© by PSP Volume 31– No. 01A/2022 pages 1240-1249 Fresenius Environmental Bulletin

NEW APPROACH TO ECOLOGICAL STRUCTURE EFFECTS OF MEDICAL AROMATIC PLANT EXTRACT/BORAX ON THE ANATOMICAL STRUCTURE OF WOOD AND HUMAN/ENVIRONMENTAL HEALTH

Hatice Ulusoy[1,*], Huseyin Peker[2]

[1]Forest Department, Mugla Sitki Kocman Unıversity, Mugla, Turkey
[2]Forest Industrial Engineering, Artvin Coruh Unıversity, Artvin, Turkey

ABSTRACT

In this century, in which human and environmental health are prioritized in the usage of medical aromatic plant extract and boron chemical, both separately and in combination, when the effect of wood on the anatomical structure is assessed in the context of hygiene/antimicrobials, it opens up additional areas to be addressed (indoor/outdoor spaces, hospitals, space, and so on). In order to determine the anatomical characteristics, cross-sections (transverse/radial/tangential) of the wood samples were obtained and interactions/changes in the anatomical structure were identified under the light microscope, and the retention scale was created in relation to this. The retention level of both medicinal aromatic plant extract and borax in wood is the highest in mahogany wood (2.88%), while the lowest percentage is found in oriental spruce wood (0.35%). In comparison to the control sample, the air/full dry specific density change produced good outcomes in both wood types. The highest air-dried specific density value was found in borax (0.58 g/cm^3) in mahogany wood, and in Çaşır (*Ferula comunis L.)* plant, borax and ferula+borax (0.38 g/cm^3) in spruce wood. In both wood species, retention occurred in sap rays and there was no retention in the traheid/trahe cells, which act as conduction, and retention was determined in these cells, since they are sapphire cells and cells that act as storage.

KEYWORDS:
Medicinal aromatic plant, Anatomy, Wood, Cross-section, Human/environment healthy

INTRODUCTION

When we examine textual sources from throughout the world that date back thousands of years, we find the following: China. The Chinese Pharmacopoeia, authored by the Chinese emperor Shen Nung around 3200 BC, is one of the earliest known written documents, according to Pen T'srao. More than 300 medicines are contained in this Pen T'srao. They have a lot of prescriptions and natural medications on them. Egypt: At 1862, the Ebers papyrus, written approximately 1550 BC, was discovered in Thebes. It contains information on over 700 medications and 800 prescriptions. Hittites: In the tablets that have remained from the Hittites, who lived in Anatolia between the 16th and 12th centuries BC, there are several prescriptions written for therapeutic purposes [1].

Medicinal and aromatic plants make up a significant portion of today's plant commerce. While the majority of these plant species in commerce are harvested from nature, only a small percentage of them are cultivated and utilized in the field. Discovering novel active substances for application in the treatment of diseases depends on the continuation of research on plants. It was discovered that 2618 of the 3500 novel active compounds discovered as a consequence of studies conducted in 1985 were of herbal origin [2]. Throughout history, wood and annual plants have played a vital part in human life. These materials have been applied to build shelters, cook, and make tools and equipment since the early ages. The advantages, functionality, strength, ease of production, and attractiveness of these materials were swiftly discovered by mankind. In the Egyptian pyramids, even materials made of less durable species have survived to the currrent day because they have been under dry conditions for thousands of years [3, 4].

Considering the preservation of wood (biotic/abiotic) and its effects on environmental/health factors, it is necessary to develop new products and the impregnation processes to be utilized should not pose a risk [5]. The necessity of developing novel materials that contribute to human/environmental health has evolved as a result of the pressures produced by the threat of some impregnation materials to mankind due to their poisonous component structures [6]. In recent years, interest in medicinal plants and studies on them has increased. The main reasons for this increased interest are that synthetic medications are incredibly expensive, have many adverse effects and do not have the ability to treat every disease [1]. The impregnation process' success and degree of protection are determined by the impregnation material's and wood's qualities, as well as the net amount of dried impregnation material attached to the wood (retention) and the impregnation material's depth of penetration into the wood.This is critical for protecting wooden materials (furniture, construction materials, and so on) against a variety of hazards (biotic-abiotic-burning-air effects, etc.) [7]. In the impregnation process, the effectiveness depends on the impregnation material, wood property, retention level (adhesion), permeability level, and the anatomical structure depends on the drying/ slit opening process made beforehand. Wood impregnation is complicated by passage aspiration in coniferous woods and the creation of gauze in leafy woods, as well as different foreign particles deposited in the aperture in the passage membranes. It has been reported that performing the peeling process before starting the impregnation process reduces the level of free water in the lumen to 20% humidity, thus increasing the depth of impregnation effect with drying [8]. For this reason, environmentally friendly technologies for providing dimensional stability (stabilization) and preventing biological breakdown (degradation) have begun to be researched [9]. It has been stated that fragmentation in spring and summer wood, cracks in the core rays and separation at the annual ring boundaries are more common in the heat-treated wood material; the effects of the heat treatment on these anatomical features of the wood material vary according to the species and the heat treatment temperature and duration; the heat-treated wood material became more brittle in both species. While interpretations are made in studies where the effects of heat treatment on the mechanical properties of wood are evaluated, it has been stated that the effects of heat treatment on the anatomical structure should also be considered [10].

The effects of anatomical structures and processing conditions on the surface roughness of some wood species were investigated. The anatomical effects of roughness and deformations in self-rays on the tangential surface as a result of wood processing have been determined [11]. Trache cells consist of spindle cells in the cambium. They are in charge of water transfer as well as mineral compounds dissolved in the soil being transmitted from the root to the leaves. Trache cells, which are stacked on top of each other in the direction of the tree's length, have transverse walls between themselves. Over time, these walls breakdown and vanish, resulting in the formation of trache cells [12].

With its antibacterial/antifungal structure, medicinal aromatic herbs play a critical role in human/environmental health, and products derived from these plants are now widely used (cream, lotion, food industry, pharmaceutical industry, etc.). Extract may be produced from the stem, leaves, and even the plant's waste when it is used in wood. This improves the product's economy. For this purpose, in this study, it is aimed to create new areas of use by determining the level of retention and anatomical structure of the medicinal aromatic plant, Çaşır (*Ferula comunis L.*) plant, either alone or in association with borax. In terms of cleanliness and health, the extract structure of these plants can be employed in any location where humans exist (indoors, outdoors, hospitals, etc.). scriptures.

MATERIALS AND METHODS

Wood Material and Plant Type. Spruce and mahogany wood from our nation were employed in the study, as well as Çaşır (*Ferula comunis L.*) plant and borax, both of which have been shown to have antibacterial/antioxidant characteristics in the literature.

Plant Supply And Extract Preparation. Drying of Çaşır plants taken fresh from Erzurum was carried out in the laboratory of Artvin Çoruh University until they reached a constant weight level of approximately (1-2 months). After drying, it was brought to powder level in grinders. The powdered plants weighed as 10.26 g, and the extraction was carried out in water for 24 hours at room temperature with agitation and completion with the solvent at the determined volume levels by filtering. It was then filtered using filter paper and completed with water to a final volume of 5 L [13].

Experiment Sample Preparation and Impregnation Process. During the preparation step of the test samples, special attention was paid to guarantee that the samples were free of fiber defects, cracks, knots, or color problems. It was prepared in accordance with the TS 2470 (1984) guidelines. It was treated to 45 minutes of vacuum and 45 minutes of diffusion [14]. The test samples were made entirely dry to prevent the impregnation substance from being impacted by wood moisture. After impregnation (ASTM D 1413–76) and diffusion, the samples were maintained in an air-dry condition for a while. It was then positioned in such a way that they did not touch each other before being placed in the oven. The oven temperature was set at 103±2ºC, and it was left in there for 24 hours to dry entirely. It was taken out of the oven at the end of the time period and perfectly dry measurements were taken diffusion [15, 16].

Retention (%) Properties. After the impregnation process, the amount of remaining material (% retention) compared to dry wood was calculated using the formula [16, 17].

$$R(\%) = \frac{Sfdwoai - Sfdwbi}{Sfdwbi} \times 100$$

Sfdwoai = Sample full dry weight after impregnation (g)

Sfdwbi = Sample full dry weight before impregnation (g)

Anatomical Experiments and Preparation of Preparations. To examine the anatomical features of wood species, the "Preparation Method" was applied. Three preparation samples were collected from the tip of each tree species test sample for general anatomical measurements. The wood samples from which anatomical sections were taken were heated in distilled water until totally collapsed in order to soften them and remove the air in their tissues. The samples were then maintained in a 1/1/1 combination of alcohol, glycerine, and distilled water until the sections were cut. In order to counteract the effects of fungi, a little amount of crystalline acid phenol (Phenol) was added to the solution. The "Reichert" Guided Microtome was used for sectioning processes from the samples brought to this stage. Each sample was cut into 15–20 m long longitudinal radial (radial) and longitudinal tangential sections. Before being processed into continuous preparations, they were rendered transparent in sodium hypochlorite for 15-20 minutes and then washed with distilled water. It was coloured with saffron after being washed in distilled water with acetic acid for 1-2 minutes to neutralize the medium. Following dyeing, the sections thoroughly washed with distilled water were passed through a series of 50%, 75%, and 95% alcohol, respectively, and the longitudinal radial (radial) and longitudinal tangential sections were turned into continuous preparations in glycerin-gelatin with "basic fuchsin", respectively [17,18].

RESULTS AND DISCUSSION

Extract Properties. Table 1 shows the characteristics of the herbal extract and borax solution which is prepared at 1% concentration used in the impregnation.

pH/ density did not vary significantly, which could be attributable to wood type, anatomical structure, plant extract/concentration, or impregnation time/method.

Retention Amount (%). The % retention values are presented in Table 2.

The highest retention is mahogany wood borax (2.88%); the lowest adherence was determined in spruce wood ferula extract (0.35%).

Air/Fully Dry Specific Density (g/cm^3). Specific density weight changes are given in Table 3.

When the change in specific gravity of air-dry and full-dry was examined, both wood types gave positive results compared to the control sample. The highest air-dried specific gravity value was found in mahogany wood (0.58 g/cm^3), and in spruce wood at the same rate (0.38 g/cm^3) in ferula, borax and ferula+borax.

Anatomical Changes. By comparing it to a control sample, the transverse, tangential, and radial retention in oriental spruce wood impregnated with a mixture of 1 % ferula plant extract, borax, ferula+ borax was evaluated.

TABLE 1
Extract feature

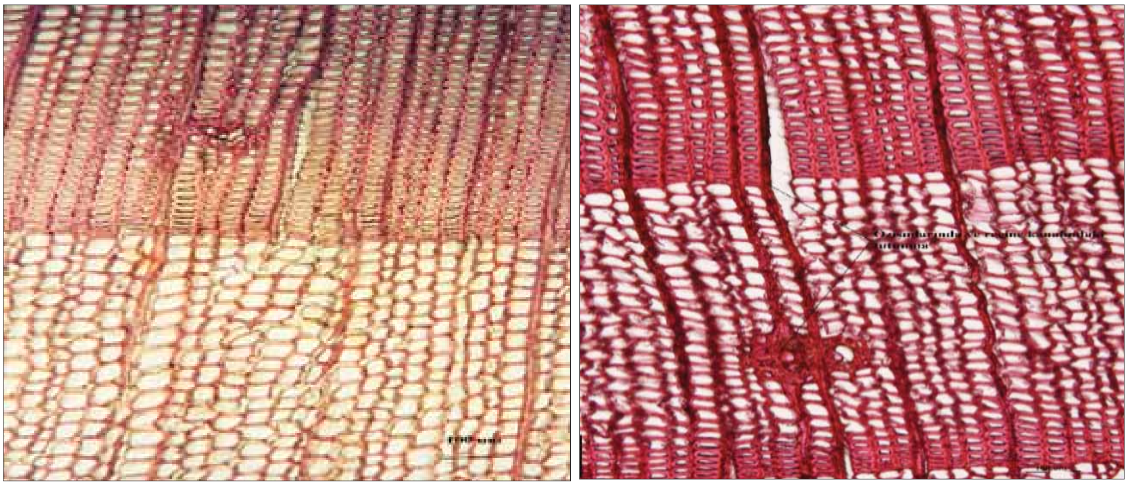
Concentration	Extract	Solvent	Temp. (ºC)	pH		Density (g/ml)	
				BI	AI	BI	AI
%1	Ferula	Distilled water	22ºC	7.17	7.17	0.987	0.987
	Borax			10.35	10.35	1.005	1.005
	Ferula+Borax			8.10	8.10	0.990	0.992

***BI**: Before Impregnate ***AI**: After Impregnate

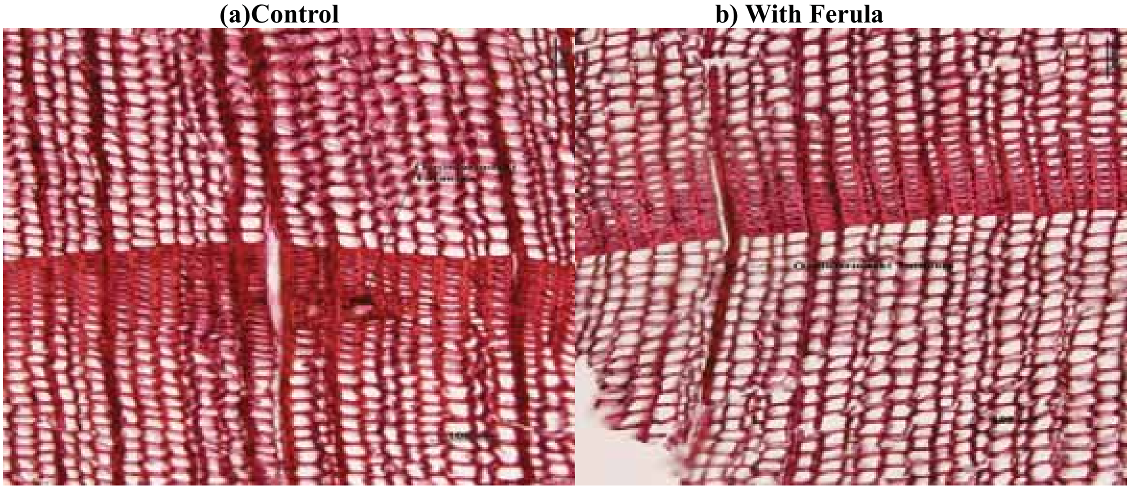
TABLE 2
% Retention level and duncan test results

Concentration (%)	Wood Type	Plant Extract/Borax	Vacumm/ diffusion time (min)	Retention (%)	
				Mean	HG
%1	Spruce wood	Ferula plant	45 minute	0.35	F
		Borax		1.64	C
		Ferula+Borax		1.12	D
	Mahogany wood	Ferula plant		0.60	E
		Borax		2.88	A
		Ferula+Borax		2.01	B

HG: Homogeneity group



(a)Control **b) With Ferula**



(c) With Borax **(d) With Ferula+ Borax**

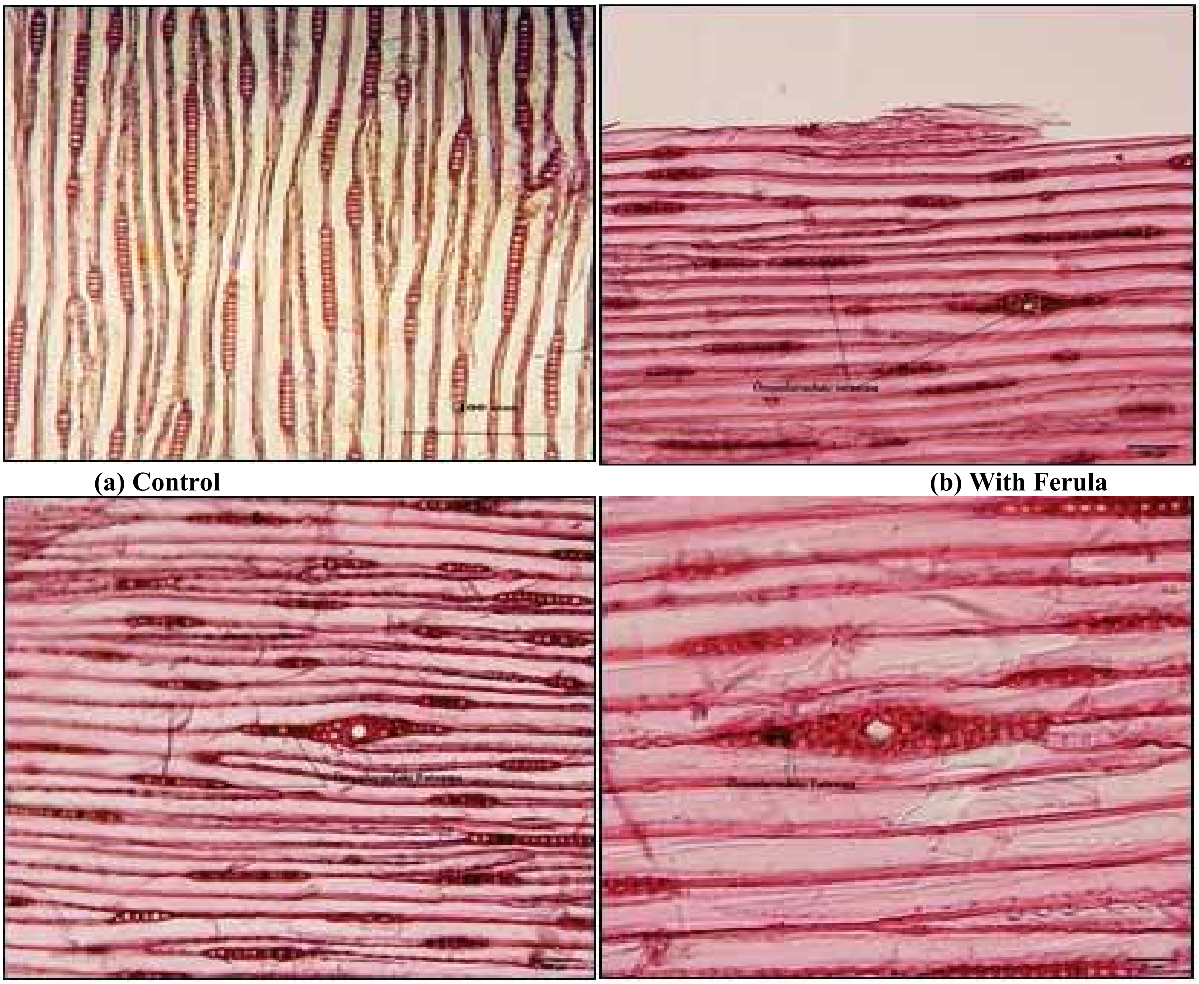
FIGURE 1
Appearance of Retention in Transverse Section of Impregnated Eastern Spruce Wood

Anatomical Changes in Eastern Spruce Wood. The control sample was compared to the transverse, tangential, and radial attachments of oriental spruce wood treated with 1 % Ferula plant extract, Borax, Ferula and Borax mixture. Figure 1a: Control, 1b: Ferula, 1c: Borax, and 1d: Ferula+Borax) are cross-sectional images from this research.

In the examination made in cross-section; Compared to the control (a) sample, it was observed that only the self rays and resin canals of Ferula (b) adhered to borax (c) and Ferula+borax (d) only self rays.

It was determined that the adhesion was very intense in Ferula (b) and borax (c), and it decreased observably after the mixture of Ferula plant extract and borax (d) impregnation material. Self rays are parenchymal cells that act as storage in coniferous trees, and they facilitate radial food exchange [19]. It is inferred that the impregnation compounds employed in the impregnation procedure have distinct effects on the wood cells, and the plant extract decreases the borax substance's action. Factors affecting the impregnation process include wood material characteristics, impregnation method, flow paths of liquids, passage aspiration features etc. [20]. In a research; it was resulted that the epithelial cells around the resin were affected in the impregnation processes and resulting in inconsistencies in the transition between cells as compared to the control group. It has been reported that the impregnation method and system have an effect in this sense [21]. The retention in the tangential section was compared with the control sample and their appearances are shown below (Figure-2a: Control, 2b: Ferula, 2c: Borax and 2d: Ferula+Borax).

In the examination in the tangential section; Compared to the control (a) sample, it was observed that only self rays were adhered in Ferula (b), borax (c) and Ferula+borax (d). The retention was found to be quite strong in ferula (b) and borax (c), and it significantly diminished after the mixture of ferula plant extract and borax was applied (d). The sapphire parenchyma cells are storage cells that store side components in the chemical structure of the wood in addition to the primary components.



(a) Control **(b) With Ferula**

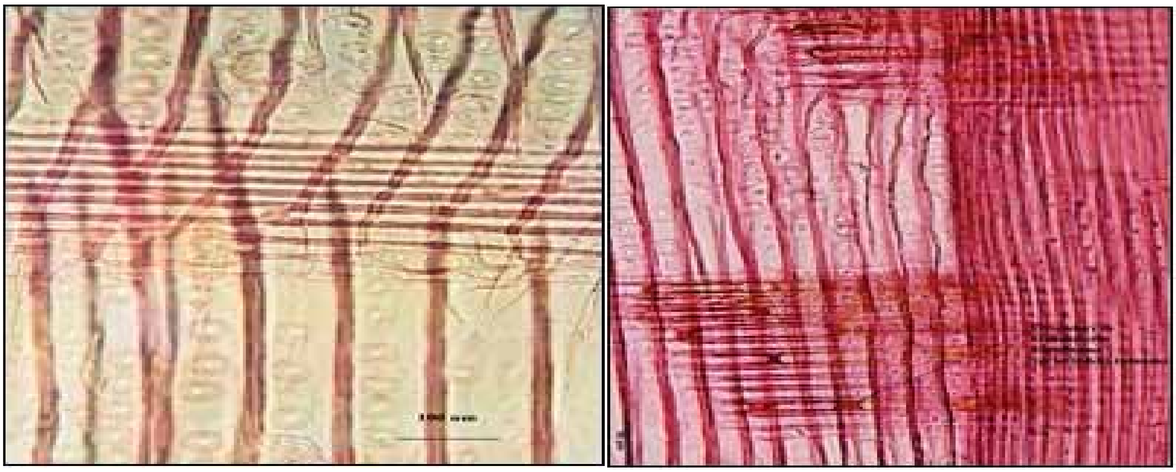
(c) With Borax **(d) With Ferula +Borax**

FIGURE 2
The retention in the tangential section was compared with the control sample and their appearances

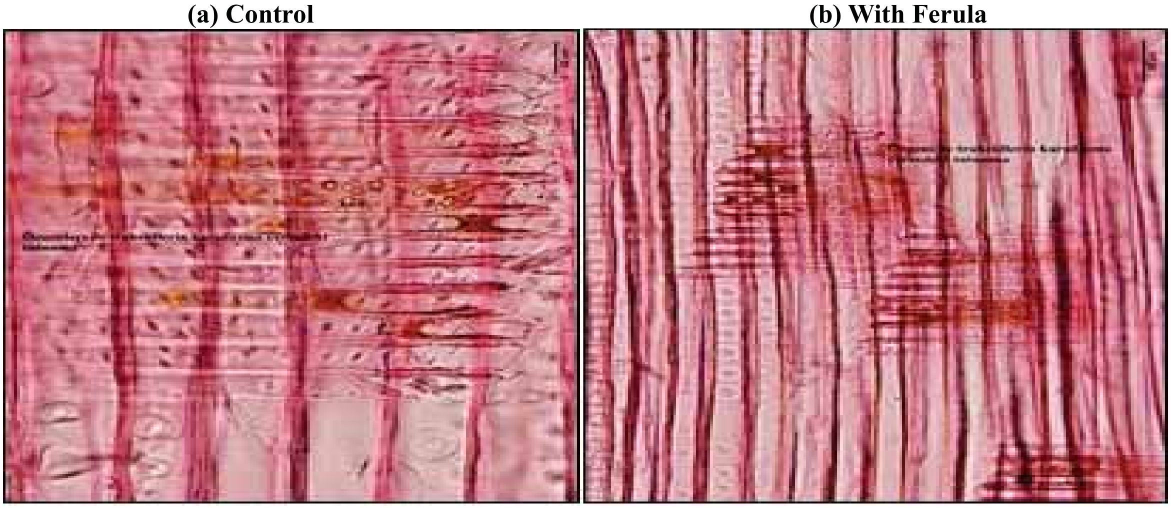
It can be said that the reason for the retention of the impregnation substance in the self rays may have caused the self rays to absorb these substances faster due to its storage task. They're cells whose rays create changes in wood's physical qualities. Wood's splitting property rises along self rays on tangential surfaces. Wood's resistance property can be improved by adhesion in self-rays [19]. The retention in the radial section was compared with the control sample and their appearances are presented below (Figure-3a: Control, 3b: Ferula, 3c: Borax and 3d: Ferula+Borax).

According to examination in the radial section; Compared to the control (a) sample, it was observed that there is intense retention in Ferula (b), non-intense in borax (c) and intense in Ferula+borax (d) at the meeting places of self-rays and tracheid's. The retention was found to be greater in ferula (b) and ferula plant extract with borax (d). Sapphire parenchyma cells are located in coniferous woods within the radially located self rays. They store nutrients and transmit information via their rays. The cells of the saphenous parenchyma have thin walls and simple channels. In comparison to the longitudinal tracheid's, they are relatively small cells. Near the channels that supply conduction between the parenchyma cells, significant wall thickenings (nodular thickening) can be noticed. In the location where the sapphire parenchyma cells come into touch with the longitudinal tracheid's, junctional passageways emerge, allowing nutrients to travel from cell to cell [19]. The retention was largely noticed outside the junction tunnels in the radial section. It can be concluded that these wall thickenings are the cause of adhesion outside of the meeting point channels.

Anatomical Changes in Mahogany Wood. Transverse, tangential and radial retention in mahogany wood impregnated with 1% Ferula plant extract, borax, Ferula and borax mixture was evaluated by comparing with the control sample. The cross-section images in this evaluation (Figure-4a: Control, 4b: Ferula, 4c: Borax and 4d: Ferula+Borax) are given.



(a) Control **(b) With Ferula**



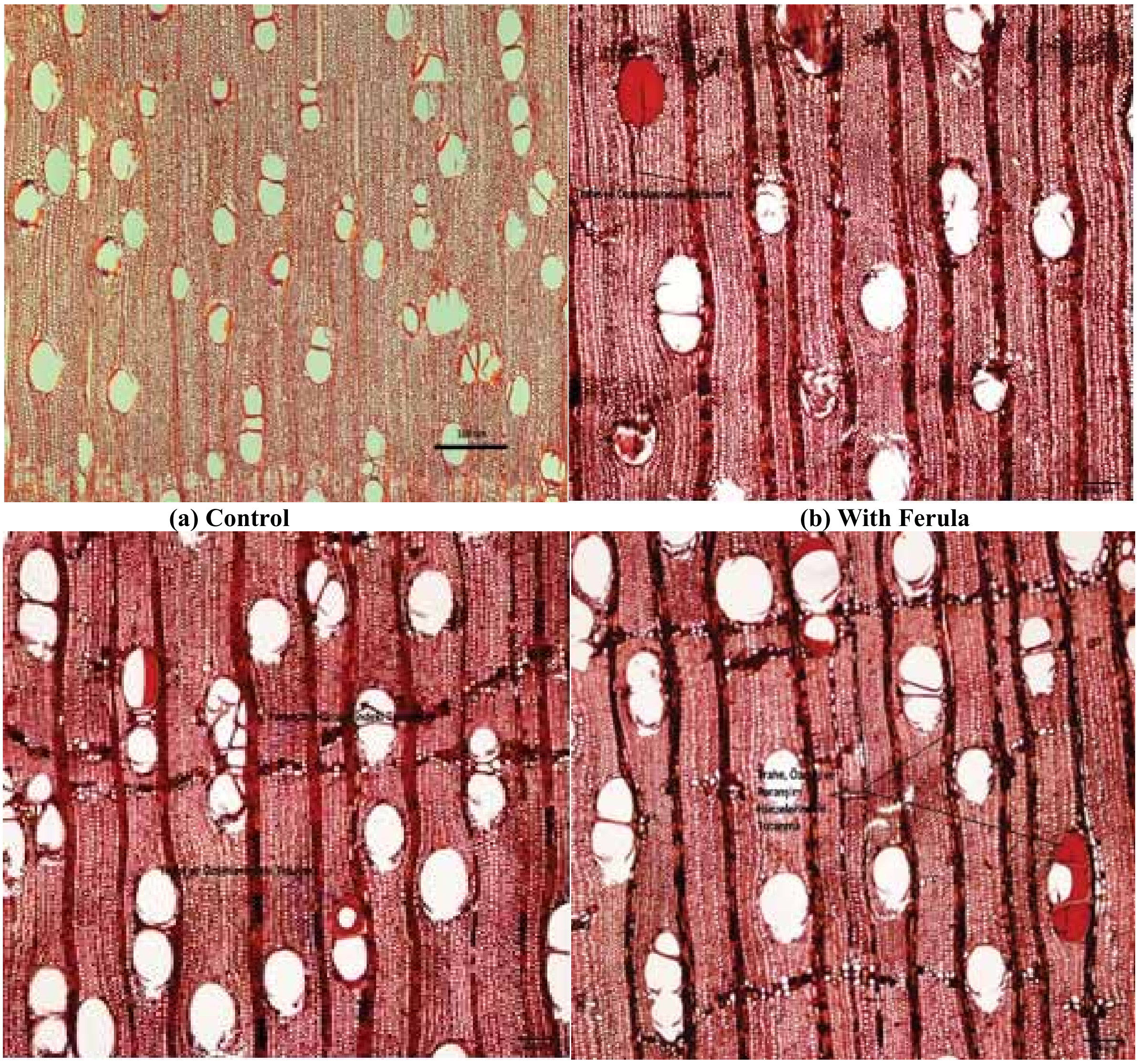
(c) With Borax **(d) With Ferula+Borax**

FIGURE 3
Appearance of Retention in Radial Section in Impregnated Eastern Spruce Wood

In the examination made in cross-section; Compared to the control (a) sample, adherence was observed in the trachea (b) trachea and selfrays, and in the boraxed (c) and washed+boraxed (d) trachea, self rays and border parenchyma cells. Strand parenchyma (longitudinal parenchyma) are cells that arise from the transverse division of spindle-like daughter cells in the cambium.

They retain the cambium cell's original form. The membranes of the passageways between the trachea and parenchyma cells in deciduous trees are quite thick. This thick passage membrane protects the live parenchyma cell from the tremendous suction strength in the nearby trachea [19]. It was determined that the retention was more intense in borax (c), in the mixture of compost plant extract and borax (d) than in the mixed (a). According to these results; it can be concluded that the impregnation substance is more effective than the plant extract in mahogany wood and it retains well. The anatomical structure, solution characteristics, density, and tulle formation in leafy trees may have all contributed to this condition. The tangential section's state of retention was compared to the control sample, and the results are presented below. (Figure-5a: Control, 5b: Ferula, 5c: Borax and 6d: Ferula+Borax).

In the examination carried out in the tangential section; Compared to the control (a) sample, it was observed that there was intense retention in the self rays and fiber cells in Ferula (b), Ferula+borax (d), and more intense retention in borax (c) self rays and fiber cells (libriform fibers). Deciduous trees have fiber cells, but coniferous trees do not. In wood, fiber cells act as support cells. It is the name of a certain cell type found in leafy trees in terms of cell morphology. Fiber tracheids and libriform fibers are the two types of fiber cells found in deciduous trees. Libriform fibers have simple passageways. Fiber cells are primarily responsible for providing mechanical support to trees. Wood has an impact on the material's strength, hardness, weight, and chemical content [19]. The impregnating agent borax, it can be argued, is more successful at attaching to fiber cells. In mahogany wood, the adhesion in the fiber cells can be said to support the wood's support mechanism. The state of retetention in the radial section was compared with the control sample. The views of this comparison are shown below (Figure-6a: Control, 6b: Ferula, 6c: Borax and 6d: Ferula+Borax).



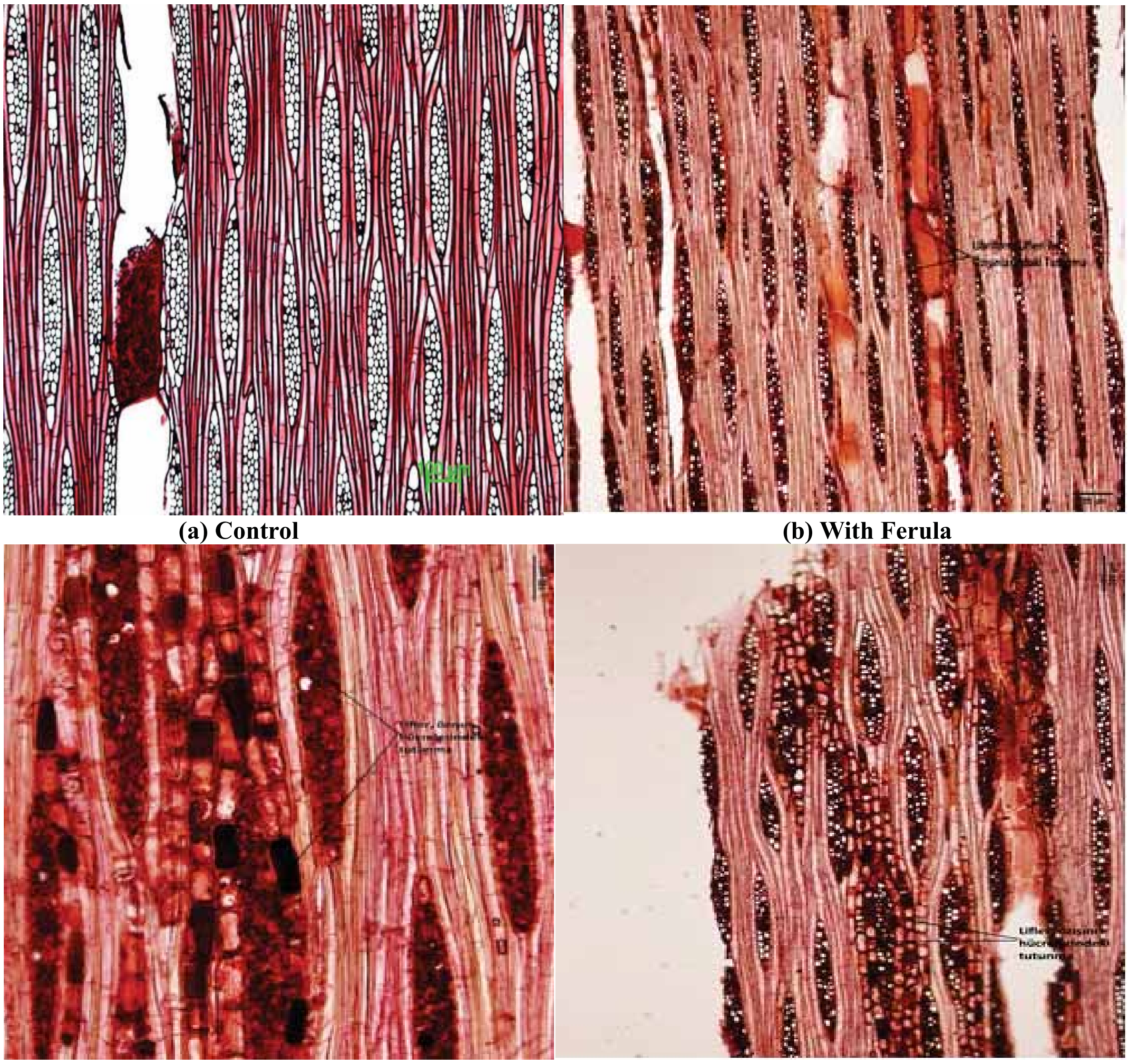
(a) Control **(b) With Ferula**

(c) with Borax **(d) with Ferula+Borax**

FIGURE 4
Appearance of Retention in Transverse Section of Impregnated Mahogany Wood

In the examination in the radial section; Compared to the control (a) sample, it was observed that in Ferula(b), borax (c), Ferula+borax (d) piriform fibers adhered at the same intensity at the meeting points of the self-rays and trachea cells. In broad-leaved trees, self rays have a variety of cell shapes, cell arrangements, and foreign substances. It is wider and higher than the self-rays in coniferous trees [19]. It can be concluded that lack of significant differences between the cell diameters of spring wood and summer wood in trachea cells in mahogany wood, as well as their scattered tracheal structure and larger and higher self-rays, may have resulted in higher retention at the trachea encounter with self-rays.

According to experiment results; it was discovered that the impregnation with borax was more efficient in the retention of eastern spruce and mahogany wood, and the retention of both species diminished after the treatment with mixture of turquoise and borax. Mahogany wood has higher adhesion than other woods, which might be attributed to the anatomical structure of leafy trees. The passage aspiration structure in eastern spruce is a structure known to be among the most important elements that make it difficult for the material to stick in the impregnation process. It is known that the anatomical structure of wood, specific gravity, wood type, humidity, cutting orientation, and impregnation processes are all recognized to be crucial criteria at the region where wood is used. It can be inferred that the impregnation materials applied in the impregnation procedure in both types of wood have distinct effects on the wood cells, the plant extract reduces the effect of the borax substance, and this might be attributable to the anatomical structure of the trees.



(a) Control (b) With Ferula

(c) With Borax (d) With Ferula+Borax

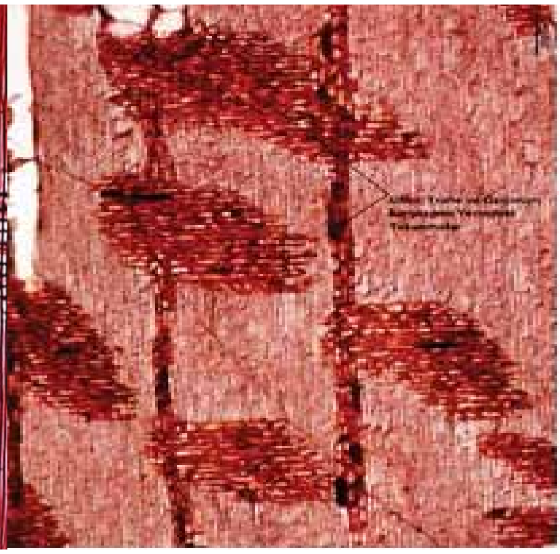
FIGURE 5
Appearance of Retention in Tangential Section of Impregnated Mahogany Wood

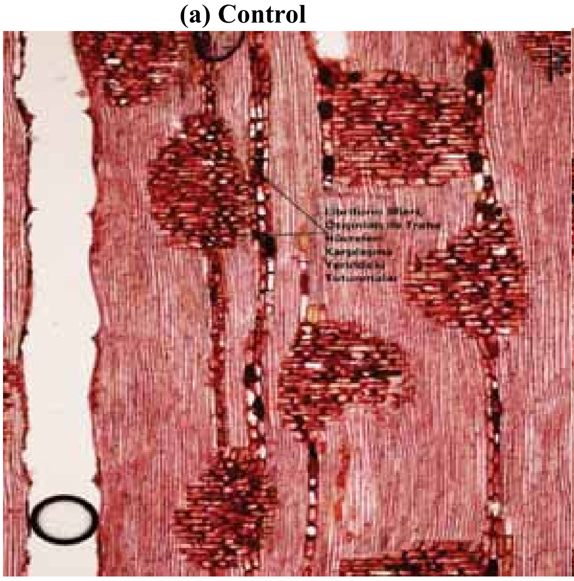
It can be concluding that the wood density reduces after the impregnation with borax material compared to the impregnation made with the extracts, and the drying of the impregnation material, which has better retention, is also faster. Wood with a high density can be better impregnated, and its rapid moisture loss under high temperature conditions shows a more negative structure in terms of dimensional stability. It can be implied that retention rate is higher in the dense woods of coniferous and leafy trees. Clinging has been observed in saplings of both tree species. There was no attachment in the tracheid and trachea cells that perform the transmission function. The explanation for this; the fact that the impregnation ingredient was unable to adhere to these cells due to the strong liquid flow in the wood. Since the sapphire cells are the cells that serve as storage, retention has taken place in these cells.

CONCLUSIONS

It has been observed that the adhesion is intensely in the sapphire cells. In coniferous woods, the auto ray parenchyma cells are placed in the radially located self-rays where they store nutrients and transmit them in the radial direction. It can be inferred that this feature of the self-rays may have been effective in the uptake of the impregnation material due to the fact that the retention is in the self-rays and the self-rays have the task of storing nutrients. Gate aspiration occurs especially in the cell wall of coniferous trees. Since the dawn of time, medicinal aromatic plants and other plant kinds have been utilized for therapeutic purposes in both our country and other countries, as well as in a wide range of sectors where mankind is in need.


(a) Control


(b) With Ferula


(c) With Borax

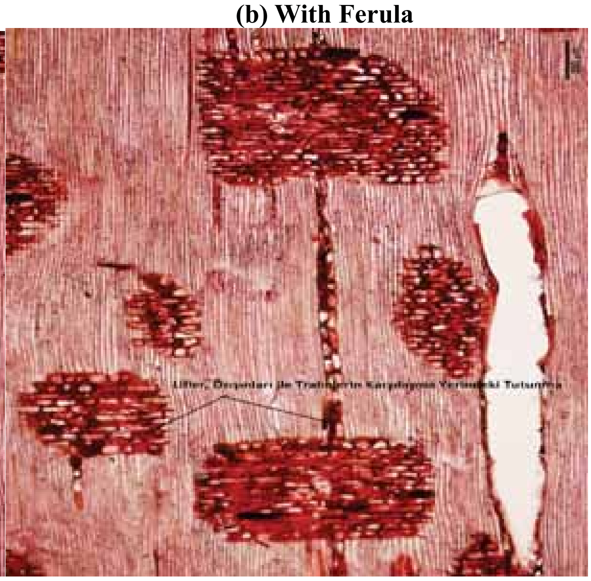

(d) With Ferula+Borax

FIGURE 6
Appearance of Retention in Radial Section of Impregnated Mahogany Wood

Today, these plants are utilized in perfumery industry, food/food additives, seasonings, a broad variety of natural oils, and in this research, when human/environmental health is taken into consideration, they are also employed in products such as furniture (indoor/outdoor), paper industry, wooden toy industry, park/garden furniture to create a hygienic structure by using. It was concluded that the organic preservative (impregnation-top surface) substance (bioenergy) obtained from the tea extract showed similar properties in terms of retention values and % retention rates in all wood species [22]. The vacuum approach is recommended, however alternative methods like as pressure, dipping, brush applications, and so on can also be employed. The antioxidant levels of the same species of plants in different solvents can be compared, and the solvent with the best activity can be identified. When evaluated in general, it was determined microscopically in radial, tangential and transverse sections that the anatomical structure plays an important role in the retention of the medicinal aromatic plant extract to the wood. While chemical/synthetic products are still commonly employed in the twenty-first century, it has once again been proved that this substance is human/environment friendly. Natural construction materials, like as toys used by our children and wooden items used in the workplace, are particularly important in terms of family and individual health in our homes, where we spend a large portion of our lives. There have been significant advancements in natural raw materials and auxiliary materials in addition to technological advancements. The increased importance of using environmentally friendly, natural, and healthy products in the production and use of wood materials has increased in recent years due to an increase in diseases, particularly cancer cases, an increase in interest in natural and healthy products, and an increase in environmentalist attitudes. At this point, knowing the anatomical structure of wood materials and expanding such research are critical in the manufacture of ecologically friendly goods. It is advised that the diversity of scientific investigations on this issue be increased.

REFERENCES

[1] Özata, N. (2006) Phytotherapy and Aromatherapy Wood. Aritan Publications. Istanbul. 1-8.

[2] Güler, S. (2004) Ethnobotanical Effects Of Some Medicinal And Aromatic Plants Naturally Distributed In Erzurum Region. Ministry Of Environment and Forestry Publication. No: 209.

[3] Bozkurt, A.Y., Erdin, N., Ünligül, H. (1995) Wood Pathology Textbook, İ.Ü. Publications, Istanbul. 1-2.

[4] Rowell, R.M. (2001) Performance Driven Composites from Lignocellulosic Resources. International Conference on Science and Technology of Composite Materials. 29-32.

[5] Kartal, N., Engür, O., Köse, Ç. (2005) Environmental Problems Related to Impregnated Materials and Impregnated Wood Material, Journal of Istanbul University Faculty of Forestry. Modification of Waste. 17-23.

[6] Tomak, E.D. and Yıldız, Ü.C. (2012) Usability of Vegetable Oils as a Wood Preservative, Artvin Coruh University Journal of Forestry Faculty. 13(1), 142-157.

[7] Baysal, E., Peker, H., Çolak, M., Göktaş, O. (2003) Density, Flexural Strength and Elasticity Module of Beech Wood Treated with Various Impregnation Materials, Fırat University. Science and Engineering Journal. 15(4), 655-672.

[8] Örs, Y., Efe, H., Atar, M. (2001) The Effects of Impregnation and Lightening Process on Varnish Addition Hardness in Scots Pine (*Pinus sylvestris* L.) Wood. Journal of Gazi University Institute of Science. 14(2), 487-503.

[9] Baysal, E. (1994) The Effect of Various Boron and Wr Compounds on Some Physical Properties of Red Glass Wood, Karadeniz Technical University, Graduate School of Science, Master's Thesis, Trabzon.

[10] İçel, B., Şimşek, Y. (2017). Evaluations on Microscopic Images of Heat Treated Spruce and Ash Woods, Süleyman Demirel University, Journal of Science Institute. 21(2), 414-420.

[11] Ulusoy, H. (2011) Anatomical Structures of Some Wood Types and Effect of Processing Conditions on Surface Roughness, Karadeniz Technical University, Institute of Science and Technology, PhD Thesis, Trabzon.

[12] Merev, N. (2003). Wood Anatomy Book, Karadeniz Technical University, Faculty of Forestry, General Publication No: 209, Faculty Publication No: 31, Trabzon.

[13] Ceylan, Ş. (2020) Possibilities of Using Irradiant Plant (Antioxidant/antibacterial) Extract in Wood Industry (Furniture/Construction), Artvin Coruh University, BAP Project, Artvin.

[14] TS 2470 (1976). Sampling Methods and General Properties for Physical and Mechanical Experiments in Wood, Turkish Standardization Institute, TSE, Ankara, Turkey.

[15] ASTM D 1413–76 (1984) Standartd Methods of Testing Preservatives by Laboratory Soilblock Cultures, Annual Book of ASTM Standards, USA.

[16] Baysal, E. (1994) The Effect of Various Boron and Wr Compounds on Some Physical Properties of Red Glass Wood, Karadeniz Technical University, Institute of Science, Master Thesis, Trabzon.

[17] Bozkurt, A.Y. (1992) Wood Anatomy Book, Istanbul University Faculty of Forestry Publication No: 3652, Faculty Publication No: 415, Istanbul.

[18] Merev, N. (1998) Wood Anatomy Book, , Wood Anatomy of Natural Angiospermae Taxa in the Eastern Black Sea Region, Black Sea Technıcal Unıversity, Forestry Faculty, General Publication No: 189. Fac. Publication No: 27, Trabzon.

[19] Bozkurt, A.Y., Erdin, N. (2000) Wood Anatomy Book, Istanbul University Faculty of Forestry Publications, Istanbul.

[20] Bozkurt, A.Y., Göker, Y., Erdin, N. (1993). Impregnation Technique Book, Istanbul University Faculty of Forestry Publications, Istanbul.

[21] Akbaş, S. (2011). Investigation of the Efficacy of Bio-oil Obtained from Kargı (Arundo donax L.) Annual Plant as a Wood Preservative, Karadeniz Technical University, Graduate School of Science, Master Thesis,Trabzon.

[22] Atılgan, A., Ersen, N., Peker, H. (2013). Retention Values in Wood Species Treated with Tea Plant Extrac. Kastamonu University, Forest Faculty Journal. 13(2), 278-286.

Received: **21.06.2021**
Accepted: **08.08.2021**

CORRESPONDING AUTHOR

Hatice Ulusoy
Forest Department,
Mugla Sitki Kocman Unıversity,
Mugla – Turkey

e-mail: haticeulusoy@mu.edu.tr