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Natural Ingredients against Biofilm Formation

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Abstract
Biofilms are a community of microorganisms attached to a surface by polysaccharides, proteins, and nucleic acids. Early steps in biofilm formation require the synthesis of different bacterial surface appendages including flagella that allow reversible attachment and cell motility which is a determinant of biofilm architecture. Most bacterial communities grow in 3-dimensional biofilm structures on surfaces in natural, clinical, and industrial settings. Bacterial biofilm formation can cause serious problems in clinical and industrial settings, which drives the development or screening of biofilm inhibitors. Some biofilm inhibitors have been screened from natural products. This review is about the various natural products which acts against the biofilm formation.

INTRODUCTION

A biofilm is a matrix of microorganisms with extracellular substances (EPS) that can be formed on different surfaces. These surfaces can be animal tissue (meat, fish products), catheter, teeth, stainless steel, plastic, glass, teflon, rubber, wood, etc. Biofilm formation can be divided into 5 parts. First (1-2): reversible and irreversible attachment to the surface; 3: development of the extracellular matrix; 4: maturation of the biofilm and; 5: dispersion. In reversible stage, the bacteria attach to surfaces with van der Waals attraction forces, electrostatic forces and hydrophobic interactions. During this phase, bacteria can be removed from surfaces easily for example by rinsing. If bacteria interact with surfaces by dipole-dipole, hydrogen, ionic or covalent bonding, removal will be more difficult [1, 2]. The finishes of stainless steel surfaces also influence bacterial attachment. The adherence is stronger to untreated or sandblasted surfaces than to electropolished area [3]. After attachment the bacteria form microcolonies and produce a matrix called extracellular polymeric substance (EPS). The EPS protects bacteria within the biofilm (cells are more tolerant to stress factors) and is responsible for binding. It is composed of polysaccharides, proteins, nucleic acids, lipids [4]. When biofilms consists of different microorganisms, the matrix is thicker and more stable than the matrix of single species biofilms . If the biofilm reaches the maximum, starvation, enzymatic degradation and increased fluid shear will appear. The cells from the top of the biofilm will disperse and colonize new surfaces. Biofilms can occur in different industrial and medical environments. 65-80% of infections are related to biofilms [5]. In the food industry biofilms can be found in dairy, fish processing, poultry meat and ready-to-eat food factories and can cause serious hygiene and technological problems by cross contamination. Biofilms have part in outbreaks of pathogens and increase the risk of contamination in food plants.

BIOFILM FORMATION

Biofilms are a community of microorganisms attached to a surface by polysaccharides, proteins, and nucleic acids. E. coli biofilm development is a complex process that leads to beautiful structures that are important for disease and for engineering applications (note the first engineered biofilm was created to secrete peptide antimicrobials to reduce corrosion. These matrices are formed through at least five developmental stages that include (i) initial reversible attachment of planktonic cells to a solid surface, (ii) transition from reversible to irreversible attachment, (iii) early development of biofilm architecture, (iv) development of microcolonies into a mature biofilm, and (v) dispersion of cells from the biofilm to return to the planktonic state. Early steps in biofilm formation require the synthesis of different bacterial surface appendages including flagella that allow reversible attachment and cell motility which is a determinant of biofilm architecture. For irreversible attachment, flagella synthesis is repressed and adhesive organelles like curli fimbriae, encoded by the csg operon, and type I fimbriae, encoded by fim genes, are important for biofilm formation.The mannose-sensitive, type I fimbriae also mediate adherence and antibiotic-resistant pod formation that is important for invasion of host cells in some urinary tract infections, and bundle-forming pili and the EspA filament are important for biofilm formation by enteropathogenic E. coli. Note that conjugation plasmids increase biofilm formation in a manner independent of flagella, type I fimbriae, outer membrane autotransporter Ag43 (promotes autoaggregation), and curli due to an envelope stress response. This review focuses on E. coli biofilm formation and inhibition based on recent developments in the field (primarily whole transcriptome profiling) with both pathogenic and non-pathogenic strains. More comprehensive reviews of E. coli biofilm formation are available such as the that of Ghigo and colleagues. Biofilm formation can be reduced by various natural ingridients.

GINGER EXTRACT AGAINST BIOFILM FORMATION:

Ginger (Zingiber officinale), a member of the Zingiberaceae family, is a popular spice used globally especially in most of the Asian countries [6]. Chemical analysis of ginger shows that it contains over 400 different compounds. The major constituents in ginger rhizomes are carbohydrates (50–70%), lipids (3–8%), terpenes, and phenolic compounds [7]. Ginger has staring potential for treating a number of ailments including degenerative disorders (arthritis and rheumatism), digestive health (indigestion, constipation and ulcer), cardiovascular disorders (atherosclerosis and hypertension), vomiting, diabetes mellitus, and cancer. It also has anti-inflammatory and anti-oxidative properties for controlling the process of aging. Bacterial biofilm formation can cause serious problems in clinical and industrial settings, which drives the development or screening of biofilm inhibitors. Some biofilm inhibitors have been screened from natural products or modified from natural compounds. Ginger has been used as a medicinal herb to treat infectious diseases for thousands of years, which leads to the hypothesis that it may contain chemicals inhibiting biofilm formation[8]. The various study uses different assays and analysis to test the activity of ginger extract against biofilm formation[9].

ESSENTIAL OILS:

The essential oils helps in formation of biofilm. These essential oils are used as natural preservatives and sanitizers in the food industry. Essential oil damage the cell wall and membranes of microorganisms, alter the morphology and coagulate the cytoplasmatic material. Most of them are recognized as safe and can be used directly in foodstuff. Latest research reported the good antimicrobial effects of Essential oil on pathogenic and spoilage bacteria. Besides this, they have good anti-biofilm forming and anti-QS effect[10]. The strong aroma of essential oil can affect organoleptic properties of foods. Essential oils which combines antimicrobial efficiency gives a pleasant flavour effect. These results lead to the conclusion that essential oils can be used as alternative sanitizers and preservatives in the food industry. The main obstacle for using essential oils as antimicrobials and food preservatives is that most often they cause negative organoleptic effects when added in sufficient amounts to provide an antimicrobial effect. The different methods that can be used[11]. The recent study used Agar dilution assay, resazurin assay to check the activity of ginger extract against biofilm formation.

EFFECTS OF BERBERINE IN BIOFILM FORMATION:

Berberine is a natural isoquinoline alkaloid isolated from various Chinese herbs, including Hydrastis canadensis, Berberis aristata, Coptis chinensis, Coptis rhizome, Coptis japonica, Phellondendron amurense and Phellondendron chinense schneid. In clinical practice, berberine has been used in the treatment of enteritis for thousands of years in China [12]. More importantly, synergy of berberines enhanced the inhibitory efficacy of other antibacterial [13,14]. Berberine, one of the most important members of the protoberberine group of alkaloid, exhibits antimalarial, antisecretory, and anti-inflammatory as well as anticancer activities with relatively low cytotoxicity [15]. It has also been reported that berberine is useful in the treatment of gastroenteritis, diarrhea, and cholera diseases [16]. Berberine has antimicrobial activity against several bacterial species, and interferes with the adherence of Streptococcus pyogenes to host cells, either by preventing the complexing of lipoteichoic acid with fibronectin or by dissolution of such complexes once they are formed [17]. It can also improve intestinal health and lower cholesterol. Berberine is able to reduce glucose production in the liver. Human and animal research demonstrates that 1500mg of berberine, taken in three doses of 500mg each, is equally effective as taking 1500mg of metformin or 4mg glibenclamide, two pharmaceuticals for treating type II diabetes. Effectiveness was measured by how well the drugs reduced biomarkers of type II diabetes. Berberine may also synergize with anti-depressant medication and help with body fat loss. Berberine's main mechanism is partly responsible for its anti-diabetic and anti-inflammatory effects. Berberine is able to activate an enzyme called Adenosine.
The recent study uses various assays and analysis to check the effect against biofilm formation[18].

HONEY AGAINST BIOFILM FORMATION:

Honey has been used as a source of nutrients as well as a medicine since ancient times. Honey can be used as a temporary dressing in burns[19]. It has also been found to be effective in the management of radiation-induced mucositis in patients receiving head and neck radiotherapy. Honey may have a similar antibacterial effect on Streptococcus mutans, which is considered the main causative organism of dental caries [20]. S. mutans along with other oral bacteria forms on the tooth surface a microbial community surrounded by extracellular matrix and salivary proteins [21].collectively known as dental biofilm. Cariogenic bacteria within this biofilm utilize dietary sugars and produce lactic acid as a by-product [23]. This acid attacks and demineralizes the tooth structure, leading to decay.Very limited studies have investigated the effect of honey on S. mutans. These studies investigated the effect of honey on several strains of oral bacteria [24]. Here, we tried to explore the effect of honey on the growth and viability of S. mutans, as well as determine the effect of natural honey on S. mutans biofilm formation.Many agents have been considered in the goal of preventing dental caries, including chlorhexidine, fluoride and xylitol. However, the dietary effect of ingestible carbohydrate sources cannot be ignored. Honey is sometimes used as a sugar substitute to limit the exposure to sucrose [25]. The effect of honey on S. mutans biofilms can provide evidence on both the cariogenicity and antibacterial properties of honey. In this study, we investigated the effect of honey on the growth, viability, and biofilm formation of S. mutans. Statistical Analysis and biofilm assay are the methods used.

CONCLUSION

Biofilm formation of pathogenic bacteria on surfaces and on foods represents a big challenge to the food industry and healthcare. The removal of biofilms is difficult and in spite of the efforts for good sanitization surfaces and products can be contaminated which can lead to severe health problems.

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