Industrial uses of coconut products

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Being environment-friendly, attempts should be made to give an environmental designation to coconut products. Coconut oil, which is more popularly used in cosmetics, is a natural product of renewable resource. It can be efficiently promoted for the niche markets

India ranks third in the world in coconut production. Being an important perennial crop and a source of number of by products, its use has to be encouraged in niche products and thereby encash benefits. This article covers the effectual use of coconuts including its, desiccated form and the shell, along with the technical and economic feasibility of these products for industrial use.

The coconut tree popularly called 'Kalpa Vriksha' is nature's gift to humanity and its fruit, coconut is a valuable product. Shell, kernel, copra and oil derived from coconut are the important products that have to be used efficiently. The fresh kernels are nutritive for health due to proteins with essential amino acids and the oil. Earlier coconut oil was considered to aggravate the cardio vascular diseases due to its high content of saturated fats. The findings differ now. There is no scientific evidence to prove its harmful effects. In fact, the saturated fatty acids consist of medium chain fatty acids, which form a part of baby foods, weaning foods and other special preparations essential for good health.

Shell products

Coconut shell, the hard woody layer directly covering the coconut meat or kernel, is multifariously used in products like charcoal, activated carbon, shell flour etc. The burning of coconut in a limited supply of air sufficient only for carbonisation produces charcoal. Coconut shell charcoal, produced by the pit method, drum method or kiln method, reportedly contains the highest percentage of fixed carbon of all the ligneous charcoals.

The major use of this charcoal is as base material for activated carbon. This product has certain natural outstanding properties and is excellent for specific purposes. It is superior to other carbons, has more resistance to abrasion, higher capacity of absorption and higher purity in ash. This type of activated carbon has a small macropore structure, which makes it ideal for gas/vapour phase applications and for the removal of taste and other compounds. The activated carbon can be commercially produced by the steam activation or chemical activation process. Each method of production has its own advantages and disadvantages. Activated coconut shell carbon has good international market.

Coconut shell flour is clear, light brown, free-flowing powder, which results from pulverising of the shells of matured coconuts. It is produced in different mesh sizes, the most common of which is 100 mesh. This

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powder can be used as biodegradable filler in plastics as a substitute for sawdust and other fillers.

Copra and desiccated copra

Copra is the dried coconut meat or kernel from which coconut oil is extracted with meal as its byproduct. Depending on the process of extraction, copra is reported to produce from 57 to 64 per cent coconut oil. High-grade copra is obtained from matured, ungerminated nuts. Nuts intended for the production of copra are stored for 3-4 weeks after harvest before splitting. This practice enhances the quality of copra, as the moisture content of the fresh meat is reduced, thus making the meat thicker for oil, resistant to microorganisms and easier to detach from the shell during the subsequent drying process.

Desiccated coconut is the pure white, dehydrated and shredded meat of the coconut, which is prepared from the kernel. It is an excellent food product, popular in USA. Being one of the high value-added item, the industry has tremendous scope in India and abroad. The fat present in desiccated coconut is edible and highly digestible. The proteins have all the amino acids essential for human growth. Sugars are present as sucrose, glucose and galactose whereas carbohydrates are in the form of cellulose and pentose.

Cocochemicals

Cocochemicals are derivatives obtained from coconut oil. These chemicals can be divided into basic or primary groups, namely glycerol, fatty alcohols, methyl esters and soaps. The simple chemical process to produce these primary chemical derivatives is by hydrolysis (fat splitting). It is the treatment of coconut oil with high-pressure steam resulting in 3 mols of fatty acids and 1 mol of glycerol. Direct esterification of coconut oil with methanol gives methyl esters of coconut oil and glycerine. Hydrogenation of oil at high pressure and temperature in the presence of a catalyst gives a product suitable for bakery products.

Coconut oil and its derivatives

Some consumers prefer fresh coconut oil extracted form good quality copra, for its characteristic flavour and colour, while others prefer the bland oil obtained after refining and de-odourising the raw oil. The main use of coconut oil, raw or refined, is for edible purpose particularly in South India. The bland oil remaining stable for long period of storage is preferred for use in food processing. The hardened coconut oil is preferred as a coating for cookies and candies.

The next important use of coconut oil is in the manufacture of soaps, since the lower fatty acids present in it give profuse lather. One can incorporate this oil up to 25 per cent along with other oils to obtain a good toilet soap. But with the high cost of coconut oil, one has to resort to the use of merely 5-10 per cent. Among the vegetable oils, coconut oil has maximum content of glycerine (13.5 per cent), is premiumly priced and finds good demand as natural glycerine for use in cosmetics. Hence, it is worthwhile to hydrolyse non-edible grade of coconut oil by splitting under high-pressure process, and fractionate the mixed fatty acids to recover the glycerine. In fact, the efficiency of recovery of glycerine by this process is more compared to the conventional method. In order to conserve coconut oil in soap manufacture by Alpha Olefin Sulphonate (AOS), which is currently available in India. This substitute has additional advantages of improving the lime dispersing properties.

Major component fatty acid of coconut oil is lauric acid (50 per cent approx) followed by myristic acid (20 per cent approx), both of which have wide industrial applications. On the other hand, the undesirable short chain volatile acids of caproic/caprylic and carpric (15 per cent approx) which are skin irritants in soaps, can be frationated and converted into value-added products like artifical fruit flavours, perfumes, chemical intermediates and plasticisers. Some of the applications of these derivatives are outlined in table 1.

Table 1. Applications of derivatives of coconut oil fatty acid

Coconut fatty acid derivatives	Application
Ethyl caproate	Synthetic flavours
Amyl caproate	do
Allyl caproate	do
Ethyl caprylate	perfumery intermediate
Amyl caprylate	do
Butyl caprylate	do
Barium caprylate/ caprate	Stabiliser for PVC
Allyl caprate	Sweet banana/ pineapple odour
Amylose caprate	Dip type coating for food products
Butyl caprate	Apricot odour
Capryl caprate	Chemical pruning activity on plants
Lauryl alcohol	Detergent base
Sodium lauryl sulphate	Cosmetics and toiletries
Sodium lauryl ether sulphate	Shampoo
Iso propyl myristate	Cosmetics

Coconut oil in cosmetics

Among the vegetable oils of Indian origin, coconut oil has the largest application in cosmetics. It is the oldest and most widely used because of its low incidence of irritation, sensitisation and for the simple good feel it gives on the human skin. The following information highlights the applications of coconut oil in cosmetics.

As body oil: Coconut oil, mostly preferred for massaging before bathing - especially in case of newborn babies is due to its low viscosity, pleasant aroma and easy washability. Moreover, the trend now is to substitute synthetic liquid paraffin oil with stabilised vegetable oil like coconut oil, which is more natural in relation to composition of the skin fats. Liquid paraffins are chemically unrelated to the skin fats. The age old use of coconut oil as a body and hair oil is due to the unique unsaponifiable matter (0/1-0.4 per cent) consisting of sterols, tocopherol, squalene and tritterpene alcohol. The thin film of coconut oil left on the body acts as a protect of the skin; thus, it is a unique natural vegetable oil suitable for cosmetic use.

As hair oil: The oil is also commonly used as hair oil. However, it has a tendency to become rancid on storage. This can be prevented by incorporation of anti-oxidants in small quantities. In order to attract consumers, the incorporation of fragrances came into vogue, which adds to the cost of the finished product. In order to prevent the oil from becoming rancid and also on account of its high price, mineral oils are admixtured with the coconut oil. These mineral oils are petroleum products with toxic aromatics that are eliminate by chemical treatment. These are then termed as 'liquid paraffins' and permitted for use in cosmetics. They may be safe if properly purified and tested by sophisticated instruments, as it is found that on application these liquid paraffins get absorbed into the skin and may be harmful.

In campaigns, these are called as non-sticking hair oils by TV and other media. What good or harm it does to human body is to be judged by the user. Industry likes to use liquid paraffins due to its stable price, non-sticky nature and resistance to rancidity. As per the Bureau of Indian Standards (BIS) hairoil shall be any one of the following three types.

- The first containing single or mixture of vegetable oil
- The second containing only liquid paraffins and
- The third type allows mixture of vegetable oils and liquid paraffins.

Hair oil manufacturers are taking undue advantage of the lacuna in standards by labelling as 'Coconut Hair Oil', which is actually a mixture of coconut oil and liquid paraffin. It is high time that BIS rectifies such anomaly.

Oil based surfactants

Copra has the highest oil content (around 65 per cent) as compared to other oil-bearing materials. The production of coconut oil in the last four years has increased. Consumers generally prefer expelled coconut oil for its natural characteristic flavour for edible purpose, while the solvent extracted oil is used for industrial purposes. But the high price of coconut oil compared to other oils, restricts its consumption for both edible as well as for industrial purposes.

Among the vegetable oils, coconut oil is unique as it contains maximum amount of saturated fatty acids, the predominant one being lauric acid. This when neutralised by sodium or potassium alkalis gives a soap that has excellent lathering, detergency and hardness properties. This, coconut oil forms as important raw material in the production of toilet soaps, liquid soaps, shaving cream and natural shampoo. All over the world, good quality toilet soap contain 20-25 per cent of coconut oil and rest being other hard fat. In India, mutton tallow imports is banned and substitute is hardened vegetable oil such as rice bran, castor, linseed or imported palm stearin or palm oil. It is interesting to note that due to high price of coconut oil, its use in toilet soaps is kept at minimum level resulting in soaps with poor lathering properties.

Many of the toilet soaps in India are currently made with only 50-60 per cent of fatty matter against the minimum requirement of 78-79 per cent of total fatty matter for export, on the pretext that India is trying to economise on the fatty raw materials, which have to be imported. Thus, one will find that the annual consumption of coconut oil in soaps in India has comparatively decreased due to reduced quantity, while the production of soap has increased mainly due to increase in population.

This would mean less market demand for coconut oil, the main reason being high cost of coconut oil. Even for edible purpose, consumers have switched over to other cheaper oils like palmolein.

The word 'surfactant' means surface active agent and soap falls under this classification as a natural surfactant, whereas the terms 'surfactant' is generally used for synthetic surfactants that are derivatives of fatty acids, namely, sodium lauryl sulphate and sodium lauryl ether sulphate. These constitute the active ingredients in a synthetic shampoo, which is fully biodegradable. Soap from coconut oil can be made by the cold process, the semi-boiled process and the full boiled process. The glycerine liberated during saponification remains in the soap and is wasted. While in the full-boiled process, the byproduct glycerine is recovered by treatment with chemicals and the yield is poor. The modern trend is to split the coconut oil under high pressure by hydrolysis with water in an autoclave without any catalyst and recover the valuable glycerine, which, in turn has many applications. It is an important ingredient in both, powders and toothpaste.

Sodium lauryl sulphate has detergent powers far exceeding those of natural soap. Soaps are ineffective in hard water, sensitive to the presence of other ions. Hence synthetic detergents are superior and are effective in hard water and seawater. The other derivatives of lauric acid namely, sodium lauryl ether sulphate, sodium lauryl sarcosinate are all useful surfactants in industry, principally as emulsifiers, solubilisers, dispersants or detergents. They enable the formulator to make homogenous mixture, dispersion or emulsion of oily or waxy substance with water to disperse solids in liquids or disperse mutually insoluble liquids with other liquids. Creams and lotions are made more attractive in appearance, convenient to use and stable in storage, through the appropriate use of surfactants. Thus, many surfactants are obtained from coconut oil.

New materials on the horizon

The higher fatty acid fraction (nearly 20 per cent) of coconut oil fatty acids, consisting of C16-C18 fatty acids, can be converted to alpha olefins by dehydration on the fatty alcohol fraction at elevated temperature with catalyst. The sulphonated alpha-olefin (AOS) is a good raw material for toilet soap, detergent and shampoo. The new material on the horizon is attracting immense attention in India, as it can be manufactured from natural fats and oil, to be completely environment-friendly. Toilet soap with 10 per cent AOS is claimed to be better than that with 15 per cent coconut oil. Also AOS costs less than coconut oil. It has even lime soap dispersing action, preventing the formation of a bathtub ring. Toilet soap has appeared in the market based on a combination of regular soap and AOS. The expensive coconut oil in the toilet soap base can be reduced or eliminated by the addition of AOS, which gives excellent flash foam. This is another reason for decrease in demand of coconut oil in toilet soap.

A recent development, which is not yet commercialised in India, is the use of methyl ester sulphonates from hydrogenated coconut oil by reaction with methyl alcohol. The glycerol can be recovered while the coconut methyl esters are sulphonated under optimum conditions and neutralised as sodium salt. This sodium methyl ester cocoate is a good surfactant, 100% biodegradable and relevant as scum dispersants. The high price of coconut oil and other techno-economic viability has prevented its implementation. It is a valuable substitute for linear alkyl benzene sulphonate (LABS) developed from renewable natural fats and oils. Another surfactant that has been developed from coconut oil is mono-ester formed by the reaction of lauric acid with sucrose. This mono-ester is soluble in many organic solvents, including ketones, alcoholes and chlorinated hydrocarbons.

These sucrose mono-esters are useful as detergents, emulsifiers and wetting agents. They are neutral. Being non-toxic, they can be used in cleaning food-processing equipment, kitchen utensils, washing pesticides from fruits and vegetables as well as food emulsifiers and components of drugs and cosmetics. The diesters of sucrose are even more soluble in solvents and oils than mono-esters. They can be used as emulsifiers for water-in-oil emulsion. The above surfactant is not commercially viable today on account of mass production problems due to the high priced coconut oil and sucrose. The applications of various surfactants are summarised in table 2.

Table 2. Surfactants from coconut oil and their application

Coconut surfactants	Application
Sodium cocoate	Toilet soaps
Potassium cocoate	Natural coconut shampoo
Sodium lauryl sulphate	synthetic shampoo & toothpaste
Monoethanolamine lauryl sulphate	Emulsifier
Diethanolamine lauryl sulphate	Clear shampoo perlising agent
Triethanolamine lauryl sulphate	Shampoo
Ammonium lauryl sulphate	Shampoo
Sodium mono laurate	Soaps
Polyxyethylene sorbitan monolaurate	Emulsifier, dispersant and detergent
Sodium lauryl sarcosinate	Shampoo
Sodium alpha-olefin sulphonate C14 - C18	Synthetic shampoo and wool washing detergent, toilet soaps as lime soap dispersants
Sodium or potassium methyl ester sulphonates of hydrogenated coconut oil	100% biodegradable; Substitute for sodium linear alkyl benzene sulphonate
Sucrose mono-esters of coconut oil	Detergent, emulsifier and wetting agent (cleaning food processing equipments)
Lauryl amine-oxide	Shampoo conditioner

Conclusion

The coconut palm contributes greatly as a source of coconut oil, copra, shell, fibre, carbon etc. Its success as a perennial oil crop is implicit, as it provides raw material for numerous industries with consistent production. It is necessary to focus on the nutritional, textural and taste characteristics of desiccated coconut and its oil. The medium chain fatty acids of the oil fraction are used in baby foods and weaning products. There is no scientific evidence against the high-saturated contents of coconut oil, mainly consisting of lower and medium chain fatty acids compared to animal fats, which have saturated higher chain fatty acids.

Mineral oils, known as liquid paraffins derived from petroleum, will soon be ousted as major component in cosmetics and skin care products. These synthetic oils penetrate the skin and enter human body, which could be harmful. Industries would be insisted upon to abandon petroleum-based products and substitute thems by natural products like coconut oil, which is environment-friendly and biodegradable. Thus coconut oil products can be promoted for the niche market.

Being environment-friendly, attempt should be made to give an environmental designation to coconut products. Coconut oil is a natural product of renewable resource, hence should be grown in larger quantities, unlike petroleum-based oils that are close to running out. There is a growing concern among medical researches about the human body's inability to break down petroleum derivatives versus natural vegetable oil based oleo chemicals like coconut oil. The price of petroleum feedstocks is bound to increase and industries will be compelled to use coconut oil, which could be cheaper if productivity is increased. Thus, it is hoped, coconut oil will find a unique place in cosmetics in this millennium.

COCONUT DISEASES

Thanjavurwilt/Ganoderma disease/Basal Stem Rot

Symptom: Decay of root system, flaccidity of spindle leaves, browning of outer leaves, arrested fruit set and appearance of bleeding patches on the basal region on the stem are the symptoms observed. Ultimately the palm dies off. In advanced stages, the bracket of fungus causing the disease is seen on stumps.

Management: Apply 50 kg organic manures and 5 kg neem cake fortified with antagonistic fungi per palm and provide irrigation. Provide drainage channels between rows of palms. Isolate the affected palm from the healthy ones by digging a trench around the affected palm. Adopt Phytosanitary measures - removal of dead palms, burial of the affected roots and bole in a pit. Inter cropping of banana is desirable as the root exudates of banana are found to inhibit the growth of pathogens. Apply calixin @ 2 ml per 100 ml of water through root feeding at quarterly interval for one years. Drench soil with 0.1% calixin @ 25 l per palm.

Source: CPCRI