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Antibacterial Properties of Plant-Based Textiles

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Abstract: *The current trend of increasing respect for nature requires biodegradability of textiles and non-polluting products for textile finishing. The present study aims to make a synthesis of the knowledge on antimicrobial plant-based textiles and natural antibacterial treatment of textiles in the literature. The methodology carried out was to search articles, theses, and dissertations available in databases such as (Science Direct, EiCompendex, Inspec and Web of Science, and Google scholar) that deal with the issue of antibacterial textiles of plant origin. The results obtained show two types of textiles: natural antibacterial and non-natural antibacterial. Many antibacterial test works show that E coli is a bacterium that is inhibited by many natural antibacterial textile fibers. A non-antibacterial textile can become antibacterial after treatment with natural antibacterial substances. Also, an antibacterial fiber can be reinforced with antibacterial properties by other antibacterial agents. Several antibacterial substances have been proposed for the antibacterial treatment of textiles, namely: tea tree oil, Neem, eucalyptus oil, and albizia extracts, but have not yet been tested.*

Keywords: *Antibacterial textile, antibacterial plant textile, and antibacterial textile agents*

I. INTRODUCTION

Antibacterial textiles have appeared on the "consumer" market in the form of socks, sports underwear, bathroom linen (towels, gloves...), bedding (pillows, duvets...), and interior furnishings [1][2][3]. The three main areas of use are care and therapy devices, diagnostic and monitoring devices, and protective and hygienic devices [1][3]. Within this area are chemical textiles or textiles with antibacterial properties attributed to chemicals such as ticlosan and derivatives, zeolites (aluminosilicate: Ag+, Cu, Ag+ Zn), quaternary ammoniums, mineral powder (Ag and Cu), arsenic, phenol, copper sulphide, magnesium peroxide, chitosan, chloramine, zinc oxide, Ag ions, polyethylene glycol, 2-pyridineethiol, PolyHexaMethyleneBiguanide (PHMB), TiO2 [3][4][5][6]. Textile effluents are a source of pollution of water and even of the environment in general. With the current trend of increasing respect for nature, the biodegradability of fibers is becoming more and more important [7]. The protection and improvement of the environment is a matter of major importance that affects the well-being of people and the economic development of the whole world (Principle 2 of the United Nations Conference on the Environment (1972)) [8]. The objective of the study is to synthesize the knowledge on antimicrobial plant-based textiles and natural antibacterial treatment of textiles in the literature. Ultimately, the aim is to develop tools to take better advantage of antibacterial textiles to improve our environment and health.

II. METHODOLOGY

Data collection and knowledge synthesis on antibacterial plant-based textile fibers

The synthesis of knowledge on antibacterial plant-based textiles was carried out on the basis of available articles, dissertations, and theses. It covered the last 20 years, since 2001. In particular, the databases (ScienceDirect, EiCompendex, Inspec and Web of Science, and Google schola) provided access to scientific and technical journals dealing with the issue of antibacterial plant-based textiles (Textile Research Journal, Journal of Textile Science & Engineering, Journal of Industrial Textiles, Journal of Fashion Technology & Textile Engineering, Fashion and Textiles, Indian Journal of Fibre and Textile Research, International Journal of Clothing Science and Technology, The Indian Textile Journal, etc.). A series of keywords were used to conduct this information search. These keywords are

Antibacterial textile

Antibacterial plant textile

Antibacterial textile agents

Inclusion criteria: This meta-analysis includes three types of antibacterial textile fibers. Antibacterial natural fibers, antibacterial natural fibers reinforced with natural antibacterial substances, non-antibacterial natural fibers treated with natural antibacterial substances. These studies provide a formal synthetic methodology that allows data from different studies selected on transparent criteria to be collated and analyzed.

Exclusion criteria: The articles, theses, and dissertations that were excluded from this meta-analysis refer to synthetic antibacterial textiles, artificial antibacterial textiles, plant textiles treated with chemical antibacterial agents.

III. RESULTS AND DISCUSSION

A total of 14 studies offered accessible results, but only 5 presented usable data, i.e., evaluated antibacterial plant textiles to act on bacteria as well as plant textiles treated with natural antibacterial substances (Figure 1).

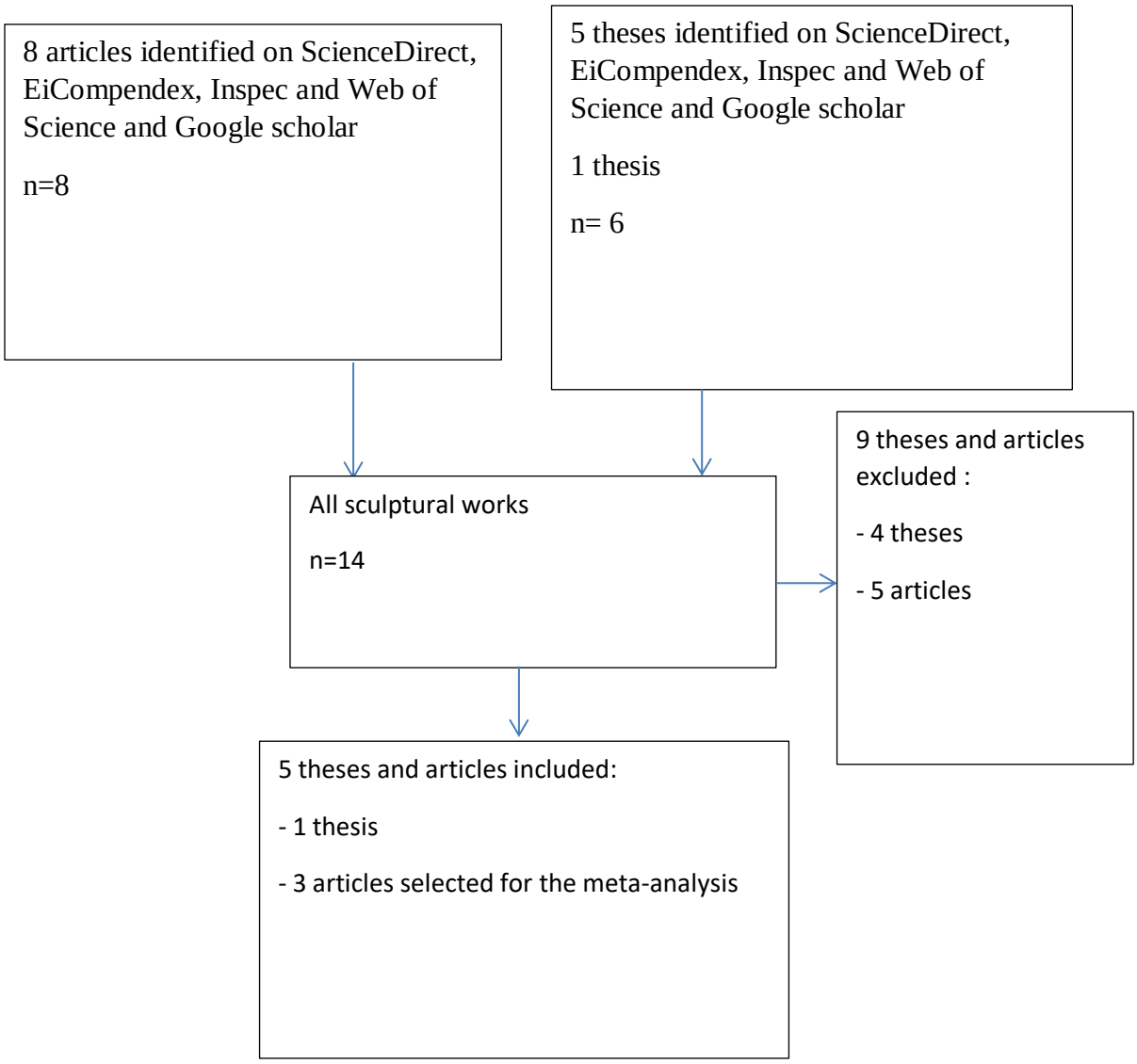

Figure 1: Flow Chart of the articles, thesis, and theses included in the study.

Identification of antibacterial plant textiles: The study identifies and defines the contours of antibacterial plant textiles. Table 1 shows the plant textiles according to their antibacterial properties.

Table 1: Identification of antibacterial fibers and the bacteria that these fibers can inhibit

Textile fibers	Antibacterial properties	Photochemical screening	Inhibition of bacteria	References
Sidarhombifolia	Antibacterial	Saponins, glycosides, steroids, polyphenol Flavonoids and anthraquinones	E. coli S. Typhi S. aureus and S. pyogenes	[9] [10] [13]
Cotton	Not antibacterial			[11]
Neem	Antibacterial		E coli Staphylococcus Aureu	[14]
Linen	Antibacterial		E colie	[5]
Chanvre	Antibacterial	Cannabinoid	E coli	[5]

The table1 illustrates two types of textiles, namely, natural antibacterial and non-natural antibacterial. Sidarhombifolia fiber inhibits E. coli S. Typhi S. aureus an and S pyogenes. Neem fibre inhibits E coli, Staphylococcus Aureu, chanvre and linen fibre inhibits E colie. Cotton fabric is so far not antibacterial. Table 1 shows that E coli is a bacterium inhibited by several natural antibacterial textiles. It illustrates that many antibacterial tests of plant-based textiles have been done with the E coli bacterium. Photochemical screening done on aids rhombifolia fiber shows that it contains saponins, glycosides, steroids, polyphenol, flavonoids, and anthraquinones [9] [10] [13]. Photochemical screening of Neem and linen fibers has not been done to identify the elements in these fibers that may be responsible for inhibiting bacteria.

Natural treatment of textiles of plant origin with antibacterial plant substances: The textile industry is a domain from the fiber, through spinning, weaving, knitting, or non-weaving to finishing. Antibacterial plant substances, namely kadukai, Tulsi, aloe vera, lemongrass oil, karpuravilli, have been used in the treatment of cotton, bamboo, and soy fabrics and tested on two bacterial cells (S aureun and E coli). These tests were favorable, i.e., the textiles treated with these substances inhibited both bacterial cells [11]. Table 2 shows that the textile can be treated in one of the above-mentioned steps. This means that the fiber, yarn, or fabric can be treated with natural antibacterial substances.

Table 2: Treatment of textiles with an antibacterial agent

Textile fibers treated with an antibacterial agent	Anti-bacterial property	Fourier Transform Infrared Test	Photochemical screening	Inhibition of bacteria	References
Cotton treated with Aloe Vera	Non-antibacterial fiber treated with an antibacterial agent	Active ingredients of aloe vera attach to the hydroxyl group of cotton And the fiber consists	75 nutrients 200 active compounds including 20 minerals	E. coli S. aureus	[11]

		of cellulose hemicelluloses Lignin Pectin Lipid	18 amino acids 12 vitamins		
Sidarhombifolia treated with aloe vera	Antibacterial fiber treated with an antibacterial agent	Active ingredients of Alose Vera attach to the hydroxyl group of Aida rhombifolia And the fiber consists of cellulose hemicelluloses Lignin Pectin Lipid	Saponins, glycosides, steroids, polyphenol Flavonoids anthraquinone lipid	E. coli S. Typhi A. hydrophila P. aeruginosa V. cholerea.	[13]

Table 2 shows us that a non-antibacterial textile can, after treatment with natural antibacterial substances, become antibacterial. Also, an antibacterial textile can be reinforced with other antibacterial agents. The cotton fabric, which is not antibacterial at the beginning, has been treated with aloe vera gel. After this treatment, the cloth inhibited the cell of E. coli and S. aureus. Sidarhombifolia, which inhibits E. coli, S. Typhi, S. aureus and S. pyogenes, has no effect on A. hydrophila, P. aeruginosa, and V. cholerea after antibacterial treatment with aloe vera. This makes it clear that each textile fibre inhibits a certain well-defined type of bacteria. Since there are several types of bacteria depending on their shape, composition... And also the infrared test shows that the active ingredients of Aloe vera bind with the hydroxyl groups which is a cross-linking agent of macromolecules [11][13].

Substances that have been reported in the literature but have not yet been tested: Several antibacterial substances have been proposed for the antibacterial treatment of textiles, namely: tea tree oil, Neem, eucalyptus oil [11] and albizia extracts [12]. Neem attracts our attention as there is also Neem textile fibre [14]. Poutoum (2019) showed in his work on albiziazygia (fabaceae) plant extract on bacteria that the antibacterial power of plants depends on the parts (leaves, trunks and roots) of the plants [12]. Leaves do not have the same antibacterial power as the trunk and roots. From this point of view, future work is needed, namely:

- Study of treatment of Neem textile with Neem oil in order to verify the capacity of Neem oil in strengthening the antibacterial power of this textile.
- The treatment of textiles with the different substances mentioned above, namely: tea tree oil, Neem, eucalyptus oil and albizia extracts.
- Comparison of the antibacterial power of textiles of vegetable origin treated with the different substances, such as for example the textile of linen functionalized with aloe vera gel or eucalyptus gel, with the aim of finding a textile which has a good antibacterial power according to the inhibition time of the bacteria and the concentration of antibacterial substances on the inhibition of the bacteria.

Discussion : This research aims at advancing knowledge on the antibacterial properties of plant-based textiles in order to not only promote sustainable development, but also to improve hygiene and the control of bacterial infections that can originate from textiles. It reveals that antibacterial properties can be achieved on many purely natural textiles. The fact that the fibre does not inhibit a type of bacteria

does not mean that a fibre is not antibacterial. For example, Sidarhombifolia fibre does not inhibit A. hydrophila, P. aeruginosa and V. cholerea bacteria. And it inhibits S typhoid and E coli [13]. There are several types of bacteria. This work shows that treatment of textiles with natural antibacterial agents can reduce the inhibition time of bacteria by increasing the ability of a fibre to inhibit a specific bacterium. Aida rhombifolia fibre inhibits salmonella typhi cells, while coating with aloe vera gel accelerates inhibition [13]. Treatment of textiles with natural agents can also give textiles antibacterial power to enable it to inhibit certain well-defined bacteria. Cotton initially had no reaction on E. coli and S. aureus cells and treatment with aloe vera inhibited both [11]. Also Sidarhombifolia which initially had no reaction on A. hydrophila, P. aeruginosa and V. cholerea cells treated with aloe vera inhibited these three cells [13]. This work allows us to see that for antibacterial textiles, it is useful to identify as many bacteria as possible that may be responsible for skin infections since the textile is in contact with the skin. In short, to study the antibacterial power of textiles in relation to the bacteria those are responsible for skin infections and the secretion voices.

IV. CONCLUSION

At the end of this work, the objective was to make a synthesis of the knowledge on antimicrobial textiles of plant origin and natural antibacterial treatment of fibres in the literature. Sidarhombifolia fibre inhibits E. coli S. typhi S. aureusan and S pyogenes. Neem fibre inhibits E coli, Staphylococcus Aureu, chanvre and linen fibre inhibits E coli. Cotton fibre does not react on the bacteria that have been tested so far. Many antibacterial test works show that E coli is a bacterium that is inhibited by several antibacterial natural textile fibres. A non-antibacterial fibre can be treated with natural antibacterial substances. Also an antibacterial fibre can be reinforced with antibacterial properties by other antibacterial agents. Antibacterial plant substances namely kadukai, Tulsi, aloe vera, lemongrass oil, karpuravilli have been used in the treatment on cotton, bamboo and soybean fabrics and the test on two bacterial cells (S aureun and E coli) were favourable. Several antibacterial substances have been proposed for antibacterial treatment of textiles namely: tea tree oil, Neem, eucalyptus oil and albizia extracts. Future work will include the following:

- Study of treatment of Neem textile with Neem oil in order to verify the capacity of Neem oil in strengthening the antibacterial power of this textile.
- The treatment of textiles with the different substances mentioned above, namely: tea tree oil, Neem, eucalyptus oil and albizia extracts.

Comparison of the antibacterial power of textiles of vegetable origin treated with the different substances, such as for example the textile of linen functionalized with aloe vera gel or eucalyptus gel, with the aim of finding a textile with a good antibacterial power according to the inhibition time of bacteria and the concentration of antibacterial substances on the inhibition of bacteria.

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