



BAMBOO FIBER ANTIBACTERIAL EFFECT (A REVIEW)

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Abstract: *This article analyzes the current known information and data on the bamboo plant natural properties: UV protection properties, natural resistance to pests and fungal infestations due to an antimicrobial agent known as 'bamboo kun'. Bamboo has a bacterial rate of up to 99.8%. The bamboo fibers air permeability is 20% higher than that of cotton, and the absorption capacity is 60% higher. After processing, the bamboo fiber contains no harmful chemicals (as specified in the Okeo-Tex Standard 100 - global testing and accreditation system for harmful substances screening in consumer fabrics). The Fabrics Verification Association of Japan confirms that even after 50 industrial washes the bamboo fiber samples keep their properties. Tests conducted by this association show that about 70% of the bacteria with which the bamboo fiber sample was infested were destroyed. Other studies on bamboo fiber confirm very good antimicrobial properties being followed by the combined fabric 50/50% bamboo / cotton, cotton and viscose. Currently bamboo fibers are used in the manufacture of underwear, socks, bed linen, towels, and bathrobes. The information got as a result of the present study allows to realize the research hypothesis, a step that will be preceded by the own experimental research carrying out in order to determine new directions of bamboo fibers use in the medical field.*

Key words: *Bamboo, fiber, antimicrobial effect, multifunctional clothing, medical clothing.*

1. INTRODUCTION

Daily, man comes into contact with numerous viruses, fungi and bacteria, which settle on his skin and clothing. In textiles, microorganisms multiply rapidly, under the action of heat and moisture. Although most of them are non-pathogenic, there are some that present a real danger to the body.

Developing new multifunctional clothing problem is current for the textile and medical field researchers. An increased interest is presented by the clothing having the monitoring role of the wearer's health as well as the clothing that has any diseases improving properties [1-4]. In this sense, an important role belongs to the multifunctional fabrics.

Around the world, antimicrobial textiles currently find an increasing spectrum of use: from improving daily hygiene conditions to prophylaxis, improvement and treatment of some diseases. In



hospitals it is recommended to use underwear and light clothing made of such materials, possessing bactericidal properties. To prevent complications that may occur in various diseases due to the “unhealthy” properties of clothing, it is recommended to use antimicrobial materials [1].

The bacteriostatic agent possesses various mechanisms of action on microbes: stagnation of the process of osmosis and diffusion of nutrients for microbes, slowing down the processes of multiplication of microbes, killing microbes [2-4]. Some antimicrobial agents are extremely irritating and toxic, which leads to the need to conduct studies that allow the creation of new types of antimicrobial materials [3, 4].

2. EXAMPLES OF GLOBAL STUDIES IN BAMBOO PROPERTIES

What is important for antimicrobial textiles is the determination of the requirements imposed on them: the use of bacteriostatic substances, which do not pose a danger to the health of the wearer, in sufficient quantities for killing microbes; increased action of the bactericidal agent and a fairly wide field of use for the treatment of diseases with the preservation of properties for the duration of wearing; the ability to preserve antimicrobial properties throughout operation, after several washes and / or sterilizations by different methods [1, 4].

In the specialized literature, from the group of antimicrobial and antiseptic fibers are mentioned those based on polyvinyl alcohol (PVA). A representative fiber in this regard is BIOKRIL, with a special and long-lasting antimicrobial efficacy, due to its structure that allows the antimicrobial agent to continuously diffuse to the surface of the fiber. Another acrylic fiber is also COURTEX, in which a number of metal salts of Ag and Zn are inserted, which are fixed to the support, by complex chemical bonds [1, 4]. These fibers have bactericidal properties. Another fiber with antimicrobial properties is also the fiber Microsafe Celanese. Fiber Amicor has included in its structure antibacterial agents, for the elimination of unpleasant odors because of sweating. The fibers covered with Silver X-Static know various fields of use in medicine, due to the bactericidal properties they possess [1-4].

There are opinions that state that bamboo fiber naturally possesses antibacterial, hypoallergenic and deodorizing properties. Bamboo is the plant that has the fastest growing pace in the world. It grows on average by 10 cm per day, but there are species that grow by a millimeter every two minutes [5, 6]. The growth cycle of bamboo is fast and lasts from three to four months, the plants become mature in three to seven years [5, 6]. Although some species bloom every year, most of them flower in frequently, at intervals between 40 and 60 years and even up to 120 years [6]. Once a bamboo has blossomed, the seeds will fall on the ground, and the plant will die. In the textile form, bamboo retains many of the properties that the plant has [6]. Bamboo absorbs water very well, being able to take up to three times its weight in the water. The absorbency allows removing moisture from the skin so that it can evaporate [7]. Bamboo captures warm air in its transverse fibers to keep warm in case of low temperatures. The air permeability of bamboo fibers is 20% higher than that of cotton, and the absorption capacity is 60% higher, which provides increased comfort in the case of high temperatures [7]. After processing, bamboo fiber does not contain harmful chemicals (as specified in the standard Oeko-Tex 100 - global Testing and accreditation system for screening of harmful substances in consumer textiles) [8]. The fiber is naturally smooth and round, without chemical treatment, which means that it does not have sharp branches that irritate the skin. Bamboo also has many antibacterial qualities, which the bamboo fabric is able to retain, even after several washes [9, 10]. This helps to reduce bacteria that develop in clothes and can cause unpleasant odors. The bamboo plant has protective properties against UV rays and a natural resistance to pests and fungal infestations due to an anti-microbial agent known as "bamboo Kun", which prevents harmful materials from growing on the plant [7-11]. It is considered that bamboo

naturally possesses hypoallergenic, antibacterial, air freshener properties, has the ability to preserve temperature and attract moisture [8-10]. The bamboo plant is extremely durable because it grows naturally without the need to use pesticides or fertilizers and is completely biodegradable, so this eliminates the problem of disposal [8-11]. The processes of transformation of bamboo into fabrics can occur mechanically and chemically. The mechanical process is similar to other loose fibers: the fibers are extracted by maceration, which can be traditional or by means of natural enzymes, to break the wooden walls of the plant, after which the extracted fibers are combed and cleaned before spinning [8, 10]. All this increases production costs, risking the positioning of the eventual finished product out of the market. Bamboo can also be used as a raw material for viscose [5-14].

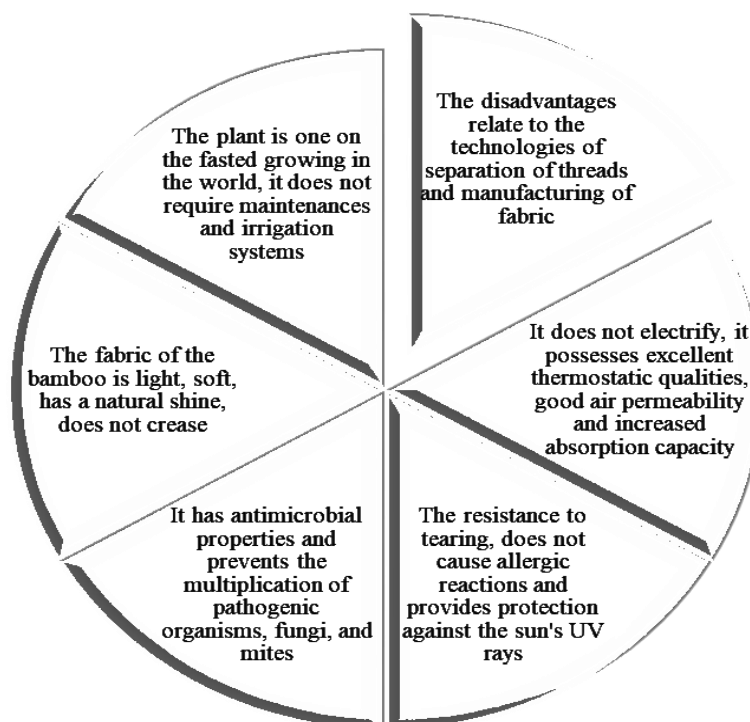


Fig. 1. Bamboo – advantages and disadvantages

Bamboo is the multifunctional fiber that revolutionized the textile industry, which leads to the need to conduct studies that would confirm or not the assumptions about its multiple advantages.

A group of researchers from Portugal conducted studies of 3D textile structures of different composition. Bamboo, cotton, polyester and bioactive polyester in proportions from 14 to 72%. 72% antimicrobial fiber spacing, such as bamboo, was not active against the tested micro-organisms, while flattened knitted fabrics made from the same yarn were effective against *E. coli*, *P. aeruginosa* and *T. rubrum*. Textiles subjected to testing are recommended for use as lining material for footwear [4].

In another study, bamboo raw materials obtained from the Anhui Taiping test center of the international bamboo and rattan center were tested. The outer and inner layers of bamboo were removed, and then cut into blocks of 10 mm. All the blocks were washed with ultrasound with deionized water and alcohol for 30 minutes at room temperature. To remove the impurity inside the bamboo structure, all samples were vacuum impregnated under water several times and then dried for 24 hours at 60 °C in vacuum. The obtained samples were subjected to antibacterial testing by the



bacteriostatic circle method, with the purpose of observing the growth inhibition properties against Gram-negative bacteria (*E. coli*) and Gram-positive bacteria (*B. subtilis*) [9].

Studies investigating the antimicrobial functionality of bamboo fiber were conducted on samples obtained from bleached bamboo material. The samples were incubated at 37 °C for 18 to 24 hours. A clear area of inhibition was observed for both tested microorganisms: *E. coli* and *S. aureus* [12].

Natural bamboo fibers produced from bamboo *Neosinocalamus affinis* have been subject to investigation with the aim of determining the natural bacterial rate and its influence factors. The results of antibacterial tests showed that natural bamboo fiber does not have natural antibacterial properties compared to other textile fibers [8, 10]. The linear relationship between moisture and bacteriostatic rate suggests that hygroscopicity may be a factor influencing the antibacterial performance of the fiber. A method of extraction could improve the antibacterial property of natural bamboo fiber against bacteria; therefore, extracts have influence on this [11, 14].

3. RESULTS AND DISCUSSION

Antimicrobial properties of bamboo fiber are proven by scientific studies conducted by several teams of researchers. The results from such studies are shown in table 1 and figure 2 [5-14].

Table 1. Antimicrobial properties of bamboo fiber

Team of authors- conducted studies	Studies	Obtained results
Lixia Xi, Daochun Quinn, Xin An and Ge Wang – Resistance of natural Bamboo fiber to microorganisms and factor that may affect such resistance [10]	This study investigates antimicrobial properties of natural bamboo fiber compared to cotton, jute fiber, flax fiber, ramie fiber. The bamboo fibers tested were obtained by extraction using different solvents: cold water, hot water, ethanol, benzene, benzene/ethanol, 1%NaOH. The bacteria studied were <i>Escherichia coli</i> and <i>Staphylococcus aureus</i> , and <i>Candida albicans</i> .	The results showed that natural bamboo fiber was not effective against <i>E. coli</i> , <i>S. aureus</i> , and <i>C. albicans</i> . By comparison, the bacteriostatic rate of ramie against <i>S. Aureus</i> was over 90%, and that of regenerated bamboo fiber was 75,8%. Jute and flax had bacteriostatic rates against <i>C. albicans</i> of 48% and 8,7% respectively. The method of extraction of bamboo fiber with hot water proved to be the most effective against <i>E. Coli</i> , with a value of 70% proximity; the use of the 1% NaOH solution achieved an efficiency of more than 67%; at the same time it was proved that the antimicrobial properties of bamboo fiber do not have resistance against <i>C. Albicans</i> .
T. Afrin, T. Tsuzuki, R.K. Kanwar and X. Wang – The origin of the antibacterial property of bamboo [11]	The origin of antibacterial activity of plant extracts from Australian-grown bamboo (<i>Phyllostachys pubescens</i>) is investigated. Bamboo extracts were made using water, dimethyl sulphoxide (DMSO) and dioxin.	It was found that the extract made in 20% DMSO aqueous solution showed weak antibacterial activity, whereas the extract made using 90% dioxin aqueous solution exhibited strong antibacterial activity, even after 20 times dilution. The results

	Gram-negative bacterium, Escherichia coli (E. coli) - ATCC 25922 was used as test organism.	indicate that antibacterial agents of P. pubescence are located in lignin, not in hemicellulose or other water-soluble chemical components.
C. Javakarbnu – Antimicrobial properties of bamboo fabric finished with Vempadam Bark [12]	For antibacterial testing was adopted the parallel streak method against microorganisms E. coli and S. aureus.	The tests showed a durability of antimicrobial properties up to 10 washing cycles and an inhibition zone of 35 mm against S. aureus and 34 mm against E. coli.
Textile verification Association of Japan – Studies on bamboo fiber and antibacterial effect [13]	We analyzed the antibacterial and antifungal behavior of bamboo fiber socks, compared to 100% cotton, 100% viscose and 50/50% bamboo/cotton socks.	Bamboo has very good antimicrobial properties, followed by the combined fabric 50/50% bamboo / cotton, cotton and viscose. The results also showed that there was no antimicrobial activity level for cotton samples.
Junyi Zhang, Bo Zhang, Xiufang Chen, Bingbinng Mi, Penglian Wei, Benhua Fei and Xindong Mu – Antimicrobial bamboo materials functionalized with ZnO and Graphene Oxide Nanocomposites [14]	For antibacterial testing was adopted the bacteriostatic circle method. The results were estimated by their growth inhibitory properties against Gram-negative bacteria (E. coli) and Gram-positive bacteria (B. subtilis). The antibacterial performance was estimated by the size of the inhibition zone.	It can be observed an inhibition zone 2,15 cm for Gram-negative bacteria (E. coli) and an inhibition zone 2,5 cm for Gram-positive bacteria (B. subtilis).

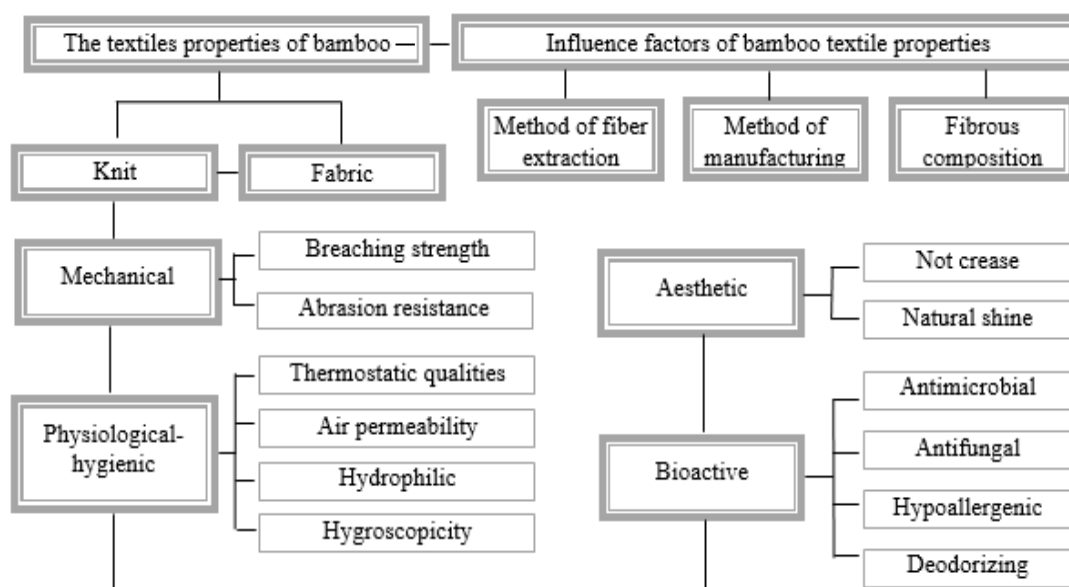


Fig. 2. The properties of bamboo fiber

4. CONCLUSIONS

In the study, we can say that the bamboo fiber exhibits a number of advantages. At present bamboo has various fields of use: in construction, in papermaking, in the manufacture of dishes, the



newest bamboo is used in the textile industry. The properties of bamboo fiber are influenced by the method of fiber extraction and the method of manufacturing textiles: fabric or knit, the type of knit. Some studies confirm the antimicrobial properties of bamboo fiber, at the same time the results of other studies demonstrate antibacterial inactivity of natural bamboo fiber. Antibacterial agents of bamboo are located in lignin [9, 11]. The information obtained from this study is insufficient to confirm or not the antimicrobial properties of bamboo, as the results obtained differ from one study to another. In order to materialize the research hypothesis, it is necessary to carry out own experimental research in order to determine new areas of use of bamboo fibers in the medical field.

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