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Investigation of the effect of myrtle spurge (*Euphorbia myrsinites* L.) extract on some mechanical properties of fabrics

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Mersin sütleğeni (*Euphorbia myrsinites* L.) ekstraktının kumaşların bazı mekanik özellikleri üzerine etkisinin araştırılması

Abstract: Textile products have the most direct relationship with the human body after food products. Dye residues and chemicals on our clothes can penetrate our bodies through sweating and respiration which affects our health. The purpose of this study was to investigate the effect of the extract obtained from *Euphorbia myrsinites* L. on various mechanical properties of fabrics and to find natural alternatives to currently used chemicals to improve these properties. In the study, an extract was obtained from the dried *E. myrsinites* samples by the decoction method. The extract was applied to various fabrics to determine the most suitable fabric, and a sample fabric was produced. The friction fastness, touching, flammability, crease resistance, and abrasion resistance tests were performed on the produced sample and standard fabrics. As a result of the study, it was revealed that the sample fabric produced using Euphorbia extract outperformed the standard fabric in wet and dry friction fastness, crease resistance, and mechanical friction resistance tests. It also reached the desired levels of toughness, density, and smoothness in the touching test. The fabric ignited approximately 13-14 seconds in flammability tests, and this result was considered positive as the criterion for these tests performed in advanced laboratories is 10 seconds. Based on the findings of this study, it can be suggested that fabrics which do not wrinkle, wear out quickly, or burn easily can be produced by using Euphorbia extract instead of chemicals that are harmful to health.

Key words: *Euphorbia* extract, natural fabric, dye releasing, friction resistance, fire resistance

Özet: Tekstil ürünleri gıda maddelerinden sonra insan vücuduyla en doğrudan ilişkiye sahiptir. Giysilerimizdeki boya kalıntıları ve kimyasallar terleme ve solunum yoluyla vücudumuza nüfuz edebilir ve sağlığımızı etkileyebilir. Bu çalışmanın amacı, *Euphorbia myrsinites* L.'den elde edilen ekstraktın kumaşların çeşitli mekanik özellikleri üzerindeki etkisini araştırmak ve bu özellikleri iyileştirmek için şu anda kullanılan kimyasallara doğal alternatifler bulmaktır. Çalışmada kurutulmuş *E. myrsinites* örneklerinden kaynatma yöntemiyle bir ekstrakt elde edilmiştir. En uygun kumaşı belirlemek için ekstrakt çeşitli kumaşlara uygulanmış ve bir numune kumaş üretilmiştir. Üretilen numune ve standart kumaşlar üzerinde sürtünme haslığı, dokunma, yanıcılık, kırışma direnci ve aşınma direnci testleri yapılmıştır. Çalışma sonucunda, sütleğen ekstraktı kullanılarak üretilen numune kumaşın, ıslak ve kuru sürtünme haslığı, kırışma direnci ve mekanik sürtünme direnci testlerinde standart kumaştan daha iyi performans gösterdiği ortaya çıkmıştır. Ayrıca dokunma testinde de istenilen tokluk, yoğunluk ve pürüzsüzlük seviyelerini göstermiştir. Kumaşın yanıcılık testlerinde yaklaşık 13-14 saniyede tutuşmasıyla birlikte, gelişmiş laboratuvarlarda yapılan bu testlerde kriter 10 saniye olduğu için bu sonuç olumlu olarak değerlendirilmiştir. Bu çalışmanın bulgularına dayanarak, sağlığa zararlı kimyasallar yerine sütleğen ekstraktı kullanılarak kırışmayan, çabuk yıpranmayan ve kolay yanmayan kumaşlar üretilebileceği ileri sürülebilir.

Anahtar Kelimeler: Sütleğen ekstraktı, doğal kumaş, boya dökme, sürtünme direnci, yanma direnci

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1. Introduction

People have been interested in plants since their existence. According to archaeological findings dating back to ancient times, people primarily benefited from plants for sustenance and to overcome health problems (Ersöz, 2010). *Euphorbia* L. is among such important plants. *Euphorbia*, which is among the *Euphorbiaceae* family, includes more than 2.150 species, most of which are of economic importance (Horn et al., 2012). *Euphorbia*, one of the plants used as medicines in 60 pieces of Boğazköy cuneiform text of the Hittites (1700-1200 BC), is also included in the list of plants suitable for preparing medicines by the World Health Organization (Başaran, 2012). In particular, it has been explained that *Euphorbia* species commonly used in traditional medicine contain essential oils, oxygenated sesquiterpenes, sesquiterpene hydrocarbons (Salehi et al., 2019), and macrocyclic diterpenoids (Vasas & Hohmann, 2014). Moreover, it has been reported that it contains gallic acid, phenolic compounds, quercetin, jatrophane diterpene, jatrophanepolyester, tigliane diterpene, and cycloartane-type triterpene (Chaabi et al., 2007; Haba et al., 2007; Hohmann et al., 2002). The plant is rich in flavonoids, the largest group of resin, gum, and plant phenolics. As strong antioxidants, flavonoids protect the cells against anti-radicals, inhibit the proliferation of bacteria and viruses, and provide resistance to cancer formation and heart attack (Xing et al., 2002; Dartay, 2010).

The usage areas of *Euphorbia* plants in traditional medicine are divided into three categories: treatment of digestive system disorders, infections, and skin/subcutaneous cellular tissue disorders (Salehi et al., 2019). The specific plant parts used can vary depending on the geographical distribution of *Euphorbia* species. *E. hirta* L., *E. thymifolia* L. and *E. lathyris* L. are the most commonly used species (Ernst et al., 2015).

Generally, *Euphorbia* species are widely used for the treatment of the following disorders: dysentery, asthma, bronchitis, cough (Hargreaves, 1991; Van Sam et al., 2008), skin diseases, ringworm, gonorrhea (Lai et al., 2004; Ernst et al., 2015; Mali and Panchal, 2017b), hemorrhoids (Gürhan & Ezer, 2004; Gupta, 2011), cancer and liver diseases (Hsieh et al., 2015; Mali & Panchal, 2017a,b), snake and scorpion bites (Hsieh et al., 2015; Mali and Panchal, 2017a,b) healing of wounds (Lai et al., 2004; Kaval et al., 2014; Ahmed et al., 2016), and lowering cholesterol (Maurya et al., 2012). Ashraf et al. (2015) revealed in their study that euphorbia extract, exhibiting excellent antioxidant, antimicrobial, and anti-tumor (anti-cancer) properties, was a valuable resource for the pharmaceutical industry. It is also used in the production of latex, paint, natural rubber (Rizk, 1987; Dabholkar et al., 1991), and as a food additive to preserve foods (Toro-Vazquez et al., 2007). On the other hand, some *Euphorbia* plants, especially their latex or milky sap, can irritate the skin, mouth, and throat, causing a burning sensation, acute inflammation, and nausea (Bhatia et al., 2014). Notably, some species possess the ability to bind oxygen. Because of these characteristics, roots, branches, seeds, and milk of euphorbia are widely used in fishing (Dartay, 2010). Additionally, environmentally friendly composites with enhanced oxygen retention capacity have been produced from renewable materials by using banana polyester fiber and euphorbia (Rai et al., 2011). Research on developing composites with various properties using different types of euphorbia is ongoing (Kumari et al., 2020; Mwaikambo et al., 2024).

It is remarkable that the studies on *Euphorbia,* which grows naturally in vast areas of the earth and has a very rich species diversity, are concentrated in the field of health, while there are few studies on *Euphorbia* in our country. Besides health, people also prioritize food and clothing. As seen in the literature, euphorbia is also used for food supply purposes (e.g., fishing, honey). However, there are limited studies on the use of euphorbia in the production of fabrics that people use in many areas (clothing, coating, protection, etc.) (Bhandari et al., 2020; Koo and Park, 2022). It has been also seen that these studies are mostly related to dyeing**.** In this study, it was aimed (i) to investigate the effect of euphorbia extract on various mechanical properties of fabrics (friction fastness, fire resistance, wrinkle resistance, abrasion resistance, etc.), and (ii) to find a natural alternative to health-threatening chemicals used in fabric production.

2. Materials and Method

2.1. Material

In the study, euphorbia plants collected from Uçmakdere location of Tekirdağ province (latitude: 40°80'00.3", longitude: 27°36'60.5", altitude: 203 m) were used as the material. The collected plants were identified at the university and determined to belong to *E. myrsinites* species.

2.2. Method

2.2.1. Drying plant samples

The collected samples were sterilized by washing them first with water and then with a 5% isopropyl alcohol solution. After the samples were dried at room temperature (10-15 days), they were ground into powder and stored in airtight containers.

2.2.2. Obtaining extract from *E. myrsinites*

The Decoction (boiling) method was preferred by paying attention not to use chemical substances while obtaining the extract (Fueki et al., 2015). In the modified method, 10 g of the plant sample was weighed and mixed with 200 ml of distilled water. The mixture was boiled for 5 minutes and then filtered hot. In the method followed, it is desired to remove the water to be able to obtain the extract in a raw form. However, the water was not removed after filtration since dilution would also be performed in experiments on fabrics.

2.2.3. Determination of to which fabrics the obtained extract can be applied

Compatibility studies were performed based on Vinyl acrylic copolymer, Biopolymer, and PVA (Polyvinyl Alcohol) fabric structures to determine with which fabric structures the extract would comply.

2.2.4. Obtaining and controlling sample fabrics

To obtain a sample fabric, X (each firm has its own base structure) base structure (93.95%), Euphorbia extract (5.5%), and the protecting agent (0.55%) were stirred at 2000 rpm for 2 rad/s. The mixture was then filtered, and quality control was performed by examining its properties, such as appearance, film property, viscosity, pH, and refractive index, to determine whether it could be used as fabric.

2.2.5. The use of extract together with various fabrics

In this stage performed to determine the effect of Euphorbia extract on various fabrics, the Foulard process used in the Pad-Batch (impregnation) method was followed (Ömeroğulları Başyiğit, 2021**).** In the impregnation method, the fabric was treated in a bowl (foulard) with a solution to be impregnated in a very short time and in a short flotte ratio, and then the mangle process was performed. The fabric impregnated in the foulard was then subjected to complementary processes such as fixation and washing. Since the machine used for impregnation is foulard, the method is known by this name. In the study, knitted and polyester (PES) fabrics and 20 g/l extract were used in the foulard process. After the fabrics were dried (105 °C) in the drying-oven, other stages of the study were performed.

2.2.6. Finishing (apre) study

Finishing processes, indispensable for the textile industry, are applied to give new properties to textile products and to improve the properties available in the structure of the product. Most of the fabrics are subjected to the finishing process before they are used. Finishing processes are divided into two categories based on the application methods: Mechanical finishing (dry finishing) and chemical finishing (wet finishing).

In this study, chemical finishing was applied in an attempt to modify the retention, appearance, or handling properties of fibers by attaching the extract applied to fabric. Impregnation, the most applied method of applique in chemical finishing processes,and the foulard process described in the previous step were employed Here, the application was performed on one side of the fabric under standard finishing application conditions (Table 1).

2.2.7. Friction fastness test

This test was performed to determine whether the dyed yarn would stain the fabric rubbed by friction effect in later use. A Crockmeter (rubbing test apparatus), sufficient amount of fabric for wet and dry rubbing fastness tests, cotton rubbing cloth (pH: 5.5), and distilled water were used as materials. The tests were conducted in two stages.

Dry rubbing fastness test: The sample fabric was stretched longitudinally in the weaving direction and placed in the test apparatus. The cotton rubbing cloth was attached by being stretched on the rubbing finger with a flap. A 10 cm² area of the dry sample was subjected to 10 cycles of back-and-forth rubbing process within 10 seconds (Fig. 1).

Wet rubbing fastness test: A sufficient amount of the sample fabric was stretched longitudinally in the weaving direction and positioned to align with the test apparatus' path. The cotton rubbing cloth was wetted with distilled water, stretched, and attached to the rubbing finger by a flap. The wet sample was subjected to ten cycles of back-and-forth rubbing process along a 10 cm^2 straight line within 10 seconds.

The samples obtained as a result of the two tests were evaluated based on the greyscale (ISO 105-A03) (Önem et al., 2012). This scale was prepared with 1 pair of white and 4 pairs of gray and white pieces of sheet or fabric (Fig. 2). Apparent shades are available on the greyscale. To determine the degree of releasing, the material polluted as a result of the test is placed side by side with the original undyed fabric, and the difference between them is compared using the differences in the greyscale.

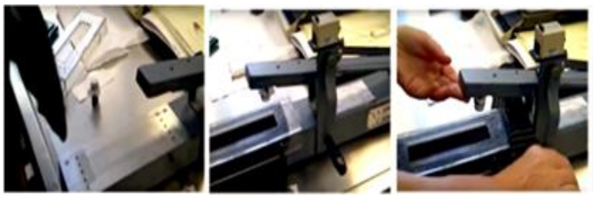

Figure 1. Dry rubbing fastness test.

2.2.8. Touching test

The subjective evaluation of a feeling such as softness, toughness, density, drapability, smoothness, thickness, and temperature perceived through the sense of touch on textile products is expressed as touching. W.S. Howorth and P.H. Oliver have revealed that there is a correlation between the touching properties and mechanical properties of fabrics (Gürcüm, 2010). Since the mechanical properties of fabrics were examined in this study, experienced personnel from the R&D department of the factory were consulted for the touching test.

2.2.9. Flammability test

Various flammability tests are performed in advanced laboratories and there are special devices for these tests. In this study, the ISO 6940 test was modified and applied. This test was performed using a setup that we created to closely simulate the standard conditions after reviewing the devices used in laboratories. The sample fabric was stretched vertically and attached to metal stands on both ends. The flame device was approximated to the fabric and held at a point for 10 seconds, and whether it ignited was observed

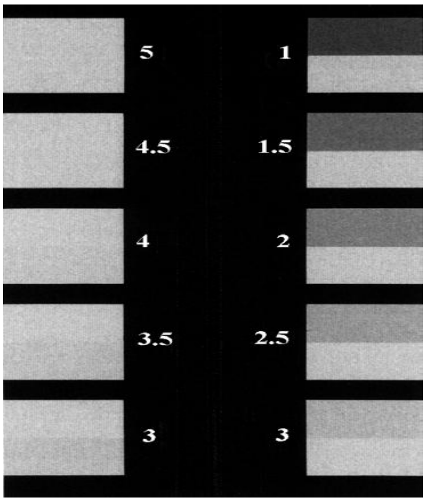

Figure 2. Greyscale (ISO 105-A03)

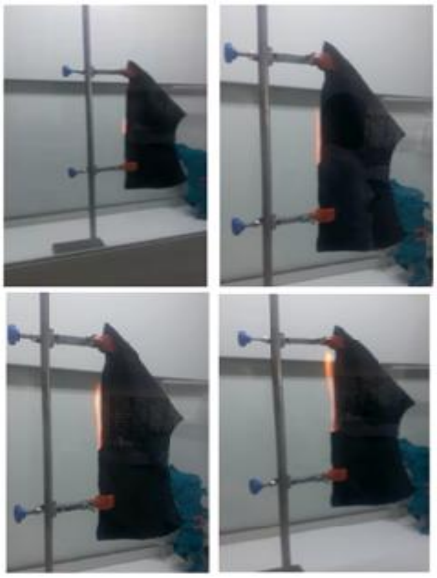

Figure 3. Flammability test

Table 1. Finishing application conditions

X base structure	20 g/l	Sample	20 g/l
Method	Foulard	Method	Foulard
pH	5 – 5.5	pH	5 – 5.5
	105 °C and N.C.	Drying	105 °C and N.C.

(Fig. 3). The flame length of the burners used as a flame source under standard conditions was set to 25 mm (our source was a little stronger).

2.2.10. Crease resistance test

The crease resistance is the process by which fabrics are wrinkled under a certain pressure to ensure ease of use and return to their original state when the pressure effect is eliminated The resistance of fabrics, which are textile products, show to wrinkles occurring during use and their ability to recover from this resistance are expressed by the crease recovery angle. The crease recovery angle is determined by measuring the untwisting and the angle of recovery on a horizontally folded fabric (TS 390 EN 22313). In this study, angle measurement was not performed due to the lack of necessary equipment, and it was evaluated by receiving help from experts.

2.2.11. Abrasion (Abrasion Resistance) test

When the fabrics used in clothing production are rubbed against another material, yarns and fibers come out of the fabric's surface, and thereby wear and tear occur on the surface. Abrasive resistance is the fabric's ability to withstand wear and tear caused by friction against other materials. Abrasion resistance, along with breaking strength, is one of the most important properties determining the overall strength of textile products. Abrasion resistance is determined depending on the number of revolutions at a time during which yarn break is observed, weight loss after a certain cycle, or color change after a certain number of cycles. The Martindale method (TS EN ISO 12947-4) was used in the abrasion test (Çatal, 2015). The sample fabric was placed on the Martindale apparatus, and the abrasion between units making a circular harmonic motion with respect to each other under 9 KPa pressure was monitored. 5000 cycles were performed by controlling every 1000 cycles.

3. Results and Discussion

In the study, the usability of the extract, obtained from *E. myrsinites* via the boiling method, in the production of various fabrics was investigated. It was seen that the extract and PVA base structure were suitable, and a sample fabric was produced (PRD 702). R&D studies of the produced sample fabric were carried out and the results were evaluated. The results were found to comply with the desired standard properties, and other tests were carried out on the sample fabric (Table 2).

First, the dry and wet rubbing fastness tests were performed on the produced sample fabric (PRD 702) and the results were compared with the X-based fabric used as standard (Kleber IR). Then, the results were evaluated by the greyscale (Fig. 2). In the dry rubbing fastness test, it was determined that the sample fabric had the same properties as the standard fabric and showed the desired value (1) in all textile products in the greyscale. This result shows that the fabric did not release the dye by abrasion and did not dye its surroundings (Fig. 4). The wet rubbing fastness test revealed that the sample fabric gave better results than the standard fabric and did not release its dye during washing (Fig. 4). Carcinogenic azo dyestuffs, allergic fabric dyes, and heavy metal-containing materials are used in many fabrics, and these substances affect our bodies through sweating when the fabric release the dye or does not retain the dye sufficiently**.** In addition to dye, substances such as chloric aromatic compounds, o-phenylphenol, biphenyl, aromatic hydrocarbons, benzylbenzoate, N-alkylphthalimide, sodium silicate, and salt are used to retain the dye and to prevent color from bleeding in fabrics. Many of these substances irritate the skin, damage the eyes, cause DNA damage and bladder cancer (Velicangil and Velicangil, 1987; Topuzoğlu and Orhun, 1993; Öztürk, 2021).

In the study, the touching test revealed that the sample fabric produced by adding extract had more desired properties than the standard fabric. The results of this test vary depending on where the fabric will be used. The fabrics to be used in cloth production are not desired to be too hard, dense, or heavy. It was observed that the sample fabric gave toughness, density, and smoothness at the desired level without weight.

In the flammability test performed, it was determined that the ignition time of the sample fabric was 13-14 seconds,

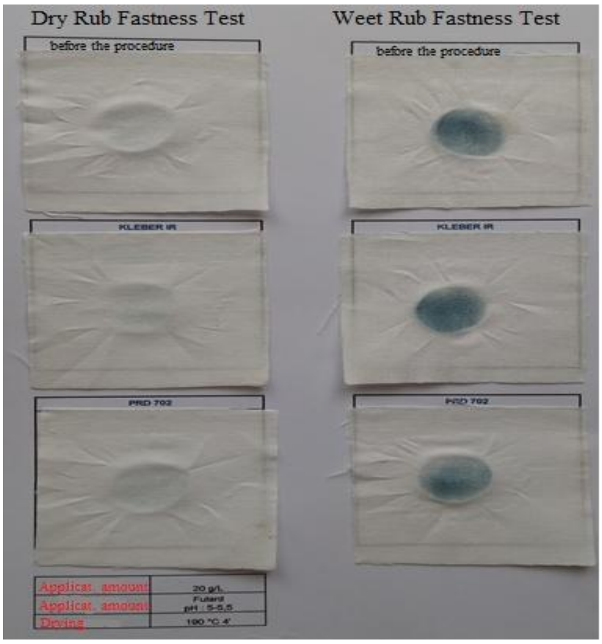

Figure 4. Results of the dry and wet rubbing fastness tests

Table 2. Quality control values of the sample fabric

R & D Study Code	Appearance	Viscosity	K.M. %	pH	K.I.	Film property
PRD702	greenish, viscose **	1.600 CPS	9.5	5	1.3460	Hard, difficult to separate from glass, not adhesive

Table 3. Flammability test results

Knitted Fabric (after touching)	Knitted Fabric (After drying at 105 °C)	PES Fabric (After drying at 105 °C)	PES Fabric (after touching)
Method	Foulard	Method	Foulard

while the ignition time of standard fabric was 9-10 seconds. The flammability test was also implemented on fabrics with different structures. In the experiments carried out with knitted and PES fabrics, it was observed that the ignition times of both fabrics were similar to the sample fabric (in 13-14 s) (Table 3). However, these tests are performed with special devices kept at a certain distance from the flammable fabric at a lower severity, and 10 seconds is used as the criteria (ISO 6940). Since the intensity of the flame in the setup that we created was too high, it was normal for the fabric to ignite in 13-14 seconds.

Halogen-based additives (e.g., pen-taBDE, octaBDE, and decaBDE) are mostly used as flame retardants in fabric production. However, these substances have been banned because they accumulate in the food chain of living beings and have a negative effect on the liver, thyroid, reproductive system, and neurological development (Zhao, 2010; Gaonkar, 2021). Nowadays, inorganic-based materials are also used as additives in polymers to give flame-retardant properties. For example, zinc borate is used as an additive in polymers (such as PET, polyamide, polyethylene, and rubber) and in dyestuffs. The clustering of zinc borate in the polymer matrix and the formation of aggregates pose a problem in distributing it well in the matrix. Furthermore, it acts as waste, polluting the environment over time as it is released on the surface. This problem is not only specific to zinc borate but also applies to low molecular weight, inorganic, and organic-based additives. New flame retardants are also needed due to the effects of halogen-based additives on the environment and human health (Eren & Aşçı, 2015). For this reason, in the study, it was aimed to produce fire-resistant fabric using the oxygen retention property of Euphorbia (Rai et al., 2011). A natural flame retardant can be developed by conducting further research on the Euphorbia extract.

Crease resistance test results showed that PES fabrics in which euphorbia extract was used outperformed standard PES fabrics. After bidirectional pressure, the sample fabric exhibited fewer marks compared to the standard fabric (Fig. 5-6). The crease-resistant finishing was applied to the fabrics to prevent wrinkling, and melamine-based chemicals and formaldehyde were used in these processes. Formaldehyde was included in the list of carcinogenic chemical substances (Öztürk, 2021). It was observed that the crease resistance property of the sample fabric produced in this study was high when compared to the standard fabric. The use of natural substances should be preferred instead of health-threatening carcinogenic chemical substances.

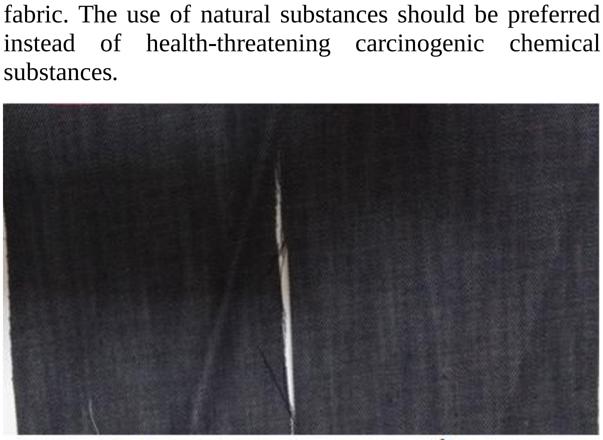

Figure 5. Result of the crease resistance test carried out by the pressure applied from the front side. a: standard fabric (Kleber IR), b: sample fabric (PRD 702)

As a result of the mechanical abrasion resistance test, it was determined that the sample fabric produced using *Euphorbia* extract was more resistant to abrasion than the standard fabric. Although both fabrics were resistant to 3500-4000 cycles at 9 KPa, it was observed that the abrasions in the standard fabric started earlier and were more severe than in the sample fabric. The fabrics with which our body is in constant contact are desired to be healthy and durable. It is preferred that mechanical friction and abrasion are minimal in fabrics. Formaldehyde or formaldehyde bisulfite with the same effect is used for good retention of the dye during dying and to avoid damage to fibers (resistance to mechanical abrasion) during the use of the fabric. However, these substances are carcinogenic (Gaonkar, 2021; Öztürk, 2021).

In general, in the textile industry, various chemicals are used as additives to make fabrics or other products more durable (friction, abrasion), soft, water and oil-repellent, stain-resistant, fire-resistant, wrinkle-resistant, and resistant to bacteria and fungi. Some of these chemicals are Per-and Polyfluoroalkyl Substances (PFAS), Nonylphenol Ethoxylates (NPEOs), Decabromodiphenyl Ether (decaBDE), Organotin Compounds (OTCs), Phthalates, Bisphenol A (BPA), and Short Chain Chlorinated Paraffins (SCCPs) (Gaonkar, 2021). Many of these chemicals can enter the body through the outer layers of the skin by contacting the skin when we wear our clothes. In addition, as fabrics wear out, fibers enter the body through breathing or swallowing and cause health problems (Lensen et al., 2007; Gallagher, 2008). The chemicals used in textile products cause many disorders such as cancer, endocrine-reproductive-nerve-immune systems disruption, liver and kidney damage, increase in cholesterol levels, DNA damage, and inhibition of baby development (Gaonkar, 2021; Öztürk, 2021). Moreover, since they are toxic to aquatic and terrestrial creatures, they affect the survival, growth, development, and reproduction of these living beings (Gaonkar, 2021). Besides,living beings, the environment is also affected negatively by the chemicals used in the textile industry. Firstly, a lot of water and energy is consumed by the textile industry. As this industry is the second sector that pollutes fresh water the most worldwide. Chemicals used in production processes cause water and air pollution (Toprak & Anis, 2017). Some of the chemicals used are banned due to the harm they cause. For example, halogenated compounds used as fire retardants and brominated diphenyl derivatives have been banned because the former cause environmental problems, the latter

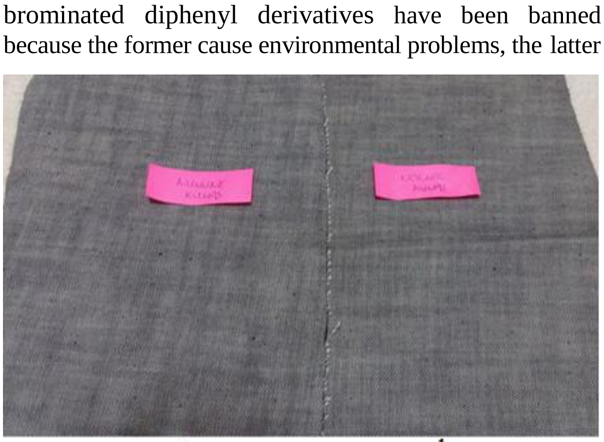

Figure 6. The result of the crease resistance test performed with the pressure applied from the reverse side. a: sample fabric (PRD 702), b: standard fabric (Kleber IR)

cause high toxicity for humans and animals (Zhao, 2010; Van der Veen & de Boer, 2012). Many alternative substances to the chemicals used in fabric production have been suggested and many studies have been conducted on this subject. However, the suggested substances are generally chemicals and their harms are no less than these substances (Horrocks et al., 2005; Atakan et al., 2019; Gaonkar, 2021). Therefore, this current study is highly important.

In this study, the effect of the extract, obtained from the euphorbia (*E. myrsinites*) plant by applying the boiling method without using chemicals on fabrics, was examined and some mechanical properties were tried to be improved. The study revealed that fabrics with the desired properties (e.g., wrinkle-free, paint-resistant, and friction-resistant) can be produced by using euphorbia extract instead of fabrics irritating the skin and containing carcinogenic substances.

Burn-resistant fabrics can also be produced by taking advantage of the oxygen retention feature of euphorbia. However, some euphorbia species may harm health when used unconsciously or excessively (Bhatia et al., 2014). For this reason, it is recommended not to use euphorbia directly (especially as tea). In this study, euphorbia was not used directly; very little percentage (0.2 - 0.3%) of euphorbia extract was used. Even though it was used proportionately less, it created the desired effect. It is also known that euphorbia extract is used in the treatment of many skin disorders (e.g., warts, eczema, and calluses) and hemorrhoids and that it has healing, antioxidant, antimicrobial, and anti-cancer effects (Baytop, 1999; Gupta, 2011; Ashraf et al., 2015; Ahmed et al., 2016). It is believed that the data obtained from this study can be further developed in various fields such as textile, biotechnology, biology, and chemistry. This could lead to the production of fabrics by using natural, renewable, cheap, environmentally, and health-friendly substances instead of harmful chemicals. In addition, different plants could be explored in these studies**.**

Conflict of Interest

Authors have declared no conflict of interest.

Authors' Contribution

The authors contributed equally.

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