%) and Palmitic acid (7.5% to 10.2%) and Unsaturated fats: Oleic acid (4.5% to 10%) and Linoleic acid (0.7% to 2.5%). VCO is colourless, free of rancidity, and has a specific fresh natural coconut aroma.

Common name	Compo -sition	%
Caproic acid	C 6:0	0.10 – 0.95
Caprylic acid	C 8:0	4 – 10
Capric acid	C 10:0	4 – 8
Lauric acid	C 12:0	45 – 56
Myristic acid	C 14:0	16 – 21
Palmitic acid	C 16:0	7.5 – 10.2
Stearic acid	C 18:0	2 – 4
Oleic acid	C 18:1	4.5 - 10
Linoleic acid	C 18:2	0.7 – 2.5

The toxic dose of Virgin coconut oil

In the assessment of toxicity of fermented virgin coconut oil, female and male Sprague Dawley rats were administered with FVCO by oral gavage in dosage 5000mg/kg (acute oral toxicity study), 175 mg/ kg, 550 mg/kg, and 2000 mg/kg for 28 days (sub-acute) and 90 days (chronic), respectively. The treated animals were safe with all the dosages of FVCO in acute, sub-acute, and chronic toxicity models. [10]

Molecular Mechanisms of VCO -

Effect on Inflammatory Mediators

The accumulation of nephrotoxic agents in the kidney causes inflammation and cell death by interfering with the work of various organelles such as mitochondria, lysosomes, endoplasmic reticulum, nuclei, and cell membranes. A polyphenolic fraction from virgin coconut oil (PV) inhibited edema at a dose of 80mg/kg in complete Freund's adjuvant-induced arthritis in rats. PV effectively decreased the inflammatory genes such as s COX-2, iNOS, TNF-α, and IL-6 and the concentration of thiobarbituric acid reactive substance which were elevated due to intradermal injection of complete Freund's adjuvant. [17] VCO treatment at 4000mg/kg for 7 days in the cotton pellet-induced granuloma rat model effectively decreased transudative weight which is the indication of inhibitory effect on the permeability of the vascular endothelium. [18] Varma et al. reported the anti-inflammatory and skin protective benefits of VCO in vitro. VCO effectively lowered the levels of TNF-α, IL-6, IL-8, IL-5, and IFN-γ in THP-1 (Human monocytes). [19]

Effect on Oxidative Markers

The development of superoxide anion radicals (O2•), hydroxyl radicals (•OH), and peroxyl radicals (ROO•) is caused by aerobic metabolism, UV radiation, and pollution. The oxidation of biomolecules such as lipid membranes, proteins, and nucleic acids is caused by persistently high levels of ROS. In various in vitro and in vivo animal models, Virgin coconut oil has been shown to have free radical scavenging activity against free radicals that cause oxidative stress. Due to its powerful anti-oxidant and free radical scavenging properties, virgin coconut oil has been shown to counteract the negative effects of various environmental toxins or xenobiotics that cause oxidative damage and organ dysfunction, as well as contribute to the pathogenesis of various diseases. Virgin coconut oil supplementation effectively improved the oxidative stress parameters. Virgin coconut oil markedly improved the levels of serum superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx), and levels of reduced glutathione (GSH). [20-25] SOD is a crucial detoxification enzyme that converts superoxide anions to hydrogen peroxide and oxygen. As a result, it serves as the first line of anti-oxidant defense. VCO has been shown to improve SOD activity. [24] VCO showed free-radical scavenging activity in-vitro in 1,1-diphenyl-2-picrylhydrazyl (DPPH) assay. Thiobarbituric reactive substances (TBARS) assay of the phenolic extract of VCO showed the inhibition of lipid peroxidation. The oily form was not used

in the assay because of its non reactivity to the solvent system. [26]

Anti-obesity effect

Obesity has become a major global health problem as a result of changing lifestyles and eating habits. In many countries, it has reached epidemic proportions, posing a significant public health threat. [27] The fact that MCFA has higher energy expenditure than LCFA is the most compelling argument for using it to lose weight. VCO contains a larger proportion of water-soluble MCTs which are easily hydrolyzed by lipase and absorbed through the intestine and directly sent to the liver to be rapidly metabolized into energy without storing in adipose tissue. [28] Hence, this is thought to decrease the basal metabolic rate. [27-29] Although VCO has recently gained attention as a source of weight loss, still, it is a controversial topic due to the effect of saturated fatty acids and their association with cardio vascular diseases. Studies have indicated some promising outcomes on the use of VCO as an MCT oil to promote weight loss, despite its high content of saturated fat. [30] However, the fatty acid profile of VCO is different from the MCT oils used in studies. The majority of MCTs in VCO comes from lauric acid. Classification of lauric acid as MCFA is still controversial due to clinical studies pointing out the lower percentage of lauric acid directly transported to the liver. [29] However, Kinsella et al., 2017 revealed that VCO cannot be promoted as an MCT oil since it depicts the different effects on food intake and satiety. In Support, Maher et al., 2017 also reported that MCT oils are better in fullness perception compared to VCO. [31, 32] Nevertheless, few clinical studies done on the impact of VCO consumption on body weight control showed positive outcomes. In a study of 40 women with abdominal obesity, supplementing with 30 ml (2 tablespoons) of VCO per day led to a significant reduction in both body mass index and waist circumference within 12 weeks. [27] A pilot study by Liau et al., 2011 reported a dosage of 30 mL of VCO for four weeks has reduced the weight circumference significantly among male subjects. But according to the results, there was no change in lipid profile among the men. Hence the study failed to conclude the impact of VCO consumption on weight control. [33] Further, Valente et al., 2018 evaluated the effect of consumption of VCO and extra virgin olive oil on energy metabolism, fat oxidation rates, and cardio metabolic risk markers in 17 women aged between 19 to 42. The authors reported that there was no difference in the above parameters studied between the two groups yet lower hunger suppression, satiety, and total

fullness were observed for the VCO ingested group. Still, the experimental duration in the study brought a limitation in concluding the beneficial effect of the VCO. [34] In another review by Clegg, 2017 on VCO consumption and weight loss concluded that there is no enough evidence to support the beneficial effect of VCO consumption and weight loss. [35] Therefore, consumption of VCO as a weight controlling method remains unsupported by enough scientific evidence. [29] The administration of daily 12ml virgin coconut oil boosted HDL cholesterol and decreased the TC/HDL cholesterol ratio in adults with obesity, according to a controlled, randomized clinical trial. [36]

Gastro Protective Effects

Gastric acid secretion and gastro-duodenal defense are in a physiologic equilibrium under normal circumstances. Aggressive factors such nonsteroidal anti-inflammatory medicines (NSAIDs), Helicobacter pylori infection, alcohol, bile salts, acid, pepsin, a weakened defense mechanism, and mucosal injury that can lead to ulcers can all disrupt this balance. Plant oils have been demonstrated to have significant benefits against peptic ulcer disease in investigations. The authors noted significant lowering of ulcer lesion indices (ULI) in VCO-treated groups when compared to Aspirin and HCl/Ethanol-induced gastric ulcer murine models. But there was no significant difference in ulcer lesion indices of different groups treated with 5 and 10 ml/kg of VCO. Histological studies have shown improvement in ulcer lesions in VCO-treated groups. [37] Adeniyi et al. investigated the effect of hot extracted VCO in loperamide-induced constipation in rats. Constipation affects people of all ages and is a common gastrointestinal condition. The 0.6 mL/kg/day VCO was found to be more effective than the 0.9 mL/kg/day VCO. The treated groups increased fecal pellets, the weight of wet feces, the weight of dry feces, and water content of feces than the loperamide +Normal saline group. [38] In male Wistar rats, VCO at concentrations of3, 6, and 9 ml/kg body weight showed a protective effect against indomethacin (100 mg/kg bwt) induced gastric ulcer by a significant increase ($p<0.05$) in packed cell volume (PCV), hemoglobin level, red blood cell count, significant decrease ($p<0.05$) in HDL-cholesterol, TAG concentration, and total cholesterol level compared to a control group. The VCO (9ml/kg bwt) showed a statistically significant reduction ($p<0.05$) in the gastric juice volume and showed a focal area of mucosal ulceration with evidence of healing by fibrosis when compared with the positive control group. [39] Meng et al. concluded that VCO shows a possible

association with antioxidant properties to control the regulation of prostaglandin synthesis and protect against reactive oxygen species damage. Virgin coconut oil significantly ($p<0.05$) inhibited the ulceration in cold restraint stress, piroxicam, ethanol, and pylorus ligation induced ulcer rat models. VCO significantly increased glutathione (GSH) and nitrite levels, whereas levels of SOD, GP, MDA, and CAT were significantly ($p<0.001$) reduced by VCO and increased the level of prostaglandin in rat tissue homogenate, similar to the omeprazole treated groups. [40]

Anti-Hyperglycemic Effects

There was a general belief that saturated fats might induce insulin resistance in humans, which leads to the development of metabolic disorders such as diabetes. On the contrary, VCO is found to exert anti-diabetic properties by balancing blood sugar levels. A Comparative Study by Siddalingaswamy et al. on the protective potential in a streptozotocin-induced diabetic model using methanolic extract (1:4;V:V) of hot extracted VCO (HEVCO), cold-pressed VCO(CEVCO), commercial CO (CCO) showed that 2 ml methanolic extract of HEVCO to be better hypoglycaemic and insulin-sensitizing agent comparing to other coconut oils used. The HEVCO effectively reduced blood glucose and lipids viz total cholesterol (TC), triglycerides (TG). Low and very-low-density lipoprotein and thiobarbituric acid reactive substances increased the antioxidant status by elevating activities of antioxidant enzymes such as superoxide dismutase (SOD), catalase, glutathione peroxidase (GSH-Px), glutathione (GSH) concentration, and decreased lipid peroxidation in the liver than CEVCO. [41] In a study by Mitic-Culafic et al., VCO did not decrease the diabetes-induced hyperglycemia, but it increased the abundance of probiotic bacteria, such as Lactobacillus, Allobaculum, and Bifidobacterium species in a stool sample of the rats. [42] VCO effectively improved the glucose metabolism and dyslipidemia in insulin-resistant rat models induced by a high fructose feed diet. The animal's fed VCO diet had only a 17% increase in blood glucose level compared to coconut oil-fed animals (46%). [43] VCO effectively reduced hyperglycemia in alloxan-induced diabetic rats and significantly improved antioxidant status and lowered the levels of malondialdehyde in animal models. [24, 44-47] VCO also showed its effectiveness in diabetic wound healing. Histological analysis showed increased collagen deposition with intact epidermis in the VCO treated group compared to decreased collagen deposition with damaged epidermis in both non-treated and silver

sulfadiazine (SS)- treated groups. Also, the normal group showed more fibroblasts and myofibroblasts compared to VCO and SS- treated groups. [48] The findings in these studies have provided an insight into the therapeutic properties of virgin coconut oil which could serve as a benchmark for clinical trials.

Safety Profile -

VCO is found safe for long term utilization. [09, 10]

Conclusion

Though VCO is utilised since ancient times, accurate molecular mechanism through which VCO exerts its affirmative, significant effects remains unidentified. VCO can be consumed in its natural form without any further processing, so for diverse health benefits it can be utilized as neutraceutical, supplementation and additives. Considering its various chemical, biological, pharmacological properties with safety profile it must be undergone through unbiased clinical trials for used in treating nCoV-2019 patients.

Abbreviation

VCO = Virgin Coconut Oil

Conflict of interest statement

Nil

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