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Virgin coconut oil – its methods of extraction, properties and clinical usage: a review

Y.L. Rao[1], M.M. Pai[1], P.R. Krishnaprasad[2], M.V. Pai[3], B.V. Murlimanju[1], A.Mohan[4], L.V. Prabhu[1], R. Vadgaonkar[1]

[1]Department of Anatomy, Kasturba Medical College, Mangalore, Manipal Academy of Higher Education, Manipal, Karnataka, India, [2]Department of Orthopaedics, Kasturba Medical College, Manipal-576104, Manipal Academy of Higher Education, Manipal, Karnataka, India, [3]Department of General Surgery, Kasturba Medical College, Mangalore, Manipal Academy of Higher Education, Manipal, Karnataka, India, [4]Fourth Semester Medical Student, Kasturba Medical College, Mangalore, Manipal Academy of Higher Education, Manipal, Karnataka, India.

Y. Lakshmisha Rao (ORCID ID: 0000-0002-9951-1606), Mangala M. Pai (ORCID ID: 0000-0001-6995-5807), P.R. Krishnaprasad (ORCID ID: 0000-0002-3595-6227), B.V. Murlimanju (0000-0003-1248-8296), Abhay Mohan, Manohar V. Pai (ORCID ID: 0000-0003-0765-6507), Latha V. Prabhu (ORCID ID: 0000-0002-1386-0099), Rajanigandha Vadgaonkar(ORCID ID: 0000-0001-5577-495X)

Abstract

Virgin coconut oil (VCO) is a processed edible oil, which is removed from the mature coconuts. It is a colourless water insoluble liquid and obtained by the hot and cold extraction processes. The nutritional components of VCO are mainly contributed to by lauric acid, its primary content. VCO has shown its anticancer, antimicrobial, analgesic, antipyretic and anti-inflammatory properties. Because of these medicinal properties, VCO has gained the wider attention among the medical field. Most evidently VCO has shown its potential antioxidant property, because of its phenolic compounds and medium chain fatty acids. It is one of the beneficial compounds used to prevent and treat the oxidative stress induced neurological disorders like stress, depression and Alzheimer's disease. Dietary supplementation of VCO is easy and economical and safer in daily life among all age groups. It is also beneficial for the cardiovascular, respiratory, dermatological, reproductive and bone health. It can also be applied to the skin as a moisturizer in the paediatric age group. Hence, exploration of antioxidant property as well as other beneficial effects of VCO in various health conditions will be valuable. ***Clin Ter 2024; 175 (2):83-91 doi: 10.7417/CT.2024.5037***

Key words: *virgin coconut oil, antioxidant, oxidative stress*

Introduction

Prevention and management of neurodegenerative disorders is a challenge to the medical profession for years together. Oxidative stress, caused by the Reactive Oxygen Species (ROS) is one of the major factors leading to neurodegeneration. Exposure to oxidants and subsequent mitochondrial dysfunction is the key pathology in neurodegenerative diseases like Alzheimer's and Parkinson's diseases (1). Certainly, endogenous antioxidants present in the brain can protect the neurons up to some extent. Additional support by the exogenous antioxidants are essentially required to protect the neurons effectively. The polyphenol compounds which are present in the plants, fruits and vegetables are effective radical scavengers, due to their natural chemical structure and are considered as antioxidants. Virgin Coconut Oil (VCO), which has polyphenol component, is becoming a popular antioxidant in the market (2, 3). According to Silva et al. (4), VCO helps in the transport of bio active compounds and acting as a structured lipid system. The oxidative stress resulting in DNA damage may lead to disorders like cancers, cardiovascular disorders, osteoporosis etc. (5-7). Hence the antioxidant property of VCO could be beneficial in treating the various disorders caused by the oxidative stress.

The coconut (*Cocos nucifera Linn*) crops secure major role in tropical regions as important source of food and economic shelter (8-10). VCO is a processed, edible oil extracted from the mature coconuts (11, 12). Traditionally, the VCO is used as a skin moistener. VCO has shown its anticancer, antimicrobial, analgesic, antipyretic and anti-inflammatory properties, and gained the attention in the medical field (9, 11, 13-15). The in vitro anti-microbial effects of VCO was reported by Bergsson et al. (16) and according to them, the fatty acids present in VCO is also responsible for the anti-bacterial and anti-viral properties. It is also used in cosmetic and biomedical manufacturing. However, the most evident property of VCO is the antioxidant property, which is because of its medium chain fatty acids and phenolic compounds (17). The dietary supplementation of VCO is easy and economic as well as safer in the daily life among all the age groups. Here, we attempt to explore the chemical property, method preparation and clinical use of VCO, especially its antioxidant property as the exploration of antioxidant property as well as the other beneficial effects of VCO in various health conditions is necessary.

Correspondence: M.M. Pai, MD, Professor, Department of Anatomy, Kasturba Medical College, Manipal academy of Higher Education, Mangalore – 575001, India. Telephone No. - 91 824 2211746, Telefax No. - 91 824 2421283, Email: mangala.pai@manipal.edu

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The VCO is being emerged as a potential 'miracle food' as it promotes the health like decreasing the body mass index, lowering the low-density lipoprotein, preventing the cardiovascular risks and anti-inflammation. However, literature survey did not reveal much narrative reviews about the detailed clinical indications of VCO and this was the stimulus to formulate this review. The objective of this review article is to explore in detail about the methods of extraction, physical properties, chemical composition and therapeutic implications of the VCO in the modern medicine.

Methods of extraction of VCO

The VCO will be extracted from the coconut, by shredding and cold compressing the coconut meat (9). The most popular and traditional methods of extraction of VCO are hot extraction and cold extraction processes. However, both of these methods have their own advantages and disadvantages, like low yielding of oil and losing their natural chemical components (8). The extraction method of oil has a major influence on the quantity and quality of the obtained oil (18, 19). The extraction of VCO with controlled temperature method, is more effective in terms of retaining its biologically active substances like tocotrienols, squalene and tocopherols (20). Since the properties of VCO are certainly influenced by the extraction methods, the knowledge of its various methods of extraction has to be explored. However, along with the method of extraction, the other factors like harvesting season, location, age of the tree etc., can also influence the chemical property of this oil (21, 22).

Cold extraction method

In cold extraction method, VCO is obtained by breaking the emulsion, without heating the coconut milk. This method involves the destabilization of coconut milk, which is required for the higher stability of coconut milk emulsion. The destabilization is achieved in three stages. The gravitational force is used and the cream obtained is separated in the first stage. In the second stage, oil phase moves as a group without rupturing the interfacial film, that surrounds it. This stage is called as flocculation and clustering. Whereas in the third stage, ruptured and reduced interfacial films join the oil globules. The advantage of this method is, since this method does not involve any chemical agents, it is environmental friendly and economical. Moreover, the natural and beneficial chemical components of the oil are not altered. However, the quantity of the oil yielded is very less, and this is the disadvantage of this process (8, 23).

Hot extraction method

In hot extraction method, heat is used to break the emulsion between the water and oil molecules. The heating process aims at denaturing the proteins, that stabilizes the emulsion. The heat extracted oil has shown its efficiency in reduction of the low-density lipoproteins and increasing the level of high-density lipoproteins. Interestingly this property is higher in the oil, which is extracted by the hot extraction method than the cold extraction method. However, the disadvantage of this method is loss of antioxidant property due to the heat (18, 24).

Dry and wet method

According to Ghani et al. (21), VCO can be prepared by two methods, wet method and dry method. In wet method, the oil is extracted directly from the coconut meat without the drying process. The destabilising the coconut emulsion is done by one of the following methods like: chilling, centrifuging or fermenting. Whereas in dry method, the moisture is removed from the coconut by controlled heating and the coconut is mechanically compressed to yield the oil.

Low pressure extraction and centrifugation

The low-pressure extraction and centrifugation method are a fresh dry technology, where the oil is extracted by using the low pressure in moist condition of the coconut (25). In this method, fresh and mature coconuts are taken, which are fragmented manually or by using motors. Then the coconut meat is dried, leaving 10-12% of moisture in it. and the basic coconut oil is extracted by the manual press. Finally, the VCO is obtained by the process of centrifugation (25). The advantage of this method is residues like coconut shell and husk can be used for other purposes. However, the disadvantage of this method is its higher cost and requirement of more labors (8).

Fermentation method

The fermentation method is also one of the popular methods of extraction of VCO. Here, the coconut milk is fermented by using the inoculation of *Lactobacillus.* Different proportions of coconut kernel and water are used and extraction of VCO was done by adjusting the pH and bacterial cultures (18).

Physical properties of VCO

The VCO is a colourless water insoluble liquid, which will attain the solid state at the temperature of 25˚C. Smoking point for the refined coconut oil is 232˚C, whereas for the unrefined oil, it is about 170˚C. Unrefined, bleached or deodorized coconut oil will have a typical coconut smell. VCO will form a homogenous mixture when it is mixed with water and agitated (8).

Chemical composition of VCO

The major component of the VCO is triglycerides in the form of short and medium chain saturated fatty acids (26-29). Dayrit et al. (30) used gas chromatographic analysis to check the fatty acid composition of VCO and refined coconut oil (31). But the VCO stands different in its chemical composition, due the presence of biologically active components like polyphenols, tocopherols, sterols and squalene. These biologically active components are capable of scavenging the reactive nitrogen, chlorine and oxygen species. It is also capable of binding the pro-oxidant iron. In addition, these components also can effectively inhibit the cyclooxygenases

and lipoxygenases. Hence the antioxidant property is much higher in the VCO than that of the ordinary refined coconut oil (29, 31-32). According to Isaacs and Thormar (33), VCO may also play a major role in the prevention of infectious diseases. Majority of the nutritional components of VCO are contributed by the Lauric acid (34, 35). Interestingly, Lauric acid being the medium chain fatty acid, can also be considered as long chain fatty acid, because of its digestion and metabolism. The frequency of various acids present in VCO are represented in Fig. 1. The chemical structure of lauric acid is represented in Fig. 2. Portal vein is involved in the absorption of medium chain fatty acids (36, 37). Apart from these chemical components, VCO also contains the polyphenol compounds which act as antioxidants (38). The total phenolic content of VCO is 7.78 to 29.18 mg gallic acid equivalents / 100 gm oil (20).

Clinical uses of VCO

VCO as an antioxidant (Fig. 3)

Reactive oxygen species (ROS) are produced due to the oxidative stress and this leads to the lipid peroxidation, that further lead to the cell damage. When there is increased condition of ROS, the endogenous antioxidants like superoxide dismutase (SOD), catalase, etc. will get activated to offer the first-line protection to the cells in preventing the cell death (Fig. 3). However, when there is excessive accumulation of ROS, the endogenous antioxidants will not be sufficient to eliminate the ROS and this requires anti-oxidant supplementation (39-43). VCO is among the natural products, which contain the antioxidants. The compounds present in the VCO like tocopherols, tocotrienols, phytosterols, phytostenol,

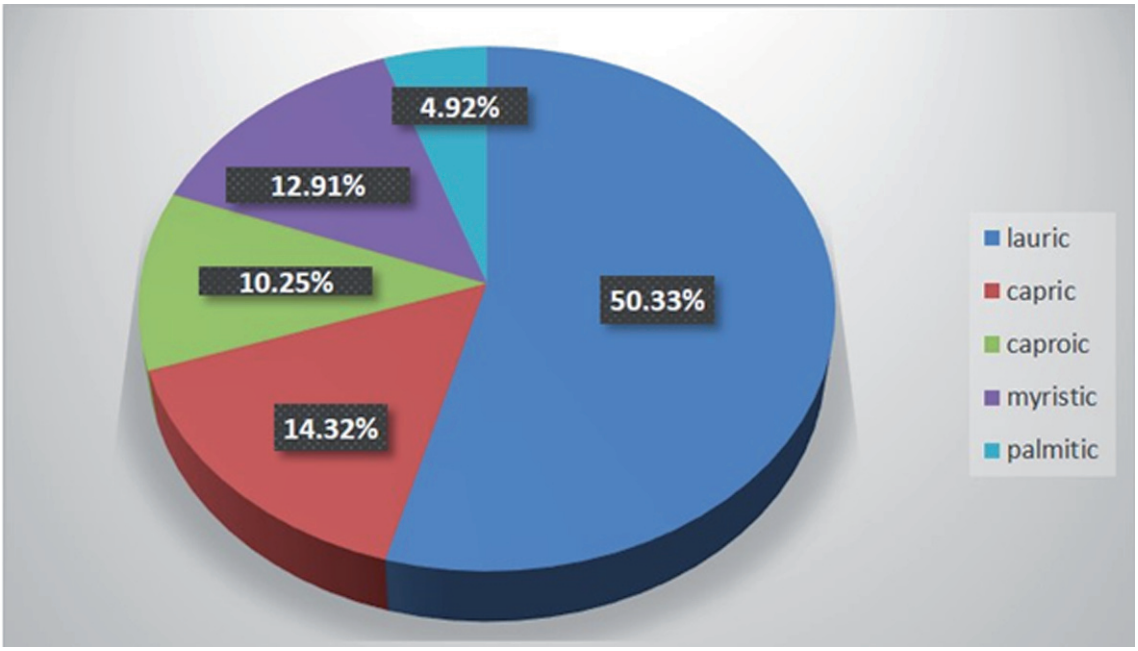

Fig. 1 Frequency of various acids present in the VCO.

Fig. 2 Chemical structure of lauric acid, the main content of VCO.

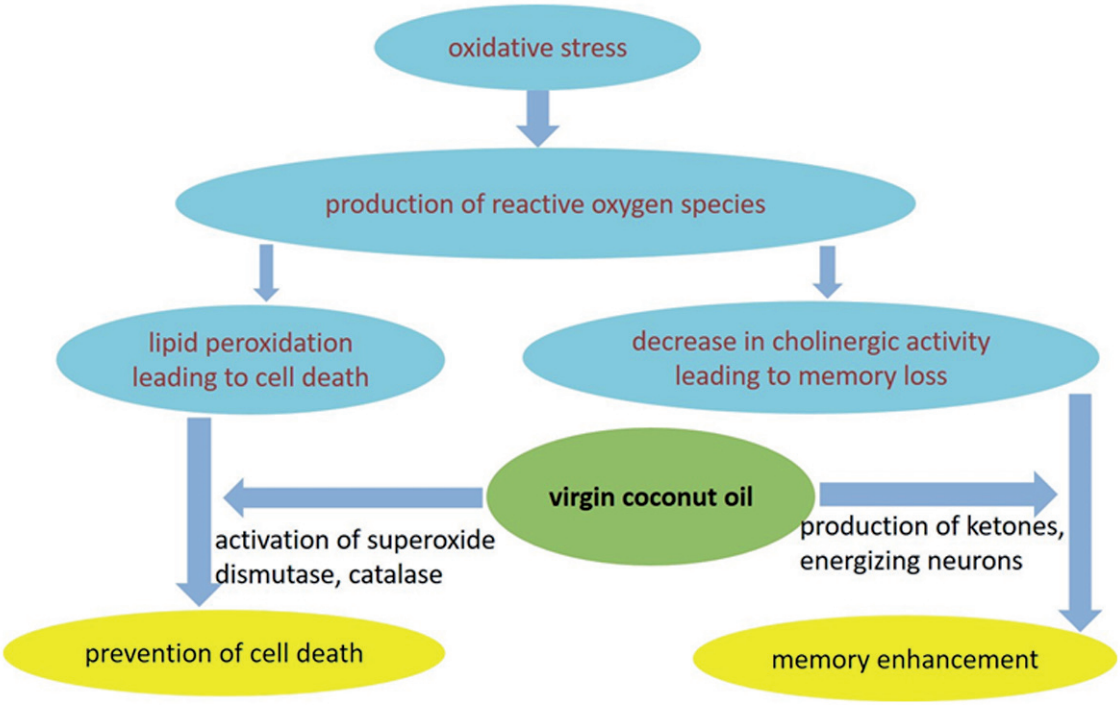

Fig. 3 Schematic representation of mechanism of prevention of cell death and memory enhancement by the VCO as an antioxidant.

flavonoids, vitamin E and phenolic compounds are responsible for its antioxidant property (17, 44-45). Carandag (45) observed the antioxidant effect of VCO in the animal model of albino Wistar rats by measuring the MalonDiAldehyde (MDA) and Glutathione Peroxidase (GPx) levels. According to them, the phenolic compounds control the fat production and reduce the inflammatory reactions.

Marina et al. (29) reported that medium-chain triglycerol found in the VCO is beneficial. Mansouri et al. (46) observed that, VCO consumption improved the oxidative stress condition and insulin resistance. VCO improves the Brain Derived Neurotrophic Factor (BDNF) in metabolic syndrome patients (46). Usually the oxidative stress leads to production of pro-inflammatory cytokines, which decrease the level of BDNF. The saturated fatty acids further increase the level of these pro-inflammatory cytokines. Contrary to this observation, VCO has promoted the formation of BDNF and this is due to the effect of lauric acid present in it (47-49). VCO also complimented the reduction of sodium fluoride toxicity through its polyphenol components (50). However, VCO oil fraction could not show any antioxidant potentials (50). Hypothetically, the polyphenol compounds, which are present in the VCO are enhanced by the lipid portion present in it, by improving its bioavailability. However, further investigations and studies are required to assess the exact antioxidant mechanism of the VCO.

Benefits of VCO on cardiovascular system

An *in-vitro* study on Sprague-Dawley rats by Nevin and Rajamohan (51) observed that VCO administration for 45 days reduced the serum lipid level and LDL oxidation by the physiological oxidants, thus proving its antioxidant property. Nurul-Iman et al. (52) demonstrated the cardio-protective effect of VCO in hypertensive rat models. Initially, the heated palm oil diet was given and after giving the VCO, the vaso-constrictor response of aortic rings was attenuated. However, the vaso-relaxation of aortic rings were not affected by the VCO administration. This cardio-protective effect of VCO was due to its antioxidant property, which reduced the cardiac lipid peroxidation (52, 53). Nevin and Rajamohan (54) observed the anti-thrombotic effect of VCO in cholesterol fed Sprague- Dawley rats. According to their study, the VCO can reduce the serum cholesterol and triglycerides along with the maintenance of blood coagulation factors. It was also observed that the higher level of antioxidant vitamins in VCO fed rats prevented the oxidation of LDLs (54).

The supplementation with VCO, in early hypertensive stage could prevent the histopathological changes in cardiomyocytes. The dietary consumption of VCO can reduce the dyslipidemia, because of its major component lauric acid (53). Vitor et al. (55) observed the neuroprotective effect of VCO in stroke-prone, hypertensive rats. The VCO being a medium chain fatty acid, gets absorbed in the gut and metabolized into acetoacetate and β-hydroxybutyrate. This lipid bi-product, acting on the hydroxyl-carboxylic acid receptor 2, induces a neuroprotective phenotype, Ly-6CLo and macrophages by infiltrating the ischaemic brain (55-57).

Dermatological application of VCO

The coconut oil is capable of penetrating the stratum

corneum, which helps in strengthening the skin lipids. It also protects the skin by forming an external coat on the surface of the skin and acts as a first line of defence against the external harmful agents like alcohol. The coconut oil can also form a coat from the inner surface of skin, which strengthens the lipids. It also protects the skin by preventing the loss of moisture (58-60).

It is also used as anti-dandruff as it consists of vitamins like E and K. It can prevent the greying of hair and can help the hair becoming glossy and bouncy. Traditionally, VCO is used as a moisturizer as it offers soothing effect on the skin and also helps in treating the skin disorders (11). Agero et al. (61) concluded from their clinical trial that, VCO can treat the xerosis. According to Varma et al. (11), VCO shows the anti-inflammatory activity by inhibiting the cytokines like TNF-α, IFNγ, IL-6, IL-8 etc. It also protects the skin from UVB irradiation by up-grading the aquaporin-3 (AQP-3). Thus VCO can be used as a therapeutic agent against various skin disorders like dermatitis, eczema, which are caused by the permeability barrier dysfunction and reduced epidermal protein expression (11). Saraogi et al. (62) observed the beneficial effects of prophylactic use of VCO against the skin damage due to excessive exposure to alcohol-based hand sanitizers, especially during the COVID time. The alcohol can lead to skin disorders by denaturing the proteins, killing the epithelial cells along with impairing the enzyme activities and barrier integrity (63). According to Saraogi et al. (62), pre-application of VCO, can avoid the skin damage caused by 70% ethanol by decreasing the trans-epidermal water loss and increasing the lipid and cytokine levels. Noor et al. (64) observed that, VCO-solid lipid particles which are prepared by the ultra-sonication, improved its dermal delivery. The entrapment efficiency was much better, when the VCO was applied as nanoparticles. According to Andayani et al. (44), the VCO can prevent the occurrence and heal the pressure sores in bed ridden patients. The vitamin E, which is present in the VCO helps in wound healing. The medium chain fatty acids in it creates an acidic environment in the wound region and prevents the growth of bacteria and other microorganisms (44, 65-66). Nevin and Rajamohan (13) studied the effect of VCO on skin and correlated its antioxidant status during the skin healing in a wound model in rats.

VCO as a respiratory medicine

VCO supplementation can be an adjuvant therapy for the allergic pulmonary disorders as it acts on the oxidative and inflammatory airway pathologies, which characterize the bronchial asthma (67). It was reported that, VCO can relieve the symptoms of bronchial asthma than preventing its onset. The inhalation of VCO can be an alternative and complementary medicine in managing the bronchial asthma (68). It has protective role during the oxidative stress and inflammatory process in the alveolar macrophages due to the particulate matter (69). VCO can be given as an additional supplement in the tuberculosis, which can help in the conversion of sputum of acid resistance bacillus (70). Glyceryl monolaurate, saturated fatty acid and lauric acid, which are found in VCO have antimicrobial properties.

VCO on bone health

Abujazia et al. (71) observed that the lipid peroxidation in bone tissue was decreased by the administration of VCO in ovariectomized, osteoporosis rat models. In menopausal women, because of the imbalance in the oxidative stress and antioxidant activity, activation of osteoclasts and inhibition of osteoblasts could be seen. The supplementation with antioxidant rich diet could prevent the serious conditions like osteoporosis and its comorbidities. Since VCO is rich in antioxidants and easy to administer, it could be a novel supplementation for the postmenopausal osteoporosis (71). It helps the elderly individuals by decreasing the inflammation of the joints and subsequent arthritis.

Clinical usage of VCO for the renal health

Famurewa et al. (72) stated that the isolated phenolic compound, from the VCO can protect the kidney against the cadmium metal toxicity due to its anti-oxidant and anti-inflammatory properties. It was reported that VCO reduced the levels of blood urea and serum creatinine levels in rats, who were allowed to perform the maximum amount of physical activity (42).

VCO and neurological health

VCO can boost the memory by increasing the antioxidants and cholinergic activities (28). VCO is the source of medium-chain triglycerides, which are transported to the liver through the portal vein and metabolized into ketones (73). These ketones rapidly supply the energy into the neurons and help in the memory enhancement (Fig. 3). The efficacy of VCO in improving the cognitive functions in Alzheimer's disease was observed by Gandotra et al. (73). The anti-oxidants are one of the beneficial compounds to prevent and treat the oxidative stress induced neurological disorders. Stress and depressions are the two major causes for most of the psychological disorders. The polyphenol found in the VCO, acts as anti-stress agent by restoring the antioxidant balance (74).

Paediatric usage of VCO

Konar et al. (75) from their randomized controlled trial, reported that application of VCO in preterm newborns, has helped in dermal maturity, prevention of sepsis, hypothermia and also helped to improve the neurodevelopmental outcome. There was no adverse effect, because of application of VCO in newborns (75).

VCO in reproductive medicine

VCO can be used as a diluent for the artificial insemination as it has shown its efficacy as the cryo-protector and maintained the quality of goat sperms by preserving the membrane integrity (76). Akintoye et al. (77) observed that, VCO up regulated antioxidants like superoxide dismutase and ketalase. This helped in the reversal of behavioural phenotypes in animal model of polycystic ovarian syndrome.

Other health benefits of VCO

VCO has other benefits like it has anti-cancerous, analgesic, anti-bacterial and anti-viral properties, antipyretic and anti-inflammatory properties. It has gained wide attention in the medical field, because of these properties. Araújo et al. (78) reported the beneficial effects of VCO on neuro-behaviour and gastrointestinal health in obesity induced male *Wistar* rats. Otuechere et al. (79) proved the hepato-protective effects of VCO in trimethoprim-sulfamethoxazole induced liver damage. VCO also reduced the formalin induced chronic inflammation by maintaining the normal cellular redox status (31). VCO is also used in the dentistry as it decreases the plaque formation and subsequent gingivitis (80). The clinical benefits of VCO among various health conditions and the mechanism of action along with the results observed by previous studies are summarized in Table 1.

Conclusion

VCO is a potential antioxidant because of its polyphenol compound and lipoic acid. It plays a vital role in the oxidative stress and can be given as a supplement as its main content is lauric acid, which helps as an antioxidant, benefiting the various organs. It is beneficial against the cardiovascular, neurological, respiratory, reproductive and bone disorders. It can also be used as a skin applicant in the paediatric age group. Dietary supplementation of VCO is easy and economical due to its simple method of extraction. It is safer to prescribe in day to day life among all the age groups. Hence, exploration of its antioxidant property as well as other beneficial effects in various health conditions is necessary. Since the properties of VCO are influenced by the extraction methods, more knowledge about the best methods of its extraction from the coconut has to be explored. The intention of the present review article is to provide the broader clinical uses of VCO and this study also provided the methods of extraction and properties of VCO.

Conflict of Interest

The authors of this manuscript state that, there are no conflicts of interest associated with this manuscript.

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Ethics approval

Since it is a review article, the institutional ethics committee approval is not applicable.

Table 1. Benefits of VCO in various health conditions, mechanism of action observed by previous studies

Protection against	Mechanism	Observation
Formalin induced chronic inflammation	Maintaining normal cellular redox status	Decrease in Paw oedema [31]
Cyclophosphamide induced decrease in WBC and haemoglobin	Maintaining normal cellular redox status	Restoration of near normal level [31]
Cyclophosphamide induced kidney and liver toxicity	Reducing the peroxidative changes	Decrease in TBARS level [31]
High refined carbohydrate diet induced osteopenia	Promotion of lower adiposity and improvement of metabolic and inflammatory disorders	Reversal of obese phenotype, appendicular and axial bone loss [81]
Ovalbumin Nebulization induced chronic allergic lung inflammation	Reversing the peribrochial inflammatory infiltrates and epithelial hyperplasia	Reversal of chronic allergic lung inflammation [67]
Dyslipidaemia and Insulin resistance	Improving the lipid metabolism	Decrease in cholesterol and glucose levels.
Gingival inflammation	Production of monoglycerides and free acids through emulsification and lipolysis of oil	Reduction of anaerobic bacteria, mutans, streptococci [82]
Obesity induced comorbidities	Protected hippocampus from degeneration and decreased M1 macrophages and increased M2 macrophages in gut	Neurobehavioral modulation and improved gut health [78]
Letrozole induced polycystic ovarian syndrome (PCOS)	Upregulating NRF 2 genes	Improvement in behavioral phenotypes [77]
Trimethoprim-sulfamethoxazole induced liver damage	Controlling the alteration in the serum biochemical end points	Restoration of near normal level of bilirubin, alkaline phosphatase and lactate dehydrogenase [79]

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