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Review Article

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Exploring the Versatile Uses and Extraction Techniques of Kokum Butter: A Comprehensive Overview

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Abstract

Kokum (Garcinia Indica) is a fruit tree with uses in agriculture, medicine, nutraceuticals industry which is frequently processed into syrup and dried products. Ayurvedic practitioners have historically utilised kokum to heal wounds, dermatitis, diarrhea, dysentery, ear infections, and to improve digestion. This review article examines the different extraction methods of kokum butter, a natural plant-based fat obtained from the kokum seeds. The traditional methods include sun drying, boiling, and hand-milling, while modern techniques include solvent extraction, supercritical fluid extraction, and enzymatic extraction. Each method has its advantages and limitations in terms of yield, purity, and environmental impact. The potential applications of kokum butter are vast, ranging from cosmetics, pharmaceuticals, and food industries. Kokum butter has a unique fatty acid composition with high levels of stearic and oleic acid, making it an ideal ingredient for skin and hair care products. In the food industry, kokum butter has a stable shelf life, making it an excellent substitute for cocoa butter in chocolate and confectionery products. Overall, this review highlights the importance of choosing the appropriate extraction method for kokum butter and its potential applications in various industries.

Key words: *Kokum butter; Fatty Acid; Brain-targeted drug delivery*

Introduction

Kokum (*Garcinia indica*), a tall and narrow tree native to India's Western Ghats, is one such medicinally significant but underutilized tree species. The fruit is spherical, dark purple when ripe, and is having numerous health-promoting characteristics. In Ayurveda it is believed to have antidiabetic, anthelmintic, cardiotonic, and anti-obesity effects and utilized in treating piles, diarrhea, tumours, pain, and heart diseases [1]. It was previously found only in the western peninsular coastal regions and the adjacent Western Ghats in the Indian states of Maharashtra, Goa, Karnataka, and Kerala, as well as parts of Eastern India in the states of West Bengal, Assam, and the North Eastern Hill regions, but it is now found growing in other parts of the Indian Region. It is evergreen tree that does not require much irrigation or the application of fertilisers, pesticides, or herbicides. The trees are typically found growing along riversides, in forests, and in barren land, and they have subsequently been grown for their fruits. It is a slow-growing tree that is normally propagated by putting the seeds in plastic bags/pots and then transplanting the seedlings into the pits. Single kokum tree bears hundreds of fruits and each fruit weigh around 21–85 g. The fruit contains 5-8 large seeds and is covered with whitish sweet pulp. Seed is solid waste generated from the kokum processing industry

which contains 40-50% fat. The seeds are placed in a pattern similar to that in orange. India currently produces 10,200 tonnes of kokum fruit per year, with the potential to yield approximately 1000 tonnes of fat [2].

The seed accounts for approximately a quarter of the total weight of the fruit, and chemical analyses have revealed that it contains 23-26% oil. At room temperature, the oil remains solid and is commonly known as kokum butter. Oil extraction is a time-consuming and laborious procedure that is carried out in an extractor. Initially, the kokum seeds are decorated, and the kernels are carefully separated. After that, the kernels are pressed in an expeller to extract the oil. The cake that remains after the extraction of the kokum butter can be used as animal feed as well as organic waste for plantation. Kokum butter has a light grey to yellow tint, a sticky texture, and a bland flavour [3].

Kokum Processing

Freshly harvested fruits are reddish green in colour and turn into full Red-purple colour in a day or two. The flesh of the fruit is juicy and has a sweetish acid taste. The normal shelf-life of fresh fruit is about five days. The common method practiced for preservation is sun drying. For this, the fresh fruits are cut into halves and the fleshy portion containing the seed is removed. The rind (skin) is then repeatedly soaked in the juice of the pulp during sun drying. The product obtained after sun drying is referred to as amsul or unsalted kokum in commerce. Salted kokum (agar) is also marketed; wherein common salt is used during soaking and drying of the rind. Lonavala kokum, Pakali kokum, Khane or edible kokum and Khoba kokum are some of the trade varieties [4].

The seeds yield a valuable, edible fat known in commerce as kokum butter. It is extracted mostly as a cottage industry by crushing the kernels, boiling the pulp in water and skimming off the fat from the top or churning the crushed pulp with water. Presently oil is obtained by solvent extraction also. The yield of oil (fat) is about 25%. Kokum butter sold in market consists of egg shaped lumps or cakes of light gray yellowish colour with a greasy texture and a bland oily taste. It is used mainly as an edible fat and sometimes as an adulterant of ghee. Refined and deodorized fat is white in colour and compares favourably with high class hydrogenated fats [5].

Kokum rind contains 2 to 3 percent anthocyanin pigments. It is a promising source of natural colourant for acid foods. Processing condition have been standardized at CFTRI, Mysore for commercial scale extraction and purification of the pigment concentration. Preliminary studies have shown that cyanidin-3-sambubioside and cyanin-3-glucoside as the major pigments present in the ratio of 4:1. Food applications for kokum colour are in the area of processed fruit products, alcoholic and nonalcoholic beverages, preservatives and instant foods [4].

Kokum Seed

The seed of Garcinia indica contains 23%-26% oil, which remains solid at room temperature. It is used in the preparation of confectionery, medicines and cosmetics. The seeds of the fruit yield 23 to 26% by weight of seeds and about 44% on the weight of kernels, a valuable edible fat known in commerce as `Kokum butter`. It is extracted mostly on a cottage industry basis by crushing the kernels boiling the pulp in water and skimming off the fat from the top; or by churning the crushed pulp with water.

Kokum seed is a good source of fat called Kokum butter. It is used in chocolate and confectionary industry. Sometimes it is also used in surfactant and ointment industries. Kokum butter is considered nutritive, astringent, demulcent and emollient. It is suitable for ointments, suppositories and pharmaceutical purposes. It is as a local application to ulcers and fissures of lips, hand etc. The oil cake left after the extraction of oil can be used for manufacture of industrial adhesives, as manure and as cattle feed. The different parts of kokum fruits are shown in Figure 1.

Kokum Butter

Kokum butter as sold in local markets consists of egg shaped lumps or cakes of light gray or yellowish colour with a greasy feel and a bland oily taste. It is used mainly as an edible fat. Refined and deodorized fat is white in colour and compares well with high class hydrogenated fats (Figure 2). This fat is rich in combined stearic and oleic acids. It contains about 75% of mono-oleodisaturated glycerides. It is suitable for use as confectionery butter. It is also suitable for candle and soap making. It possesses suitable properties for use in sizing cotton yarn. Kokum butter has been successfully used in chocolate and cocoa industry. It helps in improving texture of chocolate without affecting the flavor [6]. Recently a new fat soluble pigment called garcinol has been separated from fruit rind. Garcinol is a yellowish pigment. Crude fat content of fresh Kokum rind on moisture free basis is 10%. Garcinol is extracted using hexane from fruit rinds [7]. Since then, it has been studied for its medicinal properties.

The fat is used mainly for edible purposes obtained by primitive methods is just off white, and free fatty acid levels are low indicating absence of any powerful lipolytic activity. The fat can be easily refined in the usual way, and bleached to a near white colour in the conventional manner. Prompted by enquiries from foreign buyers and realising its potential as a high value fat for export, oil millers have in the past decade, organised the collection of kernels and the fat is now recovered in a small way (about 200 tonnes or so) for export. The residual oil in the extracted cake is also recovered by solvent extraction. Despite slight increase in FFA, this quality also finds a ready export market. Kokum butter or fat is a very clean fat with fatty acid composition showing C16 (3.4%), C18 (67.4%), C18:1 (28.1%), C18:2 (0.6%) and C20 (0.3%). It has very high symmetrical SOS content (83.4%). This has been, therefore useful for direct (without any fractionation) blending with palm mid-fraction for preparing cocoa butter substitute.

Sr. No	Parameter	Kokum Butter
A.	Physical Parameters	
1.	Total fat content (% of seed)	29.33
2.	Colour	Pale white
	odour	Neutral
3.	State at room temperature	Solid
4.	Melting point (ºC)	40.3
B	Physico-chemical properties	
1	Iodine value (g I2/100g)	32-40
2	Saponification value (mg KOH/g)	180 - 193
3	Acid value (mg NaOH/g)	< 10.0
4	Peroxide value (meq O_2/kg)	5.0
C	Fatty acid	
1	Palmitic acid	3.25
2	Stearic acid	49.33
3	Elaidic acid	3.00
4	Oleic acid	34.42
5	Linoleic acid	5.25
6	Arachidic acid	1.20
7	Eicosenoic acid	2.25
8	Other fatty acids	2.30
9	Myristic acid (C14:0)	1.20
D	Chemical properties	
1	Acid Value (mg NaOH/g of oil)	4.9
2	Saponification number (mg KOH/g of oil)	200.2
3	Iodine value	39.4
4	Free fatty acids (%)	5.64
5	Sterols	1.02
6	Vit. E (mg/100g)	20.01
7	Total Saturated FA (%)	52.78
8	Mono Unsaturated FA (%)	39.67
9	Poly Unsaturated FA (%)	5.25
E	Triacylglycerol	
1	1(3) palmitoyl-3(1) stearoyl-2 oleoglycerol (POS)	6
2	1(3)-distearoyl-2- oleoylglycerol (SOS)	72
3	1,3-dipalmitoyl-2- oleoylglycerol (POP)	Trace

(Source- [8], [9], [10], [11])

Table 1: *Characteristics and Composition of Kokum Butter.*

Nutraceutical properties of kokum butter

Kokum butter is considered nutritive, demulcent, astringent and emollient. It is suitable for ointments, suppositories and other pharmaceutical purposes. It is used for local application to ulcerations and fissures of lips, hands etc. Kokum butter is used as a specific remedy for diarrhea and dysentery [11]. Kokum butter is very soothing for burns, chaffed skin and scalds. Kokum Butter exhibits excellent emollient properties and high oxidative stability, which can assist emulsion integrity. With its relatively higher melt point, it melts slightly at skin temperatures making it ideal for lipsticks and balms; it's also a great addition to bar soaps and skin lotions.

Kokum Butter extraction

Kokum fruit harvested from the trees and collected by producer or collector by tribal people. The fruit rind, pulp and seeds are separated cutting fruit manually or by using kokum cutter. Then, the kernels are processed according to one of the two distinct traditional procedures [12,13]. The seed contains about 32–35% fat and is extracted by one of several methods – boiling, cold extraction/churning of the powdered seeds by water or simple extraction. Traditionally, kokum butter is extracted from dried kokum kernels either at the village or domestic level and sold in local markets. Traditionally the kokum butter obtained from the traditional extraction procedure not including a refining stage is called 'unrefined kokum butter'.

Traditional Method

In this method the kokum beating with a plank or a rod decorticates seeds [14]. The kernels are separated from the husk by winnowing and dried in sun and then pounded into flour. Then the pounded kernels are mixed with water and boiled. Thus, extraction is done by boiling the kernel powder in water and skimming off the released oil. Figure 3 indicates the steps involved in manufacturing of kokum butter at domestic level followed coastal region of India. In this process, the seed is cracked and the shell removed. The white kernel is then pounded in a large specially-made stone mortar and pestle (Figure 3a, b). The pounded kernel powder is put into an iron pan/M.S. pot with some water and boiled (Figure 3c). After some time, it is poured into another vessel and allowed to cool. The flow chart for traditional manufacturing method shown in Figure 4. The oil which rises to the surface on cooling becomes gradually solid, and is strongly moulded by hand into egg-shaped balls as shown in Figure 5 (d). Thus, a valuable oil or fat obtained from kokum kernels is popularly known as Kokum butter [15].

Process at small scale industries

In recent years, export of kokum butter has been initiated to different countries in Europe, Japan etc [16]. Few cottage industries in Konkan region of Maharashtra shell the kokum seeds using conventional decorticators designed for other crops like groundnut as shown in Figure 5(a). Then they follow commercial extraction of butter using screw pressing (Figure 5(b)) the kernels. Then the butter is sold by these small entrepreneurs to the traders. The traders at Mumbai or other metropolitan city for its further refining and deodorizing [17,18].

The process involved in manufacturing of kokum butter at cottage industry level followed coastal region of India showed in Figure 6 and Figure 7. However, with the increased interest in naturally derived products, organic kokum butter production is preferred and thus efforts have been made to industrially produce kokum butter by following the improved dehulling and extraction methods without solvent extraction or refining process.

In cold extraction or churning process, the kernel is pounded as above and the pulp with some water is kept in a large vessel and allowed to settle during the night. The oil rises to the surface and forms a white layer, which is removed in the morning. The mixture is then churned and oil which, like butter, rises to the surface in a solid form, is removed by hand. This process yields into the best product and is most favorably followed in the winter season [15].

Improved method

In India, the kokum kernel fat is extracted by the Indian standards on oil milling industry for Grading for kokum kernels for oil milling, IS: 8557-1977, 1983 and Kokum fat IS: 8591-1977, 1986. To extract good quality kokum fat there is a need to develop the Standard Operating Procedure (SOP). Such type efforts are made to standardize the traditional processing method of kokum oil extraction by the National Agricultural Innovation Project (NAIP) on A Value Chain for Kokum, Karonda, Jamun, and Jackfruit which was implemented at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli (Maharashtra) during 2009 to 2014. Accordingly following standard procedure was developed as shown in Fig. 8. Kokum seeds were dried using a mechanical dryer at 60 °C. The dried kokum seeds were cleaned using air screen cleaner and dirt, dust, ash, stones, other crop seeds, and other impurities were separated using air screen cleaner. Then these cleaned and dried kokum seeds were shelled by using kokum seed dehuller to obtain kokum kernels. The husk was separated from kernels. For better oil extraction, the moisture content of kernels was brought to about 10%. Then the steaming was provided to the kernels prior to oil extraction for 20 min duration (temperature of the steamed kernel was 70°C). The crude oil obtained was boiled in the large SS vessel to separate impurities. The scum collected at top of the oil and heavy but fine particles of cake settled at bottom of the vessel are separated from the oil. The clean oil is kept for solidification overnight (12 hrs). The next day, these oil/butter were churned in the spiral mixer to uniform mixing of butter. Then cubes or blocks of convenient size were made from this butter.

Advanced methods of Kokum butter extraction

Advanced extraction techniques Extract kokum fat of high yield and superior quality. In supercritical carbon dioxide extraction ($SC–CO_2$) method at 350 bar/60°C/360 min have maximum recovery of 90.24% compared to Soxhlet extraction with petroleum ether (428.6 g/kg). The kokum fat extracted from this method consist of stearic (65.8%), oleic (32.5%), and palmitic acid (1.5%) [19].

Solvent extraction method

Kokum butter is also obtained using multistage solvent extraction approach by utilizing hexane, although this technique is expensive only it is economical when done at large scale. This is the simplest and most common method of extracting kokum oil. In this scenario, the output is approximately 44% of raw Kokum butter, although such chemically treated Kokum butter is not entirely natural.

Three phase partitioning (TPP)

Three phase partitioning (TPP) is a simple innovative bio-separation and purification process in which a salt (e.g. ammonium sulphate) and water miscible aliphatic alcohol (e.g. t-butanol) are added to an aqueous solution containing proteins (Roy et al., 2005). TPP has undergone thorough testing for the simultaneous separation and purification of proteins, enzymes, and inhibitors from crude suspensions. TPP's physiochemical basis is thought to involve ionic strength effects, kosmotropy, cavity surface tension augmentation, osmotic stress, and exclusion-crowding effects [20].

Optimization of the three phase partitioning (TPP) technique for the efficient extraction of kokum kernel fat. Kokum seeds were physically extracted from mature kokum fruits, and sticky material adhering to the seeds was removed by washing the seeds three to four times in hot water. The moisture content of these seeds was then reduced from an initial value of 27% to below 10% by drying them at 70oC in a tray dryer. To retrieve the kernels, the loosening shells were carefully separated [21]. Kokum kernels that had been dried were ground into a fine powder (1000m) to facilitate the extraction. After preparation of kokum kernal powder the slurry was prepared by dispersing 1g powder in 16 ml distilled water by gentle stirring on a magnetic stirrer. Weighed amount of ammonium sulphate (10 to 60% w/v of slurry) was added to the slurry prepared and vortexed gently, followed by addition of measured amount of t-butanol (t-butanol to slurry ratio = 0.5:1 to 3:1). This slurry of salt and solvent system was mixed properly by gentle stirring on magnetic stirrer for 30 min. In order to form three phases, system was allowed to stand at 45oC in a water bath for 1h. The three phases formed were separated by centrifugation at 2900g for 10 min at 30oC. The upper organic layer of t-butanol containing extracted fat was collected and the t-butanol was evaporated on a rotary evaporator to obtain the extracted fat. They found the a maximum recovery of 95 (% w/w) fat obtained from kokum kernels with evaluated TPP system consisting of 50 (% w/v) salt concentration, 1:1 ratio of slurry to t-butanol, and a pH of 2.0 within 2h.

Exploiting such a advance technology could mobilize agro-industrial wastes such as kokum kernel for value added ingredients for food and cosmetic industries.

Cost Economics of Kokum Butter

As a result of cocoa butter's rising price and dwindling supply, the market for kokum butter is anticipated to grow quickly. As an alternative to cocoa butter, kokum butter is now being utilised more frequently. The demand for kokum butter is expected to reach US$ 652.8 million in 2022, rising at a 6.1% CAGR to US$ 1,180.1 million from 2022 to 2032. The expansion of applications in personal care and consumer goods is responsible for the expansion. A CAGR of 5.4% was seen for the market for kokum butter between 2016 and 2021. The Benefit cost ratio (B:C) for the preparation of kokum butter is 1.46. According to Future Market Insights, the market for kokum butter is anticipated to experience tremendous expansion in Europe as a result of the expanding food and beverage sector there. The market for kokum butter in Europe represents 40.2% of the global market. Continuous technical improvements in the cosmetics and personal care sector are credited with driving market growth in Europe, and significant innovations and R&D expenditures are anticipated to open up profitable chances for the growth of the kokum butter market [22].

Application of Kokum Butter

The Kokum butter has a melting point of 38 to 40°C, thus even though it is solid at room temperature, it melts when it comes into contact with the skin [23]. This property is useful for preparation of range of medicines, including creams, lip balm, and ointments. It is also traditionally used for prevention of skin drying, aids in ulcer healing, promotes skin cell regeneration, aids in emulsion stabilization and softens skin.

Oleogels Preparation

Oleogels with the potential to be utilized as drug delivery vehicles can be made by combining kokum butter and rice bran oil. The prepared oleogels are pale yellow in colour, and the whiteness index increased as the concentration of kokum butter increased. The oleogelation induced by nucleation and crystal development of the solid fats found in kokum butter, and its thermal stability is dependent on kokum butter concentration. The ocular tissues were not irritated by the produced oleogels. An increase in kokum butter content lowered the rate of drug diffusion, possibly due to drug molecule entrapment [24].

Chocolate Preparation

Kokum fat, is used as an improver to increase the hardness of chocolate. Kokum fat is added in various proportions replacing cocoa butter in dark and milk chocolate formulations and its effects on rheology, hardness and triglyceride composition were studied. The results revealed that up to 5% kokum fat addition by weight of the product did not significantly affect the plastic viscosity or yield stress of milk or dark chocolate. Milk chocolate and dark chocolate

that use kokum butter in place of cocoa butter by 10% for the milk chocolate and 5% for the dark chocolate are suitable [6].

Moisturizer

The most well-known application of kokum butter is moisturiser. To boost moisture levels, you can apply it to practically every part of your body, including your skin, lips, feet, scalp, and hair. Compared to similar plant-based butters, kokum butter is lighter. As a result of its simple absorption into the skin, you won't feel greasy after applying it. In anecdotal reports, kokum butter is usually cited as a great moisturising option for people with sensitive skin.

Fatty Acid

There are many important fatty acids in kokum butter. Omega-3 and omega-6 essential fatty acids assist human body in maintaining healthy skin cell membranes. Additionally, polyunsaturated fats support a balanced and healthy moisture barrier. Maintaining a strong natural barrier is essential for maintaining hydrated, attractive skin. Its attractiveness as a cosmetic component is further influenced by the high fatty acid contents. Fatty acids can assist a skin or hair care product become thicker without making it hard. This is so that kokum butter's emulsion stability is enhanced by the fatty acids.

Skin repair

It is well known that kokum butter can restore damaged skin and also slow down the ageing process by protecting skin from harm before it happens. Kokum butter's emollient properties make it easy for the skin to absorb. As a result, its healing abilities can penetrate the deepest levels of the dermis. It can help with the healing of ulcers as well as cracks in the lips, palms, and soles of the feet. Additionally, kokum butter can help by enhancing the natural skin barrier to reduce inflammatory skin.

Treatment for Scalp

The scalp can be treated with kokum butter to encourage strong hair development. Kokum butter is powerful enough to aid in hair restoration minimizing hair loss brought on by supplying nutrients to the hair follicle. Kokum butter is mild and light enough to apply to the scalp each which does not left any aroma behind and is less oily than other butters.

Brain-targeted drug delivery

Brain targeted drugs are those that deliver medication to the brain or central nervous system. It is used to treat tumors, alzheimer's disease, epilepsy, migraines, infections, inflammatory diseases, and disorders with a neurotransmitter imbalance. Kokum butter can be useful in formulating the Solid lipid nanoparticles because it consists of natural lipid and 80% of stearic-oleic-stearic triglycerides. Nevirapin successfully released across the blood brain barrier when incorporated in coated solid lipid nanoparticle, Polysorbate 80 loaded kokum butter solid lipid nanoparticle. It could maintain a sustained release of the drug for more than 24 h. Therefore, this discovery could provide a significant contribution to overcoming the drawbacks of traditional therapies' poor drug delivery across the blood-brain barrier and to having an effective treatment for neurological illnesses including HIV-associated neurocognitive impairments (HAND) [25].

Conclusion

The compatibility of kokum butter characteristics, such as its triglycerides' fatty acid constituents, high melting temperatures, iodine value, acid value, and saponification values led to a prospective replacement for cocoa butter fats. These findings demonstrated the positive potential of kokum fat as an enhancer of cocoa butter. Without compromising the taste or other characteristics of chocolate, the fat might be used up to 5–10% of the product's weight, which will save production costs and increase revenue for Kokum growers. Kokum butter can be used to make a variety of medicines, such as lotions, lip balm, and ointments. Additionally, it promotes skin cell regeneration, stabilises emulsions, prevents skin from drying out, and softens skin. It is also useful for formulating solid lipid nanoparticles for brain-targeted delivery of drug.

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