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AGRICULTURE, FOREST AND FISHERIES PRODUCTS

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EDITOR

Prof. Dr. Şahin PALTA

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CHAPTER 1

IMPREGNATION OF MISTLETOE (VISCUM ALBUM L.) BLACK PINE WOOD WITH SEAWEED AND CHANGES IN BENDING STRENGTH

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INTRODUCTION

Forest ecosystems are constantly facing various adverse effects caused by numerous biotic (living) and abiotic (non-living) factors. One of the most important biotic factors is mistletoe, a plant that lives as a semi-parasite on various tree species. There are three subspecies of mistletoe in Turkey (Miller,1982)These subspecies vary according to the trees they host and interact differently with these tree species. It has been reported that Viscum album L. subsp. austriacum (Wiesb.) Vollman causes significant damage in the genera Pinus, Larix and Picea, Viscum album L. subsp. Album in some deciduous tree species and Viscum album L. subsp. abietis (Wiesb.) Abromeit in taxa belonging to the genus Abies (Zuber, 2004).

Mistletoe plants penetrate the phloem and xylem of the host's branches and stems with their root-like structures called haustorium, thus sharing the water and minerals the host has absorbed from the soil (Glatzel, 1983; Tennkoon et al,1996; Poppe,1998). During this penetration, many processes such as wood formation and physiology of the host are affected (Teixeira, 2015). The transpiration rate of mistletoe is higher than that of its host (Mathiasen,2008), and it puts the host under drought stress, especially in areas with water deficit (Glatzel 2009). In addition, morphological and anatomical structural changes occur at the point where mistletoe attaches to the host's branches and stems (Popp,1995). This negatively affects the mechanical and technical properties of these areas, thus reducing the economic value of the wood (Hawksworth et al.,1996). Although there are studies worldwide on the changes caused by different species of mistletoe in the wood of different taxa, the number of studies on this subject in our country is quite small (Bilgili et al. 2017; Ulusoy et al., 2017). The findings of these studies are important in terms of revealing the effect of mistletoe infestation on the natural formation process of host wood and the anomalies occurring in specific wood elements. However, these studies have generally qualitatively revealed the changes occurring in the structure of many wood elements at the point where mistletoe attaches to the host. Therefore, quantitative measurements are also necessary to fully determine the effect of mistletoe on wood (Bilgili et al. 2017).

Although wood raw material, which is used in a wide variety of fields, has a lower density compared to other structural materials, it is consumed in large quantities today because of its useful properties such as high resistance, electrical and heat insulation, ease of processing, conversion into composite products, ability to be nailed and joined, possibility of physical, mechanical, chemical and biochemical intervention in its structure from the outside, giving a warning of danger before breaking, and having desirable acoustic properties (Yüksel, 2005).

Wood, The use of seaweed as a traditional food and complementary medicine is recorded in early archaeological data dating back ten thousand years. It has been traditionally consumed for centuries in many Asian countries such as China, Indonesia, the Philippines, South Korea, North Korea, Japan and Malaysia; however, the culinary use of seaweed began in Japan and China. Recently, it has gained more popularity in Western countries due to its functional properties and the introduction of Asian cuisine, and is now widely used as a food in the USA, South America and European countries (Bocanegra et al. 2009). Today, the popularity of seaweed has evolved into a more versatile food component that can be directly or indirectly included in the preparation of foods and beverages. Due to its functionality, seaweed and its products have a special importance in the food industry as a component in fertilizers, animal feed supplements and additives for functional foods (Rajauria et al., 2015).

The main objective of this study was to determine the effect of impregnation of mistletoe-inoculated material with seaweed extract on the level of adhesion and subsequent changes in flexural strength. In addition to increasing the usability of the mistletoe-inoculated structure, the performance of the seaweed extract was also investigated. Thus, the defective wood structure will be protected with an ecological preservative and brought to a usable level.

1. MATERIAL and METHOD

1.1. Wood/ Plant Material

In this study, black pine (*Pinus nigra)* wood, which grows naturally in our country and is known for its durability, was selected as the experimental material. The wood types used were selected. While it is rarely preferred in the construction and furniture sectors due to its mechanical properties and ease of processing, the woods were obtained from Muğla province. In the experiment, sapwood samples were prepared in the laboratory of Artvin Çoruh University in accordance with the TS ISO 3129 standard. Wood samples were obtained using a random method, and care was taken to ensure that the timber was flawless, its fibers were straight, free of splinters, reaction wood, and free from fungal/insect damage. Seaweeds were sourced from the shores of Trabzon, and subsequently extracted to create a 3% concentration solution.

1.2. Preparation of Experiment Samples

TS ISO 3129 standards were taken into consideration when preparing the test samples, and particular attention was paid to ensuring that the test/control samples were free from defects such as fungus, knots, cracks, splinters, mold, insects, etc. cuttings (livewood) with sample dimensions of 20x20x300 mm were prepared.

1.3. Impregnation Process

Impregnation was carried out according to ASTM–D 1413-76 principles. It was subjected to 30 minutes of vacuum and 30 minutes of diffusion.

1.4. Extract Preparation

In this study, seaweed samples were weighed to standard weight and then heated in 200 ml of hot water (distilled water) for 1 hour below boiling point using a reflux system. The mixture was stirred at certain intervals during heating. After the process was completed, the sample was placed in a previously prepared porous capsule and subjected to vacuum filtration. The capsule was washed several times with distilled water to ensure no sample remained in the flask, and any structure that could not be dissolved remained in the porous capsule. Subsequently, the capsule and its contents were cooled in a desiccator at 103 °C for 16 hours and weighed with an accuracy of ±0.001 g, as shown in Figure 1. (Ceylan, 2017).

1.5. Percentage Retention

After impregnation, the amount of substance remained (tkoao-% retention) compared to dry wood was calculated from the specified formula.

$$R\ (\%) = \frac{Moes - Moe\ddot{o}}{Moe\ddot{o}} \times 100 \qquad (1)$$

Moes = Sample full dry weight after impregnation (g)
Moeö = Sample full dry weight before impregnation (g)

2. RESULTS AND DISCUSSION

2.1. Solution Properties

Solution properties are given in Table 1. There was no significant change in solution pH and densities.

Table 1. Seaweed Extract Properties.

Impregnation Material	**Concentration (%)**	**Temperature (ºC)**	**pH**		**Density (g/ml)**	
			BI	AI	BI	AI
Seaweed	3%	22ºC	6.78	6.78	0.950	0.950

BI: Before impregnation **AI:** After ımpregnation

2.2. Retention (%)

The net dry impregnation material remaining amount as (%) is given in Table 2 and change of retention Figure 1.

Table 2. % Retention

Wood Type	**Impregnation Material** (Seaweed)	**Concentratio (%)**	**Retention (%)**	
			Mean	**HG**
Black pine	Control (treated)	3%	1.18	A
	Mistletoe (treated)		0.97	B

The retention rate of seaweed extract-impregnated Scots pine wood (without mistletoe) was determined to be 1.18%, while the lowest retention rate was observed in Scots pine wood impregnated with seaweed extract and mistletoe (0.97%).

Ölmez (2020) applied various plant extracts to wood materials as an impregnation process and determined high retention values as 0.76% in chestnut wood and 0.45% in Scots pine wood. This finding reported that chestnut wood could retain plant extracts more than Scots pine under the same conditions.tannins. Özçifci and Batan (2009), on the other hand, found the highest retention amount in scots pine (19.39 kg/m³ - 21.81%) and the lowest value in oak (8.742 kg/m³ - 9.15%).

2.3. Static Bending Strength (N/mm²)

The change in bending strength of black pine wood with and without mistletoe impregnation is given in Table 3.

Table 3. Static Bending Strentgh (N/mm²)

Wood Type	**Impregnation Material** (Seaweed)	**Concentratio (%)**	Bending Strentgh (N/mm²)	
			Mean	**HG**
Black pine	Control (untreated)	3%	114.18	B
	Control (treated)		119.00	A
	Mistletoe (treated)		109.56	C
	Mistletoe (untreated)		105.39	D

When the table is examined, the highest bending strength values were determined in samples impregnated with mistletoe-free seaweed extract (119 N/mm^2), in unimpregnated and mistletoe-free samples (114.18 N/mm^2), in mistletoe-containing and impregnated samples (109.56 N/mm^2), and in unimpregnated samples without mistletoe (105.39 N/mm^2).

Ulusoy et al. (2017) found the average bending strength to be 636.791 kp/cm2 for the Scots pine sample and 491.22 kp/cm2 for the other sample group affected by mistletoe. They reported that mistletoe reduced the bending strength by 22.86% and the modulus of elasticity by 56.31%. The relationship between specific gravity and bending strength was found to be normal and increasing for the Scots pine sample, and weak and increasing for the other sample group. The relationship between bending strength and the modulus of elasticity in bending was investigated, and this relationship was reported to be weak and decreasing for both sample groups.

CONCLUSION

The findings can guide both the selection of appropriate species and process parameters in industrial applications and the production of wood materials with increased durability. However, the study is limited to specific species and specific impregnation conditions. Future research should evaluate a wider range of species, different chemical agents, and alternative impregnation methods (e.g., vacuum-pressure systems or nanoparticle-based solutions). Long-term durability tests, environmental impacts (humidity, temperature, biodegradation, etc.), and economic analyses should also be conducted. This will allow for a more comprehensive assessment of the performance of impregnation processes in both laboratory and field conditions.

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CHAPTER 2

THE IMPACT OF SOLAR ENERGY USE IN FARMS ON ECONOMIC STANDARD RESULTS: A CASE STUDY OF THE KARAPINAR DISTRICT IN KONYA PROVINCE[1]

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[1] This article is based on Hakkı Şenol's master's thesis.

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1. Introduction

Ensuring economically efficient and environmentally sustainable agricultural production requires adherence to the fundamental principles of production economics. Within this framework, optimal allocation and combination of production factors are essential either to maximize profit or to achieve a given output level at minimum cost. Understanding factor–factor, factor–output, and product–product relationships is therefore critical, not only for improving resource-use efficiency at the farm level but also for mitigating the environmental impacts associated with agricultural production.

Rapid population growth and increasing food demand have led to the widespread adoption of input-intensive production technologies in agriculture. While these technologies have contributed to productivity gains, they have also exacerbated global environmental challenges, including climate change, natural resource depletion, and environmental pollution. As a result, sustainability has emerged as a central paradigm in agricultural production systems. In sustainable production models, cost minimization at the microeconomic level is complemented by the objective of reducing environmental externalities at the macroeconomic level.

Energy is one of the most critical inputs in sustainable agricultural production, and the long-term availability of energy resources has become a major global concern. The depletion of fossil fuel reserves and their adverse environmental effects have accelerated the transition toward renewable energy sources. Due to their spatial distribution and suitability for decentralized applications, renewable energy technologies offer significant potential for agricultural and rural regions. In this context, Türkiye has strengthened its policies on clean energy and sustainable production technologies in line with its commitments under the United Nations Framework Convention on Climate Change and the Kyoto Protocol, aiming to play an active role in carbon markets (World Bank, 2021).

In agriculture, energy is extensively used both directly and indirectly in production processes, including tillage, irrigation, crop management, heating and cooling of greenhouses and livestock facilities, and milk milking systems (Singh et al., 2002; Öztürk, 2010; Çelik et al., 2020; Mohammadi et al., 2018). The rising cost of fossil fuel–based energy and its negative environmental impacts have made the adoption of renewable energy sources a strategic necessity for agricultural enterprises. Consequently, the use of geothermal, hydropower, bioenergy, wind, and particularly solar energy systems has expanded in recent years, contributing to lower production costs and improved energy efficiency in agricultural operations (Campana et al., 2016; Karaağaç et al., 2020; Aydoğdu & Karakaya, 2021).

Among renewable energy technologies, solar energy systems (SES) have gained particular attention due to their potential to reduce greenhouse gas emissions and enhance energy self-sufficiency in agricultural enterprises (El Chaar et al., 2011; Mandelli et al., 2016). Despite their well-documented technical and environmental benefits, the economic feasibility of solar energy investments remains highly context-specific, as installation costs, efficiency levels, and economic returns vary significantly across regions and farm types. This highlights the importance of conducting regionally grounded economic analyses to assess the viability of solar energy systems in agricultural production.

Although a growing body of literature has examined renewable energy use in agriculture, empirical evidence on the economic impacts of renewable energy adoption at the farm level remains limited in Türkiye. Region-specific analyses focusing on the economic performance of agricultural enterprises adopting renewable energy technologies are scarce.

The primary objective of this study is to analyze the economic effects of renewable energy use in agricultural production in Karapınar district of Konya province, Türkiye. By providing an empirical assessment of the economic performance of agricultural enterprises utilizing renewable energy systems, this study aims to contribute to the literature on sustainable agricultural energy use and to inform both producers and policymakers regarding investment decisions in renewable energy technologies.

2. Materials And Methods

2.1. Data Source

The primary data of this study were obtained from face-to-face surveys conducted with agricultural enterprises operating in the Karapınar district of Konya Province, Türkiye. Secondary data were collected from relevant literature and official statistical sources. All data refer to the 2021–2022 production period.

2.2. Method

2.2.1. Sampling Procedure

The study aims to compare the annual economic performance of agricultural enterprises using Solar Energy Systems (SES) with those not using any renewable energy source. To this end, a representative sample of agricultural enterprises was selected from the study area.

The sample size was determined using a single-stage clustered random sampling method based on population proportions. The sample size was calculated using the formula proposed by Çiçek and Erkan (1996):

$$n = \frac{N(pq)}{(N-1)D^2 + pq} \qquad D = \left(\frac{d}{t}\right)^2$$

where *n* denotes the sample size, *N* the total number of enterprises in the population, *t* the critical value corresponding to a 90% confidence level, *p* the probability of occurrence of the investigated event (assumed as 0.05), $q = 1 - p$, and *d* the acceptable margin of error (5%). Based on these parameters, the sample size was calculated as 52 agricultural enterprises. Of these, 13 enterprises used SES, while 39 enterprises did not use renewable energy. The surveys were conducted randomly.

Following data collection, enterprises were classified into three farm size groups according to their land holdings in order to analyze differences across size categories (Table 2.1).

Table 2.1. Distribution of sampled agricultural enterprises by farm size

Farm size (da)	0–200	201–500	≥501	Total
SES users	4	6	3	13
Non-users	17	10	12	39
Total	21	16	15	52

2.2.2. The Methods of Date Analysis

The annual economic performance of agricultural enterprises was analyzed using the Laur accounting method. Gross Production Value (GPV) was calculated by valuing crop and livestock outputs at farm-gate and market prices and adding the increase in productive fixed assets in plant and animal production (Kıral, 1986). Both main and by-products were included in crop production value calculations (Kıral, 1999).

Gross profit was obtained by subtracting variable costs from GPV (Erkuş et al., 1995). Gross output was calculated by adding non-farm agricultural income and the imputed rental value of farm residences to GPV. Total production costs consisted of variable and fixed costs (Erkuş, 1985). Net output was derived by deducting total production costs from gross output (Demirci, 1978). Farm family income was calculated by subtracting interest on debts and land rent from net output and adding the imputed value of family labor (Erkuş and Demirci, 1996).

Non-farm agricultural income included revenues from machinery services and agricultural activities performed by family members outside the enterprise (Kıral, 1986). The imputed rental value of residences was estimated based on building values (Kıral, 1995; Aras, 1988).

Input, repair, and maintenance costs were calculated based on actual expenditures reported by farmers (Demirci, 1978). Cash wage payments were evaluated according to farmer declarations, while in-kind payments were valued at farm-gate prices. Interest on debts was calculated using farmer-reported data and the agricultural credit interest rates applied by Ziraat Bank of Türkiye and Agricultural Credit Cooperatives during the study period.

Depreciation costs were calculated for land improvements, buildings, machinery, and breeding livestock using standard depreciation rates (Table 2.2). For livestock, the depreciable value was defined as the difference between breeding and slaughter values; no depreciation was applied to young animals (Erkuş et al., 1995).

Table 2.2. Depreciation rates

Asset category	Depreciation rate (%)
Reinforced concrete buildings	2.00
Adobe/wooden buildings	4.00
Land improvements	5.00
Agricultural machinery	10.00
Tractors and tillage equipment	6.67
Trailers and harvesting machinery	10.00
Motor pumps and cultivation equipment	25.00
Solar Energy Systems	10.00

Finally, financial and economic profitability ratios were calculated to assess the profitability performance of the farms (Erkuş et al., 1995; Çiçek, 1996).

3. Results and Discussion

The annual production results of the examined farms indicate that gross production value and gross farm income vary between farms using solar energy systems (SES) and those not using such systems, with differences related to land endowment, cropping patterns, livestock holdings, and off-farm income. Both indicators also increase with farm size (Table 3.1).

Table 3.1. Econonic standard results in the surveyed farms

Farm Size Classes (Da)		Gross Production Value (GPV) (1)	Variable Costs (2)	Gross Profit 3 = (1-2)	TL/da*	Gross Output (4)	Total farm operating expenses (5)	Net Output 6= (4-5)	TL/da*	Debt Interest (7)	Return on Equity 8= (6-7)	Family Labor Compensation (9)	Net Farm Family İncome 10= 8+9	TL/da*
01-200	Farms using SES	2.165.184,02	437.017,50	1.728.166,52	10.728,49	2.310.684,02	889.667,50	1.421.016,52	9.022,33	47.500,00	1.373.516,52	144.375,00	1.517.891,52	9.637,41
	Farms not using SES	1.467.948,13	486.713,00	981.235,13	7.159,17	1.595,035,66	805.005,77	790.029,89	5.764,12	22.382,00	767.647,89	122.323,53	889.971,42	6.493,30
	Average	1.591.579,60	469.787,34	1.121.792,26	7.958,80	1.722,175,78	794.301,72	927.874,06	6.583,00	27.167,00	900.707,06	126.523,81	1.027.230,87	7.287,91
201-500	Farms using SES	4.005.425,22	1.006.089,80	2.999.335,42	8.179,93	4.185.675,72	1.693.283,71	2.492.392,01	6.797,37	52.333,00	2.440.059,01	162.500,00	2.602.559,01	7.097,82
	Farms not using SES	3.209.661,39	1.349.457,00	1.860.204,39	5.688,70	3.362.161,39	1.877.417,00	1.484.744,39	4.540,50	40.200,00	1.444.544,39	207.200,00	1.651.744,39	5.051,21
	Ortalama	3.508.108,94	1.246.288,07	2.261.820,87	6.615,83	3.670.940,19	1.833.944,42	1.836.995,77	5.373,22	44.750,00	1.792.245,77	190.437,50	1.982.683,27	5.799,35
501-+	Farms using SES	23.600.675,26	5.608.516,21	17.992.159,05	12.851,54	23.833.508,09	7.146.854,82	16.689.653,27	11.921,18	128.333,00	16.561.320,27	311,500,00	16.872.820,27	12.052,01
	Farms not using SES	19.870.213,31	7.152.182,85	12.718.030,46	7.044,36	20.115.004,98	8.235.433,18	11.879.571,80	6.579,95	119.333,00	11.755.238,80	275.583,33	12.030.822,13	6.663,73
	Average	20.614.979,71	6.843.392,59	13.771.587,12	7.986,63	20.857.371,21	8.013.672,32	12.843.698,89	7.448,52	121.133,00	12.722.565,89	282.766,66	13.005.332,55	7.542,25
Overall Average of Farms	Farms using SES	7.956.650,42	1.903.614,70	6.053.035,72	11.193,36	8.138.342,73	2.716.613,16	5.421.729,57	10.025,94	68.385,00	5.353.344,57	191.307,69	5.544.652,26	10.253,25
	Farms not using SES	7.575.860,00	2.754.471,62	4.821.388,38	6.896,56	7.745.680,74	3.357.241,40	4.388.439,34	6.277,27	56.782,00	4.331.657,34	191.243,59	4.522.900,93	6.469,61
	Average	7.670.056,20	2.539.421,98	5.130.634,22	7.779,35	7.842.845,58	3.194.651,31	4.648.194,27	7.047,84	59.683,00	4.588.511,27	191.259,62	4.779.770,87	7.247,35

- TL/da: Turkish Lira per decare

Gross production value and gross farm income per decare differed significantly across farm size groups. Importantly, within the same size categories, SES-adopting farms consistently exhibited higher gross production value and gross farm income than non-adopters (Table 3.2), suggesting positive economic impacts of solar energy adoption on agricultural enterprises.

The study demonstrates that variable costs generally increase with farm size for both farms employing SES systems and those without. In crop production, costs consistently rise with farm size, while in livestock production, variability is higher due to differences in herd size across farm size categories (Table 3.3). Importantly, per-decare variable costs in crop production are significantly lower in farms utilizing SES systems, primarily owing to reduced electricity expenses (Tables 4 and 5). These results highlight that the adoption of SES systems can effectively reduce operational costs, particularly in crop enterprises. The findings further suggest that farm size and renewable energy adoption interact to influence overall production costs.

Table 3.2. Gross Production Value (GPV) and Gross Output per Decare of the Surveyed Farms (TL)

Farm Size Classes (Da)		Crop Production Value	Total Gross Production Value	Gross Revenue
		TL/da	TL/da	TL/da
01-200	Farms using SES	5.398,02	13.747,20	14.671.01
	Farms not using SES	3.891,23	10.710.26	11.637,50
	Average	4.210,97	11.291,81	12.218,35
201-500	Farms using SES	8.605,00	10.925,87	11.417,56
	Farms not using SES	6.469,12	9.815,48	10.281,84
	Ortalama	7.326,87	10.261,23	10.737,51
501-+	Farms using SES	7.490,24	16.857,63	17.023,93
	Farms not using SES	6.624,47	11.005,81	11.141,39
	Average	6.765,11	11.955,35	12.095,93
Overall Average of Farms	Farms using SES	7.630,08	14.713,29	15.049,27
	Farms not using SES	6.372,32	10.836,59	11.120,99
	Average	6.634,52	11.624,76	11.891,75

Table 3.3. Total Variable Costs in Surveyed Farms (TL/da)*

Farm Size Classes (Da)		Variable Costs					
		In Crops Production		In Livestock Production		Total	
		Value (TL)	Rate (%)	Value (TL)	Rate (%)	Value (TL)	Rate (%)
01-200	Farms using SES	192.617,50	44,08	244.400,00	55,92	437.017,50	100,00
	Farms not using SES	310.701,24	63,84	176.011,76	36,16	486.713,00	100,00
	Average	280.749,24	59,76	189.038,10	40,24	469.787,34	100,00
201-500	Farms using SES	857.673,13	85,25	148.416,67	14,75	1.006.089,80	100,00
	Farms not using SES	1.096.377,00	81,25	253.080,00	18,75	1.349.457,00	100,00
	Ortalama	1.032.456,82	82,84	213.831,25	17,16	1.246.288,07	100,00
501-+	Farms using SES	2.852.516,21	50,86	2.756.000,00	49,14	5.608.516,21	100,00
	Farms not using SES	5.268.807,85	73,67	1.883.375,00	26,33	7.152.182,85	100,00
	Average	4.785.492,59	69,93	2.057.900,00	30,07	6.843.392,59	100,00
Overall Average of Farms	Farms using SES	1.123.914,70	59,04	779.700,00	40,96	1.903.614,70	100,00
	Farms not using SES	2.033.356,24	73,82	721.115,38	26,18	2.754.471,62	100,00
	Average	1.803.660,44	71,03	735.761,54	28,97	2.539.421,98	100,00

*:All costs are expressed in Turkish Lira per decare (TL/da).

Table 3.4. Variable costs per decare in crop production for farms with SES systems (TL/da)*

Farm Size Classes (Da)	Seeds	Fertilizer	Pesticides	Labor	Fuel	Electricity)	Machinery repair and maintenance	Harvesting	Marketing	Total
0-200	268,25	238,10	157,94	173,81	38,52	12,70	49,21	264,79	5,08	1.208,40
201-500	249,54	644,08	251,82	434,00	39,93	12,50	38,18	665,22	3,82	2.339,09
501-+	273,81	540,47	180,59	330,43	35,38	14,42	23,10	638,10	1,21	2.037,51
Average of Farms	265,72	545,80	200,85	363,76	39,81	13,45	30,16	616,43	2,38	2.078,36

*:All costs are expressed in Turkish Lira per decare (TL/da).

Table 3.4. Variable costs per decare in crop production for farms with non-SES systems (TL/da)*

Farm Size Classes (Da	Seeds	Fertilizer	Pesticides	Labor	Fuel	Electricity)	Machinery repair and maintenance	Harvesting	Marketing	Total
0-200	268,67	303,00	115,88	273,89	38,00	834,33	46,35	381,54	5,24	2.266,90
201-500	259,33	531,19	206,12	317,77	41,15	1.389,91	33,94	569,72	3,70	3.352,83
501-+	261,76	471,77	148,12	232,14	45,30	1.176,09	16,16	566,16	0,83	2.918,33
Average of Farms.	262,06	464,49	152,32	239,72	44,18	1.172,53	20,87	550,80	1.55	2.908,53

*:All costs are expressed in Turkish Lira per decare (TL/da).

Çizelge 3.6. Total fixed costs in surveyed farms

Farm Size Classes (Da)		Depreciation		Family Labor Compensation		Building Repair and Maintenance		Total		per Decare
		Value (TL)	Rate (%)	Value (TL)	Rate (%)	Value (TL)	Rate (%)	Value (TL)	Rate (%)	TL
01-200	Farms using SES	300.775,00	66,45	144.375,00	31,89	7.500,00	1,66	452.650,00	100,00	2.873,97
	Farms not using SES	179.671,07	58,41	122.323,53	39,77	5.594,12	1,82	307.588,72	100,00	2.244,19
	Average	202.737,48	60,48	126.523,81	37,74	5.957,14	1,78	335.218,43	100,00	2.378,28
201-500	Farms using SES	500.527,24	72,83	162.500,00	23,65	24.166,67	3,52	687.193,91	100,00	1.874,15
	Farms not using SES	301.460,00	57,10	207.200,00	39,24	19.300,00	3,66	527.960,00	100,00	1.614,56
	Ortalama	376.093,85	64,00	190.437,50	32,41	21.125,00	3,59	587.656,35	100,00	1.718,90
501-+	Farms using SES	1.193.171,94	77,56	311,500,00	20,25	33.666,67	2,19	1.538.338,61	100,00	1.098,81
	Farms not using SES	770.667,00	71,14	275.583,33	25,44	37.000,00	3,42	1.083.250,33	100,00	600,00
	Average	851.179,74	72,73	282.766,66	24,16	36.333,33	3,11	1.170.279,73	100,00	678,69
Overall Average of Farms	Farms using SES	600.460,00	73,86	191.307,69	23,53	21.230,77	2,61	812.998,46	100,00	1.503,41
	Farms not using SES	392.754,40	65,16	191.243,59	31,73	18.771,79	3,11	602.769,78	100,00	862,21
	Average	444.583,17	67,85	191.259,62	29,19	19.386,54	2,96	655.229,33	100,00	993,49

The analysis of fixed costs indicates that they generally increase with farm size for both farms employing SES systems and those without. However, when expressed on a per-decare basis, fixed costs were observed to decrease as farm size increased. Notably, farms with SES systems exhibited higher fixed costs than farms without SES systems, both at the farm size group level and per decare, primarily due to differences in depreciation expenses. Specifically, the share of depreciation in SES farms ranged from 66.45% to 77.56% across farm size categories, whereas in non-SES farms, it ranged from 57.10% to 71.14%. At the farm-level average, depreciation accounted for 73.86% of fixed costs in SES farms, compared to 65.16% in non-SES farms (Table 3.6). These results underscore the impact of SES system adoption on the composition of fixed costs in agricultural operations.

Gross profit exhibited a positive correlation with farm size in both renewable energy-utilizing and non-utilizing agricultural enterprises, with distinct patterns emerging between the two groups (Table 3.1). In solar energy system (SES)-equipped farms, the 501+ decare category achieved the highest gross profit per decare, whereas in non-SES farms, the 0–200 decare category outperformed larger farms. Notably, across all farm size categories, SES-utilizing farms consistently realized higher gross profit per decare compared to their non-SES counterparts. This advantage appears to result from a dual effect: first, elevated gross production value per decare driven by optimized production patterns and improved productivity; second, substantial reductions in variable costs, particularly electricity expenses, facilitated by on-site renewable energy generation. Quantitatively, SES farms incurred an average electricity cost of only 13.45 TL per decare, representing a mere 0.65% of total variable costs, in stark contrast to 1,172.53 TL per decare (40.31% of variable costs) in non-SES farms (Tables 3.4 and 3.5). These findings highlight the transformative potential of SES adoption in agriculture, demonstrating that integration of renewable energy not only mitigates operational costs but also amplifies farm-level profitability, particularly in larger-scale operations.

In the farms examined, the net output value increased with farm size in both SES farms and non-SES farms (Table 3.1). On the other hand, the net output per decare differed among farm size groups in both SES farms and non-SES farms. Nevertheless, the net output per decare was found to be higher in SES-equipped farms compared to non-SES farms, both across farm size groups and on average (Tables 3.7 and 3.8). This can be attributed to the higher gross production value per decare in SES-equipped farms and, despite higher fixed costs, lower variable costs per hectare in these farms.

Equity return (net profit) is calculated by deducting interest on borrowed capital and land rent from net output. Since none of the surveyed farms operated rented land, net profit was determined by subtracting only interest expenses from net output. The analysis results indicate that, in both farms with SES and those without SES, net profit increases as farm size expands (Table 3.1). Equity return (net profit) per decare varies across farm size groups in both SES and non-SES farms. However, for all farm size groups as well as on average across all farms, net profit per decare was found to be higher in farms equipped with SES compared to those without SES (Tables 3.7 and 3.8).

Table 3.7. Some performance criteria per decare (TL/da) in farms using SES

Farm Size Classes (Da)	Gros Profit TL/da	Net Output TL/da	Return on Equity	Net Farm Family Income
01-200	10.728,49	9.022,33	1.373.516,52	9.637,41
201-500	8.179,93	6.797,37	2.440.059,01	7.097,82
501-+	12.851,54	11.921,18	16.561.320,27	12.052,01
İşlet. Orta.	11.193,36	10.025,94	5.353.344,57	10.253,25

Çizelge 3.8. Some performance criteria per decare (TL/da) in farms not using SES

Farm Size Classes (Da)	Gros Profit TL/da	Net Output TL/da	Return on Equity	Net Farm Family Income
01-200	7.159,17	5.764,12	767.647,89	6.493,30
201-500	5.688,70	4.540,50	1.444.544,39	5.051,21
501-+	7.044,36	6.579,95	11.755.238,80	6.663,73
İşlet. Orta.	6.896,56	6.277,27	4.331.657,34	6.469,61

Farm family income derived from annual operating results consists of equity return, entrepreneurial profit, and the imputed wages of the family labor (Oğuz and Bayramoğlu, 2014). Farm family income is one of the key indicators used to assess the performance and success of farm management. In the surveyed farms, Farm family income was observed to increase in parallel with farm size in both SES and non-SES farms (Table 3.1). Farm family income per decare differs by farm size groups in both SES and non-SES farms. In particular, farms with a size of 501 decares and above exhibited higher agricultural income per decare in both farm types.

Annual activity results alone are insufficient for evaluating the profitability levels of farms. The assessment of farms’ positions at a macro level and their comparability with other farms is possible through profitability ratios. Profitability is one of the key indicators demonstrating whether the capital allocated to production activities is being used efficiently and profitably. In this context, profitability is calculated in terms of return on assets and return on equity ratios.

The return on assets is defined as the ratio of net output to total assets, reflecting the profitability of a farm’s total capital. This ratio, when compared with nominal interest rates, indicates the performance of capital relative to its alternative uses (Bayramoğlu, 2013). Within the scope of this study, it was determined that the return on assets ratio of farms with and without solar energy systems (SES) increased with enterprise size. On average, the return on assets ratio was calculated as 31.89% for farms with solar energy systems, while it was

28.39% for farms without such systems (Table 3.9). In both groups, the return on assets ratio exceeded the 2021 market interest rate of 13.00%, indicating that farms utilized their capital efficiently and that capital profitability was at a satisfactory level.

Çizelge 3.9. Return on assests and return on equity in surveyed farms

Farm Size Classes (Da)		Total Assets	Net Output	Return on Assets Ratio	Return on Eguity	Equity	Return on Eguity Ratio
		TL	TL	(%)	TL	TL	(%)
01-200	Farms using SES	7.230.000,00	1.421.016,52	19,65	1.373.516,52	6.755.000,00	20,33
	Farms not using SES	5.334.950,00	790.029,89	14,81	767.647,89	5.111.130,00	15,02
	Average	5.695.810,00	927.874,06	16,29	900.707,06	5.424.140,00	16,61
201-500	Farms using SES	12.088.340,00	2.492.392,01	20,62	2.440.059,01	11.565.010,00	21,10
	Farms not using SES	9.410.800,00	1.484.744,39	15,75	1.444.544,39	9.008.800,00	16,04
	Ortalama	10.424.930,00	1.836.995,77	17,62	1.792.245,77	9.977.430,00	17,96
501-+	Farms using SES	39.668.350,00	16.689.653,27	42,07	16.561.320,27	38.385.020,00	43,15
	Farms not using SES	34.821.850,00	11.879.571,80	34,12	11.755.238,80	33.628.520,00	34,96
	Average	35.798.330,00	12.843.698,89	35,88	12.722.565,89	34.587.000,00	36,78
Overall Average of Farms	Farms using SES	17.002.300,00	5.421.729,57	31,89	5.353.344,57	16.318.450,00	32,81
	Farms not using SES	15.455,710,00	4.388.439,34	28,39	4.331.657,34	14.887.890,00	29,19
	Average	15.729.480,00	4.648.194,27	29,55	4.588.511,27	15.132.650,00	30,32

The return on equity ratio, on the other hand, reflects the profitability of equity, indicating the return on investments made by farm owners. In the examined farms, the return on equity ratio was found to increase with enterprise size, similar to the return on assets. On average, the return on equity ratio was calculated as 32.81% for farms with SES and 29.19% for those without SES (Table 3.9). These findings suggest that the use of solar energy has a positive effect on equity profitability in agricultural enterprises.

The evaluation of whether farms efficiently utilize external financial resources is commonly conducted through a comparison of return on assets and return on equity ratios. Elevated return on equity ratio signifies that the farms employ their equity capital at a return exceeding the cost of external financing. Conversely, a lower return on equity ratio indicates that the return on the capital employed within the farms falls below the cost of external funds, implying that the utilization of credit is not economically justified. In the present study, across the examined farms—both those utilizing and not utilizing solar energy systems (SES)—return on equity ratio was observed to be higher than, or closely aligned with, return on assets across all enterprise size categories. These findings suggest that, in the enterprises under consideration, the interest rate on capital is lower than, or approximately equivalent to, the returns generated by the capital employed, thereby supporting the rationality of external financing utilization.

Capital turnover, one of the annual performance indicators used to assess operational efficiency in agricultural enterprises, indicates the number of years required for Gross Agricultural Output (GAO) to compensate for total assets. The capital turnover ratio is defined as the ratio between the income generated from production activities and the capital employed. The average capital turnover ratio was calculated as 46.60% for enterprises utilizing solar energy and 49.02% for enterprises not utilizing solar energy. The capital turnover ratio increased consistently with enterprise size groups in the agricultural enterprises examined (Table 3.10).

All of these findings align with the growing literature on agrivoltaic and solar energy integration in agriculture. Systematic reviews indicate that co-locating solar photovoltaics (PV) with agricultural production enhances land use efficiency and can improve profitability by generating dual revenue streams from food and energy (Pandey, Lyden, Franklin, & Millar, 2025). Studies have also reported that agrivoltaic systems can reduce irrigation demand and increase water-use efficiency, which may indirectly contribute to higher agricultural incomes, particularly under arid and semi-arid conditions (Pandey et al., 2025). Reduced energy costs and enhanced operational resilience against fluctuating energy prices further support the economic performance of farms incorporating renewable energy systems (Soto-Gómez, 2024).

Table 3.10. Capital turnover ratio and period in surveyed farms

Farm Size Classes (Da)		Gross Production Value	Total asset	Capital turnover ratio	Capital turnover period (Years)
		TL	TL	%	Years
01-200	Farms using SES	2.165.184,02	7.230.000,00	29,95	3,34
	Farms not using SES	1.467.948,13	5.334.950,00	27,52	3,63
	Average	1.591.580,18	5.695.810,00	27,94	3,58
201-500	Farms using SES	4.005.425,22	12.088.340,00	33,14	3,02
	Farms not using SES	3.209.661,39	9.410.800,00	34,11	2,93
	Ortalama	3.508.108,94	10.424.930,00	33,70	2,97
501-+	Farms using SES	23.600,675,26	39.668.350,00	59,50	1,68
	Farms not using SES	19.870.213,31	34.821.850,00	57,06	1,75
	Average	20.614.970,71	35.798.330,00	57,59	1,74
Overall Average of Farms	Farms using SES	7.956.650,42	17.002.300,00	46,80	2,14
	Farms not using SES	7.575.860,00	15.455,710,00	49,02	2,04
	Average	7.670.056,20	15.729.480,00	48,76	2,05

Economic analyses in integrated agricultural solar systems suggest that while initial investment costs remain a challenge, potential operational savings and income diversification can yield favorable returns under appropriate policy and market conditions (Trommsdorf et al., 2023). Additionally, agrivoltaics research emphasizes that improved land-use efficiency and dual use of space may lead to greater profitability relative to standalone agricultural or PV systems, especially when policy incentives and optimized system designs are in place (Jean & Rosentrater, 2025).

Overall, the positive relationship between SES adoption and elevated economic performance observed in this study is consistent with broader empirical and theoretical evidence. Adoption of solar energy systems appears to offer both direct cost savings and indirect benefits such as enhanced production continuity, risk mitigation, and improved resource use efficiency, thereby contributing to more sustainable and resilient farming operations.

4. Conclusions and recommendations

This study analyzed the annual economic standart results of farms using solar energy systems (SES) and those not using SES in Karapınar district of Konya province. Overall, the annual economic standard results of the examined farms increased in parallel with farm size in both SES-using and non-using farms groups. However, since SES-using and non-using farms differed in terms of average land size and number of livestock across farm size groups, comparing annual standard economic results on a per-decare basis provides more meaningful and reliable outcomes.

The comparison of annual economic standard results indicators per decare revealed that, across all farm size groups and for the overall average, SES-using farms achieved consistently higher results than non-using farms. On average, SES-using farms recorded a gross margin of 11,193.36 TL per decare, a net output value of 5,429.57 TL, and a farm family income of 10,253.25 TL. In contrast, the corresponding values for non-SES farms were 6,896.56 TL, 6,277.27 TL, and 6,469.61 TL, respectively. Accordingly, both return on assets and return on equity ratios were found to be higher in farms utilizing solar energy systems compared to those that did not. These findings clearly demonstrate that the adoption of solar energy systems significantly enhances profitability in farms.

The higher annual operating results observed in farms utilizing solar energy systems (SES) are largely attributable to differences in variable costs, particularly in crop production. An examination of variable costs in crop production reveals that the per-decare variable cost was calculated as TRY 2,078.36 in farms equipped with SES, whereas this figure reached TRY 2,908.53 in enterprises without SES. Notably, the share of electricity (irrigation) expenses within total crop production costs was only 0.65% in SES-equipped farms, compared to 40.31% in those without SES. These findings clearly indicate that the adoption of solar energy systems significantly alters the cost structure of agricultural production, leading to substantial cost savings and improved economic performance.

It was determined that the profit margin of farms utilizing solar energy systems (SES) increased as a result of a reduction in variable costs. However, due to the high installation costs of solar energy systems, the fixed costs of these farms were found to be higher compared to those of farms not using SES. Nevertheless, since the decrease in variable costs exceeded the increase in fixed costs, the annual standard results of farms utilizing SES were realized at a higher level.

Overall, the findings of this study indicate that in the Karapınar district of Konya Province—characterized by a dominant continental climate and long sunshine duration—the use of solar energy systems (SES) in agriculture significantly reduces production costs, particularly under conditions of high electricity expenses related to irrigation. The adoption of SES increases income per unit area and profitability, thereby strengthening the economic sustainability of agricultural enterprises. In regions with low precipitation, irrigation through deep groundwater wells substantially increases electricity consumption, which constitutes a major component of operating costs. In this context, the widespread adoption of solar energy investments in agriculture is of great importance not only for enhancing farm-level profitability but also for ensuring environmental and economic sustainability using renewable energy sources. However, the reduction in electricity costs resulting from SES usage may lead to increased water consumption, which necessitates careful attention to the efficient use of limited water resources in the study area. Considering these aspects, promoting renewable energy investments (such as solar and wind energy) in rural areas can reduce energy costs for farmers, enhance agricultural profitability, and contribute to the economic, social, and environmental sustainability of rural communities.

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CHAPTER 3

THE LEVEL OF USE OF FLY ASH IN THE WOOD PRESERVATION INDUSTRY

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INTRODUCTION

Fly ash (FA) is a significant byproduct of the combustion of pulverized coal in thermal power plants. It is transported by flue gases and collected in cyclones or electrostatic filters. In Turkey, more than 16 million tons of fly ash are currently generated annually. The increasing amount of fly ash, an industrial waste, brings with it environmental problems. Numerous studies are being conducted in Turkey and worldwide on fly ash recycling and its applications. Fly ash is widely used in the construction sector. It has common applications in cement and concrete production, aerated concrete and brick production, soil and road stabilization applications, lightweight aggregate production, etc. (Görhan et al.,2008). In Turkey, one of the most important issues that remains current is saving energy and raw materials. At the forefront of Turkey's medium and longterm energy production policies is energy production from thermal power plants. The slag and fly ash produced from these units, which burn solid fossil fuels (such as lignite), create a significant environmental problem. Unfortunately, the utilization of fly ash, which has technological and economic value, remains at a very low level. Due to the harmonization process and our membership in the Environment Agency, implementing and realizing recycling strategies in the energy sector is one of Turkey's important tasks. In our country, a significant portion of electricity is still produced through thermal power plants. the share of natural gas-fired power plants was 48.6%, the share of hydroelectric power plants was 18.7% and the share of lignite-fired thermal power plants was 20% in electricity production (EPDK, 2021). In addition In thermal power plants, low-calorie lignite coal is ground to a fine size and burned as fuel to generate energy. During the combustion of coal dust, ash particles with a size ranging from 1150 µm are produced, carried along by the flue gases and captured in the chimneys with the help of electrostatic filters. Increased coal consumption due to increasing energy demand leads to an increase in the amount of ash obtained as waste during coal combustion. This ash, an industrial waste obtained from thermal power plants, is called fly ash (Arunta 2006; Aksoy et al 2007). According to the Turkish Statistical Institute (TÜİK), 11.84 million tons of fly ash were produced in thermal power plants in Turkey in 2003, 13.34 million tons in 2004, and 16.01 million tons in 2006. Between 2003 and 2006, an average of 10% of the generated waste was recovered outside the plant, while 90% was disposed of. On average, 79% of the disposed waste was stored in ash dumps/dams. The largest share of the waste composition of thermal power plants consisted of mineral wastes (ash, slag, fly ash and gypsum) (Türk Haber Bülteni,2006-2007-2008). In Turkey, the annual amount of fly ash is expected to exceed 50 million tons by 2020 (Tütünlü et al.2001). Currently, numerous studies are being conducted on the uses of fly ash, and more importance is being given to the use of industrial wastes in civil engineering applications (Cultrone et al. 2009; Karahan et al. 2007).

Wood is an indispensable material for living spaces. Therefore, the demand for wood is increasing rapidly in parallel with the rapid increase in the world population, and this situation necessitates the inclusion of all local wood species in the industry. (Buğahan, 2013). Wood, which has been used for various purposes since the beginning of human history, is one of the most important raw materials. With the rapid development of technology, the areas of use of wood have diversified and the amount used has increased. This increase in the use of wood causes it to be among the decreasing natural resources today (Kartal and Imamura, 2004). Impregnated wood is an important building material due to its aesthetic appearance, economy, and resistance to biotic and abiotic pests. Impregnated wood is used as roof elements, joinery and coating material, and as a carrier and decorative material in molds and scaffolding (Kartal, 2000; Can, 2018).

The main components of fly ash are SiO_2, $Al2O_3$, Fe_2O_3, and CaO, MgO, SO_3 alkali oxides. Its use in wood materials, paints, varnishes, etc., its resistance to water effects, its resistance to abrasion, scratches, and impacts (hardness) on wood surfaces and laminate flooring, and its high resistance to fire, mold, and insect infestation have been reported in the literature. Based on this information, attempts have been made to determine its level of use by preparing solutions at various concentrations and impregnating wood materials with them to determine their retention properties.

1. MATERIAL and METHOD

1.1. Wood Material and Treatment

Within chestnut wood were used in the experimental study; radial cuts were made in accordance with TS 2470 (1976) standards. Fly ash was used as an impregnation material, and solutions of 2% and 4% were prepared at various concentrations (by dissolving it in hydrochloric acid).

1.2. Preparation of Experiment Samples

It was paid attention that the wood materials used in the study were sapwood parts with smooth fibers, no cracks, no knots, no density and color difference, no reaction wood, not damaged by fungi and insects, and were processed according to TS 2471,2472 standards.

1.3. Impregnation Process

Impregnation was carried out according to ASTM–D 1413-76 principles. It was subjected to 30 minutes of vacuum and 30 minutes of diffusion.

1.4. Solution Preparation

After obtaining fly ash from the relevant sources, it was diluted with hydrochloric acid and water to prepare concentrations of 2% and 4% (Ceylan, 2017).

1.5. Percentage Retention (net dry matter amount)

After impregnation, the amount of substance remained (tkoao-% retention) compared to dry wood was calculated from the specified formula.

$$R\,(\%) = \frac{Moes - Moe\ddot{o}}{Moe\ddot{o}} \times 100 \qquad (1)$$

Moes = Sample full dry weight after impregnation (g)
Moeö = Sample full dry weight before impregnation (g)

1.6. Evaluation of Data

SPSS statistics program was applied to evaluate the data. Homogeneity groups were formed by analyzing values resulting from wood type effect and % concentration change and simple variance analysis was applied.

2. RESULTS AND DISCUSSION

2.1. Solution Properties

Solution properties are given in Table 1. There was no significant change in solution pH and densities.

Table 1. Solution Properties.

Impregnation Material	**Concentration (%)**	**Solvent**	**Temperature (ºC)**	**pH**		**Density (g/ml)**	
				BI	**AI**	**BI**	**AI**
Fly ash	2%	HCl-Water	22ºC	7.65	7.65	0.989	0.989
	4%			8.66	8.66	1.110	1.110

BI: Before impregnation **AI:** After ımpregnation

2.2. Retention Amount (% Retention)

The net dry impregnation material remaining amount as (%) is given in Table 2.

Table 2. % Retention

Wood Type	Impregnation Material	Concentration (%)	Retention (%)	
			Mean	HG
Chestnut	Fly ash	2%	2,35	B
		4%	3,77	A

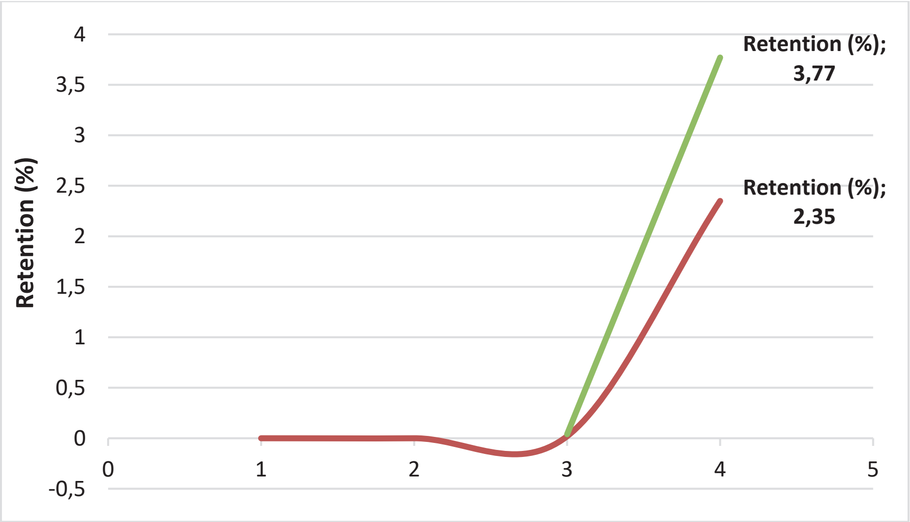

Figure 1. Change of Retention

The highest retention rate in chestnut wood was determined at a concentration of 4% (3.77%), and the lowest at 2%. The acidic structure can partially cause hydrolysis in the wood. Breaking the cellulose chain can lead to a decrease in mechanical properties. Despite all this, retention occurred in the wood. This suggests that it is directly proportional to the wood type, anatomical structure, impregnation method, and impregnating agent.

Aluminum oxide (A_2O_3), found in the composition of fly ash, is a reinforcing material that significantly increases the resistance (hardness) of wood surfaces and laminate flooring against abrasion, scratches, and impacts. (Al_2O_3), which is especially used in transparent nano coatings, increases the surface hardness and lifespan of the wood without altering its natural texture, and provides protective properties for restoration processes. (Aksu, 2020).

CONCLUSION

The disposal of fly ash, which is produced in large quantities in Turkey and worldwide, presents both environmental and economic problems. Recycling fly ash is of great importance for the protection of natural raw material resources and the environment. It would be appropriate to conduct new research to increase fly ash consumption and develop new uses and applications. It is considered appropriate that R&D studies should focus on increasing the amount of fly ash used and developing new areas and methods of application. Its use in the wood industry, on a certain scale and in specific areas, would be possible.

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CHAPTER 4

IMPREGNATION OF BLACK PINE WOOD WITH LIQUIDAMBAR PLANT EXTRACT AND DYNAMIC BENDING STRENGTH CHANGE

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INTRODUCTION

Storax oil has been known since ancient times. Its trade was carried out by the Phoenicians. The ancient Egyptians used this oil in the preparation of mummies. It is known as Cleopatra's beauty elixir. It is known to have been used as a medicine starting from the time of Hippocrates (460-377 BC), known as the father of medicine. It is known that the Roman emperor Caracalla, who lived in the 3rd century and suffered from stomach ulcers, was treated at the Asklepions in Epidaurus, Kos, and Pergamon, which were health centers of the time. He is said to have found healing at the Pergamon Asklepion with a kind of elixir made by mixing storax oil and pine resin with honey, and after his recovery, he made donations to the city and doctors to express his gratitude. During the reign of Suleiman the Magnificent (1520-1566), the region between Marmaris and Fethiye was given to his sister, Mihrişah Sultan. To generate income for the foundation established in the name of Mihrişah Sultan, her husband, the Khedive of Egypt, Ali Pasha, exported the region's styrax oil to Egypt (Özcan et al. 2005, Atay, 1985, İstek and Hafızoğlu 2004). Duru et al. (2002) Pure frankincense oil is obtained by alcohol extraction and extract distillation of crude frankincense oil. Studies to date have indicated that frankincense oil contains high molecular weight compounds such as acids, alcohols, esters, and phenols, and includes molecules such as cinnamic acid, styracin, styrol, styrone, storesinol, and storegenin. Top et al. (2007) It is known that the balsam of the styrax tree has been used by the local people for various purposes, primarily in medical treatment, from ancient times to the present day. The woody part remaining after the styrax balsam is extracted is called incense, and in ancient times, incense was used as a fragrance in churches and temples during religious ceremonies. The ancient Egyptians used this balsam in mummification, and Queen Cleopatra even used a substance derived from this oil as perfume. Furthermore, it was used as a medicine by ancient physicians during the time of Hippocrates due to its healing effects. Among the people, styrax balsam is used as an expectorant and in the treatment of asthma, bronchitis, and lung diseases.

Wood, which has been used for various purposes since the beginning of human history, is one of the most important raw materials. With the rapid development of technology, the areas of use of wood have diversified and the amount used has increased. This increase in the use of wood causes it to be among the decreasing natural resources today (Kartal and Imamura, 2004). Impregnated wood is an important building material due to its aesthetic appearance, economy, and resistance to biotic and abiotic pests. Impregnated wood is used as roof elements, joinery and coating material, and as a carrier and decorative material in molds and scaffolding (Kartal, 2000).

The use of medicinal aromatic plants (MAPs) dates to ancient times. These medicinal plants have been used by humans for therapeutic and other purposes. In addition, essential oils obtained from these medicinal plants have been used with the physical and emotional treatment method called aromatherapy. According to the World Health Organization (WHO), in most developing countries such as Asia, Africa and Latin America, about 80% of the population still relies on traditional herbal medicines for their primary medical requirements . (Parvin et. al., 2023). The use of Medicinal and Aromatic Plants (MAPs), present in numerous plants and products, dates to ancient times. Humans have utilized these products for therapeutic and various other purposes. These value-added products have also been commercialized globally. Turkey is advantageous in terms of its geopolitical structure and rich flora. The production, cultivation, and export activities of these products are also prominent in Turkey (Atak, 2024). Güngörmez (2015) The most positive aspect of the organic dyeing process is the economic recovery of waste plant material in addition to obtaining healthy products. Today, many different cancers are rapidly occurring and the lack of this aspect of the organic dye structure, the antimicrobial structure of some plants, and their easy use in children's toys has been reported.

Liquidambar plant leaf waste/residues were collected, an extract was obtained, and solutions of various concentrations were prepared and impregnated into wood material. Subsequently, a dynamic (shock) bending strength test was performed. In this way, the scale of use of black pine wood and liquidambar leaf extract, which are among the main resources of our country, was determined.

1. MATERIAL and METHOD

1.1. Wood /Plant Material

In the experimental study, black pine (*Pinus nigra*) wood was obtained and experimental samples were prepared in accordance with TS 2470 (1976) standards. Extracts were prepared using the leaves of the sweetgum tree (*Liuimdambar Orientalis*), which is described in the literature as a medicinal aromatic plant (antibacterial/antioxidant).

1.2. Preparation of Experiment Samples

It was paid attention that the wood materials used in the study were sapwood parts with smooth fibers, no cracks, no knots, no density and color difference, no reaction wood, not damaged by fungi and insects, and were processed according to TS 2471,2472 standards.

1.3. Impregnation Process

Impregnation was carried out according to ASTM–D 1413-76 principles. It was subjected to 30 minutes of vacuum and 30 minutes of diffusion.

1.4. Extract Preparation

Black pine and medicinal and aromatic plant species were supplied from Muğla province and dried in the Artvin Coruh University laboratory for 1-2 months to reach a constant weight. After 1-2 months of drying, they were turned into powder by passing through a cutter grinder (Ceylan, 2017).

1.5. Percentage Retention (net dry matter amount)

After impregnation, the amount of substance remained (tkoao-% retention) compared to dry wood was calculated from the specified formula.

$$R\,(\%) = \frac{Moes - Moe\ddot{o}}{Moe\ddot{o}} \times 100 \qquad (1)$$

Moes = Sample full dry weight after impregnation (g)
Moeö = Sample full dry weight before impregnation (g)

1.6. Evaluation of Data

SPSS statistics program was applied to evaluate the data. Homogeneity groups were formed by analyzing values resulting from wood type effect and % concentration change and simple variance analysis was applied.

2. RESULTS AND DISCUSSION

2.1. Solution Properties

Solution properties are given in Table 1.

Table 1. Solution Properties.

Impregnation Material	Concentration (%)	Solvent	Temperature (ºC)	pH		Density (g/ml)	
				BI	AI	BI	AI
Sweetgum plant Extract	2%	Distilled	22ºC	4.15	4.15	0.868	0.868
	4%			4.46	4.46	0.870	0.870

BI: Before impregnation **AI:** After ımpregnation

There was no significant change in solution pH and densities.

2.2. Retention Amount (%)

The net dry impregnation material remaining amount as (%) is given in Table 2.

Table 2. % Retention

Wood Type	Impregnation Material	Concentration (%)	Retention (%)	
			Mean	HG
Black pine	Sweetgum plant Extract	2%	0.66	B
		4%	0.85	A

In the impregnation of sweetgum plant extract, the highest retention rate was observed at a concentration of 4% (0.85%), and the lowest retention rate was observed at a concentration of 2% (0.65%). This may be due to the type of wood, the concentration ratio, and the anatomical structure of the wood. time.

The highest retention values were observed in samples impregnated with 1% solution. It is stated that the retention ratio varies due to the properties of the solutions and the anatomical structure (Alkan, 2016).

2.3. Dynamic Bending Strength (Kgm/cm^2)

The variation in dynamic bending resistance is given in Table 3.

Table 3. Dynamic Bending Strength

Wood Type	Impregnation Material	Concentration (%)	Dynamic Bending Strength	
			Mean	HG
	Control	-	0.38	C
Black pine	Sweetgum plant Extract	2%	0.47	A
		4%	0.41	B

A partial increase in dynamic bending strength was observed in the impregnated groups compared to the control sample. The highest shock resistance value was determined at a concentration of 2% (0.47 kgm/cm^2), and the lowest in the control sample (0.38 kgm/cm^2). This can be attributed to the wood type, anatomical structure, and solution properties.

CONCLUSION

Healthy products and methods are essential for maintaining the environment and human health. Products such as furniture, paper industry, park/garden furniture, and wooden toy industry are of great importance for a healthy life. Children, who grow up playing from their first months, are surrounded by toys; we can say that a high level of hygienic structure is created by impregnating wooden toys and using this material. With its resistance to impacts, earthquakes, etc., as demonstrated by dynamic bending tests, styrax extract can be used in many areas. The antioxidant and antimicrobial properties of extracts obtained from many plants are attracting great interest in both academic circles and the food, cosmetic, and pharmaceutical industries. This is because their potential use as natural additives stems from the increasing trend of replacing synthetic preservatives with natural ones. In this respect, working with endemic plant species is of great importance in uncovering their unknown bioactive properties.

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CHAPTER 5

SHELL MORPHOMETRICS OF *THEODOXUS ANATOLICUS* (RÉCLUZ, 1841) (GASTROPODA, NERITIDAE) IN YARIŞLI LAKE (BURDUR, TÜRKIYE)

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Introduction

The genus *Theodoxus* Montfort, 1810, constitutes one of the most common and ecologically relevant groups within the aquatic malacofauna of the Western Palearctic region. Species of this genus occupy diverse freshwater habitats, where they contribute substantially to ecosystem functioning. By regulating the growth of algal communities and serving as a food source for other aquatic organisms, *Theodoxus* snails play a pivotal role in sustaining ecological balance and nutrient cycling in freshwater systems (Kiss-József Rékási and Richnovszkyt 1995; Lappalainen et al. 2001; Råberg and Kautsky 2008; Peters and Traunspurger 2012). Due to their ecological sensitivity, *Theodoxus* species have been widely employed as environmental and habitat indicators in ecological and paleoecological studies. Their responsiveness to physicochemical fluctuations enables researchers to use them as reliable bioindicators for assessing environmental health (Alhejoj et al. 2017) and reconstructing past ecological conditions (Moissette et al. 2016). Consequently, this genus has become a valuable model group for understanding habitat quality and environmental dynamics in aquatic ecosystems. In addition to their ecological significance, certain *Theodoxus* species act as hosts for a variety of trematode and ciliate taxa, making them a focal point of parasitological investigations (Abdel-Hafez and Ismail 1987). These host–parasite relationships not only influence snail population dynamics but also contribute to the overall parasitic diversity and trophic interactions within freshwater communities. Taxonomically, more than 35 extant *Theodoxus* species have been described to date, with distributions spanning Europe, Western Asia, and North Africa (Welter-Schultes 2012; Encyclopedia of Life 2018; IUCN 2019; MolluscaBase 2019; Glöer 2019). Their occurrence in both freshwater and mesohaline environments demonstrates a remarkable ecological tolerance and adaptive capacity (Bănărescu 1991; Bandel 2001). Such adaptability, combined with their widespread distribution and ecological versatility, underscores the genus's importance for biogeographical, evolutionary, and environmental research (Sands et al., 2020).

Theodoxus anatolicus was initially reported by Martens (1874) to possess an extensive distribution across Anatolia, Mesopotamia, and several Turkish and Greek islands in the Aegean. Later, Roth (1987) re-examined the species' range and concluded that *T. anatolicus* is restricted to the southern portion of western Anatolia, attributing records from eastern Anatolia to *T. jordani*. Schütt and Şeşen (1989, 1992) proposed a more moderate perspective, indicating that *T. anatolicus* occurs in the northwestern part of Hatay Province in southern Türkiye. Bank (2006) further extended the known distribution by reporting the presence of *T. anatolicus* on the Greek Aegean Islands, thereby lending support to Martens' (1874) broader range hypothesis. However, extensive sampling by Sands et al. (2019) provided genetic confirmation of *T. anatolicus* only in southwestern Anatolia, corroborating Roth's (1987) assessment of a more limited distribution.

Burdur Province, located within the Mediterranean eco-region in southwestern Türkiye, encompasses part of the Lakes Region, which derives its name from the tectonic depressions north of the Taurus Mountains that are filled by various lakes. The province exhibits a transitional climate, influenced by both Mediterranean and continental conditions (Kaplan and Örücü, 2019). Among its water bodies, Yarışlı Lake is an alkaline lake primarily sustained by groundwater inflow, with surface levels subject to substantial seasonal fluctuations due to changes in the precipitation–evaporation balance (Anonymous, 2013). As one of the smallest natural lakes in Burdur (Aksoy et al., 2019), it is particularly vulnerable to anthropogenic pressures such as pollution, soil erosion, and habitat degradation (Kebapçı and Balpınar, 2024). The present research is aimed to evaluate shell morphometrics of *Theodoxus anatolicus* from Yarışlı Lake, located in Burdur Province, Türkiye.

Material and Methods

Theodoxus anatolicus (n:30) were obtained from Yarışlı Lake (Burdur, Türkiye) (x: 37,5446390 y: 29,9442820) (x,y coordinate: WGS_1984_UTM_Zone_37N (6°) (Figure 1) in October 2025.

Figure 1. Sampling area of *Theodoxus anatolicus.*

The sampling procedure involved the use of metal-framed scoops, shovels, and a rake for dredging the bottom substrate. Snails were hand-collected from sandy and vegetated areas at depths of up to 1 m, then preserved in styrofoam boxes at +4°C. Species identification was performed by referencing illustrations and descriptions of *Theodoxus* species reported in previous studies (Sands et al., 2020) (Figure 2).

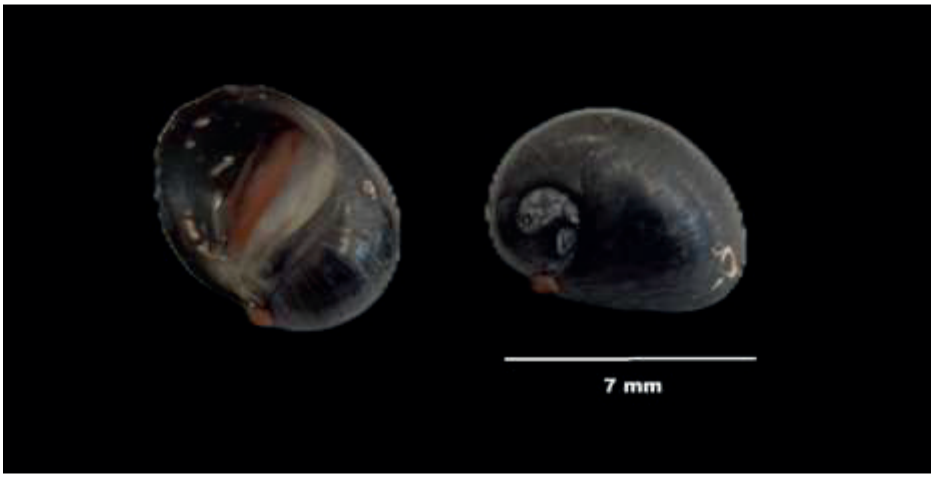

Figure 2. *Theodoxus anatolicus* from Yarışlı Lake.

Shell dimensions—including shell height (SH), shell width (SW), aperture length (AL), and aperture width (AW)—were recorded using a digital caliper with a precision of ±0.01 mm, while specimen weights were measured using an analytical balance with an accuracy of ±0.001 g.

The dataset was processed and analyzed using Microsoft Excel®, and principal component analysis (PCA) was conducted with PAST 4.03 to assess correlations among the variables.

Results

Distinguishing features

Theodoxus anatolicus can be identified by several distinctive morphological and genetic features. The shell is typically black, semi-globular in shape, with fine striations and a corroded apex, measuring 7–10 mm in height and 8–11 mm in length (Glöer, 2019). Morphologically, it possesses a pseudo-apophysis on the operculum, and its periostracum exhibits a uniformly black pattern. The columellar plate does not extend beyond the shell margin, and fine structural details of the operculum further aid in its identification. Genetically, analyses of mtDNA and nDNA indicate that the species forms an independent monophyletic clade, confirming its distinct status (Sands ve ark., 2020).

Shell Morphometrics

In this study, the mean morphometric values of *T. anatolicus* were recorded as 7.13±1.39 mm for shell length (SL), 5.59±0.97 mm for shell width (SW), 5.48±1.02 mm for aperture length (AL), 4.96±1.02 mm for aperture width (AW), and 0.114±0.07 g for body weight (W).

In this study, the suitability of principal component analysis (PCA) was assessed using Bartlett's test and the Kaiser-Meyer-Olkin (KMO) measure, which yielded a value of 0.890. PCA effectively summarized the correlation matrix, and Bartlett's test results were significant ($p = 0.000$; $p < .001$), indicating that the variables were interrelated and PCA was an appropriate method. The first two principal components (PC1 and PC2) accounted for approximately 92.764% of the variation in the shell characters dataset, with elevation being the major contributing factor. Furthermore, a strong correlation was observed among shell length (SL), shell width (SW), shell height (SH), and weight (W) (Figure 3).

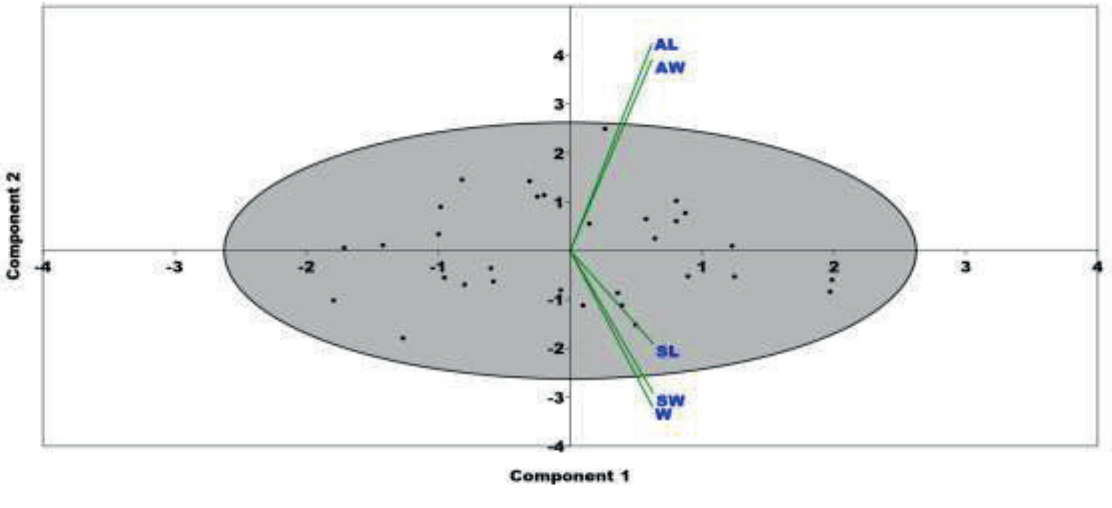

Figure 3. Analysis of shell morphometric traits (SL, SH, SW) and weight (W) using principal component analysis.

In *T. anatolicus*, there was a strong correlation between shell length-shell width, shell length-aperture width, shell length-aperture length, shell length-weight, shell width-aperture length, shell width-aperture width (Table 1).

Table 1. Correlation analysis of measured shell traits.

	SL	**SW**	**AL**	**AW**	**W**
SL		0,944	0,899	0,902	0,930
SW	0,944		0,899	0,886	0,944
AL	0,899	0,899		0,921	0,877
AW	0,902	0,886	0,921		0,895
W	0,930	0,944	0,877	0,895	

Discussion

This study reports, the presence of *T. anatolicus* in Yarışlı Lake, expanding the known distribution range of this species within Türkiye. Accurate identification of freshwater snails is often complicated by significant phenotypic variation, particularly in shell morphology, which can mask subtle differences among species. Such morphological similarities frequently result in the underestimation or oversight of species, especially in regions that have not been thoroughly surveyed. Therefore, detailed examination of the malacofauna in Yarışlı Lake is critical, not only for documenting local biodiversity but also for contributing to broader knowledge of Türkiye's freshwater snail fauna. Understanding these populations can provide valuable insights into patterns of species richness, endemism, and zoogeographic distribution, which are essential for conservation planning and for elucidating ecological and evolutionary processes within freshwater ecosystems.

Morphometric analyses combined with measurements of shell size and body weight, provide valuable insights into the diversity, growth patterns, and differentiation of *Theodoxus* species. Marković et al. (2019) indicated that operculum morphology, analyzed through geometric morphometrics, offers reliable characters for species identification. While sexual dimorphism in operculum shape and size was absent, specific structural traits such as an outwardly extended rib and a short basal tip allowed clear separation among species, emphasizing the taxonomic importance of fine opercular features. Elkarmi and Ismail (2006) highlighted the significance of integrating shell morphometrics with body weight data to understand population structure. Their study on *Theodoxus macri* revealed clear relationships between shell length, shell width, and weight across different age classes, reflecting both growth dynamics and allometric trends. Theoretical maximum shell sizes estimated via von Bertalanffy and Richards models (~17.2 mm and ~12.9 mm, respectively) along with corresponding shell and body weights (~44.4 mg and ~36.1 mg) further underscore the utility of combining morphometric and weight measurements to assess species growth and functional morphology. Zettler et al. (2004) investigated *Theodoxus fluviatilis* populations from both brackish and freshwater habitats. Despite environmental differences, no significant variation was observed in shell size, operculum, radula morphology, or body weight, indicating a high level of phenotypic plasticity. These findings suggest that some *Theodoxus* species can maintain consistent morphological and weight characteristics across contrasting habitats, although subtle population-level differences may still occur. In the current study, the maximum measurements were 9.48 mm for SL and 0.295 g for W.

Variation in shell length, width, whorl height, and weight in gastropods may indicate how biological and ecological influences affect both shell morphology and body growth (Kutluyer and Kocabaş, 2022). In current study, s strong relationship between shell length (SL), shell width (SW), shell height (SH), and weight (W) was identified through principal component analysis (PCA).

Collectively, this study demonstrate that combining shell morphometrics with body weight data provides a comprehensive approach for evaluating *Theodoxus* species' taxonomy, population structure, and ecological adaptation. Such integrated analyses are particularly valuable for detecting intraspecific variation, resolving taxonomic ambiguities, and understanding the evolutionary and ecological factors that influence shell and body size in freshwater gastropods. Future research should continue to incorporate both morphometric and weight data alongside molecular analyses to fully elucidate species boundaries and adaptive strategies within the genus.

Acknowledge

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CHAPTER 6

ABILITY OF SOME MISTLETOE (VISCUM ALBUM L.) WOOD SPECIES TO BE IMPREGNATED WITH SEAWEED EXTRACT AND PYROLYSIS

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INTRODUCTION

In this century, new industries that use wood as a raw material are developing. In our country, where forest resources remain constant or are even decreasing day by day, there is a shortage of raw materials in the wood processing industries. In order to meet the raw material needs of these industries on the one hand, and to meet the needs of the growing population for timber and increase per capita consumption on the other, it is necessary to increase the degree to which our forests are utilized, to ensure that the produced materials are used for a long time, and to discover new raw material sources (Ulusoy et al.,2017). Our country is one of the rare countries in the world that has been able to increase the amount of its forest areas. Forest areas are an indispensable part of terrestrial ecosystems. Our forests cover 29.2% of our country's surface area, amounting to approximately 22.7 million hectares. The annual current growth in our forests totals 47.2 million m³ (2.1 m³/ha), and our timber reserves are around 1.6 billion m³. As a result of the maintenance, protection, and regeneration efforts carried out in our forests, positive developments are observed not only in the increase of area and tree reserves but also in the growth and increment relationships (Ogm, 2021).

Forest ecosystems struggle with various adverse effects stemming from abiotic and biotic factors. Mistletoe, which lives as a semi-parasite on trees, is one of the most important biotic factors. Mistletoe infesting pine trees causes deformities in the crown structures of individuals, differentiations in the structure of the branches, and reductions in growth characteristics such as diameter, height, needle length, and number of needles. Mistletoe competes with the trees for water and mineral nutrients, hindering their normal development and causing them to weaken. They can also cause drying out due to the effects of secondary factors such as drought, insects, and fungi (Ringling et al, 2010). Mistletoe is an evergreen, semi-parasitic plant that can live on the branches and trunks of trees and has chlorophyll, meaning it is capable of photosynthesis. Its leaves are four times longer than their width, have entire margins, and are in a shrub form with green young shoots. Mistletoe, which develops slowly at first on the host tree, may take many years to produce flowers and seeds (Yüksel et al., 2005). Wood, which has been used for various purposes since the beginning of human history, is one of the most important raw materials. With the rapid development of technology, the areas of use of wood have diversified and the amount used has increased. (Kartal and Imamura, 2004). Impregnated wood is an important building material due to its aesthetic appearance, economy, and resistance to biotic and abiotic pests. Impregnated wood is used as roof elements, joinery and coating material, and as a carrier and decorative material in molds and scaffolding (Kartal, 2000; Can, 2018). The Mistletoe plants, by competing with the trees for water and mineral nutrients, hinder the normal development of the trees and cause them to weaken. They can also cause drying out due to the effects of secondary factors such as drought, insects, fungi, etc. (Dobbertin and Ringling, 2006). In the ocean, forests filled with life grow in coastal waters across the globe. Rather than trees, these forests are built by billowing seaweed—kelp. Kelp are algae that grow using the sun's energy, much like marine seagrasses and plants on land. They are critical habitats that provide a home for other ocean life and protect coastlines. Among the kelp fronds fish, crustaceans like crabs, sea stars, and other sea creatures seek refuge from the tumultuous open ocean. (URL-1).

Many flame-retardant chemicals are used to prevent combustion in wood and cellulosic materials. Products based on boron compounds are used alone or in combination as flame-retardants due to their smoke-suppressing properties. It has been reported that the amount of heat transferred to the interior due to charring on the surface of the wood material is insufficient to allow the combustible gases inside the material to escape, thus stopping ignition on the surface (Baysal, 1994). Flame retardant chemicals cannot completely prevent wood from burning. However, they can make it more difficult for the wood to ignite and slow down the rapid spread of fire once it has started (Dubey et al., 2012).

This study aimed to impregnate mistletoe-infused black pine and poplar wood with seaweed extracts (1%) and subsequently determine some of their technological properties. The study explored how the mistletoe structure negatively impacts wood, making it unusable or ineffective in the furniture/wood industry. Furthermore, the use of ecological impregnation agents on organic wood structures was investigated to determine changes in retention/ pyrolysis (combustion) properties. The primary objective was to achieve a positive impact on human and environmental health by avoiding any chemical additives.

1. MATERIAL and METHOD

1.1. Wood/ Treatment Material

Within black pine (*Pinus nigra*) and poplar (*Populus nigra L.*) were used as wood materials. Their usage level is of great importance, especially in the wood industry and in historical wooden artifacts. The wood material was sourced from commercial firms and adhered to TS EN 2470,2471 standards. Seaweed was obtained from the coasts of Trabzon and the extract preparation process was carried out.

1.2. Preparation of Experiment Samples

The TS ISO 3129 standards were taken into consideration when preparing the test samples, and particular attention was paid to ensuring that the test/control samples were free from defects such as fungus, knots, cracks, splinters, mold, insects, etc. cuttings (livewood) with sample dimensions of 20x20x20 mm were prepared.

1.3. Impregnation Process

Impregnation was carried out according to ASTM–D 1413-76 principles. It was subjected to 30 minutes of vacuum and 30 minutes of diffusion.

1.4. Extract Preparation

In this study, seaweed samples were weighed to standard weight and then heated in 200 ml of hot water (distilled water) for 1 hour below boiling point using a reflux system. The mixture was stirred at certain intervals during heating. After the process was completed, the sample was placed in a previously prepared porous capsule and subjected to vacuum filtration. After washing the capsule structure again with 200 ml of hot distilled water, excess water was removed using a suction (pump) system. Subsequently, the capsule and its contents were cooled in a desiccator at 103 °C for 16 hours and weighed with an accuracy of ±0.001 g, as shown in Figure 1 (Ceylan, 2017).

1.5. Percentage Retention

After impregnation, the amount of substance remained (tkoao-% retention) compared to dry wood was calculated from the specified formula.

$$R\ (\%) = \frac{Moes - Moe\ddot{o}}{Moe\ddot{o}} \times 100 \qquad (1)$$

Moes = Sample full dry weight after impregnation (g)
Moeö = Sample full dry weight before impregnation (g)

1.6. Pyrolysis Process

The pyrolysis process was carried out according to ASTM D 1102-84 (2021) standards. Wood samples prepared in tolerant dimensions (110x20x20 mm) were placed inside a steel wire cage and subjected to 1300 °C light blue flame combustion using a blowtorch. Flame combustion was carried out for 5 minutes for spruce samples and an average of 8 minutes for beech-acacia and chestnut samples. Afterwards, the charred part on the surfaces was scraped off with a planing machine and samples with dimensions of 100x10x10 mm were prepared. The flammability of combustible materials that have undergone ignition is determined by the oxygen index test. This value indicates the amount of oxygen that must be present in the environment for combustion to continue; it determines exactly how the combustion process takes place and the amount of carbon in the residues and decomposable organic matter after combustion ASTM 2863-09.

1.6. Evaluation of Data

SPSS statistics program was applied to evaluate the data. Homogeneity groups were formed by analyzing values resulting from wood type effect and % concentration change and simple variance analysis was applied.

2. RESULTS AND DISCUSSION

2.1. Solution Properties

Solution properties are given in Table 1. There was no significant change in solution pH and densities.

Table 1. Seaweed Extract Properties.

Impregnation Material	Concentration (%)	Temperature (ºC)	pH		Density (g/ml)	
			BI	AI	BI	AI
Seaweed	1%	22ºC	7.46	7.46	0.992	0.992

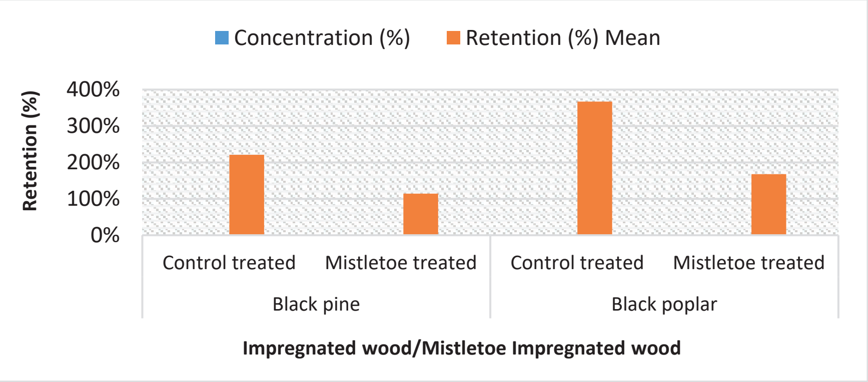
BI: Before impregnation **AI:** After impregnation

2.2. Retention (%)

The net dry impregnation material remaining amount as (%) is given in Table 2 and change of retention Figure 1.

Table 2. % Retention

Wood Type	Impregnation Material (Seaweed)	Concentratio (%)	Retention (%)	
			Mean	HG
Black pine	Control treated	1%	2.20	B
	Mistletoe treated		1.14	D
Black poplar	Control treated		3.67	A
	Mistletoe treated		1.68	C



The amount of solid matter retained relative to the weight of completely dry wood (%) was determined to be lowest in poplar wood without mistletoe (3.67%) and lowest in black pine wood with mistletoe (1.14%). Mistletoe negatively affected adhesion in both wood types during the impregnation process.

Yaşar (2014), in his study using natural impregnation agents, reported that the highest retention value was 15.41 kg/m³ in sessile oak impregnated with oak acorns, and the lowest retention value was 10.95 kg/m³ in Scots pine and Taurus cedar impregnated with pine tannins. Özçifci and Batan (2009), on the other hand, found the highest retention amount in Scots pine (19.39 kg/m³ - 21.81%) and the lowest value in oak (8.742 kg/m³ - 9.15%).

2.3. Limiting Oxygen Index (LOI) Test Results

The limiting oxygen index (LOI) test results for different wood types are given in Table 3.

Table 2. Limiting Oxygen İndex (LOI)

Wood Type	Impregnation Material (Seaweed)	Concentratio (%)	LOI (%)	
			Mean	HG
Black pine	Control treated	1%	26.5	E
	Control untreated		32.5	A
	Mistletoe treated		31.4	B
Black poplar	Control treated		27.2	D
	Control untreated		25.5	F
	Mistletoe treated		28.5	C

According to the limiting oxygen index (LOI) test results after pyrolysis for all wood types; When the table is examined, the highest LOI value was observed in the impregnation of Scots pine wood with seaweed extract (32.5%), while the lowest LOI value was observed in the control samples. In particular, the nitrogen, phosphorus, potassium, calcium, magnesium, iron, zinc, and copper content in the seaweed positively affected the combustion parameter. The LOI value showed a more favorable performance in the impregnated samples compared to the control sample.

CONCLUSION

The technological and mechanical properties of wood can be studied by examining their variations with a wide range of impregnation agents and methods, depending on their intended use. To conserve the valuable forest resources of our country and improve the durability of wood in all environments, it is suggested that various impregnation agents and their different concentrations be tested to investigate increases, decreases, and changes in mechanical properties and durability. The magnesium and other components present in the structural composition of this type of ecological organic material have had a positive effect on combustion (pyrolysis).

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