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Review Article

Use of *Hibiscus sabdariffa* L. and *Rosmarinus officinalis* L. in the formulation of antibacterial soaps

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Abstract

Background: In principal, phytotherapy is the study of medicinal plants and their applications in the treatment and cure of diseases. Medicinal plants have been in use since antiquity and their importance is growing empirically among people around the world.

Materials and Methods: Although, it is not very common to find herbal medicines sold over-the-counter in pharmacies, their use has been gaining popularity. In recent times, the indiscriminate use of medicines, particularly antibiotics, has become a matter of major public health concern in view of increasing bacterial resistance to certain antibiotics. Proper hygiene of the body, especially the hands, is of paramount importance to prevent cross-infection, particularly among healthcare professionals. Therefore, the use of antiseptics has become essential in the daily activities.

Results: Herbal formulation, being natural products, can prove to be useful alternatives to combat common pathogens, as they are safe for human body. Several plant species have been studied in search of antibacterial alternatives and many of them have been exploited for their use as phytocosmetics.

Discussion and Conclusions: *Hibiscus sabdariffa* L. and *Rosmarinus officinalis* L. have been found to possess strong antibacterial properties and therefore can be used as phytocosmetics in the form of soaps.

Keywords: Phytocosmetics, Anthocyanins, Essential oil, *Streptococcus pyogenes, Staphylococcus aureus*.

Background

Plants have been used for curative purposes, since the beginning of human civilization as human beings sought to cure various diseases using different species of plants. Currently, this search has gained momentum even though the synthetic drugs can be easily obtained from any pharmacy.[1] One of the factors that has necessitated use of natural products derived from plants is the increasing resistance of common pathogens to synthetic antimicrobials that are currently in use all over the world.[2] In some regions of the world, the use of antimicrobials or antibiotics requires no prescription. This not only makes it easier to obtain them over-the-counter from any pharmacy but also encourages their irrational and unmindful use leading to possibility of increasing resistance to certain drugs.[3] In such cases, rational use of the antibiotics is of paramount importance to fight those bacteria which are causing serious damage to human health.[4]

Another problem that has already become an aggravating public health issue is healthcare-related infections. This is considered to be the main form of dissemination and transmission of microorganisms by healthcare professionals to patients and these transmissions occur through simple fact of non-hygiene or poor hand hygiene. Experts suggest that simple infection control measures can be implemented and approximately one third of hospital infections can be prevented by maintaining proper hand hygiene.[5,6]

Simply cleaning hands using effective products can be a simple strategy in prevention of cross contamination, as this has been proved by many scholars around the world. However, some healthcare professionals continue to ignore the importance of proper hand hygiene leading to severe bacterial contamination in hospitals.[6,7]

In order to avoid cross-contamination the use of antiseptics becomes essential in daily activities. In view of increasing incidences of bacterial resistance to synthetic antibiotics herbal alternatives are becoming popular in order to combat common pathogens. The use of plant based new natural products has shown significant antimicrobial effect in several studies aimed at overcoming threatening problems caused by various pathogenic bacterial strains that show resistance to allopathic medicines. Therefore, the plants have been demonstrated to play an important role in therapeutic treatment.[8,9]

Several plant species have been studied in search of antibacterial alternatives, such as hibiscus - *Hibiscus sabdariffa* L. (belonging to the Malvaceae family) and rosemary - *Rosmarinus officinalis* L. (belonging to the Lamiaceae family), to fight bacteria such as *Streptococcus*

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pyogenes and *Staphylococcus aureus* commonly associated with human skin.[10-12]

Materials and Methods

Bacterial resistance

The association between inappropriate use of antibiotics and the emergence of antimicrobial resistance is one of the current public health problems of global relevance. Some factors that contribute to the high rate of inappropriate antibiotic use are: sale of over-the-counter antibiotics by a large number of pharmacies and drugstores, mis-diagnosis of viral or bacterial infections, wrong timing of treatment and mis-calculated dosages. These factors lead to increasing risk of developing bacterial resistance endangering the patient's health.[13,14]

Bacterial resistance happens naturally over the time usually through genetic changes.[15] *Escherichia coli*, for example, takes approximately 20 minutes to double, thereby increasing the possibility of producing many generations in a few hours, providing many opportunities for evolutionary adaptations. Consequently, frequent use of antibiotics may be one of the factors responsible for the emergence of resistance of these bacteria. In addition, bacterial conjugation may favor the transmission of resistance elements such as plasmids.[16]

Some of the mechanisms of bacterial resistance may include modification or destruction of the antibiotic, reduction of drug cell permeability or existence of efflux pumps, alteration of antimicrobial target molecules and the production of alternative molecules that are not inhibited by the antibiotics. All these make it difficult to treat patients by antibiotic therapy.[13]

Staphylococcus aureus

Staphylococcus aureus is a well known pathogenic bacterium. The species of this genus are immobile, facultative, non-spore forming aerobes which are gram-positive cocci. They are found in various parts of the human body, such as the nasal passages, throat and skin, as part of the normal skin microbiota. However, it can cause a number of limited or systemic infections, such as pneumonia, infectious endocarditis, bacteremia, food poisoning, staphylococcal scalded skin syndrome, and toxic shock syndrome.[17-20] *S. aureus* is one of the most flexible and tolerant bacterium, able to survive antimicrobial therapies with high virulence for humans.[21]

One of the main features of *S. aureus*, which represents a major clinical and public health problem, is the rapid ability of these bacteria to acquire resistance to antibiotics.[20-24] Since,1940 onwards, penicillin was used, but in the later years it was suggested that certain bacterial strains were penicillinase producers which created resistance to penicillin action. As early as the 1960s, methicillin was released, but in just one year resistant strains were found which were titled with the acronym MRSA (methicillin-resistant *Staphylococcus aureus*).[19,20,22,24]

Streptococcus pyogenes

Streptococcus pyogenes is a β-hemolytic bacterium known as Lancefield group A streptococcus. Morphologically, it is a gram-positive, spherical coccus, forming small chains in clinical samples and larger chains in liquid medium. They can cause various diseases, such as pharyngitis, impetigo, erysipelas, cellulitis and puerperal sepsis.[25,26]

This bacterium has several virulence factors, namely: cell wall with lipoteic acids and adhesins, hyaluronidase that contributes to the ability to cause invasive infections; some strains have polysaccharide capsules, protein M, which provides resistance to phagocytosis and the release of inflammatory mediators that induce toxic shock, necrotizing fasciitis, acute rheumatic fever, and acute glomerulonephritis.[25]

Hibiscus sabdariffa L. (Hibiscus)

The hibiscus is a plant species from East Africa, belonging to the family Malvaceae and was introduced in Brazil by slaves.[27,28] It is known by various popular names in different regions of the world.[29] In popular medicine, the plant has numerous uses such as diuretic, in the treatment of gastrointestinal ,and liver infections, fever and hypertension.[30]

Anthocyanins (flavonoids present in various plant species) are found in large quantities in the hibiscus, especially in the corolla of the flowers. Their alcoholic extract has greater antimicrobial potential, as compared with the alcoholic extract of seeded fruits which lack anthocyanins. Hydroalcoholic extraction has been suggested to have high efficacy in the extraction of phytochemical antimicrobial compounds, especially the phenolic compounds, which have strong antibacterial activity. The presence of such compounds was observed in *H. sabdariffa* by phytochemical research.[31-33]

This efficacy was also observed in research carried out at the Federal University of Rio Grande do Sul (UFRGS), in Porto Alegre, where the alcoholic extract of the *H. sabdariffa* petals was more effective against *S. aureus, Enterococcus faecalis, E. coli* and *Salmonella enteritidis* as compared to other parts of the plant such as seeded fruits. It is believed that its antibacterial activity is related to anthocyanins, since higher amounts were found in the alcoholic extract of the petals. This further proves the association with the antibacterial activity of this plant with the flavonoids present in the petals.[33]

The anthocyanins present in *H. sabdariffa* are phenolic compounds responsible for the red color of flowers, widely used as a natural color in many foods, having the ability to protect against oxidative damage, and may contribute to the prevention of some diseases, such as cardiovascular disease, cancer, Alzheimer's, diabetes mellitus, and other chronic diseases associated with oxidative stress.[34,35]

The antioxidant activity that protects the cell membrane

from the action of lipid peroxidation by being able to stabilize reactive oxygen species (ROS) is related to the anthocyanins that provide this mechanism by being able to stabilize the (ROS) by their group reaction hydroxyl with the radical, causing it to become inactive.[35]

Other studies also provide information on the antibacterial and oxidative activity of *H. sabdariffa*, it is believed that these activities are related to the large amount of anthocyanins in the plant, as reported by Chao and Yin.[36] In addition, the plants may have other phytochemicals to protect against a variety of microorganisms.[36,37]

As mentioned earlier, bacteria are becoming resistant because they have the genetic ability to resist certain antibiotics. Therefore, there is a great demand to create drugs of natural origin. According to the available literature, *Hibiscus* possesses phenolic compounds which show strong potential of antibacterial activity against gram-positive bacteria, making it a useful alternative of to minimize the possibility of bacterial resistance.[33,38]

Due to its proven antibacterial activity, *H. sabdariffa* can be considered as a viable alternative of natural antibiotic against *S. aureus* and *E. coli*. The inhibition of these strains by the concentrated extract of *H. sabdariffa* petals has been convincingly demonstrated.[39]

Another study also evaluated the antibacterial properties of the alcoholic extract of *H. sabdariffa* petals against strains of *S. aureus, E. coli, Bacillus stearothermophilus* and other microorganisms reaffirming their relationship with flavonoids, also present in flowers. Furthermore, this study reported that the antibacterial power of *H. sabdariffa* could be compared with the antibiotic streptomycin except that it did not inhibit *E. coli.*[40] Some authors have also described plant activity against *S. aureus*, *E. coli, P. aeruginosa* and *S. pyogenes*, showing that *H. sabdariffa* had more activity against gram-positive bacteria than gram-negative bacteria.[41,42]

Rosmarinus officinalis L. (Rosemary)

Rosmarinus officinalis L. is a plant of European Mediterranean origin, however, it is known by several popular names such as scented rosemary, garden rosemary, house rosemary, common rosemary, rosemary, among others. It is used for a variety of purposes, including therapeutics, and yet a few studies have been conducted on this plant.[43-45]

The therapeutic properties of this plant are attributed to some compounds present in it, such as diterpenes rosmanol, rosmarinho diphenol and rosmariquinonaque, which are responsible for the antioxidant property of the plant and the presence of borneol, pinenos, cineol and camphor, which are responsible for its antimicrobial activity. The antibacterial activities can be tested by bacteriological assays with plant extract and synthetic antibiotics used against sensitive and resistant forms of bacteria.[44] Through the technique of agar orifice it is possible to assess bacteriostatic and fungiostatic activity of *R. officinalis*.[46]

Some compounds present in the essential oil of *R. officinalis* and used against strains of gram-negative bacteria suggest that it has the ability to break or penetrate the outer lipid layer of the bacteria mentioned.[47]

Results

It has been suggested that the results obtained from the evaluation of antimicrobial efficacy were influenced by the chosen methods and types of extractors (juices, essential oil and extraction by water or other solvents) and the part of the plant and its physiological characteristics. These factors not only determined the antibiotic activity but also influenced derivation of useful compounds of different nature. Antimicrobial substances obtained from plants are tested by observing the growth of microorganisms placed in contact with tissues or extracts. To test these substances several methods are used, differentiated by sensitivity or principles, as well as by the microorganisms used.[48]

Discussions

The primary action of essential oils is believed to be on the destabilization of the cell wall. It has been shown that the antibacterial activity of essential oils may be more efficient against gram-positive bacteria, since there is a greater interaction with hydrophobic wall structures when compared to gram-negative cell wall structures, which have hydrophilic compositions. These results still need to be elucidated further in view of the diversity of observations made by different group of scientists. The change in ion transport is detrimental to the microbial cell, as the relative hydrophobicity of carvacrol and thymol allows diffusion through the polar polysaccharide matrix of the bacterial wall, while the hydrophobic property may lead to specific interactions with the bacterial membrane causing dispersion of the cell membrane polypeptide chains, promoting membrane destabilization. Actions that are related to denaturation of cytoplasmic proteins and inactivation of cellular enzymes through the action of essential oils also lead to bacterial cell death.[49-52]

These differences can be explained by the variation in hydrophobic behavior. More hydrophobic microorganisms are more sensitive to essential oils than hydrophilic ones. Further, vegetative cells are more hydrophilic, which could require a higher concentration of essential oils to inhibit their growth.[53]

One study has shown that rosemary alcohol extract effectively inhibited the growth of *Salmonella typhimurium, S. aureus, Listeria monocytogenes* and *Yersinia enterocolitica*.[54]

The antibacterial action of ethanolic and methanolic extracts of *R. officinalis* was also verified in a study with 20 different microorganisms using the disc diffusion method. Some of these bacteria were *E. coli* and *S. aureus*. However, *E. coli* was not sensitive to either of the compounds, while *S. aureus* had 17 mm inhibition halos in both.[55]

Compound extraction

The final yield of compounds to be obtained is directly related to the choice of solvent that will extract the different metabolites. Each type of substance will express itself with compatible extractors since many substances are heat sensitive and cannot withstand high temperatures. For example ethanol is a great solvent and has the ability to extract numerous constituents. This is due to some factors, such as its amphiphilic nature, which allows the extraction of both polar and nonpolar substances and its boiling point of 78.3°C, which is favorable for extraction of various constituents.[56-58]

Conclusions

H. sabdariffa and *R. officinalis* are excellent plant options that can be associated with antibacterial phytocosmetics, with the advantage that they are already well known species and studied for various purposes, including topical use. Plant extracts and essential oils, among other components of plant origin, are a great alternatives for the production of antibacterial soaps, considering that they are first choice hygiene items when aiming to perform asepsis of the various parts of the body, mainly the hands.

Competing Interests

None.

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