Non food uses of nata de coco
a microbial cellulose

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Cellulose is the most abundant organic polymer on earth. It is an important structural component of the primary cell wall of plants, many algae and Oomycetes. Paper and paper boards are mainly produced from lignocellulosic material (plant origin). The derivatives like cellophane and rayon are also made in smaller quantities. Wood pulp and cotton are the main sources of cellulose for industrial use.

However, plant materials are not the only source of this valuable polymer. Microbial cellulose is a form of cellulose that is produced by bacteria. Some bacteria from the genera *Aerobacter, Acetobacter, Achromobacter, Agrobacterium, Alacaligenes, Azotobacter, Pseudomonas, Rhizobium and Sarcina* can synthesize cellulose when they are cultivated under adequate conditions. Of the above, *Acetobacter xylinum*, now known as *Gluconacetobacter xylinus* is

> Nata de coco is a chewy, translucent, jelly-like food produced by the fermentation of coconut water which gets converted into cellulose through the microbial action of *Acetobacter xylinum*. Originating in the Philippines, nata de coco is most commonly used as a candy or dessert, and can garnish a variety of foods, including pickles, drinks, ice cream,puddings and fruit cocktails

most preferred for commercial production due to its behaviour for producing enough cellulose. *G. xylinus* extrudes glucan chains from pores into the growth medium. These aggregate into microfibrils which forms into a three-dimensional coherent network of pure cellulose nanofibers or microbial cellulose ribbons. The production occurs mostly at the interface of liquid and air.

The bacterial cellulose is finer and more intricate in structure, the fibres are longer and stronger and has more absorbent per unit volume compared to the plant cellulose. The quality of the pellicle is determined by the strain of *G. xylinus* and media used. It has higher purity, crystallinity and degree of polymerization. It can be produced on a variety of substrates, can be grown to any shape virtually. No *hemicellulose* or *lignin* need to be removed as done in plant cellulose production. Bacterial cellulose is kept pure and handled carefully during subsequent manufacturing. It remains hydrated during other processes like pasteurization and infusion with ingredients based on the need. Conversely, wood pulp or cotton fibers are heavily processed and chemically treated.

Various kinds of sugars are used as substrate for production of bacterial cellulose. Coconut water is also one of the substrate from which microbial cellulose called Nata de coco is widely produced and mainly marketed as a dessert food. It is also used as an ingredient in other food products, such as ice creams, fruit cocktails, etc. Nata de Coco is low in calories, has no cholesterol and is high in dietary fiber which is good for digestive system.

Bacterial cellulose is an interesting, renewable and biodegradable material with extended commercial application due to its high purity, dietary fibre content and special physico-chemical characteristics. Apart from food sector, the bacterial or microbial cellulose is widely used in the paper industry, electronics, cosmetics and tissue engineering considering its remarkable mechanical properties, conformability and porosity.

Medical nonfood uses of bacterial cellulose

Bacterial cellulose is biocompatible and non-toxic and hence it is a suitable material for medical applications. The use of bacterial cellulose gels for the fabrication of biomedical products has advantages over the use of other types of cellulose and polymers. These advantages include the fact that the three dimensional shape and the fiber network architecture can be controlled.

Wound dressing

The dried, translucent, semi-opaque, biosynthetic cellulose membrane are widely used for wound dressing. The commercial products claim that the fluid balance is improved and the mechanical cellular matrix bridges the wound bed, thus promotes distribution and concentration of growth factors and nutrients needed for healing, while protecting the wound from environmental contamination. Studies have shown that the bacterial cellulose accelerates the process of healing of the skin in comparison with conventional wound dressings. It was further reported that these coverings reduce wound pain, accelerate re-epithelization and reduce wound infection rates and scarring.

Tissue engineering

Microbial cellulose has been used as a scaffold for tissue engineering application due to its biocompatibility. The scaffolds should have interconnecting pores of appropriate scale to favor tissue integration and vascularization, appropriate surface chemistry to favor cellular attachment, differentiation and proliferation, adequate mechanical properties and should be made from materials with

controlled biodegradability so that tissue will eventually replace the scaffold. Most of these requirements are met by the microbial cellulose, except biodegradability due to its high degree of crystallinity and a compact structure. However, researchers have overcome this by an *in vitro* chemical treatment which kept the original network structure intact and made a bacterial cellulose based scaffold that it could degrade in water, phosphate buffered saline and the simulated body fluid.

The investigations are on to create artificial blood vessels using bacterial cellulose as it is strong enough to cope with blood pressure and works well with the body's own tissue. It is claimed that the material also carries a lower risk of blood clots than the synthetic materials currently in use. The laboratory trials have positive response on the use of bacterial cellulose modified for addressing the issue of blood clotting, as real blood vessels have an internal coating of cells that ensure that the blood does not clot.

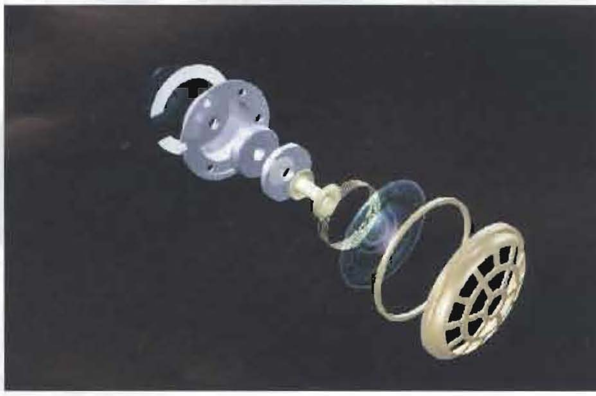
Other uses

Other less-documented biomedical applications include the use of bacterial cellulose for the production of contact lenses, electro conductive composite hydrogels biosensors, membranes for topical delivery of lidocaine, synthetic dura mater, bladder neck suspension, implantable soft tissue replacement, etc.

Non medical applications of microbial cellulose:

Use in acoustics

Traditionally, membrane of cone loudspeakers are made of paper (cone paper), formed with cellulose fibers. The biocellulose cone is normally made from kenaf (*Hibiscus cannabinus*), also called Deccan hemp and Java jute. Considering the good mechanical properties of bacterial cellulose made from nata de coco, several very thin layers of biocellulose membranes fused together by a special process to produce the biocellulose diaphragm.



The loudspeakers with biocellulose membranes were found to exhibit acoustic response in a wider frequency range and of higher effectivity and high sound quality in comparison with that produced from a plant cellulose diaphragm. Improvement of the mechanical properties can be achieved by treating the biocellulose with alkali or oxidant solutions. It means that the replacement of cone paper loudspeaker with a cone biocellulose is prospective. The nata de coco diaphragms are already in use in high-end earphones/ headphones of popular brands.

Use in cosmetics

Not all cellulose is the same. Most of the facial masks in the market use paper, technically made of cellulose from wood or cotton fiber. There is a tremendous difference. Biocellulose is hydrophillic, which has the ability to both absorb or donate moisture to the surface it is in contact with. Bacterial cellulose's inclination to reach moisture equilibrium makes it more helpful as it moisturizes dry skin and normalizes oily skin simultaneously. Cosmeceutical ingredients are even added for the facial masks.

As the fibers are stronger, the bacterial cellulose masks are more durable. These can be applied, removed, and re-applied if necessary. The super hydration also helps it cling tightly to the skin which aids in gentle opening of pores during use.

Other uses

Researches are ongoing to evaluate a possible role for bacterial cellulose in the following applications of matrix for electronic paper; high strength paper; substrates for OLEDs; gloss surface finish in magazines, etc.

With some fusion of science and creativity, fashion designers manage to create non-woven, eco-friendly dress materials from bacterial cellulose.

It is reported that nata de coco hydrogel, systhesised using radical polymerization from nata de coco, finds application as nano reactors for preparation of iron nano particles from ferrocenium reduction. The nanoscale iron particles are widely used in medical and laboratory applications. Researches have found that nanoscale iron particles can be effectively used to treat industrial sites contaminated with chlorinated organic compounds. However, these are not commonly used due to lesser production and higher price.

Disadvantages of bacterial biocellulose

Though the microbial cellulose produced from various substrates, including coconut water, have several advantages, large scale commercialization is prevented as the price is much higher than plant cellulose. This is due to the low volumetric yields, high priced sugar substrates and lack of large scale production. Since it is a cultured material which takes minimum ten days to manufacture and because the entire organic process must be done cleanly and avoid harsh chemicals it is more expensive to create.

Future thrust

Microbial cellulose is biocompatible and non-toxic. The research is to be geared up to evaluate a possible role for bacterial cellulose in the several new applications, making the product cheaper by improvement in production process to enhance the yield. Development of new strain of *G. persimmonis* for producing substantial amounts of bacterial cellulose both under stationary and submerged agitated conditions has also been reported. Cellulose production using laboratory fermentor has substantially reduced the duration from 12-14 days (stationary cultivation) to 5-7 days (agitated conditions). The effects of different parameters like strain, agitation, dissolved oxygen levels, media rheology, etc. on bacterial cellulose production are to be investigated and standardized.

Popularizing the products for dessert, dietary, medical and other uses may attract more entrepreneurs in the fields. India is the world leader in coconut production. Several industries in the country are manufacturing value added products like desiccated coconut powder, virgin coconut oil, coconut oil, coconut milk and milk based products, where the coconut water is wasted except for making some vinegar. For appropriate largescale production, a specific knowledge about these byproducts and a proper standardization of them are required. This may yield additional income to the existing entrepreneurs or may help in flourishing small entrepreneurs.

The Government of India through Coconut Development Board extends financial assistance as back ended credit linked subsidy at different levels for development of technologies; demonstration of technologies; adoption of technologies; market research and promotion under the Technology Mission on Coconut programme.. Interested government institutions, societies, research organizations, cooperative societies, NGOs, individuals and other organizations are eligible for submission of projects under TMoC for availing financial assistance. ■

Source • *Handbook of natural fibres: Types, properties and factors affecting breeding and cultivation, RM Kozłowski - 2012 • https://www.belmondobeauty.com/what-is-bio-cellulose/ • https://www.belmondobeauty.com/what-is-so-special-about-biocellulose-facial-masks-2/• https://www.biorepublic.com/blogs/news/biocellulose-its-benefits • https://en.wikipedia.org/wiki/Microbial_cellulose • https://en.wikipedia.org/wiki/Nata_de_coco • http://aip.scitation.org/doi/abs/10.1063/1.4895233 • https://www.researchgate.net/publication/284051871_Applications_and_Products-Nata_de_Coco*