Research Article

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Authors: Murat KODALOĞLU

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USE OF PLANT RESOURCES AS ANTIBACTERIAL TEXTILES FOR HEALTH AND HYGIENE APPLICATIONS: ECO-FRIENDLY NATURAL SUSTAINABLE APPLICATION OF SAP FROM GRAPEVINE PRUNING FOR COTTON FABRICS

Murat KODALOĞLU[1*]

[1]Isparta University of Applied Sciences, Vocational School of Technical Sciences, Occupational Health and Safety Program, Isparta, Turkey.

[*]Corresponding Author: muratkodaloglu@isparta.edu.tr
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ABSTRACT: As people move away from synthetic products containing chemicals and become more interested in natural products, there has been an increase in the use of plants. Studies have shown that antibacterial extracts obtained from plants can be used to obtain antibacterial materials in the textile industry. In this study, sap flowing from a vine branch, which is quite rich in bioactive components, was used to provide antibacterial properties. Vine sap is a sustainable product that is a natural source of phenolic compounds for health and hygiene applications. By applying natural vine-sap phenolic compounds to 100% cotton fabric, its antibacterial properties were determined according to the AATCC 100 test method, which is frequently used in textiles, against Staphylococcus aureus and Escherichia coli bacteria. In the data obtained as a result of the study; It was determined that 100% cotton fabrics containing vine-sap phenolic compounds showed good antibacterial activity. The effects of concentrations in different concentrations of liquors on the fabric were investigated. In order to test the washing resistance of the applied fabrics, the fabrics were subjected to 1-10 repeated washings.

Keywords: Textile, Antibacterial , Grapevine, Sustainable, Human health.

1. INTRODUCTION

It is known that microorganisms can grow and reproduce on textile materials. Textile materials contain the appropriate humidity, temperature and nutrients for microorganisms to multiply and live. When microorganisms settle on the textile product, both the textile product and the user are harmed. Textile products with antibacterial properties help reduce the damage caused by microorganisms. The textile industry has also made an intensive effort to produce functional textile products in recent years. In this context, antibacterial textiles have attracted great attention. Textile materials can be made antibacterial by various methods. One of these methods is the transfer of natural vine-sap phenolic compounds containing antibacterial properties to the textile material. Consumers are increasingly adopting a hygienic lifestyle and have a wide range of requirements and expectations for finished textile products with antibacterial properties, which are made to prevent bacteria, fungi and other microorganisms that are harmful to human health from settling or multiplying on textile surfaces. The most important feature expected from antibacterial substances to be used in textiles is that the substance used does not negatively affect human and environmental health. For this reason, in recent years, the importance given to obtaining environmentally friendly and natural plant-based antibacterial substances and

applying these substances to textile materials has been increasing day by day. Many of the extracts obtained from the roots, stems, leaves, flowers, fruits and seeds of various plant species contain phenolic, terpenoids, flavonoids, alkaloids, polypeptides, polyacetylenes, etc. substances that function as antibacterial. Some of these substances act as bactericides and some have bacteriostatic effects. In this context, the research on the antibacterial activities of plant extracts and their use in the textile sector are increasing day by day. In antibacterial finishing processes, the presence and reproduction of microorganisms are stopped by transferring antibacterial agents to textile materials with the maximum application of liquor [1]. The vine tree where the grapes grow should be pruned in the spring in order to produce better fruit. During pruning, the transmission pipes open as a result of injury in the branches and trunks of the trees that are cut, and a strong liquid flow occurs on the cross-sectional surface. This event is called "Crying, Bleeding or Sap Flow". This sap is not pure water but contains organic substances, sugar, amino acids, hormones, vitamins and enzymes. The amount of liquid released by pruning can be up to 1 litre per day.

In this study, vine-sap phenolic compounds, which are released as waste material and have many positive effects on human health with their antioxidant, anti-inflammatory and antibacterial properties, were used for extraction. The obtained extraction product was applied to a 100% cotton textile product by the impregnation method. However, this product, which has high antibacterial properties, has never been used as an antibacterial finishing material before. Cotton fiber, which is the most commonly used among natural fibers, was preferred in the study. Since cotton fiber has a natural cellulosic structure, it can be a food source for bacteria. In addition, it can contain the liquid that bacteria need due to its moisture retention feature. Therefore, it is important for cotton fabrics to have antibacterial properties. The effect of different liquor concentrations on fabric properties was investigated. After the applique processes, washing was repeated to investigate the resistance of the modification to washing.

Dorosh et al. (2021) When grapevine by-products were examined in terms of their bioactive compound contents, it was found that they were rich in phenolic compounds and minerals (K, Ca, Fe, Mg, P and Zn), polyphenols from the compounds, antioxidant properties and beneficial effects on human health were examined [1]. Guerrero et al. (2020) Grapevine sap is extremely valuable compounds due to its antimicrobial, antioxidant and anticancer properties [2]. Santamaría et al. (2022) showed that sap obtained from grapevines had a positive effect on different antibiotics [3]. Zheng et al. (2020) showed that grapevine sap has antifungal effects that can be considered as a bacteriostatic agent against Botrytis cinerea [4]. Šuković et al. (2020) studied the use of grapevine sap as an antioxidant in a vineyard based on the sustainability of physico-chemical oxidation [5]. Jesus et al. (2020) Grapevine pruning residue was analyzed for phenolic content, polyphenolic profile, antioxidant activity, antimicrobial activity, and anticancer activity [6]. Dorosh et al. (2022) studied the bioactive properties of phenolic compounds of grapevine sap, which have various potential applications, associated with numerous health benefits [7]. Acquadro et al. (2020) showed that grapevine sap is a source of environmentally friendly natural compounds, in addition to increasing its economic value in the field of health [8].

There are many methods to destroy microorganisms today. However, these methods can have a toxic effect on humans and the environment in practice. For this reason, the antibacterial method to be used in the textile sector should not only kill microorganisms, but should also be safe for humans and the environment and should not adversely affect other properties of the textile material.

2. MATERIAL AND METHODS

For grapevine sap extraction; 80% petroleum ether to remove oil, 99.5% methanol, ethanol and 100% acetic acid chemicals used for phenolic compounds and Akrohob DAN new liquid, an aqueous dispersion of polyurethane, was used as a crosslinker. The components of the natural grapevine sap phenolic compounds to be used in the study were determined[9-13]. The antibacterial activity of the processed textile products, together with the transfer of natural grapevine sap phenolic compounds to 100% cotton fabrics, was determined according to the AATCC 100 test method. For the tests, Escherichia coli and Staphylococcus aureus bacteria were used as bacterial species. In this study, it will be attempted to provide antibacterial properties to 100% cotton fabric thanks to grapevine sap extraction phenolic compounds, which have many positive effects on human health with their antibacterial properties[14-18]. The steps to be followed in the study; first of all, grapevine sap and 100% cotton fabric were obtained, vine sap was subjected to extraction process and phenolic compounds were obtained, phenolic compounds present in the obtained extraction were determined and antibacterial finishing process was performed by impregnation method on cotton fabric.

2.1. Bacteria Used in Antibacterial Tests

Staphylococcus aureus is a gram-positive bacterial species from the Staphylococcaceae family. They are round in shape and are immobile. The optimum growth temperature is 30-37°C, pH 7-7.5. Staphylococus aureus bacteria are resistant to heat, and when cultures are kept at 4°C and room temperature, they maintain their viability for months. Escherichia coli is a gram-negative bacterial species from the Enterobacteriaceae family. The bacteria are rod-shaped, 2-6 µm long and 0.1-0.5 µm wide. They grow best at body temperature, i.e. 37°C, and at an optimal pH of 7-7.2 [19-21].

2.2. Antibacterial Tests

All tests performed to determine antibacterial activity are based on the calculation of the decrease in the population of the microorganism. These antibacterial tests can be divided into two groups as qualitative (tests of the inhibition zone observed in agar medium) and quantitative (tests based on bacterial count). In our study, AATCC 100 tests were selected as the quantitative test method.
The scope of the study is the application of natural grapevine-sap phenolic compounds to non-sterile cloths and the antibacterial properties of the cloths after the process are given as antibacterial activity results against Staphylococcus aureus and Escherichia coli bacteria.

The percentage decrease in the number of bacteria in the antibacterial test result is calculated using the formula below.

Bacteria reduction rate (%) = [(B – A) / B] x 100

A: Number of organisms in neutralization that have contacted the “24 hour contact time” sample
B: Number of organisms in neutralization that have contacted the “0 hour contact time” sample

2.3. Washing Test

Washing repetitions to determine resistance to washing; each sample was processed in the washing machine at 40 ^{0}C for 30 minutes. Each sample was washed from 1 to 10 times with washing water and after each wash, the fabrics were dried in the dryer and made ready for the

next wash. The aim of this test was to see the change in the antibacterial properties of the fabric after washing.

3. RESULTS AND DISCUSSIONS

To evaluate the processes, antibacterial activity was compared by concentration, extraction time and washing. Figure 1 shows the graph showing the relationship between Escherichia coli, concentration (mg/ml) and extraction time (min.).

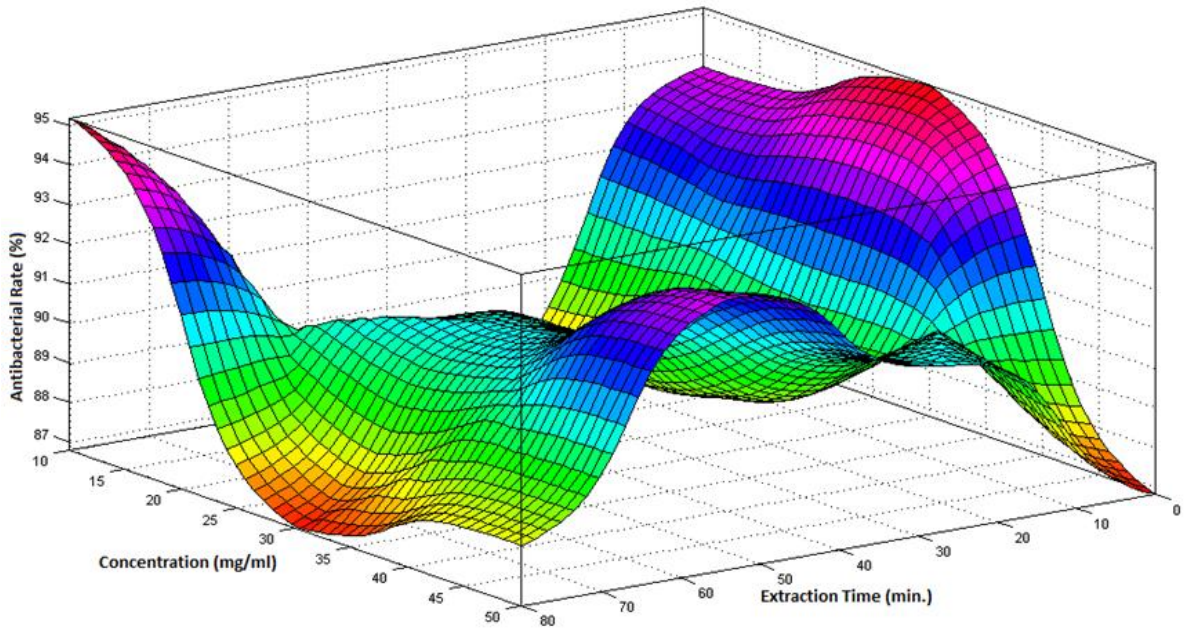

Figure 1. Escherichia coli, relationship between concentration (mg/ml) and extraction time (min.)

Extraction time significantly affects the concentration of extracts by affecting their antioxidant activity. There are significant differences between the applications that show the highest values in terms of antibacterial activity. Figure 2 shows the graph showing the relationship between S.aures, concentration (mg/ml) and extraction time (min.).

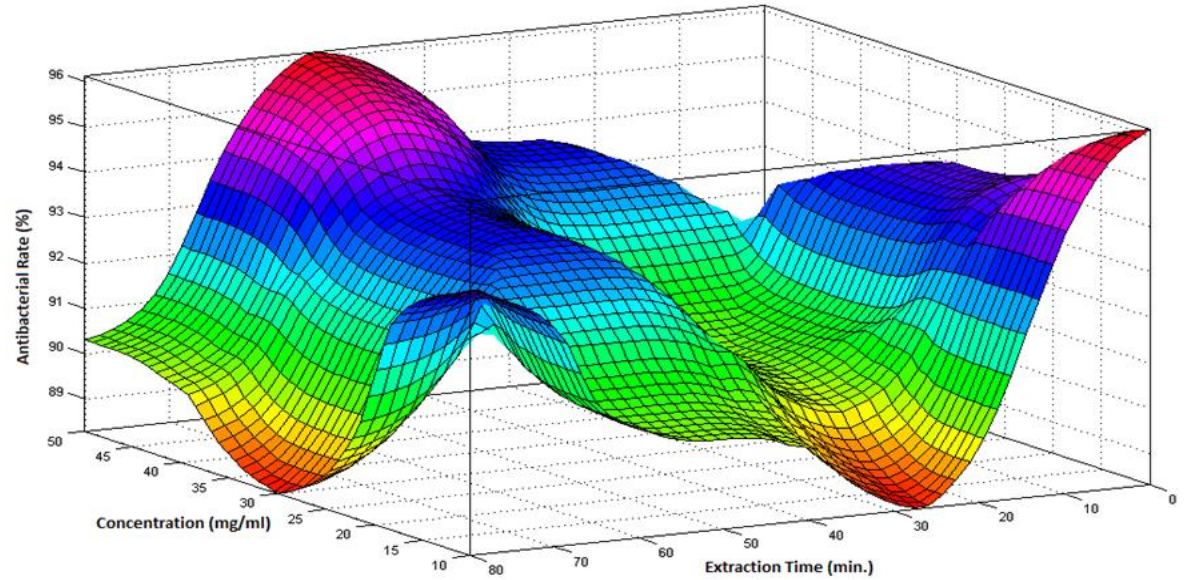

Figure 2. Staphylococcus aureus, relationship between concentration (mg/ml) and extraction time (min.)

Significant changes were observed in the antibacterial levels obtained at different extraction times, among which the extract times with the highest values were Staphylococcus aureus bacteria 50 min extraction time, 50 mg/ml concentration, 97% antibacterial activity and Escherichia coli 30 min extraction time, 25 mg/ml concentration, 96% antibacterial activity results were better. Therefore, 30 minutes can be considered as a sufficient time to be used in all extraction processes, because the use of shorter extraction times is a significant economic advantage. Staphylococcus aureus bacteria 30 min extraction time, 35 mg/ml concentration, 91% antibacterial activity and Escherichia coli 20 min extraction time, 30 mg/ml concentration, 88% antibacterial activity results were observed against a significant decrease in the lowest values in accordance with the results. When the comparison based on the extraction method is made, it means that the highest value of the concentration was obtained in the extracts obtained, which positively affects the theory. Figure 3 shows the graph showing the relationship between Escherichia coli, concentration (mg/ml) and washing process (num.).

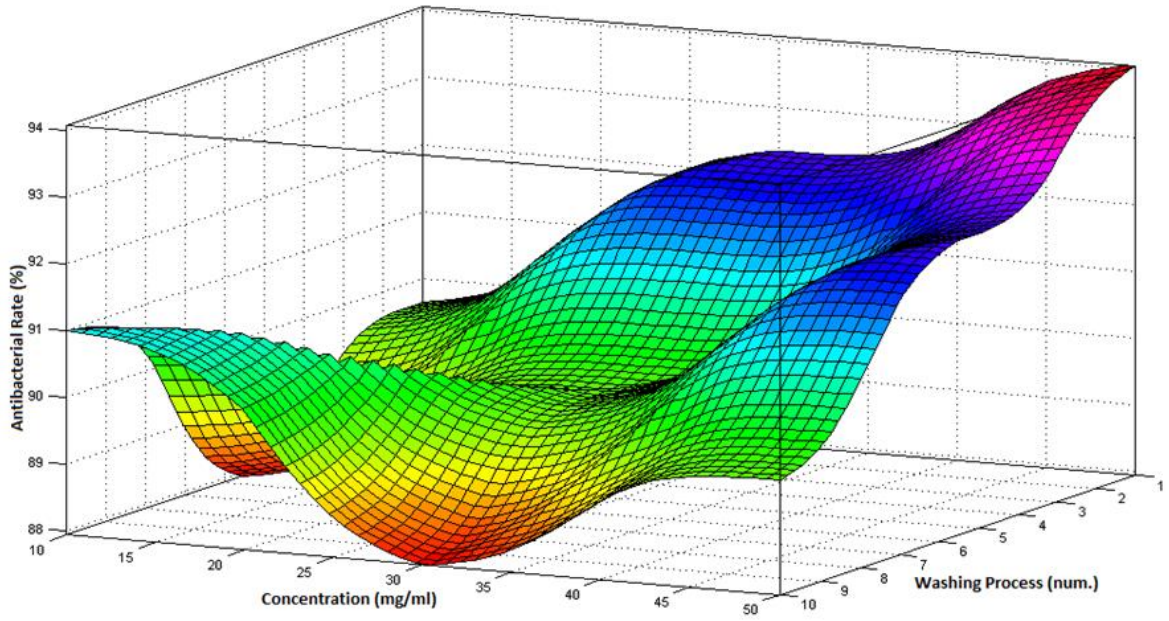

Figure 3. Escherichia coli, relationship between concentration (mg/ml) and washing process (num.)

It was observed that the fabric treated with grapevine sap extraction exhibited good antibacterial activity against ‘‘Escherichia coli’’ bacteria and it was stated that there was a good antibacterial activity with 91% antibacterial activity at a concentration of 50 mg/ml. It was also determined in the study that the antibacterial activity was still effective even after 10 washings. Figure 4 shows the graph showing the relationship between S.aures, concentration (mg/ml) and washing process (num.).

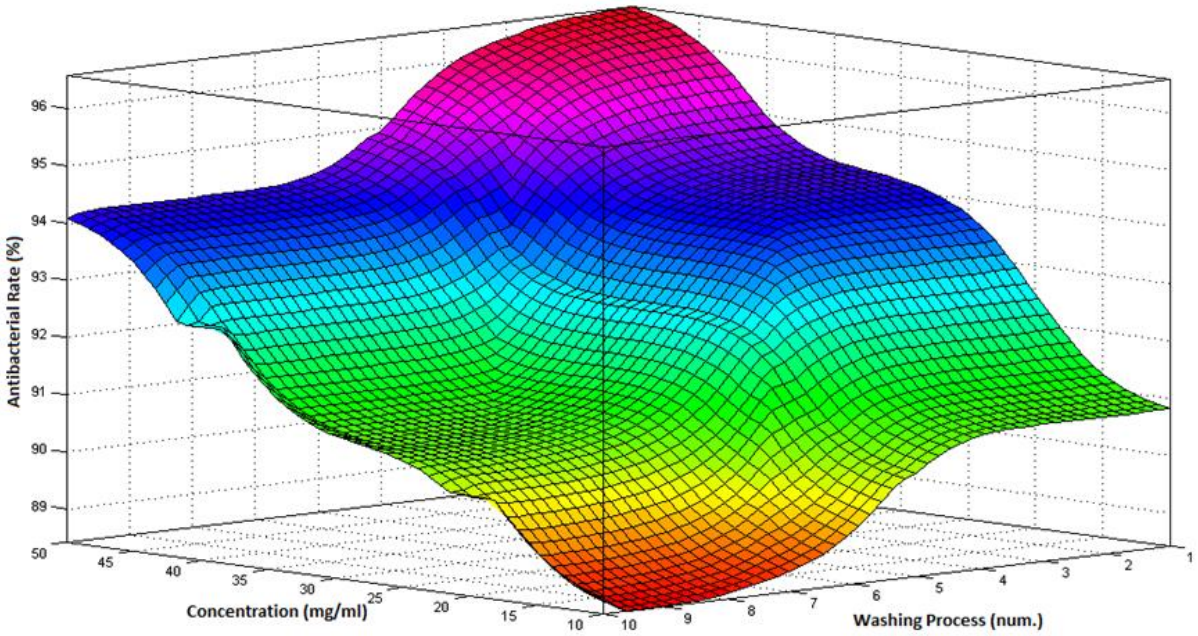

Figure 4. Staphylococcus aureus relationship between concentration (mg/ml) and washing process (num.).

It was observed that the fabric treated with grape sap extraction exhibited good antibacterial activity against ‘‘Staphylococus aureus’’ bacteria and it was stated that it had an excellent antibacterial activity with 94% antibacterial activity at a concentration of 50 mg/ml. In addition, it was determined in the study that the antibacterial activity was still effective even after 10 washings. Accordingly, grape sap extraction exhibited strong activity against the ‘‘Staphylococus aureus’’ bacteria and the grape sap extraction used greatly increased the antibacterial activity. It showed less antibacterial activity against the ‘‘Escherichia coli’’ bacteria. In addition, increasing the amount of grape sap extraction used against this bacterial species changed the antibacterial activity very little. In general, grape sap extraction was found to be strong antibacterial against the ‘‘Staphylococus aureus’’ bacteria. Figure 5 shows the graph showing the relationship between Escherichia coli, extraction time (min.) and washing process (num.).

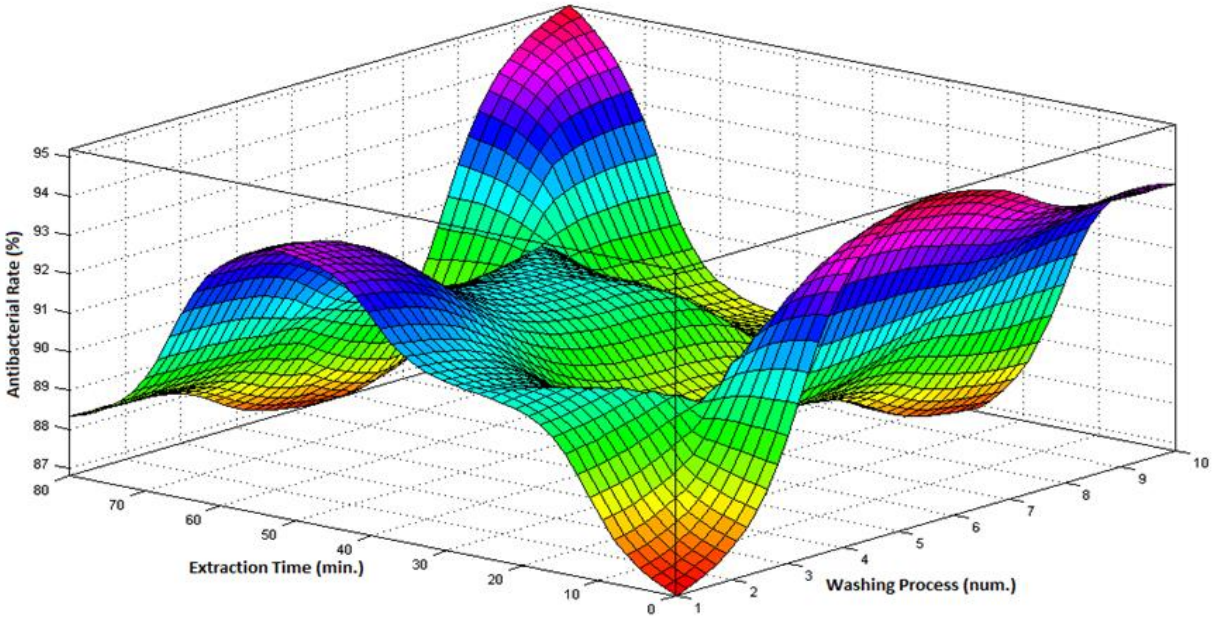

Figure 5. Escherichia coli, relationship between extraction time (min.) and washing process (num.).

The antibacterial activity and washing resistance of the fabric treated with grape sap extraction against ‘‘Escherichia coli’’ bacteria were determined to have good antibacterial activity according to the 80 min extraction time. It was determined that the treated fabric had antibacterial activity up to 10 washes, but the fabric treated with 10 min extraction time had antibacterial activity even after 7 washes. As a result of the washing processes, it was stated that it showed a stronger effect against Escherichia coli bacteria with 70 min extraction time and 92% antibacterial activity after 7 washes. Figure 6 shows the graph showing the relationship between S.aures, extraction Time (min.) and washing process (num.).

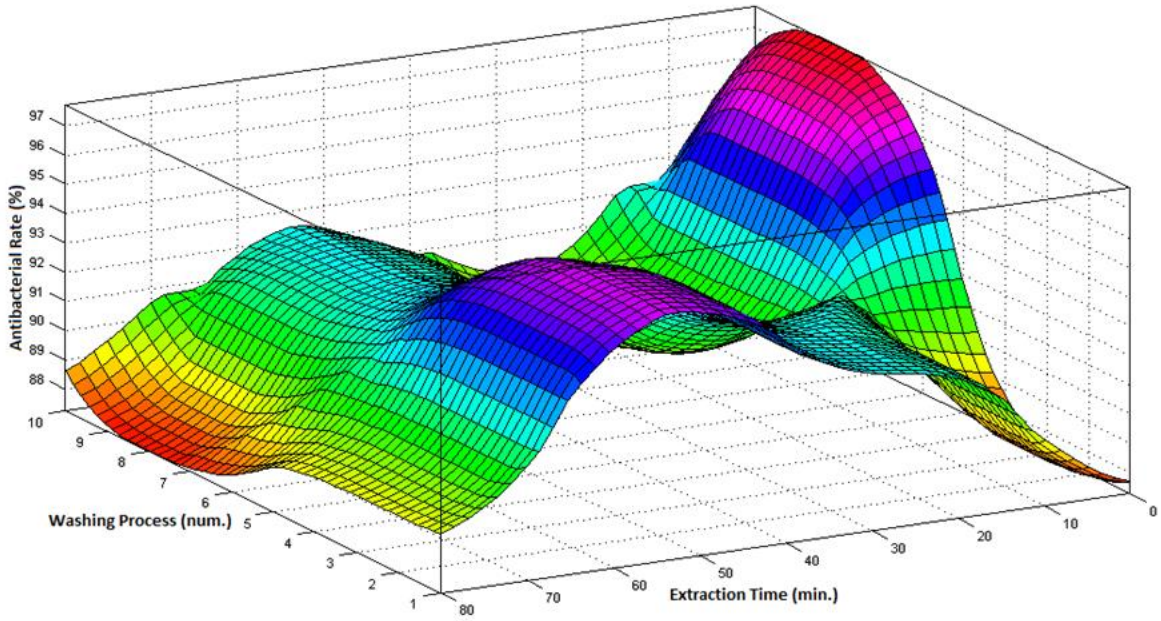

Figure 6. Staphylococcus aureus, relationship between extraction time (min.) and washing process (num.).

The antibacterial activity and washing resistance of the fabric treated with grape sap extraction against ‘‘Staphylococus aureus’’ bacteria were determined to have good antibacterial activity according to the 5 min extraction time. It was determined that the treated fabric had antibacterial activity up to 7 washes, but the fabric treated with 10 min extraction time had antibacterial activity even after 10 washes.

It was determined that the antibacterial activity was permanent on the fabric at the end of consecutive washings. As a result of the washing processes, it was stated that Staphylococcus aureus bacteria showed a stronger effect against the bacteria with 30 min extraction time 7 washes 94% antibacterial activity results.

When the antibacterial activity of the fabrics was examined after the process, it was determined that ‘‘Escherichia coli’’ and ‘‘Staphylococus aureus’’ bacteria were the most effective and that ‘‘Staphylococus aureus’’ bacteria after 10 washes.

5. CONCLUSIONS

In antibacterial textile production, heavy metals such as silver and zinc are generally used, and these heavy metals can be dangerous for the environment and human health. It is of great importance that herbal substances replace synthetic and heavy metal-containing antibacterial substances used in the textile sector. In this study, the extraction of polyphenolic compounds

from grapevine sap was evaluated according to different concentrations, extraction times and washing numbers, and two bacteria were compared. These results show that the extract time used at higher concentrations showed more effect in antibacterial activity.

It provided 97.9 % antibacterial activity against Escherichia coli bacteria and 99.1 % antibacterial activity against Staphylococus aureus bacteria. The decreases detected in antibacterial activity indicate that the effectiveness of the finishing process was damaged by washing. As a result of 10 washings, it was determined that the fabrics had no antibacterial activity against Escherichia coli 87.9 % and Staphylococus aureus 89.8 % bacteria. Table 1 shows Escherichia coli antibacterial test results.

Table 1. Escherichia coli antibacterial test results

Antibacterial Activity				
Concentration (mg/ml)	Washing Process (num.)	Extraction Time (min.)	Antibacterialate Rate (%)	To Evaluate
10	1	40	89,7	Acceptable
		80	86,8	Acceptable
	5	40	88	Acceptable
		80	94,9	Decent
	10	40	91	Decent
		80	93,7	Decent
30	1	40	92,3	Decent
		80	88,3	Acceptable
	5	40	89,8	Acceptable
		80	86,9	Acceptable
	10	40	87,9	Acceptable
		80	95,2	Perfect
50	1	40	94,1	Decent
		80	91	Decent
	5	40	92,4	Decent
		80	88,4	Acceptable
	10	40	89,7	Acceptable
		80	86,8	Acceptable

Table 2 shows Staphylococus aureus i antibacterial test results.

Table 2. Staphylococus aureus antibacterial test results

Antibacterial Activity				
Concentration (mg/ml)	Washing Process (num.)	Extraction Time (min.)	Antibacterialate Rate (%)	To Evaluate
10	1	40	90,8	Decent
		80	87,7	Acceptable
	5	40	90,3	Decent
		80	91,6	Decent
	10	40	88,7	Acceptable
		80	96,4	Perfect
30	1	40	94,2	Decent
		80	89,9	Acceptable
	5	40	92,6	Decent
		80	88,8	Acceptable
	10	40	90,9	Decent
		80	88,6	Acceptable
50	1	40	96,6	Perfect
		80	92,5	Decent
	5	40	95	Perfect
		80	91,1	Decent
	10	40	94,1	Decent
		80	89,6	Acceptable

All variables in the process of providing antibacterial properties were evaluated according to the concentration of phenolic compounds, depending on the conditions due to sustainability and the results obtained to characterize them directly. This study will shed light on future studies on the use of grapevine sap in the textile sector. It is also thought that the use of natural resources that do not contain any chemicals and are not harmful to the body will contribute to the literature. It is also important in terms of increasing the use of plants in textiles. Many of the extracts obtained from the roots, stems, leaves, flowers, fruits and seeds of various plant species contain substances such as phenolics, terpenoids, flavonoids, alkaloids, polypeptides, polyacetylenes, etc. that act as antibacterials. Some of these substances act as bactericides and some have a bacteriostatic effect. In this context, the research on the antibacterial activities of plant extracts and their use in the textile sector is increasing day by day.

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