ANALYSIS OF IMPREGNATION/COMBUSTION (TGA) OF MEDICAL AROMATIC PLANT EXTRACT ON WOOD IN ECOLOGICAL SYSTEM (HUMAN/ENVIRONMENTAL HEALTH)

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ABSTRACT

Within the scope of the research, the impregnation of ferula plant extract (1%, 3%, 5%) from medicinal aromatic plant (antioxidant/antibacterial) species, which has a significant place in the ecological system, into the wood of scotch pine (Pinus sylvestris L.) was carried out and the thermal combustion (TGA) feature of the impregnated wood was analyzed. With the destruction of today's forest resources, instead of synthetic preservatives that threaten human/environmental health, medicinal aromatic plants and wastes, which are indispensable materials of humanity, applied in various fields in the ecological environment, as impregnation material in the wood industry (indoor/outdoor furniture, hospitals, playgrounds, children's toys) was planned and fire parameter change, which is a threat to human/environmental health, has been investigated.

According to the research results; pre-impregnation and post-impregnation changes on concentrations were not determined. In terms of retention, the highest value was determined as 1% ferula extract (3.99%), and the lowest as 1% ferula extract (insect + fungi) samples (2.83%). In TGA analysis, the residue amount was determined as 22.23% in the highest 5% ferula extract (with insects). Compared to the control sample, positive results were obtained in impregnated (intact) samples.

KEYWORDS:
Ecosystem, tga analysis, medicinal aromatic plant, human/environment, antioxidant/ antibacterial

INTRODUCTION

The polluted air we breathe throughout the day, harmful substances in spoiled foods, additives, unconscious nutrition and inactivity create substances called free radicals in the body. Oxygen, which is ruptured by these harmful effects from the outside, freely circulates in the body and causes tissue damage by breaking hydrogen atoms. Free radicals especially attack the cell and immune system. Molecules that minimize and block the effect of free radicals in the body and prevent chain reactions that may cause many diseases and premature aging are called "antioxidant" substances. As is known, antioxidants are mostly found in plants with green and red leaves. At the same time, vitamins A, C and E show natural antioxidant properties [1]. Many herbs known as medicinal plants have been found by the public through trial and error. The use of such wild plants in the treatment of diseases in the world and in our country goes back to ancient times [2]

Humankind have used plants for various purposes from history to nowadays. They have benefited from plants to cure diseases, to feed, to shelter, to defend and to warm up, and still continue to use plants. They have discovered them by trial and error, relying on their instincts, today this is applied more consciously on many areas such as food, pharmacy, cosmetics, paint, agriculture, medicine. Turkey has quite a large area of an agricultural country and in terms of medical aromatic plants to be due to a rich flora [3].

It is not possible to define medicinal plants completely. Today the term "medicinal" and "aromatic" plants are often enunciated together. Medicinal and aromatic plants are plants which are applied as drugs to prevent diseases, maintain health or cure diseases. While medicinal plants take place in areas such as nutrition, cosmetics, body care, incense or religious ceremonies, aromatic plants are utilized for their fragrance and taste [4].

When the developments in the production and use of medicinal and aromatic plants in the 20th century are analyzed, the innovations brought by technology, social and political changes at the beginning of the century have led to the rapid decline of the use of plants as medicine. The synthesis of sulfa drugs in the 1930s and organic chemicals in the 1940s encouraged the production of synthetic drugs in addition to medical plants. New definitions of plants and treatments with the economic and social changes following World War II, caused a decrease in the use of plant extracts and plants until the end of the 1970s in western countries, which modernized with industrial advances as a result of the acquisition of synthetic chemical drugs [5].

In recent years, as the inconsonance of synthetic substances with human and nature has been observed, there is a transformation towards natural products with the sloganizing "green revolution" and "return to nature" in the modern world. One of the product groups that gains importance in this sense are aromatic and medicinal plants [6].

With the rapidly increasing world population today, forest resources are running out as a result of unconscious consumption as well as the increasing needs of human beings due to the developing technology and living standards. Wood material, which has a wide range of uses, is a natural and renewable raw material that can appeal to every field. Being light compared to concrete, iron, aluminum, PVC and other various building materials, being easy to process, being continuous in production, having superior physical and mechanical properties in various places of use, It has a wide range of applications in many industries such as paper and cellulose, board, furniture and so on. Wood is a flammable material and it is of great significance to perform the impregnation process and determine the effect on fire resistance (275 °C) in order to provide the most effective fire resistance. However, it encounters the presence of any flame source very much a can be ignited at low temperatures [7].

It has been reported that wood is subjected to impregnation with some vegetable oil structure and as a result, there is an increase in weight and density values [8, 9]. Tomak [9] impregnated some wood species with oil products from some plants, and determined that the pressure resistance is decreased.

Peker [10] subjected the extract (extract) obtained from waste tea to impregnation and subsequently investigated the surface hardness by applying it as a secondary treatment with water-based varnish, and determined that tea extract gave positive results in scotch pine/beech wood when used with water-based varnish. Özdemir [11] investigated the change in their technological properties by impregnating Scotch pine and oriental beech wood with "Ferula Plant" extract (1% -3%) and reported that it showed positive values in both adhesion and physical/mechanical properties.

To determine the thermal stability of wood material, thermogravimetric analysis (TGA) method is applied. Physical and chemical changes that occur in the material can be characterized. By determining the mass losses occurring while heating the material whose thermal properties will be determined, From the temperature-mass loss graph, the temperature value at which the break occurs is found as the decomposition temperature. For the determination of decomposition temperatures, It has been reported that the first order derivative of weight loss (TGA) is utilized.

Medical aromatic plant (antioxidant/antibacterial), which can be considered as a non-wood forest product within the vitality of the ecosystem (human-environmental health), is impregnated with wood material by obtaining extract (extract) from both itself and its wastes, providing protection to organic wood and providing protection to wood in all areas (interior/outdoor furniture, wooden toys, hospitals, pharmacies, hygienic environments, laboratories, etc.). In this study, it was tried to research the adhesion/burning (TGA) changes of the extract on wood material.

MATERIALS AND METHODS

In the study, the wood of scotch pine (control, insect, insect + fungus) was preferred both intact and wood with pest. Plant extract (*Ferula comunis* L) (Figure 1), whose antibacterial/antioxidant properties have been searched in the literature, were prepared in concentrations (1%, 3%, 5%) [12].

FIGURE 1
***Ferula comunis* L.**

Preparation of Experiment Samples. It is obtained from the wood of the yellow pine, which is a coniferous type of wood, with insects and bugs +fungi, wood chips were taken to represent the entire main mass, that is, the entire material from which the sample was taken. The samples, which were ground on a 40 and 60 mesh (250 1847 micron) sieves were obtained by grinding in a laboratory type Willey mill [13].

Impregnation Process. Aqueous solutions of wood preservatives with a concentration of 1, 3, 5% for impregnation were prepared with distilled water. Wood flour was immersed in about 100 g solution at 60 ° C for 2 hours. The treated wood samples were subsequently dried at 60 C until they had the unchangeable weight. Wood flour and the impregnation procedure for wood samples was similar as represented by Jiang et al. [14]; Yunchu et al. [15]. Subsequently, the wooden samples were moisture at 20 ° C and 65 °C for two weeks (% relative humidity)

Thermal Analysis (TGA). Thermogravimetric analysis is an analysis procedure that is the decrease in weight of polymeric or other samples at a certain temperature increase rate is precisely determined. The main usage of this method include thermal degradation of polymeric materials and analysis of kinetic events result from degradation [16]. TGA analysis is applied according to ASTM E1131-08, about 10 mg wood flour passing through a 40 mesh sieve, not passing through a 60 mesh sieve, 50 ml/min, under nitrogen gas at a flow rate of 57, 10 ° C/min, temperature rise from 25 °C to 600 ° C by increasing. As a result of the experiment, the percent weight loss occurred in the sample at the highest temperature point, the time period when the instant weight loss amount is the highest, the fast pyrolysis temperature point values were examined. Also, weight loss curves with temperature were obtained graphically [17].

RESULTS AND DISCUSSIONS

Extract (Solution) Feature. Solution properties are given in Table 1.

The extract concentration was used as 1, 3, 5% and there was no change in pH/density before and after impregnation. It has been reported in the literature that the acidic/basic structure has a positive/negative effect on both the anatomical and technological properties of wood.

% Retention Amount (Retention). % Retention values are given in Table 2 and the corresponding graphic in Figure 2.

TABLE 1
Solution Properties

Plant Extract/Boric Acid (%1-%3)		Solvent Substance	Temperature (ºC)	pH		Density (g/ml)	
				BI	AI	BI	AI
1%				7,17	7,17	0,987	0,987
3%	Ferula plant	Water	22ºC	7,14	7,13	0,965	0,962
5%				7,19	7,18	0,962	0,962

*BI: Before impregnation AI: After impregnation

TABLE 2
% Retention Values and Duncan Test Results

Group	Wood type	Concentration	Destructed	% Retention	HG
1		**Control**	Without impregnation	-	-
2		%1 Ferula	Intact/ impregnated	3,99	a
3		%3 Ferula		3,51	b
4		%5 Ferula		3,53	b
5	Yellow pine wood	%1 Ferula	With insect/ Impregnated	3,18	d
6		%3 Ferula		3,40	c
7		%5 Ferula		3,39	c
8		%1 Ferula	With insect +fungi/ Impregnated	2,83	h
9		%3 Ferula		2,96	g
10		%5 Ferula		3,05	f

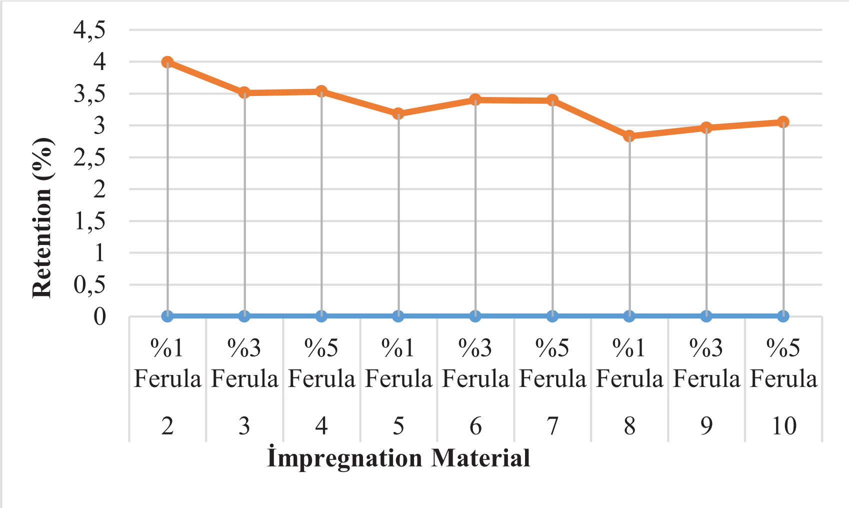

FIGURE 2
% Retention Change

According to Duncan test results; The highest % adhesion was achieved in the impregnation of 1% ferula extract (3.99%) in the intact wood type, and the lowest 1% ferula extract was observed in the insect+fungi yellow pine wood (2.83%). We can conclude that the occurrence resulting from degradation negatively affects the impregnation/retention of wood material affected by insect and fungal pests, both in terms of its anatomical structure and its components (cellulose-hemicellulose-lignin). Although various plants grown in an ecological environment are also applied for impregnation, we can infer that the structure of medicinal aromatic plants (antioxidant/antibacterial) is compatible material in terms of human/environment.

Şimşek [18] impregnated scotch pine wood with CCA, CBA and valex, resulted that the highest retention was in the CCA substance and the concentration was effective here in the insect experiment, and the highest retention value in the impregnation process in the fungal rot samples was resulted in the valex material. Peker et al. [19] performed impregnation with waste tea plant extract, the lowest % retention value in iroko wood (1.58%), the highest % retention rate in beech wood (6.75%), the lowest total retention iroko (31, 27 kg/m3), the highest total retention value was found in beech wood (100.65 kg/m3).

Bal [20] determined that the process performed with ACQ in wood is effective on the mechanical properties and retention is positively affected and provides rapid penetration. Alkan [21] impregnated the yellow pine wood with boron compounds and kebracodan, and reported that the highest retention obtained at 1% concentration. Atılgan [22] investigated the adhesion and color changes of various natural dyes with/without mordant and stated that positive results were obtained in both adhesion and color change. Flynn [23] stated that the differences in retention rates may have resulted from the wood type, the anatomical structures of the trees, and thus the physical properties, impregnation and solution. Flynn [23] also reported that many factors related to the anatomical structure, such as heartwood, sapwood, spring wood, summer wood, density, heartbeam, traheid, resin, affect the permeability (permeability).

Thermogravimetric (TGA) Analysis. The intact/with insect/with fungi+insect structure of the yellow pine wood was impregnated with herb extract from medicinal aromatic plants (1%, 3%, 5%) and TGA analysis was performed and TGA-DTG values analysis weight loss and weight loss derivative were presented on Figure 3, 4 and 5. TGA analysis was applied for the thermal strength of the samples and DTG curves were created.

In Figure 3, TGA and derivative graphs of samples impregnated with 1%, 3% and 5% extract are given. According to the weight loss and derivative graphs, it is observed that the impregnation process reduces temperature of peak by 1 °C. However, we can conclude that the extraction process has a partial effect on thermal properties. The residue amount (%) at 550 °C was determined at maximum 3% extract concentration as (20.04 %).

Figure 4 gives that the weight loss and derivative graphs of the samples damaged by fungi. It is seen that the peak temperature of the control sample was around 381 °C, but this temperature dropped to 375-377 °C due to fungal damage. It is observed that the derivative graphs formed in all graphs which do not form a clean sharp peak, show slightly declining trend towards the low temperature region. These peaks are due to the composition of the sample. As the hemicellulose and similar components which are more easily pyrolysis, increase, this region becomes clearer or expands more and may form new peaks. As can be seen from the graphs, the twisting occurred at 340 °C in the control sample declined to 332 °C with fungal damage and even formed a new inflection point at around 277 °C. This can be result from, as expected, the amount of low molecular weight cellulose and hemicellulose increased due to rotting arising from fungal damage. It can be concluded that ferula plant extract in the graphs of does not form the desired effective protective performance on destructed samples (insect, fungus, etc.) and this may result from the destruction of the wood material. The residual amount (%) in the wood at 550 °C was determined at the maximum 1% extract concentration as (21.62%).

A wide graph of decomposition graph is observed in the fungal and insect-damaged samples (Figure 5) and underwent pyrolysis at a lower temperature compared to the control sample. The strengths of the samples impregnated with the ferula extract did not increase, on the contrary, decreased; it is concluded that this result from the wood structure (cellulose, hemicellulose, etc.) affected by fungi/insect pests. The residual amount (%) at 550 °C was gained as 21.47 % at maximum 5% extract concentration. As the extract concentration increased, the residue amount increased.

According to Wang et al. [24] the reason for the acceleration of the degradation is that the bonds in fire retardants such as P-O-C (Phosphorus-Carbon) are much less stable than the C-C bonds in the control sample and are generally due to decomposition at 180 °C. According to Başak et al. [25] this early decomposition prevents the formation of flammable gases and also supports the formation of carbonized coal. Tutuş et al. [13] determined that the thermal degradation of wood and wood components occurs between 300-500 °C.

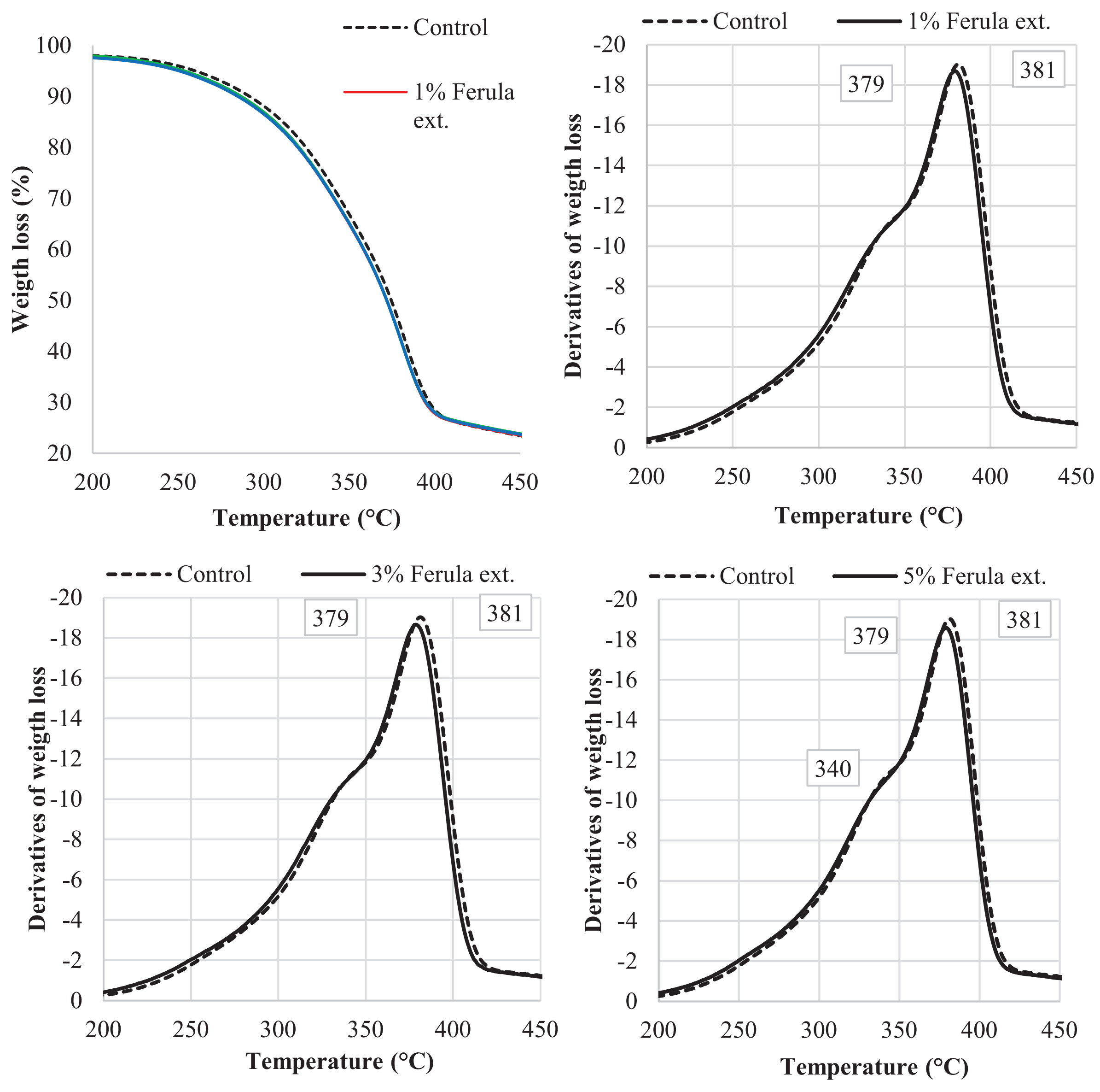

FIGURE 3
Effect of extraction process on thermal strength of intact samples

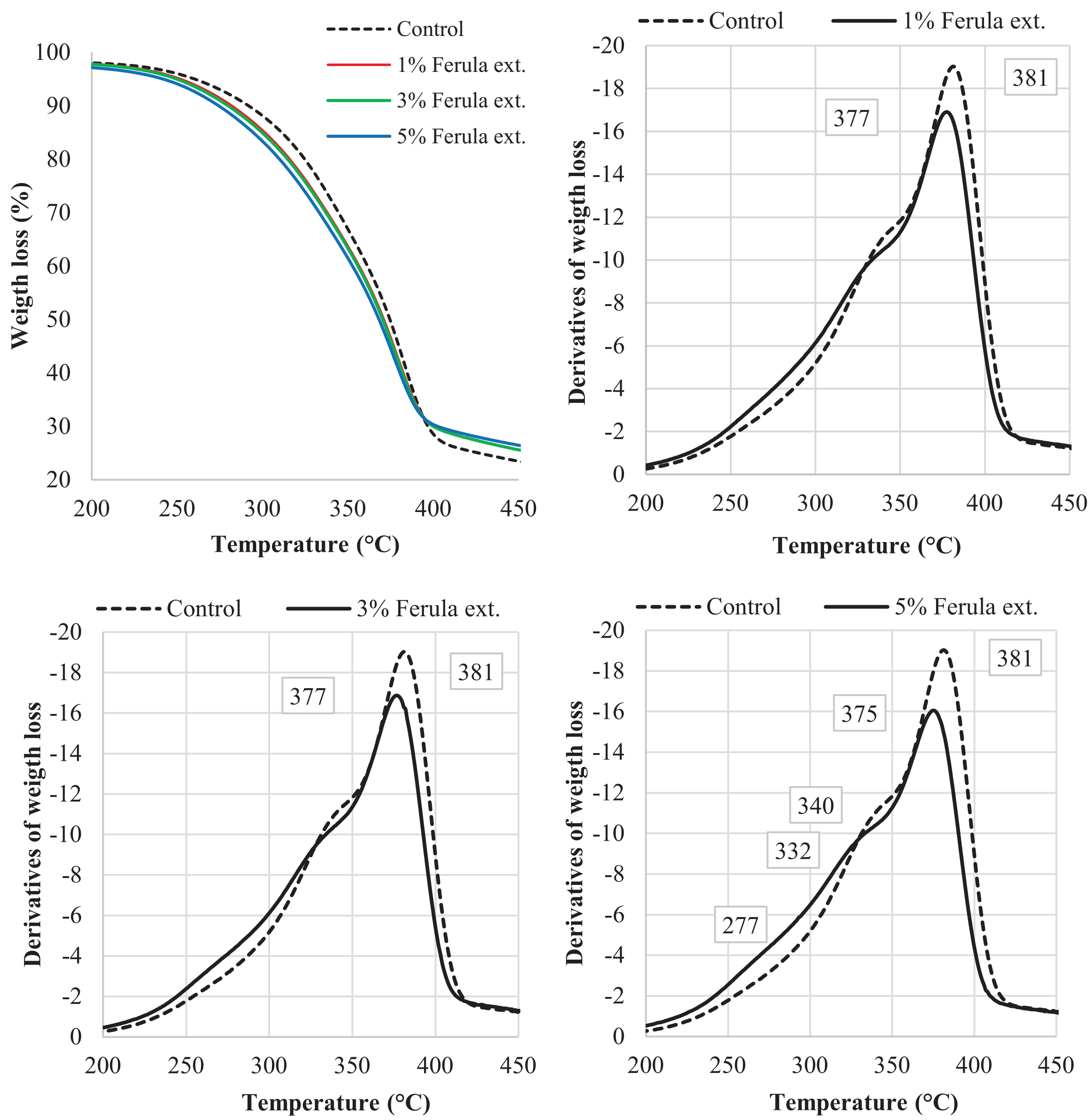

FIGURE 4
Thermal properties of insect-damaged samples

According to Shafizadeh [26] Depolymerization of cellulose is very rapid at above 300 ° C and anhydro-sugars, randomly connected oligosaccharides and levoglucosan are produced. The char, as an aromatic polycyclic structure, was clarified by Collard et al [27]. Higher crosslinking and thermal stability of the residue results from intra- and intermolecular rearrangements.

Wood usually has a greater shoulder area because of hemicellulose degradation prior to cellulose degradation [28, 29]. Slopiecka et al. [30] Then, due to the splitting of cellulose macromolecules, the sharp weight reduction can be seen at 351 ° C. Lignin degradation begins at temperatures above 351 ° C and the residue consists mostly of lignin charcoal.

Especially in the century we live in, the efforts to obtain new organic and human/environmentally friendly impregnation /surface protectors are processing rapidly, on the other hand, the recycling of all wood raw materials such as waste woods/wood material damaged by pests in the rapidly decreasing cycle of forest existence is of great importance. Even if new areas are created in order to replace forest resources, the possibility of material recycling and reuse must also be created.

A more antioxidant/antibacterial structure will be obtained by obtaining extracts from the medicinal aromatic plant itself and its wastes and the wood material can be utilized in every field.

The desired goals in the research have been achieved and new impregnation methods and processes in different concentrations can be carried out in all future scientific researches.

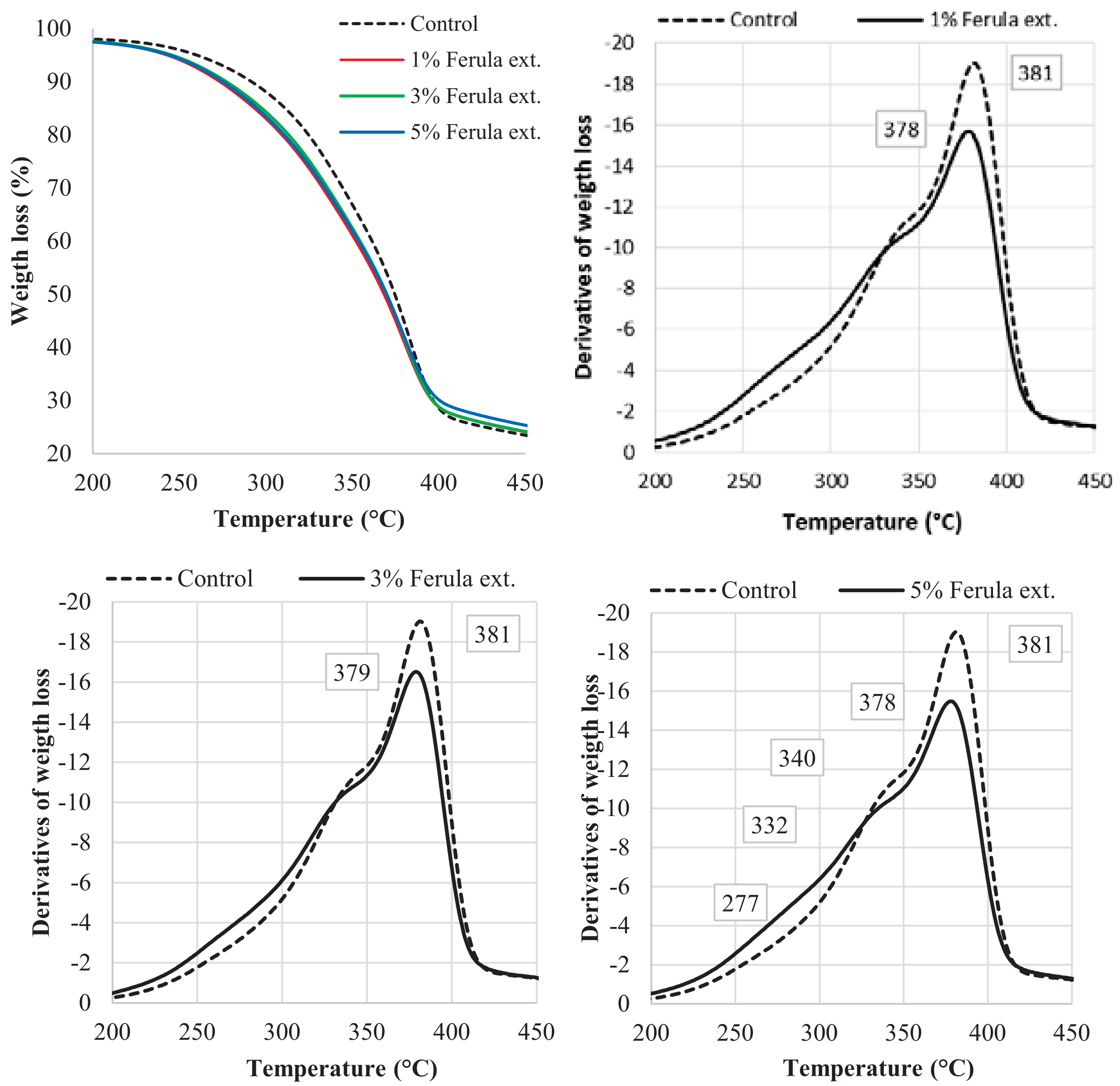

FIGURE 5
Thermal properties of fungal and insect-damaged samples

Medicinal and aromatic plant extracts can be tried with boron compounds. Thus, the level of effect can be increased. Multiple experiments can then be carried out. Physical/mechanical properties, water intake tests can be improved with the versatility of the researches. Various experiments can be applied with adhesion tests on the material and with water-based varnishes.

CONCLUSIONS

In the research, the impregnation property of the yellow pine wood with the medicinal aromatic plant extracts in various concentrations and then the thermal properties were determined. Retention was occurred on intact, with insect, with fungus+insect woods of yellow pine impregnated with ferula plant extract, a high retention rate in wood samples that did not suffer any damage in terms of retention, while partial declines were observed in the wood structure exposed to other harmful effects. This situation is clearly observed in TGA analysis.

REFERENCES

[1] Alaca, G.F. and Arabaci, O. (2005) Natural antioxidants in some medicinal plants and their importance. Turkey VI. Field Crops Congress, Antalya, (Compilation Presentation). 1, 465-470.

[2] Yigit, N., Benli, M. (2005) Antimicrobial activity of thyme (*Thymusvulgaris*) plant, which is widely used in our country. Orlab OnLine Microbiology Journal. 3(8), 18-25.

[3] Göktaş, O., Gıdık, B. (2019) Usage areas of medicinal and aromatic plants. Bayburt University. Science Journal. 2, 136-142.

[4] Working Group (2005) Medicinal and Aromatic Plants Working Group-ECP/GR. https://www.ecpgr.cgiar.org/working-groups/medicinal-and-aromatic-plants (Accessed date: 10 March 2021).

[5] Craker, L.E., Gardner, Z., Etter, S.C. (2003) Herbs in American Fields: A horticultural perspective of herb and medical plant production in the united states. 1903-2003. Hort. Science. 38, 977-983.

[6] Ramazan, T., Muharrem, G., Haluk, T. (2017) Usage areas of medicinal and aromatic plants in food industry. TÜRKTOB (Turkey Seed Union), Ministry of Food. Agriculture and Livestock-Western Mediterranean Agricultural Research Institute. 54-59.

[7] Kolman, F., Cote, J.R. (1968) Principles of Wood Science and Technology, I. Solid Wood: Springer–Verlag. 149-151.

[8] Bazyar, B., Parsapajouh, D., Khademiesalam, H. (2010) An investigation on some physical properties of oil heat treated poplar wood. 41. IRG Annual Meeting, Biarittz, IRG-WP 10-40509.

[9] Tomak, E.D. (2011) The Effect of Oily Heat Treatment and Impregnation with Emulsion Techniques on Preventing Washing of Boron Compounds from Solid Wood. Black Sea Technical University, Graduate Institute of Natural and Applied Sciences, Doctoral thesis, Trabzon.

[10] Peker, H. (2015) The use of waste tea extract dye with various mordant-water solvent varnishes and its effect on hardness change. Politeknik Journal. 18(2), 73-78.

[11] Özdemir, B. (2019) Effect of Işgın (*Rheum ribes* L.) plant extract on wood impregnation property and technological properties. Master thesis at Artvin Çoruh University, Graduate School of Natural and Applied Sciences, Artvin, Turkey.

[12] Çetin, S. (2017) Determination of antioxidant and antimicrobial activities of some plants grown and used for medicinal purposes in Erzurum province. Master thesis at Artvin Çoruh University, Graduate School of Natural and Applied Sciences, Artvin, Turkey.

[13] Tutuş, A., Kurt, R., Alma, M.H., Meriç, H. (2010) Chemical analysis and thermal properties of scotch pine wood. 3rd National Black Sea Forestry Congress, May 20-22. V, 1845-1851.

[14] Jiang, J., Li, J., Hu, J., Fan, D. (2010) Effect of nitrogen phosphorus flame retardants on thermal degradation of wood. Construction and Building Materials. 24(12), 2633-2637.

[15] Yunchu, H., Peijang, Z., Songsheng, Q. (2000) TG-DTA studies on wood treated with flame retardants. Holz als Roh-und Werkstoff. 58(1), 35-38.

[16] Le Van, S.L. (1984). Chemistry of fire retardancy. The Chemistry of Solid Wood. American Chemical Society. Washington, DC. 531–574.

[17] ASTM E 1131-08 (2014) Standard test method for compositional analysis by thermogravimetry, American Society for Testing and Materials.

[18] Şimşek, U.B. (2013) Some physical and biological properties of Scotch pine wood impregnated with herbal and chemical preservatives. Master thesis at Black Sea Technical University, Graduate Institute of Natural and Applied Sciences, Trabzon.

[19] Peker, H., Atılgan, A. (2015) The use of waste tea extract dye with varnish on wood and its effect on dynamic shock bending resistance. Selcuk Technic Journal. 644-651.

[20] Bal, B.C. (2006) Investigation of some physical and mechanical properties of scotch pine (*Pinus sylvestris* L.) wood impregnated with ammoniacal copper quat (ACQ) impregnation salt. Master thesis at Kahramanmaras Sutcu Imam University, Graduate School of Natural and Applied Sciences, Kahramanmaras.

[21] Alkan, E. (2016) Investigation of physical and mechanical properties of Scotch pine (*Pinus sylvestris* L.) wood impregnated with natural preservatives and boron compounds. Master thesis at Gumushane University, Institute of Natural Sciences, Gumushane.

[22] Atılgan, A. (2009) Determination of color change values of wood dyed with plant dyes in accelerated aging environment. Master thesis at Kütahya Dumlupınar University, Institute of Science and Technology, Kutahya.

[23] Flynn, K.A. (1995) A review of the permeability, fluid flow, and anatomy of spruce (*Picea spp*.). Wood Fiber Science. 27(3), 278-284.

[24] Wang, X., Hu, Y.A., Song, L., Xing, W.Y., Lu, H.D. (2010) Thermal degradation behaviors of epoxy resin/POSS hybrids and phosphorus-silicon synergism of flame retardancy. J. Polym. Sci. Pol. Phys. 48, 693-705.

[25] Basak, S., Samanta, K.K., Chattopadhyay, S.K., Narkar, R. (2015) Thermally stable cellulosic paper made using banana pseudostem sap, a wasted by-product. Cellulose. 22, 2767–2776.

[26] Shafizadeh, F. (1982) Introduction to pyrolysis of Biomass. Journal of Analytical and Applied Pyrolysis. 3(4), 283-305.

[27] Collard, F.X., Blin, J.A. (2014) Review on pyrolysis of biomass constituents: Mechanisms and composition of the products obtained from the conversion of cellulose, hemicelluloses and lignin. Renewable and Sustainable Energy Reviews. 38, 594-608.

[28] Beall, F.C., Eickner, H.W. (1970) Thermal degradation of wood components: a review of the literature. U.S. Forest Products Laboratory. 1-26.

[29] Jeske, H., Schirp, A., Cornelius, F. (2012) Development of a thermogravimetric analysis (TGA) method for quantitative analysis of wood flour and polypropylene in wood plastic composites (WPC). Thermochimica Acta. 543, 165-171.

[30] Slopiecka, K., Bartocci, P., Fantozzi, F. (2011) Thermogravimetric analysis and kinetic study of poplar wood pyrolysis. Third International Conference on Applied Energy. 16-18 May Perugia, Italy.

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