Application of grape seed coating for antibacterial cotton fabric

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ABSTRACT – REZUMAT

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Microorganisms can reproduce rapidly on textile surfaces. It is known that textile surfaces used especially in hospitals cause the spread of infections and pose a danger. In recent years, instead of synthetic and heavy metal applications, the interest in obtaining environmentally friendly and natural plant-based antibacterial materials and textile applications has been increasing day by day. Grape skins and seeds, rich in polyphenolic compounds, are waste products from winemaking. The evaluation of such waste products is of great importance. In this study, grape seed, which is stated to have antibacterial activity in many studies, was applied to cotton textile material with the coating method and it was aimed to gain antibacterial properties to the fabric. As a result of the colour fastness tests performed according to the ISO 105-C06 standard, it was not observed that the coating process had a negative effect on the washing fastness of the fabrics. The wash fastness value of all coated fabrics is 5. As a result of the washing fastness test, it was seen that the coated fabrics were resistant to washing. As a result of the friction fastness tests performed according to the TS EN ISO 105-X12 standard, it was observed that the coated fabrics were resistant to friction. When the breaking strength and breaking elongation values of the coated fabrics were examined as a result of the strength test performed according to the TS EN ISO 13934-1 standard, it was observed that the tensile strength and elongation at break of the coated fabrics increased. Antibacterial tests against E. coli and S. aureus bacteria were performed on treated fabrics according to the AATCC 100 antibacterial test method. It is obtained as a result of the coating process for 60% coverage. As a result of the coating process, better results were obtained against E.coli bacteria. It was observed that the antibacterial properties improved as the coating rate increased. As a result of the tests, antibacterial activity was provided against both bacteria. An acceptable level of antibacterial activity was detected in the antibacterial tests of the washed fabrics.

Keywords: *grape seed, coating, cotton fabric, antibacterial activity*

Aplicarea acoperirii cu semințe de struguri pentru material textil antibacterian din bumbac

Microorganismele se pot reproduce rapid pe suprafețele textile. Se știe că suprafețele textile folosite în special în spitale provoacă răspândirea infecțiilor și reprezintă un pericol. În ultimii ani, în locul aplicațiilor din metale sintetice și grele, interesul pentru obținerea de materiale antibacteriene și aplicații textile ecologice și naturale pe bază de plante a crescut pe zi ce trece. Coji și semințele de struguri, bogate în compuși polifenolici, sunt produse reziduale din vinificație. Evaluarea unor astfel de deșeuri este de mare importanță. În acest studiu, sămânța de struguri, despre care se spune în multe studii că are activitate antibacteriană, a fost aplicată pe material textil din bumbac prin metoda de acoperire și a avut ca scop obținerea de proprietăți antibacteriene pentru suportul textil. În urma testelor de rezistență a culorii efectuate conform standardului ISO 105-C06, nu s-a observat un efect negativ al procesului de acoperire asupra rezistenței la spălare a materialelor textile. Valoarea rezistenței la spălare a tuturor materialelor textile acoperite este 5. Ca rezultat al testului de rezistență la spălare, s-a observat că materialele textile acoperite sunt rezistente la spălare. În urma testelor de rezistență la frecare efectuate conform standardului TS EN ISO 105-X12, s-a observat că materialele textile acoperite erau rezistente la frecare. Când au fost examinate valorile rezistenței la rupere și alungirii la rupere ale materialelor textile acoperite ca urmare a testului de rezistență efectuat conform standardului TS EN ISO 13934-1, s-a observat că rezistența la rupere și alungirea la rupere au crescut. Testele antibacteriene împotriva bacteriilor E. coli și S. aureus au fost efectuate pe materialele textile tratate conform metodei de testare antibacteriană AATCC 100. Se obține ca rezultat al procesului de acoperire pentru o acoperire de 60%. Ca urmare a procesului de acoperire, s-au obținut rezultate mai bune împotriva bacteriilor E.coli. S-a observat că proprietățile antibacteriene s-au îmbunătățit odată cu creșterea ratei de acoperire. În urma testelor, a fost asigurată activitate antibacteriană împotriva ambelor bacterii. Un nivel acceptabil de activitate antibacteriană a fost detectat în testele antibacteriene ale materialelor textile spălate.

Cuvinte-cheie: *sămânță de struguri, acoperire, material textil din bumbac, activitate antibacteriană*

INTRODUCTION

Grape (Vitis vinifera L.) is known as the raw material source of fruit juice and especially wine industry, and grape pulp is known as the main waste of grape processing enterprises. Tens of tons of pulp are released after the grape, which is one of the most grown fruits in the world, is processed in each harvest period. Its rich bioactive components make grape pomace a very profitable raw material for different sectors, the importance of which is increasing day by day [1, 2]. Grape seeds, whose antioxidant, anti-inflammatory and antimicrobial properties have been reported many times in the literature [3–5] constitute 38–52% of the grape pomace on a dry weight basis [6]. For

this reason, the evaluation of grape seeds and extract and recycling of waste is an economically important approach.

Microorganisms can reproduce rapidly on textile surfaces under the influence of moisture, nutrients and temperature [7–9]. Undesirable odours and stains may occur on textile surfaces with the reproduction of microorganisms. In addition, colour change and a decrease in strength can be observed on the textile surface [10]. For this reason, as a result of increasing customer demands, antibacterial products obtained by processing the textile product with substances with antibacterial properties to eliminate or minimize the effect of microorganisms that harm the product and the user have come to the fore. It is very important to provide protection against microorganisms, especially in hospitals and schools, in terms of human health [11]. It is known that many textile surfaces such as bedspreads, sheets, aprons, uniforms, towels, and curtains used in hospitals cause the spread of infections and pose a danger. In a study, it was determined that *Staphylococcus aureus* bacteria, which is the most basic resistant bacteria for nosocomial infections, is found in 65% of nurse aprons [12]. E. coli is a bacterium that is abundant in the intestines of humans and animals. Some varieties cause epidemics transmitted by food and water, causing intestinal and urinary tract infections. These bacteria are the most dangerous and resistant, and it is known that 10% of the infections they cause result in death.

The main methods applied to impart antibacterial activity to textile materials can be classified as follows [13–29]: (a) by surface application; (b) by incorporating suitable bioactive substances into polymer melts before extrusion; (c) by coating technology; (d) with natural substrates; (e) using sol-gel technology; (f) by spraying or foaming technique; (g) by chemical or physical modification of the substrate and/or the active agent; (h) with green chemistry approaches. Determination of the most appropriate physicochemical and/or chemical techniques or methods is depended on the fibre type, the fabric, the chemical structure of the active agent, the equipment, and the desired performance properties.

In recent years, instead of synthetic and heavy metal applications, the interest in obtaining environmentally friendly and natural plant-based antibacterial substances and textile applications has been increasing day by day. In this study, grape seed, which is stated to have antibacterial activity in many studies, was applied to cotton textile material with different rates of coating method and the fabric gained antibacterial properties. Antibacterial tests against E. coli and S. aureus bacteria were performed on the treated fabrics. In addition, strength tests and washing and rubbing fastness tests of the fabrics were made and evaluated.

MATERIALS AND METHODS

In this study, 100% cotton woven fabrics were used. The properties of these fabrics are shown in table 1.

Table 1

FEATURES OF COTTON FABRIC				
Cotton fabric	**Density (wire/cm)**	**Yarn number (Nm)**	**Fibre type**	**Weight (g/m²)**
Weft	13	20	Cotton	230
Warp	27	34	Cotton	

In this study, Tubicoat CRO water-based coating chemical used in coating applications was used in textiles supplied by CHT Tekstil and Chemistry. Tubicoat is a white paste-like acrylic dispersion coating chemical with an anionic character pH value of 8.5–9.5. Tubicoat forms a soft, non-sticky, wash-resistant and transparent film layer. Tubicoat is applied as a top coat. Tubicoat is suitable for direct use without dilution.

By coating, the physical and characteristic properties of fabrics are improved. Some features that cannot be gained with the existing structure of the fabric are gained by coating. Squeegee coating, wire-wrapped roller coating, cylinder coating, rotary stencil coating, spray coating, extrusion coating, powder coating, calender coating, transfer coating, sol-gel coating, and plasma coating methods are used in the coating. In this study, the squeegee coating method was used. The squeegee coating method is shown in figure 1.

The coating paste was prepared by mixing grape seed and auxiliary coating chemicals prepared at a micron scale at different rates (40%, 50% and 60%). After the fabric to be coated is fixed on a flat surface, a smooth and even population of the coating paste (paste) on the fabric is ensured with the help of the template and squeegee. Then, drying at 100 °C for 12 minutes and fixation at 120 °C for 3 minutes, the application was completed.

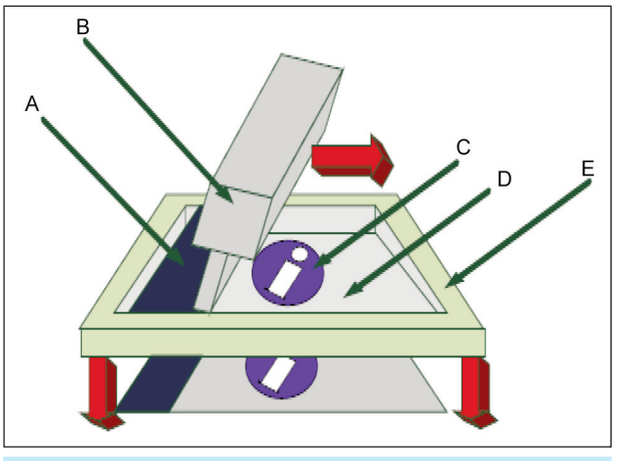


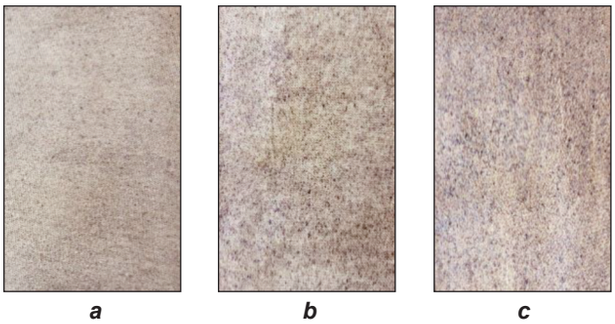
Fig. 1. Coating method: A – covering material; B – scraper (knife); C – tension cloth (gauze); D – template (frame); E – the picture that will appear if a picture is desired

In figure 1, it is shown that the grape seed is coated on the fabric using a coating chemical using a squeegee. The fabrics used in the study and the applications made are shown in table 2.

Table 2

APPLICATIONS	
Fabric	**Application**
1	Untreated fabric
2	40% Coated fabric
3	50% Coated fabric
4	60% Coated fabric

Before all tests were carried out, the fabrics were conditioned for 24 hours under laboratory conditions. To determine the washing sensitivities of the fabrics with an antibacterial finish, 1-5-10 repeated washings were carried out according to the TS EN ISO 105-C06 standard. Detergent and pure water for washing fastness test; *Staphylococcus aureus* (ATCC 6538) and *Escherichia coli* (ATCC 35218) bacteria, purified water and agar materials were used for antibacterial tests. Coated fabric images are given in figure 2.



a ***b*** ***c***

2. Fabrics coated with grape seed:
a – 40%; *b* – 50%; *c* – 60%

AATCC 100 antibacterial test method was used to quantitatively investigate the antibacterial properties of woven fabrics that were coated. To determine the effect of coating methods applied to woven fabrics on the tensile strength of fabrics, the tensile strength test of Llyod brand LR5K model strength tester according to TS EN ISO 13934-1 standard, To determine the effect of the washing process on fabrics, washing fastness test in ISO 105-C06 standard and to determine the effect of friction on fabrics, friction fastness test according to TS EN ISO 105-X12 standard was applied.

FINDINGS

Antibacterial test

In this study, AATCC 100 test method was used to determine antibacterial properties. This method is a test used to quantitatively determine the antibacterial properties of textile materials. According to this method, samples are placed in sterile containers. The number of colours that can absorb 1 ml of inoculum without leaving any liquid is determined. 1 ml of 100,000 CFU/ML inoculum is allowed to circulate throughout the heap to the samples. The inoculated inoculum is incubated for a certain contact time. At the appropriate test time, the neutralizing liquid is added to each vessel and shaken for one minute to incorporate the inoculum into the test. Serial dilutions are made and the plates are incubated. Colonies collected after incubation are counted and the percentage is calculated according to their decrease.
According to AATCC 100 antibacterial test method, fabrics' antibacterial activity values are given in table 3 against S. aureus and antibacterial activity values are given in table 4 against E. coli. In AATCC 100 Antibacterial test method, (–) values indicate a decrease in the number of bacteria, and (–) 100 indicates that all bacteria are dead. If the bacterial reductions in the media are calculated greater than 99.99%, they are considered to be "excellent", "good" if calculated between 99% and 99.99%, and "acceptable" if calculated between 0–99%.

Table 3

ANTIBACTERIAL ACTIVITY OF SAMPLES AGAINST S. AUREUS		
Fabrics	**Bacteria reduction (%)**	**Evaluation**
2	–66.67	acceptable
3	–75	acceptable
4	–89.18	acceptable

Table 4

ANTIBACTERIAL ACTIVITY OF SAMPLES AGAINST E.coli		
Samples	**Bacteria reduction (%)**	**Evaluation**
2	–89.4	acceptable
3	93.7	acceptable
4	–99.98	good

As seen in table 3 and table 4, for the 60% coated fabric, there was a reduction of 89.18% against S. aureus bacteria and a decrease of 99.98% against E. coli bacteria. The result was evaluated as 'acceptable' for S. aureus bacteria and 'good' for E. coli bacteria. For the 50% coated fabric, there was a 75% reduction against S. aureus bacteria and a 93.7% reduction against E. coli bacteria, and each person was evaluated as 'acceptable'. For the 40% coated fabric, there was a 66.67% reduction against S. aureus bacteria and an 89.4% reduction against E. coli bacteria, and it was evaluated as 'acceptable'. It was observed that as the coating rate increased, the antibacterial properties increased. As a result of the coating process, better results were obtained against E. coli bacteria.

Tensile strength

Tensile strength and elongation at break values of the samples are given in table 5.

Table 5

TENSILE STRENGTH AND ELONGATION VALUES OF SAMPLES

Fabrics	Tensile strength (N)		Elongation at break (%)	
	Warp	Weft	Warp	Weft
1	1077	285	29	75
2	1200	315	27	78
3	1226	317	30	82
4	1245	322	34	84

When the breaking strength and breaking elongation values given in table 5 are examined, it is seen that the breaking strength and breaking elongation values of the coated fabrics have increased.

Friction fastness

Friction fastness values of the samples are given in table 6.

Table 6

FRICTION FASTNESS VALUES OF SAMPLES

Fabrics	Friction fastness	
	Dry	Wet
2	5	4–5
3	5	4–5
4	5	4

When table 6 is examined, it is seen that the coating process does not affect the dry friction fastness of the fabrics, but it is effective on the wet friction fastnesses. The dry friction fastness of coated samples is 5, wet friction fastness is 4, 4–5.

Washing fastness

The washing fastness values of the samples are given in table 7.

When table 7 is examined, no negative effect of the coating process on the washing fastness of the fabrics was observed. The washing fastness value of all coated fabrics is 5. As a result of the washing fastness test, it was seen that the coated fabrics were resistant to washing.

Table 7

WASHING FASTNESS VALUES OF SAMPLES

Fabrics	Fading					
	Acetate	Cotton	Polyamide	Polyester	Acrylic	Wool
2	5	5	5	5	5	5

RESULTS AND DISCUSSION

The research of new technologies and new materials for the development of antibacterial textiles has been one of the topics of interest to researchers in recent years. Grape skins and seeds, rich in polyphenolic compounds, are waste products from winemaking. The evaluation of such waste products is of great importance. In this study, the use of grape seed in textiles has been investigated to give antibacterial activity to cotton fabrics. In this study, the coating method (squeegee coating) was used. 1-5-10 repeated washings were made to determine the washing resistance. It was not observed that the coating process had a negative effect on the washing fastness of the fabrics. The washing fastness value of all coated fabrics is 5. As a result of the washing fastness test, it was seen that the coated fabrics were resistant to washing. It has been observed that the coating process does not affect the dry rubbing fastness of the fabrics, but it is effective on the wet rubbing fastnesses. In general, it has been observed that the coated fabrics are resistant to friction. When the tensile strength and elongation at break values were examined, it was observed that the tensile strength and elongation at break of the coated fabrics increased. Antibacterial tests were carried out against E. coli and S. aureus bacteria on the treated fabricsGood antibacterial properties were obtained as a result of the coating process for 60% coating. As a result of the coating process, better results were obtained against E. coli bacteria. It was observed that the antibacterial properties improved as the coating rate increased. As a result of the tests, antibacterial activity was provided against both bacteria. In the antibacterial tests of the washed fabrics, an acceptable level of antibacterial activity was detected.

REFERENCES

[1] Barba, F.J., Zhu, Z., Koubaa, M., Sant'ana, A.S., *Green alternative methods for the extraction of antioxidant bioactive compounds from winery wastes and by-products,* In: Trends Food Sci. Tech., 2016, 49, 96–109

[2] Demirtaş, İ., Pelvan, E., Özdemir, İ.S., Alasalvar, C., Ertaş, E., *Lipid characteristics and phenolics of native grape seed oils grown in Turkey,* In: Eur. J. Lipid. Sci. Tech., 2013, 115, 641–647

[3] Oliveira, D.A., Salvador, A.A., Smânia, A., Smânia, E.F., Maraschin, M., Ferreira, S.R., *Antimicrobial activity and composition profile of grape (Vitis vinifera) pomace extracts obtained by supercritical fluids,* In: J Biotechnol., 2013, 164, 3, 423–432

[4] Sofi, F.R., Raju, C.V., Lakshmisha, I.P., Singh, R.R., *Antioxidant and antimicrobial properties of grape and papaya seed extracts and their application on the preservation of Indian mackerel (Rastrelliger kanagurta) during ice storage,* In: J. Food Sci. Technol., 2016, 53, 1, 104– 117
[5] Soto, M.L., Falqué, E., Domínguez, H., *Relevance of natural phenolics from grape and derivative products in the formulation of cosmetics,* In: Cosmetics, 2015, 2, 3, 259–276
[6] Teixeira, A., Baenas, N., Dominguez-Perles, R., Barros, A., Rosa, E., Moreno, D.A., Garcia-Viguera, C., *Natural bioactive compounds from winery byproducts as health promoters,* In: Int. J. Mol. Sci., 2014, 15, 15638–15678
[7] Cheng, W., Liu, W., Wang, Q., Wang, P., Zhou, M., Yu, Y., *Durable hydrophobic and antibacterial textile coating via PDA/AgNPs/ODA in situ assembly,* In: Cellulose, 2022, 29, 1175–1187
[8] Ye, Z., Li, S., Zhao, S., Deng, L., Zhang, J., Dong, A., *Textile coatings configured by double-nanoparticles to optimally couple superhydrophobic and antibacterial properties,* In: Chemical Engineering Journal, 2021, 420, 127680, 1–14
[9] Chen, M., et al., *Durably antibacterial cotton fabrics coated by protamine via Schiff base linkages,* In: International Journal of Biological Macromolecules, 2023, 227, 1078–1088
[10] Oğuz, N.S., *Antibacterial fabric production with radiation shielding property and investigation of its properties,* Süleyman Demirel University, Institute of Natural Sciences, PhD thesis, Isparta, 2019
[11] Devrent, N., Yılmaz, N.D., *Tekstil Endüstrisinde Kullanılan Antimikrobiyel Lifler,* In: Nonwoven Technical Textiles Technology Dergisi, 2004, 4, 48–55
[12] Boryo, D. E. A., *The effect of microbes on textile material: a review on the way-out so far,* In: The International Journal of Engineering and Science (IJES), 2013, 2, 8, 09–13
[13] Lee, H.J., Yeo, S.Y., Jeong, S.H., *Antibacterial effect of nanosized silver colloidal solution on textile fabrics,* In: Journal of Materials Science 2003, 38, 2199–2204
[14] Zhang, Z., et al., *Antibacterial properties of cotton fabrics treated with chitosan,* In: Textile Research Journal, 2003, 73, 12, 1103–1106
[15] Lim, S.H., Hudson, S.M., *Review of chitosan and its derivatives as antimicrobial agents and their uses as textile chemicals,* In: Journal of Macromolecular Science, Part C: Polymer Reviews, 2003, 43, 2, 223–269
[16] Kamel, M.Y., Hassabo, A.G., *Anti-microbial finishing for natural textile fabrics,* In: Journal of Textiles, Coloration and Polymer Science, 2021, 18, 2, 83–95
[17] Mahltig, B., Haufe, H., Böttcher, H., *Functionalisation of textiles by inorganic sol–gel coatings,* In: Journal of Materials Chemistry, 2005, 15, 41, 4385–4398
[18] Tawiah, B., Badoe, W., Fu, S., *Advances in the development of antimicrobial agents for textiles*: *The quest for natural products. Review,* In: Fibres & Textiles in Eastern Europe, 2016, 3, 117, 136–149
[19] Gao, Y., Cranston, R., *Recent advances in antimicrobial treatments of textiles,* In: Textile Research Journal, 2008, 78, 1, 60–72
[20] Dastjerdi, R., Montazer, M., *A review on the application of inorganic nano-structured materials in the modification of textiles: focus on anti-microbial properties,* In: Colloids and Surfaces B: Biointerfaces, 2010, 79, 1, 5–18
[21] Ibrahim, N.A., et al., *Innovative multi-functional treatments of ligno-cellulosic jute fabric,* In: Carbohydrate polymers, 2010, 82, 4, 1198–1204
[22] Shahid, M., Mohammad, F., *Green Chemistry Approaches to Develop Antimicrobial Textiles Based on Sustainable Biopolymers- A Review,* In: Industrial & Engineering Chemistry Research, 2013, 52, 15, 5245–5260
[23] Kasiri, M.B., Safapour, S., *Natural dyes and antimicrobials for green treatment of textiles,* In: Environmental Chemistry Letters, 2014, 12, 1, 1–13
[24] Sharkawy, A., Fernandes, I.P., Barreiro, M.F., Rodrigues, A.E., Shoeib, T., *Aroma-loaded microcapsules with antibacterial activity for eco-friendly textile application: synthesis, characterization, release, and green grafting,* In: Industrial & Engineering Chemistry Research, 2017, 56, 19, 5516–5526
[25] Fiedot-Toboła, M., Ciesielska, M., Maliszewska, I., Rac-Rumijowska, O., Suchorska-Woźniak, P., Teterycz, H., Bryjak, M., *Deposition of zinc oxide on different polymer textiles and their antibacterial properties,* In: Materials, 2018, 11, 707, 1–16
[26] Beşen, B.S., *Production of disposable antibacterial textiles via application of tea tree oil encapsulated into different wall materials,* In: Fibers and Polymers, 2019, 20, 2587–2593
[27] Das, S., Natarajan, S., *Antibacterial activity of chitosan in textiles–A review,* In: Man-Made Textiles in India, 2022, 50, 3, 96–100
[28] Lange, A., Sawosz, E., Wierzbicki, M., et al., *Nanocomposites of Graphene Oxide-Silver Nanoparticles for Enhanced Antibacterial Activity: Mechanism of Action and Medical Textiles Coating,* In: Materials, 2022, 15, 9, 3122
[29] Massella, D., Giraud, S., Guan, J., Ferri, A., Salaün, F., *Textiles for health: A review of textile fabrics treated with chitosan microcapsule*s, In: Environmental Chemistry Letters, 2019, 17, 1787–1800

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