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Biosurfactants: Unique properties and their versatile applications

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Abstract
Biosurfactants are amphiphilic biological compounds produced extracellularly or as part of the cell membrane by a variety of yeast, bacteria and filamentous fungi various substances including sugars, oils and wastes. They reduce surface tension, critical micelle concentration (CMC) and interfacial tension in both aqueous solutions and hydrocarbon mixtures. Biosurfactant derived from the probiotic species are of biomedical and food interests. They are advantageous as antibacterial and antifungal agents, and they also have the potential for use as antibiofilm agents in biomedical field.

Keywords: Biosurfactant, CMC, antimicrobial, antibiofilm agents biomedical applications

Introduction
Surfactants are surface active compounds that reduce the surface tension between two liquids, or that between a liquid and a solid. They are organic compounds that contain both hydrophobic (head part of the surfactant) and hydrophilic (tail part of the surfactant) moieties. Thus surfactant contains both water insoluble i.e. water repellent moiety as well as water soluble i.e. water loving moiety [1].

Like chemical surfactants, biosurfactants are also surface active compounds, except for the fact that biosurfactants are secreted by microbes like bacteria, fungi and yeast. Due to their amphilic nature, they contain both hydrophobic (head part of the surfactant- water repelling) and hydrophilic (tail part of the surfactant- water loving) moieties. This imparts the unique ability to reduce surface tension as they can form micelles that collect at the interface between fluids of various polarities, for example, water and oil [2]. They are used to remove oily materials from a particular media as they can rise the aqueous solubility of Non- Aqueous Phase Liquids (NAPLS) by lowering their surface/ interfacial tension at air–water and water–oil interfaces [3].

The Unique features of biosurfactants
The distinctive properties of biosurfactants when compared to their chemical surfactants, and the broad substrate availability for their production has made them appropriate for marketable applications. The typical features of microbial surfactants are related to their surface activity, tolerance to pH, temperature and ionic strength, biodegradability, low toxicity, emulsifying and demulsifying ability and antimicrobial activity [4]. The major distinctive features of each property of biosurfactant are discussed below.

Biodegradability
Biosurfactants are simply decomposed by microorganisms [5]. Artificial chemical surfactants cause adverse environmental complications and henceforward, ecofriendly biosurfactants from numerous microorganisms are involved for the biosorption of sparcely soluble polycyclic hydrocarbon, phenanthrene contaminated in aquatic surfaces [6]. Lee *et al.* (2008) mentioned concerning the action of biosurfactant sophorolipid that controlled the blooms of marine protoctist, Cochlodinium with the removal potency of 90% in thirty min treatment [7].

Low toxicity
Biosurfactants exhibit low toxicity than the chemical-derived surfactants. It absolutely was additionally reported that biosurfactants showed higher EC 50 (effective concentration to reduce 50% of test population) values than synthetic dispersants [8].

Availability of raw materials
Biosurfactants could be synthesized from very inexpensive raw materials which are available in great quantities. The carbon supply may come from hydrocarbons, carbohydrates and /or lipids, which can be used individually or together with one another [9].

Physical factors
Many biosurfactants are not influenced by environmental factors like temperature, pH and ionic strength tolerances. Lichenysin produced by *Bacillus licheniformis* strain was not influenced by temperature ranges of up to 50°C, a pH range of 4-5- 9.0, and NaCl concentration of 50g/l and Ca concentration of 25g/l. [10].

Surface and interface activity
Mulligan *et al*, (2005) [11] specified that an ideal surfactant can lesser surface tension of water from 75 to 35mN/m and the interfacial tension of water: hexadecane from 40 to 1mN/M. Surfactin has the ability to diminish the surface tension of water to 25m N/M and the interfacial tension of water: hexadecane to < 1mN/M [10].

Other advantages
Kosaric *et al*, (2001) [9] suggested that their properties of biocompatibility and biodegradability permits their application in cosmetic, pharmaceutical preparation and as food additives.

Potential Biomedical Applications of Biosurfactants
Kakugawa *et al*. (2002) and Mukherjee *et al*. (2006) testified that the biosurfactants possess a good range of applications in pharmaceutical fields like cistron delivery, agents for metastasis failure, immunologic adjuvants, antiadhesive agents in surgicals, inhibition the adhesion of unhealthful organisms to solid surfaces, recovery of intracellular product, antimicrobial activity, antiviral activity, antitumor activity and agents for the stimulation of skin fibroblast metabolism.

Gene delivery
Gene transfection [15, 16], lipofection using cationic liposomes is considered to be a promising method to transport foreign gene to the target cells without any side effects. Kitamato *et al*. (2002) demonstrated that in comparison with commercially available cationic liposomes, biosurfactant supported liposomes show growing potency of gene transfection. Ueno *et al*. (2007) are developing some novel techniques and methodologies. MEL-A containing liposomes for the liposome based gene transfection.

Agents for respiratory failure
A deficiency of pulmonary surface-active agent which is a phospholipid protein complex is accountable for the failure of respiration in untimely born infants. Isolation of the genes for protein molecules of this surface-active agent and cloning in bacteria has created potential its microbiological production for medical applications [19].

Immunological adjuvants
Bacterial lipopeptides represent potent non-toxic and non-pyrogenic immunologic adjuvants once mixed with standard antigens. A marked improvement of humoral immune effect was obtained with the low molecular mass antigens. Iturin AL, herbicolin A and microcystin (MLR) combined to poly-L-lysine (MLR-PLL) in rabbits and in chickens [20].

Antiadhesive agents in surgical
Pre-treatment of synthetic rubber with surface- active- agent produced by *Streptococcus thermophiles* inhibited by eighty five percent the adhesion of *Candida albicans* [21], while surfactants obtained from *Lactobacillus fermentum* and *Lactobacillus acidophilus* adsorbable on glass, reduced by seventy seven percent, the quantity of adhering uropathogenic cells of *Enterococcus faecalis*. The biosurfactant obtained from *Lactobacillus fermentum* repressed *Staphylococcus aureus* infection and adhered to surgical implants [22]. Surfactin attenuated the number of biofilm formation by *Salmonella typhimurium*, *Salmonella enterica*, *Escherichia coli* and *Proteus mirabilis* in PVC plates and vinyl canal catheters [23]

Antimicrobial activity
Das *et al*. (2009) have described biosurfactant created by marine *Bacillus circulans* that had a potent antimicrobial activity against gram-positive, gram-negative unhealthful and semipathogenic microbial strains together with MDR strains. Fernandes *et al*. (2007) explored the antimicrobial activity of biosurfactants from *Bacillus subtillis* R14 against twenty nine bacterial strains. Their results demonstrated that lipopeptides have a broad spectrum of action, including antimicrobial activity against microorganisms with multidrug-resistant profiles [29].

Inhibition the adhesion of pathogenic organisms to solid surfaces
Biosurfactants are found to inhibit the adhesion of unhealthful organisms to solid surfaces or to infection sites [24]. Thus, previous adhesion of biosurfactants to solid surfaces would possibly represent a brand new and effective means that of combating colonization by disease causing microorganisms [26]. Pre-coating vinyl canal catheters by running the surfactin solution through them before introducing with media resulted decrease within the quantity of biofilm fashioned by *Salmonella typhimurium*, *Salmonella enterica*, *Escherichia coli* and *Proteus mirabilis* [27]. Moreover, Rodrigues *et al*. (2004) proved that biosurfactants greatly reduced microbial numbers on prostheses and additionally induced decline in airflow resistance that follows on voice prostheses once biofilm formation.

Recovery of intracellular products
Surfactants have additionally been exploited to lyse cells after fermentation as part of the procedure for retrieval of intracellular products. Reverse particle solutions were used for selective permeabilization of *Escherichia coli* to facilitate extraction of antibiotic acylase (Singh *et al*.2007).

Antiviral activity
Antibiotic effects and inhibition growth of immunological disorder virus in leucocytes by
biosurfactants are cited in literature [29, 30]. Furthermore, Muthusamy *et al*. (2008) stated that due to the augmented incidence of HIV in women, there arose the necessity for a feminine controlled, efficacious and safe duct topical microbicide. Sophorolipids surfactants from *Candida bombicola* and its structural analogues such as sophorolipid diacetate ethyl group organic compound is the most potent

spermicidal and antiviral agent, it had been additionally testified that this substance has a antiviral activity similar to nonoxynol –9 against the human body fluid.

Anti-cancer activity

The combination of particular characteristics such as emulsifying, antiadhesive and antimicrobial activities presented by biosurfactants suggests potential application as multipurpose ingredients or additives. Scant information regarding toxicity, combined with high production costs seems to be the major cause for the limited uses of biosurfactants in food area [31]. However, the use of agroindustrial wastes can reduce the biosurfactants production costs as well as the waste treatment expends and also renders a new alternative for food and food-related industries not only for valorizing their wastes but also to becoming microbial surfactant producers. Biosurfactants obtained from Generally Regarded As Safe (GRAS) microorganisms like Lactobacilli and yeasts are of great promise for food and medicine applications though, much more research is already required on this field. The prospect of new types of surface-active compounds from microorganisms can contribute for the detection of different molecules in terms of structure and properties but the toxicological aspects of new and current biosurfactants should be emphasized in order to certify the safe of these compounds for food utilization [32].

Agents for the stimulation of skin fibroblast metabolism

The use of sophorolipids in lactone type includes a significant a part of diacetyl lactones as agents for exciting skin dermal formative cell cell metabolism and chiefly, as agents for the stimulization of scleroprotein neosynthesis, at a level of zero.01 ppm at fifth (p/p) of dry matter in formulation. This may be applied in cosmetology and conjointly in medical specialty. The pure lactone sophorolipid product is of importance within the formulation of derma antiageing merchandise due to its impact on the stimulation of cells of the dermis. By encouraging the assembly of latest scleroprotein fibres, pure lactone sophorolipids is also used each as a precaution against ageing of the skin and employed in creams for the body, and within the body milks, lotions and gels that are used for the skin [33].

Conclusion

The combination of specific characteristics like emulsifying, antiadhesive and antimicrobial activities conferred by biosurfactants suggests potential application as utile ingredients or additives. Scant data concerning toxicity, combined with high production prices appears to be the foremost cause for the restricted uses of biosurfactants in food space. However, the utilization of agro industrial wastes will scale back the biosurfactants production prices in addition because the waste treatment expends and also renders a replacement different for food and food-related industries not just for valorising their wastes however also to changing into microbic wetting agent producers. Biosurfactants obtained from usually thought to be Safe (GRAS) microorganisms like lactobacilli and yeasts are of nice promise for food and medication applications though', rather more analysis is already needed on this field. The prospect of latest kinds of active compounds from microorganisms will contribute for the detection of various molecules in terms of structure and properties however the pharmacological medicine aspects of new and current biosurfactants ought to be stressed so as to certify the safe of those compounds for food utilization.

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