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DETERMINATION OF PHENOLIC SUBSTANCES AND ANTIOXIDANT ACTIVITY IN SOME TREE BARK EXTRACTS

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Abstract

In this study, the total amount of phenolic substances and antioxidant activity were determined in extracts obtained from the barks of three coniferous (scots pine, spruce, cedar) and eight deciduous (poplar, chestnut, oak, pseudoacacia, beech, eucalyptus, iron and mimosa) tree species. The tree barks were extracted with alcohol: benzene (1: 2 v / v) solvent according to the TAPPI T 204 cm-07 standard. The antioxidant activities (AA) of the extracts were determined by the capture activity of the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical. The total amount of phenol in the contents of the extracts (TPM (mg-GAE / g-DB)) was determined by the Folin-Ciocalteu method. This study also provides information on the antioxidant activity of the extract due to its total phenolic substance dependence on oxidation-reduction reactions, and because the total amount of phenolic substance in the bark extract has a linear relationship with TPM (mg-GAE / g-DB) and antioxidant activity (AA). In comparison to the coniferous tree barks, higher tannin content and antioxidant activity were determined in the deciduous tree (excluding beech) barks. The highest TPM (mg-GAE / g-DB) and AA were found especially in the extracts of the mimosa (*Acacia Dealbata* L.), iron (*Casuarina equisetifolia* L.), oak (*Quercus pontica* L.) and poplar (*Populus tremula* L.) species.

Keywords: Antioxidation activity, extraction, tree bark, total polyphenols analysis

1. Introduction

Wood is a natural bio-composite which consists of cellulose, hemicellulose, lignin and extractives (Rowell 2012). It has remained its significance throughout the history due to its unique properties. However, alternative materials such as iron, aluminium and steel have been tried as substitutes for wood. Its low maintenance cost, easy processing and higher quantity than these make wood a more valuable material. Moreover, as being one of the environmentally friendly materials, it has been mostly preferred for variety of applications, for example, construction, furniture, siding, decking, etc. (Rowell 2012).

As a result of natural processes, biomaterials have to decompose to complete their natural cycle (Schmidth 2006). However, this is undesirable for wood as it shortens its service life. Wood is treated with toxic chemicals, such as coper-based preservatives (CCA) to eliminate the negative effects on wood and enhance its service life (Temiz et al. 2006). These chemicals are both expensive and harmful for humans as well as the environment. The increasing susceptibility against the environment has initiated new investigations about natural preservatives. In recent years, wood bark extractives have received attention. Hundreds of studies have been carried out for this purpose (Onuorah 2000, Kartal et al. 2006, Yang 2009, Singh and Singh 2011, Tascioglu et al. 2013, Durmaz et al. 2015, Özgenc et al. 2016, Ozgenc and Durmaz 2016, Can et al., 2019).

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As wood constitutes up to 20% of trees, it is accepted as the most abundant forest residue (Fengel and Wegener 1989). Tree barks are usually left in the forest or used to obtained energy (Görcelioğlu 1973, Huş 1976). They have a complex structure consisting of main cell wall components (cellulose, hemicellulose and lignin) and extractives (Sillero et al. 2019). Meanwhile, tree barks are significantly rich in extractives in comparison to wood. Polyphenolic compounds are largely found in bark, leaves and heartwood (Hillis, 1987). Therefore, these compounds conserve the tree against external threats due to having biological activities, antioxidant activity and antifungal activity (Mihara et al. 2005). Tannins, flavonoids, lignans, stilbenes, terpenes and terpenoids have been recognised as components of extractives with high protective properties (Sing and Sing 2011, Tascioglu et al. 2013). While stilbenes have fungistatic and fungitoxic properties, tannins also inhibit fungal growth (Harun and Labosky 2007). Free radicals could inhibit wood decay. Extractives from lignocellulosic materials could be used in medical treatment or as food preservative, wood adhesive (Piccand et al. 2019, Sillero et al. 2019). Antioxidants restrained the aggregation of free radicals, therefore preventing cellular damage and aging (Saravanakumar et al. 2019).

The objective of this study was to examine the antioxidant properties of bark extracts. The total amount of phenolic substances and antioxidant activities of bark extractives were determined in this study. The extracts of a total of 11 tree species (scots pine, spruce, cedar, poplar, chestnut, oak, pseudoacacia, beech, eucalyptus, iron and mimosa) were investigated for this purpose. Alcohol: benzene solvent was used for extraction.

2. Materials and Methods

2.1. Tree Barks

In this study, eleven tree species barks which were 30-40 years old in Turkey, including scots pine (*Pinus sylvestris* L.) from Trabzon, cedar (*Cedrus libani* L.) from Antalya, spruce (*Picea orientalis* L.) from Gümüşhane, poplar (*Populous tremula* L.) from Giresun, chestnut (*Cestanea sativa* L.) from Aydın, acacia (*Robinia pseudoacacia* L.) from Trabzon, oak (*Quercus pontica* L.) from Trabzon, beech (*Fagus orientalis* L.) from Gümüşhane, eucalyptus (*Eucalyptus globulus* L.) from Antalya, iron (*Casuarina equisetifolia* L.) from Trabzon and mimosa (*Acaccia dealbata* L.) from Trabzon were provided. The tree barks were dried at room temperature (~25°C).

2.2. Bark Extraction

Tree air-dried tree barks were ground with a laboratory-scale Willey mill to obtain 40-60-mesh bark powders. The bark powders were subjected to extraction with alcohol: benzene (1:2 v/v) solution in a Soxhlet extractor for 6 hours for the softwood species and for 4 hours for the hardwood species. The solvents from the extracts were concentrated with a rotary evaporator at 50°C and stored in sealed flasks at 4°C until use.

2.3. Determination of Total Phenolic Content

The total phenolic content of extracts was determined by the Folin-Ciocalteu method at 765 nm with a spectrophotometer (PG Instruments, T60/Leicestershire, the United Kingdom). A 0.1 ml aliquot of extract was combined with 0.1 ml Folin-Ciocalteu reagent, 2 ml of 2% (w/v) sodium carbonate and 2.8 ml deionised water.

2.4. Determination of antioxidant activity

The antioxidant activities of the extracts were evaluated with 2-diphenyl-1-picrylhydrazyl (DPPH) according to the method described by Yu et al. (2005). The following equation was used to determinate the inhibition of DPPH.

$$\% \text{ Inhibition} = (\text{Xcontrol} - \text{Xsample}) / \text{Xcontrol} \times 100 \quad (1)$$

Where Xcontrol is the absorbance of control at 517 nm and Xsample is the absorbance of sample at 517 nm. Antioxidant capacity was stated as mg Trolox/g dried bark extractives (mg-TE/g-DB). Three repetitions were made for each experiment.

3. Results

The total phenolic content (TPC) and antioxidant activity (AA) of the tree bark extracts of three different coniferous species and eight different deciduous species were examined. As seen in Table 1, the TPC and AA of the bark extracts were very impressive. It is shown that the total phenolic content of the bark extracts was mostly compatible with antioxidant activity. The variety of compounds especially stocked in heartwood influence the durability of wood (Schmidth 2006). Tannins included in the class of phenolics are important components of tree barks (Aydın and Üstün 2007). In general, flavonoid monomers up to 20 constitute tannins (Pizzi et al. 1986). Flavonoids are also effective on antioxidant activity (Yu et al. 2005).

According to the obtained results, the antioxidant activity of extracts was found to be higher in the deciduous tree bark extracts than the coniferous species. The highest AA activity was found to be in mimosa (91.30) for the deciduous species, while it was in spruce (81.52) for the coniferous species. Indeed, there was a gap between the coniferous and deciduous species. Meanwhile, the lowest AA was found from cedar bark extract for the coniferous species, while it was found from beech tree bark extract for the deciduous species.

The total phenolic content of the bark extracts is almost all in parallel with their antioxidant activity. Likewise, the TPC values of the deciduous tree bark extracts were higher than the coniferous tree bark extracts. Similarly, a big difference was also seen in the TPC results. It was seen that the highest total phenolic contents were found from the mimosa, iron, oak and poplar tree bark extracts, respectively. On the contrary, the lowest phenolic contents were in the beech, cedar, and pine tree bark extracts, respectively.

Table 1: Total Phenolic Content (TPC) and antioxidant activity (AA) of bark extracts.

Tree Species	TPC (mg-GAE/g-DB)	AA (%)
Pinus sylvestris L.	56.6 ± 2.2	68.9 ± 1.4
Picea orientalis L.	86.6 ± 2.6	81.5 ± 2.2
Cedrus libani L.	46.6 ± 2.1	63.6 ± 1.8
Populus tremula L.	117.1 ± 2.5	89.3 ± 2.2
Castanea sativa L.	79.8 ± 1.6	90.6 ±2.3
Queercus pontica L.	119.7 ± 3.1	91.1 ± 2.1
Robinia pseudoacacia L.	71.3 ± 1.8	87.2 ± 2.0
Fagus orientalis L.	35.6 ± 1.4	41.5 ± 1.6
Eucalyptus globulus L.	69.0 ± 1.7	88.5 ± 1.9
Casuarina equisetifolia L.	121.5 ± 2.6	90.5 ± 1.9
Acaccia dealbata L.	215.5 ± 2.8	91.3 ± 2.0

4. Discussion

Natural durability is defined as resistance against bacteria, fungi, beetles and marine borers without any treatment of wood (Schimdth 2006). At this point, it may be stated that wood extractives are responsible for natural durability. The main component of extractives is phenols such as terpenoids, flavonoids, stilbenes and tannins. These components have an effect on inhibiting fungal activity. For this purpose, the phenolic content of extractives is the most important parameter, if it is desired to evaluate them as wood preservatives. As known, plant extractives, having a potential, have been investigated to be used as natural wood preservatives in recent years (Kartal et al. 2006, Mohan et al. 2008, Yang 2009, Tascioglu et al. 2013).

In this study, the TPC contents of the tree barks were found to be low as in comparison to those reported by Sillero et al. (2019). They examined the barks of six different species and found these values to vary between 178.11 to 635.08 mg GAE/g. Piccand et al. (2019) determined the antioxidant activity of different extractives with the DPPH assay whose effectiveness is restricted in case of non-polar extractives. Therefore, they stated that the AA of the extracts was found to be low, which was compatible with our results. The solvent plays an important role to determine the TPC and AA of bark extractives.

Deciduous wood species had the highest phenolic contents. Especially the mimosa bark extractives had the highest TPC. It is known that phenolic components play a protective role against UV light (Volf et al. 2014). Therefore, the wood species which have the highest TPC and AA may be used to obtain wood preservatives, UV absorbing agents, etc. This study highlighted the importance of tree bark extracts which can be utilised in the preservative industry as well as the medicine, cosmetic and food industries.

5. Conclusion

Tree bark is regarded to be forest residue which is abandoned to decay in the forest. In this study, a total of 11 tree species were evaluated to determine the phenolic content and antioxidant activity of their barks. Therefore, it was aimed to propose various application fields. According to the obtained results, the total phenolic content and antioxidant activity of the extracts were found to be considerably high. TPC and AA results were obtained from the deciduous tree species. In particular, the best results were obtained from the mimosa, iron, oak and poplar tree bark extracts. The AA and TPC values of the coniferous species were low as in comparison to those of the deciduous species.

Deciduous tree species with high TPC have a potential. Phenols are some of the important components of tree extracts. They are evaluated in various applications since ancient times. Tannins are prevalently used in medicine due to having antiviral, antimicrobial and antioxidant properties. Moreover, they are also important for the paint industry, ink production, anticorrosion, clarifier for beer and wine, various chemical applications and the adhesive industry.

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MODELLING WATER INTAKE PROPERTIES OF HEAT-TREATED BEECH AND SPRUCE WOOD TREATED AT DIFFERENT TEMPERATURES USING BY ARTIFICIAL NEURAL NETWORKS

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Abstract

The aim of this study is the modelling the water intake rate of heat-treated oriental beech (*Fagus orientalis* Lipsky) and oriental spruce (*Picea orientalis* (L) Link) wood samples. For this purpose, all the needed data were obtained from the beech and spruce wood samples which have been subjected to heat treatment with four different temperatures (130, 150, 180 and 200 °C) and three different periods (2, 6 and 10 hour) and then which have been subjected to the water intake process at certain periods (2, 4, 8, 24, 48, 72, 168 and 336 hour). Data were modeled using artificial neural networks (ANN) method for both tree species in terms of water intake rate characteristics, separately. Two different learning algorithms (Levenberg-Marquardt (LM) and Scaled Conjugate Gradient (SCG)) were used for the modelling process. In order to achieve the best model, all nodes between 1 and 25 were tested as hidden neuron. A total of 100 models were obtained and 2 models were chosen according to the performance of the models. For two wood species, LM learning algorithm had showed better results than SCG learning algorithm. The structures of the best models for beech and spruce were determined as 3-8-1 and 3-13-1 respectively. As a result, it has been concluded that ANN applications can be evaluated within the discipline of heat-treated wood industry.

Keywords: Heat treatment, beech, spruce, water intake, artificial neural networks

1. Introduction

Wood is a building and engineering material which has a wide usage area with its many positive properties. However, size of the wood can change according to environmental conditions, also wood can be degraded by various biotic and abiotic factors and can be easily flame at low temperatures (Kim and Singh, 2000; Grexa and Lübke, 2001). Many studies have been carried out in order to minimize the negative properties of the wood and to increase the positive properties of the wood, and the methods used in this context are called "wood modification" (Esteves and Pereira, 2009; Sandberg et al., 2017). The wood modification methods can be effective physically and chemically. In the physical methods, wood cells are filled with inorganic or organic materials (Gindl et al., 2003; Tondi et al., 2013). In the chemical methods, it was used various chemicals that change the chemical composition of the cell wall components of the wood (Kumar, 2007; Mantanis, 2017). Wood modification methods often lead to high costs. Therefore, a more environmentally friendly, more economical, and more practical alternative methods are needed. One of the applications that meet all the mentioned conditions is heat treatment (Yildiz et al., 2006; Brosse et al., 2010).

Heat treatment is a process that holding the wood between 100-250 °C in a normal atmosphere, nitrogen gas or any inert gas environment for a certain period of time. Heat treatment is applied for many purposes: to provide dimension stabilization, to increase biological resistance, to improve the performance of surface treatment so on (Esteves and Pereira; 2009; Cheng et al., 2016; Chu et al., 2016; Chung et al., 2017).

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Artificial neural networks (ANN) are an information processing technology inspired by the information processing technique of the human brain. ANN simulates the way the biological system works. The imitated nerve cells contain neurons and these neurons connect to each other in various ways to form the network. Artificial nerve cells are similar in structure to biological nerve cells. Artificial neurons connect to each other to form artificial neural networks. Just like biological neurons, artificial neurons have sections where they receive input signals, collect and process these signals, and transmit outputs.

In this study, the water intake properties of heat-treated beech and spruce wood were investigated and the obtained data were modelled with artificial neural networks.

2. Materials and Methods

2.1. Heat Treatment

The data used in this study were obtained from doctoral thesis of Yıldız (2002).

The experimental design was consisted of a total of 12 variations. The samples were subjected to the heat treatment in an oven at four different temperatures (130, 150, 180 and 200 °C) and three different times (2, 6 and 10 hours) under the normal atmosphere condition. The heat-treated samples (3x3x1,5 cm) were dried to constant weight at 103 ± 2 ° C and their full dry dimensions and weights were measured.

The samples of the experimental and control groups were then placed in water at 20 ± 1 ° C with a weight placed on top. At the end of 2, 4, 8, 24 and 72, 168 (1 week) and 336 (2 weeks) hours, water was removed from the surface of the samples and measurements were made at the same sensitivity as before. The water intake rate was calculated as a percentage of the full dry weight, from the following Equation 1;

$$\text{Water Intake Rate (\%)} = 100 \cdot (Mi - Mo)/Mo \qquad (1)$$

where Mo is the oven dry mass (g) prior to the test, and Mi is the mass of the sample removed from the water after each period (g).

2.2. Artificial Neural Network (ANN) Modelling

ANN are structures formed by the connection of artificial neural cells. ANN consist of three main layers; Input layer, hidden layers and output layer.

- Input Layer: It is the layer where the inputs to the artificial neural network are given.
- Hidden Layer (s): The data of the input layer comes to this layer. The number of hidden layers may vary from network to network. The number of neurons in the hidden layers is independent of the number of inputs and outputs. In networks with more than one hidden layer, the number of cells between the hidden layers themselves may also be different. Although the number of hidden layers and the number of neurons in these layers increases the complexity and duration of the calculation, artificial neural network can be used to solve more complex problems.
- Output Layer: It is the layer that produces the outputs of the network by processing the information coming from the hidden layers.

ANN layers of this study were presented at Figure 1.

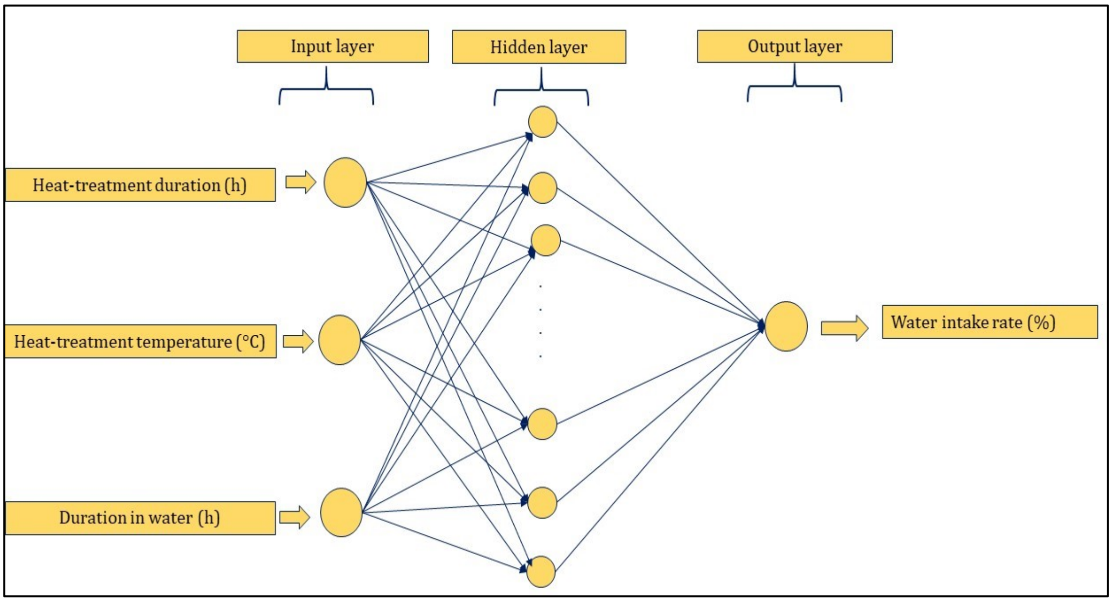

Figure 1: ANN layers of this study

The data were modeled by using ANN method, which is separate for both tree species in terms of water intake rate characteristics. 70 % of the data were used for training, 15 % for verification and 15 % for testing. Two different learning algorithms (Levenberg-Marquardt (LM) and Scaled Conjugate Gradient (SCG) were used in the modelling process. In order to achieve the best model, all numbers between 1 and 25 were tested as hidden neurons. A total of 100 models were obtained and the two best models were selected according to the performance of the models.

To determine network performance, mean square error (MSE), mean absolute percentage error (MAPE) coefficient of determination (R^2) were used. MSE and MAPE values were determined according to following Equations 2 and 3;

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(e_i - p_i)^2 \tag{2}$$

$$MAPE = \frac{1}{n}\sum\left|\frac{e_i - p_i}{e_i}\right| * 100 \tag{3}$$

where, e is the experimental result, p is the prediction result and n is the number of samples.

3. Results and Discussion

3.1. Heat Treatment

The highest and the lowest water intake rate (%) of samples were presented at Table 1.

Generally, it was observed that the water intake rate decreased as the heat treatment time and temperature increased. The changes in the sorption capacities of heat-treated wood are explained by cellulose, wood polyoses, lignin and their different thermal stability as well as their chemical structure ratios (Kollmann and Schneider, 1963).

Wood is less hygroscopic when exposed to high temperatures. The reduction in hygroscopicity depends on the combination of heat treatment time and temperature. The ratio of highly hygroscopic hemicelluloses of wood decreases at heat treated with high temperature. The explanation of the increase in dimension stabilization is based on the amount of hemicellulose in wood, which is greatly affected by the high temperature (Edvardsen and Sandland, 1999).

In theory, wood is stabilized by thermally degrading hemicelluloses containing the most hygroscopic polymers in the cell wall and reducing the amount of free polar adsorption groups that can react with water (Inoue et al., 2007; Feist and Sell, 2007).

Table 1: The highest and the lowest water intake rate (%) of samples

Heat treatment temperature (°C)	Heat treatment duration (h)	Duration in water	Wood sample	
			Beech	Spruce
130	2	2 hour	18,93±1,30	73,45±3,61
		2 week	82,77±2,72	155,38±5,30
	6	2 hour	13,56±2,72	71,17±6,20
		2 week	80,38±2,95	158,99±5,56
	10	2 hour	20,43±1,42	68,17±3,53
		2 week	71,32±2,34	165,65±8,42
150	2	2 hour	14,61±2,88	66,73±4,29
		2 week	82,80±2,17	135,25±2,88
	6	2 hour	20,33±1,69	60,67±9,40
		2 week	77,46±3,73	154,18±8,18
	10	2 hour	10,28±1,68	48,88±13,10
		2 week	82,51±4,79	154,63±5,38
180	2	2 hour	14,79±0,85	31,85±3,30
		2 week	73,75±2,77	162,26±3,53
	6	2 hour	12,77±1,59	67,67±7,69
		2 week	68,71±3,05	160,28±5,27
	10	2 hour	12,43±0,46	71,62±4,58
		2 week	63,08±3,10	154,50±5,32
200	2	2 hour	15,12±2,74	59,87±4,43
		2 week	61,02±3,86	143,00±6,42
	6	2 hour	10,91±5,49	71,19±4,95
		2 week	68,53±5,09	150,92±5,19
	10	2 hour	17,66±3,87	51,48±7,80
		2 week	74,22±4,53	154,15±9,62

In many studies, changes in dimensional stability of wood samples such as beech, alder, oak, eucalyptus, poplar, scotch pine, birch, spruce, fir, such as has been investigated specially in temperatures between 100-230 degrees and 2-48 hours of heat treatment applications. In these studies, dimension stabilization up to 55-90% has been achieved, usually depending on the technique used with increasing temperature and time (Bekhta and Niemz, 2003; Rowell et al., 2009; Srinivas and Pandey, 2012).

3.2. Modelling

For both tree species, better results were obtained from LM learning algorithm rather than SCG learning algorithm. The structures of the best networks for beech and spruce were determined as 3-8-1 and 3-13-1, respectively. Performance of optimum model for beech and spruce were presented at Table 2 and 3, respectively.

Table 2: Performance of optimum model for beech

	Training	Validation	Test	All
MSE	1,256958	4,672605	4,299709	2,198807
MAPE	2,173973	4,925614	4,814419	2,960319
R^2	0,998647	0,99291	0,992862	0,997489

Table 3: Performance of optimum model for spruce

	Training	Validation	Test	All
MSE	0,67048	11,51173	5,156684	2,26709
MAPE	0,794216	2,277427	2,030294	1,077476
R^2	0,999659	0,996869	0,989868	0,998865

Real value and ANN results for beech and spruce were presented at Figure 2 and 4, respectively. Also, coefficient of determination (R^2) for beech and spruce were presented at Figure 3 and 5, respectively.

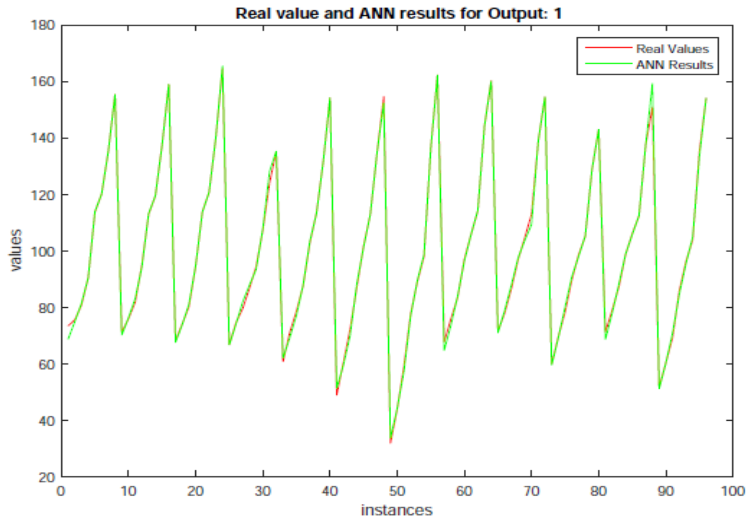

Figure 2: Real value and ANN results for beech

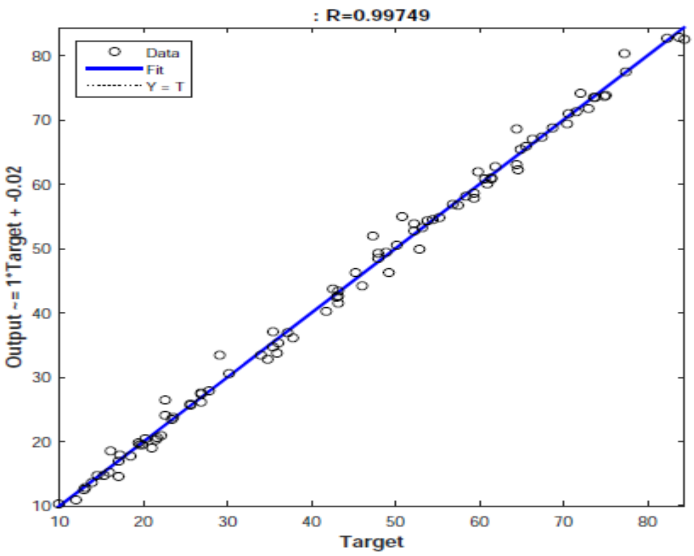

Figure 3: Coefficient of determination for beech

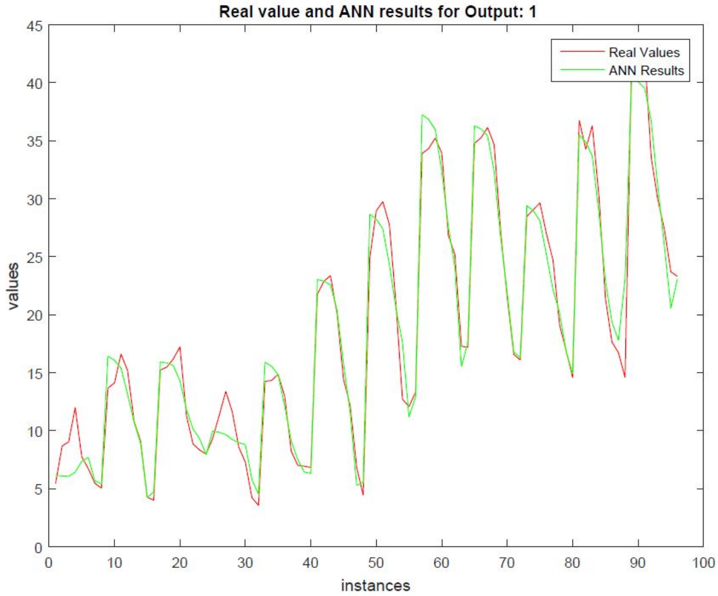

Figure 4: Real value and ANN results for spruce

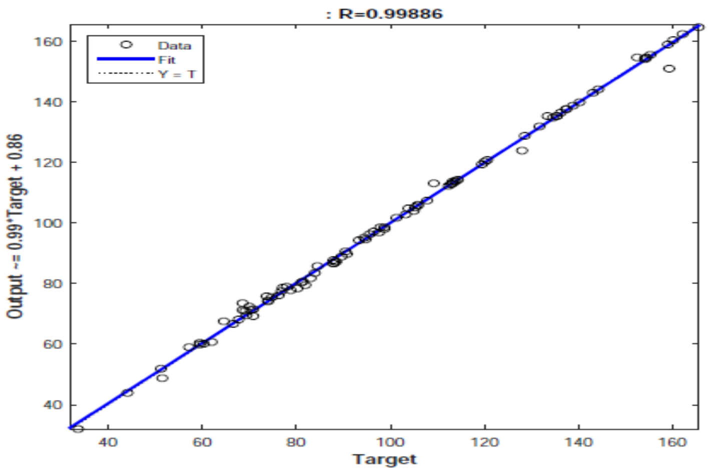

Figure 5: Coefficient of determination for spruce

It can be concluded that the closer coefficient of determination (R^2) value to 1 means that the higher the predictive success of the model. In this study, R^2 values were determined as 0.997 and 0.998 for beech and spruce samples, respectively. It can be deduced that, under the same extraction conditions, when ANN is used to estimate the experiments studied, the model predicts the values of spruce somewhat more accurately than the values of beech samples.

4. Conclusion

In this study, water intake rate of heat-treated beech and spruce were modelled using ANN.

Important findings can be sorted as below;

- Generally; it was observed that the water intake rate decreased as the heat treatment time and temperature increased.
- Wood is less hygroscopic when exposed to high temperatures.
- Heat-treated spruce wood samples were more hygroscopic than the heat-treated beech wood.
- The structures of the best networks for beech and spruce were determined as 3-8-1 and 3-13-1, respectively.
- The predictability of model for spruce were better than model for beech.

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THERMAL CONDUCTIVITY OF CROSS LAMINATED TIMBER (CLT) WITH A 45° ALTERNATING LAYER CONFIGURATION

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Abstract

Cross-laminated timber (CLT) has increasingly become a viable alternative to other structural materials, mainly because of its excellent properties related to sustainability, energy efficiency, and speed of construction. This has resulted in the recent emergence of a significant number of CLT buildings constructed around the world. Cross-laminated timber panels consist of lumber boards stacked and glued in layers, which run perpendicular to each other, making them dimensionally stable with high in- and out-of-plane strength and stiffness. Thermal conductivity is used to estimate the ability of insulation of material. Thermal conductivity of wood material has varied according to wood species, direction of wood grain, specific gravity, moisture content, resin type, and addictive members used in manufacture of wood composite panels. The aim of this study is the comparison of two types of CLT panels consisting of boards either with grain direction aligned at 45° or at 90°, in terms of their insulation properties. In the study, spruce (*Picea orientalis L.*) was used as a wood species, and was used polyurethane for CLT panels. Thermal conductivity of CLT panels was determined according to ASTM C 518 & ISO 8301. As a result of this study, it was indicated that thermal conductivity values for 90° layers were higher than the values for 45° layers.

Keywords: Cross-laminated timber, grain direction, spruce, thermal conductivity

1. Introduction

In facing the global warming trend, there is a dire need for more effective measures to sustain comfortable temperatures in living environments. To sustain an indoor temperature that is independent of outdoor temperature fluctuations, materials are needed to be developed that have superior thermal insulation abilities (Kawasaki and Kawai 2006). Wood has been intensively used as residential construction material due to its natural beauty and great properties, such as high specific strength, thermal insulation, and ease of handling and processing (Kilic et al. 2006). For example, wood's low thermal conductivity and good strength make it of special interest for building construction, refrigeration, automobile applications, and cooperage, among others (Gu and Zink-Sharp 2005; Sahin Kol and Altun 2009; Aydin et al., 2015). Technological improvements in mass timber engineering have created a renewed sense of purpose and a more versatile use of wood as a building material. Combined with environmental issues, the importance of wood-based structures is becoming more evident compared with steel and concrete, which in turn will promote further advancements toward sustainable construction solutions (Fredriksson, 2003; Buck et al., 2016). Reducing energy consumption of buildings is required in order to counteract global warming induced by carbon dioxide, and thermal insulation of a building is an important part of this process. One of the development concepts used in the design of insulation materials is to aim to achieve a low thermal conductivity (k-value). An alternative development concept is to aim to use environmentally friendly products (Sekino, 2016).

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Timber constructions have undergone a revival of popularity over the last years; this positive trend is associated to a combination of several factors. Firstly, wood-based structural products generate fewer pollutants compared to the mineral-based building materials (e.g. steel and concrete) because they are obtained from sustainable and renewable resources. Secondly, timber structural elements are prefabricated off-site and transported to the building location, where they are quickly assembled. Finally, the high strength-to-weight ratio of wood is a great advantage for structures erected in seismic-prone areas, because it limits the total mass of the buildings (Izzi et al., 2018). Cross-laminated timber (CLT) is an innovative engineering wood panel product made from gluing layers of solid-sawn lumber at perpendicular angles. Owing to the excellent structural rigidity in both orthogonal directions, CLT becomes a preferred construction material for shear walls, floor diaphragms, and roof assemblies. CLT is normally made of Spruce-pine-fir (SPF) lumber or Douglas fir-Larch lumber (He et al., 2018). Cross-laminated timber (CLT) is an engineered wood product that is playing a major role in the worldwide push for wood buildings taller than the conventional limit of 5–6 stories for light-frame wood construction (Sullivan et al., 2018). It can also be combined with other mass timber produces such as glulam beams and columns (Bolvardi et al., 2018). The higher strength, stiffness, and solid wood volume of CLT, compared to conventional light frame construction, are the specific characteristics enabling the increased building heights of wood structures (Sullivan et al., 2018).

With the increasing adversity of climate changes from global warming, discussions within the international community for establishing an appropriate response policy have become more urgent (Seo et al., 2011). In facing the global warming trend, there is a dire need for more effective measures to sustain comfortable temperatures in living environments. To sustain an indoor temperature that is independent of outdoor temperature fluctuations, materials are needed to be developed that have superior thermal insulation abilities (Kawasaki and Kawai, 2006). Thermal conductivity is a very important parameter in determining heat transfer rate and is required for development of thermal insulation of materials (Sahin Kol and Altun, 2009). Several studies about thermal conductivity of composite materials showed that thermal conductivity was influenced thickness of composite materials, density, moisture content, temperature, material space ratio and flow direction of heat (Suleiman et al., 1999; Bader et al., 2007; Sonderegger and Niemz, 2009; Aydin et al., 2015).

The aim of this study is the comparison of two types of CLT panels consisting of boards either with grain direction aligned at 45˚ or at 90˚, in terms of their insulation properties. In the study, spruce (*Picea orientalis L.*) was used as a wood species, and was used polyurethane for CLT panels. Thermal conductivity of CLT panels was determined according to ASTM C 518 & ISO 8301.

2. Materials and Methods

In this experimental study, 20 mm-thick lumber with the dimensions of 100 mm by 100 mm were obtained from Spruce (Picea orientalis L.) logs. The average moisture content was 12±3% as determined by the oven dry method according to EN 322 (1999). Afterwards, the lumber processed both edgewise and flatwise through a jointer, the dimensions of each individual board were 16 mm in thickness and 85 mm in width. Three-layer-CLT panels with 48 mm thick were manufactured by using Polyurethane (PUR) glue resin. The glue was applied at rate of 160 g/m^2 to the single surfaces of lumbers. After gluing, it was formed CLT panel drafts. The draft of CLT panels is shown in Figure 1. Two types of CLT panels were produced: transverse layers at 45° and the conventional 90° arrangement. Press pressure was 8 kg/cm^2 while pressing time and temperature were 40 min and 40°C, respectively. Two replicate panels were manufactured for each test groups. Test samples were conditioned to achieve equilibrium moisture content at 20 °C temperature and 65% relative humidity prior to testing.

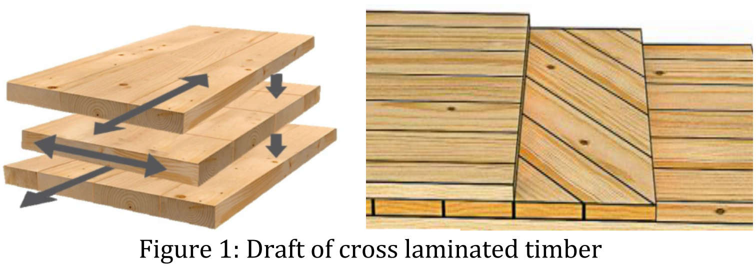

Figure 1: Draft of cross laminated timber

The thermal conductivity of the cross laminated veneer were determined according to ASTM C 518 & ISO 8301 (2004). The required sample size is 300×300×panel thickness mm. Two specimens were used for each group. The tests were made at laboratory of Forest Industry Engineering in KTU. The Lasercomp Fox-314 Heat Flow Meter shown in Figure 2 was used for the determination of thermal conductivity.

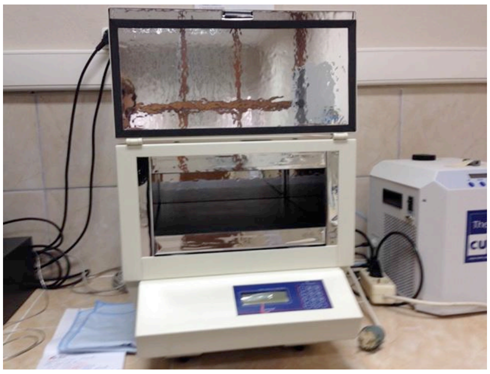

Figure 2: Lasercomp Fox-314 heat flow meter

3. Results and Discussion

As a result of this study, it was indicated that thermal conductivity values for 90˚ layers were higher than the values for 45˚ layers. The thermal conductivity values in the 45° alternating CLT layers was found to be 0,1015 W/mK and in the 90° alternating CLT layers it was found to be 0,1032 W/mK (Table 1). Wood is a hygroscopic, porous material. The unique structure of wood causes the anisotropic nature of wood in its mechanical and physical properties. Thermal conductivity of wood has been studied by many scientists (Festus et al., 2017). Several studies about thermal conductivity of composite materials showed that thermal conductivity was influenced thickness of composite materials, density, moisture content, temperature, material space ratio and flow direction of heat (Suleiman et al., 1999; Bader et al., 2007; Sonderegger and Niemz, 2009; Aydin et al., 2015). The thermal conductivity of wood varies in the three main directions of wood as they are usually referred to in the wood lumber industry – Longitudinal direction (parallel to the grain, along the length of a tree), Radial direction, (perpendicular to the grain, along the radius of the cross section) and Tangential direction (perpendicular to the grain, tangent to each growth ring) (Festus et al., 2017).

Table 1: Thermal conductivity values of CLT panels

Groups	Thermal Conductivity (W/mK)
45° alternating CLT	0,1015
90° alternating CLT	0,1032

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PRODUCTION OF *PLEUROTUS OSTREATUS*, *PLEUROTUS CITRINOPILEATUS* AND *PLEUROTUS DJAMOR* IN DIFFERENT CONTENTS AND SOME PHYSICAL ANALYSIS

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Abstract

In this study, some physical properties of oyster mushroom (*P. ostreatus*), yellow oyster mushroom (*P. citrinopileatus*) and pink oyster mushroom (*P. djamor*) were investigated. Waste sawdusts of beech, alder, chestnut and walnut wood were used as substrate. After sterilization of sawdusts, %3 mycelium and %1 calcitic lime were added to the sawdusts and placed in the nylon bags. There was only one type of sawdust in each nylon bags. The temperature of the cultivation room was 15±2 ºC, the humidity was 80 - 90%, and ventilation was made at certain intervals. In the study, while the micellization was the fastest in the *P. citrinopileatus* mushroom type grown on the beech sawdust substrate, it was the slowest in the *P. djamor* mushroom type grown on chestnut sawdust substrate. P. djamor, grown on chestnut sawdust, has been the mushroom type generally had the lowest width-length measure. For *P. ostreatus* grown on beech sawdust compost had the highest width-length dimensions. The lowest yield was seen (19.77%) in the *P. djamor* grown on the chestnut sawdust substrate. The highest yield was observed in *P. citrinopileatus* species grown on beech substrate with 31.02%. Following this, *P. ostreatus* grown on beech sawdust substrate was very close to *P. citrinopileatus* with 30.99% yield. The lowest biological activity rate was seen in (38.22%) *P. djamor* which grown on chestnut sawdust substrate. The highest biological activity rate was in *P. citrinopileatus* grown on beech sawdust substrate with 70.93%.

Keywords: *P. ostreatus*, *P. citrinopileatus*, *P. djamor*, physical analysis, wooden substrate, micellization, mushroom quality and yield, biological activity

1. Introduction

As known that *pleurotus* species fall into the category of non-wood forest products. Although there are about 40 species, 3 important species have been studied in this study (Jose and Janardhanan 2001). Oyster mushrooms are formed by decomposing lignocellulosic composts thanks to their enzymes (Zadrazil, 1978). Due to its easy breeding techniques and wide adaptability, *P. ostreatus* has an important role in recycling organic waste (Das and Mukherjee, 2007). Besides, they do not require environmental control and can be grown simply and cheaply (Josiane et al., 2018).

Oyster mushroom that is grown by imitating natural conditions has an important place in the country's economy (Josiane et al., 2018). Increasing population and diversifying agro-industrial wastes reach large volumes and cause environmental problems as well as commercial exploitation. These wastes are sometimes left in the field, and sometimes they are desired to be eliminated by burning. However, incinerated wastes return to the atmosphere as carbon dioxide, which causes the release of greenhouse gases that cause global warming. *Pleurotus* mushroom comes into play at this point and turns the waste, which is a problem for disposal, into three main outputs, making it beneficial to the environment and living beings. First, useful compost is created by using lignocellulosic waste. As the second output; A value-added product with very high nutritional value is obtained from composts. As the third output; Composed composts after mushroom production are used as animal feed or fertilizer. The composts content can be prepared depend to region. The variety of agricultural or forest waste in its content creates differences in the oyster taste, nutritional value, scent and texture of the oyster.

Today, oyster mushrooms are produced from many different composts and these are compared in terms of their nutritional values (Yıldız et al., 2017a; Yılmaz et al., 2016; Yılmaz et al., 2017).

The main aim of the study is to investigate the usage possibilities of wood production wastes in oyster production. It is also to put forth how which type of waste effects mycelium growth and mushroom quality and compare with each other.

2. Materials and Methods

The project was carried out in the laboratories of the Eastern Black Sea Forestry Research Institute and in the laboratories of the Karadeniz Technical University, Faculty of Forestry, Department of Forest Industry Engineering, Forest Biology and Wood Protection Technology Department.

2.1. Materials

For the preparation of compost, the waste parts of the furniture production woods were used. Waste wood pieces which are consist of alder, walnut, beech, and chestnut tree species were turned into sawdust (Figure 1). Micelles, chemicals and auxiliary elements required were provided from private companies.

2.1.1. Compost Content and Preparation

Wood wastes that were turned into sawdust were sterilized in autoclave at 121 °C for 30 minutes in order to eliminate harmful organisms. After this process, they were allowed to cool. The prepared composts were then filled in polypropylene bags in size of 29 x 45 cm-4 as 1 kg for each variation as seen Figure 1 (Yıldız et al., 2002). Mycelium inoculation was carried out in a sterile cabinet with the help of a sterile spatula by inoculating 3% mycelium to the upper part of the bags. 1% calcitic lime was added to the bags to regulate the Ph balance. The remaining 96% was wood sawdust (Şanlı, 2014). Only one type of wood sawdust was used in each bag. Combination variations with different wood species have not been investigated. The reason composts are of one type is to compare the impact and performance of wood on oyster mushrooms.

Figure 1: Compost materials and bags

2.1.2. Inoculation and Harvesting

Inoculated blogs were followed in the micelle development room where containing 25 ± 2 °C and 70-80% humidity also suitable light and ventilation. After the mycelium development was completed, 5 cm wide cuts were made on both side surfaces of the bags to encourage mushroom formation. The mushrooms were mostly harvested by cutting them from the surface with a knife when they reached the same size (Figure 2).

Figure 2: Growth mushrooms for measurement and analysis.

2.2. Methods

2.2.1. Measurement and Analysis

2.2.1.1. Mycelium Growth Rate: After the inoculation process, mycelium growth around the bag was daily evaluated.

2.2.1.2. Mushroom Quality Analysis: Cap length, cap width, stipe length and stipe width values were measured on the mushrooms.

2.2.1.3. Total Yield and Biological Efficiency Rate: Oyster mushroom yield was calculated as total fresh weight of mushrooms obtained from 4 flushes in the harvest period (Royse, 1985). Biological efficiencies were calculated as the percentage ratio of the fresh weight of harvested oyster mushrooms over the dry weight of substrates (Chang et al., 1981).

3. Results

3.1. Mycelium Growing Time

P. ostreatus (white oyster mushroom), *P. citrinopileatus* (yellow oyster mushroom), and *P. djamor* (pink oyster mushroom) were cultivated on four different wooden sawdusts (alder, walnut, beech, and chestnut) The mycelium growth duration (day) was presented in Table 1.

Table 1: Mycelium Growth Duration (day) of Cultivated Oyster Mushrooms

Substrates	**Oyster Mushroom (X ± SD)**		
	White Oyster	**Yellow Oyster**	**Pink Oyster**
Alder	18 ± 0.82[a]	16 ± 0.82[a]	20,3 ± 0.96[a]
Walnut	18 ± 0.82[a]	15,5 ± 0.58[b]	20,3 ± 0.96[a]
Beech	16,5 ± 1,29[a]	13 ± 0,82[b]	20 ± 0,82[a]
Chestnut	19,8 ± 1,26[b]	18,3 ± 0,5[c]	21,3 ± 0,96[a]

[a] Means having the same superscript letter(s) are not significantly different (p>0.05) by Duncan's multiple range test.

3.2. Mushroom Quality Properties

The mushroom quality properties (cap length, cap width, stipe length, stipe width) of *Pleurotus* types were presented in Table 2.

Table 2: Mushroom Quality Properties of Cultivated Oyster Mushrooms

Substrates		Cap Length (cm)		Cap Width (cm)		Stipe Length (cm)		Stipe Width (cm)	
		X	Std	X	Std	X	Std	X	Std
Alder	White	2.20[a]	0.38	8.07[b]	1.36	2.63[a]	0.23	0.49[a]	0.09
	Yellow	2.46[a]	0.56	6.23[a]	2.16	2.67[a]	0.26	0.45[a]	0.19
	Pink	2.44[ab]	0.53	5.67[a]	1.77	2.67[a]	0.18	0.42[ab]	0.09
Walnut	White	2.16[a]	0.70	6.63[a]	1.36	2.63[a]	0.15	0.52[a]	0.11
	Yellow	2.36[a]	0.51	6.06[a]	1.87	2.71[a]	0.27	0.46[a]	0.12
	Pink	2.57[ab]	0.44	5.66[a]	1.71	2.66[a]	0.17	0.48[b]	0.10
Beech	White	2.30[a]	0.78	8.70[b]	1.08	2.61[a]	0.16	0.50[a]	0.16
	Yellow	2.71[a]	0.72	7.07[a]	1.40	2.61[a]	0.20	0.40[a]	0.11
	Pink	2.83[b]	0.71	6.94[a]	1.58	2.73[a]	0.29	0.38[ab]	0.10
Chestnut	White	2.13[a]	0.61	6.49[a]	1.24	2.57[a]	0.18	0.45[a]	0.08
	Yellow	2.16[a]	0.42	5.83[a]	1.08	2.63[a]	0.18	0.41[a]	0.10
	Pink	2.07[a]	0.29	5.33[a]	0.62	2.56[a]	0.10	0.35[a]	0.04

[a] Means having the same superscript letter(s) are not significantly different ($p>0.05$) by Duncan's multiple range test.

3.3. Total Yield

Total yield (%) of the *Pleurotus* types were presented in Table 3.

Table 3: Total Yield (%) of Cultivated Oyster Mushrooms

Substrates	Oyster Mushrooms (X ± SD)		
	White Oyster	**Yellow Oyster**	**Pink Oyster**
Alder	25,04 ± 1,68[a]	25,15 ± 3,74[ab]	22,73 ± 1,26[b]
Walnut	22,04 ± 4,19[a]	28,29 ± 2,29[bc]	21,44 ± 1,9[ab]
Beech	30,99 ± 3,88[b]	31,02 ± 3,55[c]	28,81 ± 2,34[c]
Chestnut	21,74 ± 1,07[a]	21,42 ± 1,09[a]	19,77 ± 1,07[a]

[a] Means having the same superscript letter(s) are not significantly different ($p>0.05$) by Duncan's multiple range test.

3.4. Biological Efficiency

Biological efficiency (%) of *Pleurotus* types were presented in Table 4.

Table 4: Biological efficiency (%) of Cultivated Oyster Mushrooms

Substrates	Oyster Mushroom (X ± SD)		
	White Oyster	Yellow Oyster	Pink Oyster
Alder	53,75 ± 2,29[b]	58,72 ± 5,39[b]	49,45 ± 3,42[c]
Walnut	54,65 ± 8,38[b]	62,04 ± 4,07[b]	44,75 ± 2,31[b]
Beech	61,16 ± 5,32[b]	70,93 ± 7,04[c]	66,57 ± 1,93[d]
Chestnut	42,50 ± 2,16[a]	41,60 ± 2,32[a]	38,22 ± 2,16[a]

[a] Means having the same superscript letter(s) are not significantly different (p>0.05) by Duncan's multiple range test.

4. Discussion

4.1. Mycelium Growing Time

In the study, when considering the duration for the mycelium to spread out to the bag, it was determined that *P. citrinopileatus* growing on beech sawdust completed the development within 13 ± 0,82 days, as earliest. *P. djamor* mushroom grown in chestnut sawdust was also completed its mycellium development with 21,3 ± 0,96 days, as latest. (Table 1). Küçükomuzlu and Pekşen (2005) reported that *Pleurotus* spp. produced from straw and bran compost have showed the fastest mycelium development with 39.50 days. In another study, the mycelium development period for *P. ostreatus* was reported as between 28-36 days (Upadyay and Vijay, 1991). In another study, three types of *Pleurotus; P. sajor-caju, P. platypus* and *P. citrinopileatus* mushrooms were grown on a variety of agricultural wastes, such as rice straw, corn stalk, sugar cane pulp, coconut fiber and mixtures of these wastes. The beginning of primordium was observed 22-27th days (Ragunathan et al., 1996). Ragunathanand and Swaminathan (2003), in their similar study, cultivated three species of *Pleurotus*; *P. sajor-caju*, *P. platypus* and *P. citrinopileatus*, on different agricultural wastes (cotton stalk, coconut fiber, sorghum stems and mixtures of these wastes). Primordium beginning was observed between 21 and 30 days. The results of the cultivation of *P. djamor*, *P. ostreatus*, and *P. pulmonarius* species on coffee waste and wheat straw are scrutinized. Primordium growing time was given as 11-12 days in the wheat straw substrate for *P. djamor* at the earliest and 16-32 days for *P. pulmonarius* mushroom at the latest. The same values varied between 13 and 31 days in coffee waste (Salmones et al., 2005). In another study, according to the growing substrate and mushroom species, the mycelium growing time is specified between 2-8 weeks by Oei (1991). In a study, mycelium growth rates of substrates inoculated with five different *Pleurotus* species were compared after 30 days. The lowest rate of development was observed in *P. djamor* mushroom (Kalyoncu and Kalmış, 2007). The study was accordance with literature. Indeed, the shorter mycelium growing time was determined in this study compared to the literature. This situation can be attributed to the amount of substrates and type. In the study, the most suitable sawdust for oyster production was the sawdust obtained from beech wood. Chestnut wood sawdust were the substrate where the minimum mycelium development was obtained. Chestnut tree's natural strength and being antifungal can be associated with this result.

4.2. Mushroom Quality Properties

As seen Table 2, the shortest cap length was found in *P. djamor* mushroom growing in chestnut sawdust compost; The longest cap length was obtained from *P. djamor* mushroom grown in beech sawdust compost. Considering the cap width values, the shortest cap width in *P. djamor* mushroom growing in chestnut sawdust compost; the largest cap width value was obtained in *P. ostreatus* mushroom growing in beech sawdust compost. Considering the stipe length values, the shortest stipe length was seen in *P. djamor* mushroom grown in chestnut sawdust compost; The longest stipe length value was obtained from the *P. djamor* mushroom grown in beech sawdust compost. Considering the stipe width values, the smallest stipe width was seen in *P. djamor* mushroom grown in chestnut sawdust compost; the largest stipe width value was obtained from the *P. ostreatus* mushroom grown in walnut sawdust compost. *P. djamor* (pink oyster) grown on chestnut sawdust stands out with the lowest quality in general. *P. ostreatus* (white oyster) grown in beech sawdust compost is the best quality mushroom among the produced mushrooms. In a study, it was reported that the *P. citrinopileatus* has the largest cap (10,02 cm) and the longest stipe (5,42 cm) among *P. sajor-caju, P. florida, P. eous, P. citrinopileatus, P. fossulatus, P. flabellatus, P. platypus, P. ostreatus, H. ulmarius* mushroom species. *P. ostreatus* took the second place in terms of cap size (9,26 cm) and stipe length (3,20 cm) at the same study. Moreover, *P. ostreatus* (1,73 cm) and *P. citrinopileatus* (1,47 cm) had the thickest stipe in the reference study.

4.3. Total Yield

According to the results of the study, the lowest yield was seen in *P. djamor* mushroom grown in chestnut wood sawdust with 19.77%. The highest yield was obtained from *P. citrinopileatus* grown in beech sawdust with 31.02%. Following that, total yield of *P. ostreatus* mushroom grown in beech sawdust was very close to *P. citrinopileatus* with 30.99% (Table 3). *Pleurotus* spp, is one of the fungi that causes white rot in wood. Beech is one of the most suitable trees for producing mushroom, which is not resistant to fungal rot. In a study, beech, oak, pine, fir and hornbeam trees were selected to investigate rot fungi in the wood. The tree species most exposed to rot in the study was beech (Sertkaya et al., 2017). In another study, *P. ostreatus* gave the highest yield at the first measurement compared to other fungal species (Zhai and Han, 2018). In another study, *pleurotus* species were grown on cotton stipes. Yield was maximum in *P. citrinopileatus* mushrooms (Ragunathanand and Swaminathan, 2003). When the study is compared with the literature, it is seen that the results are in accordance with the literature. Considering the mushrooms and yield results in the study, the results of *P. ostreatus* and *P. citrinopileatus* show similarity with other studies.

4.4. Biological Efficiency

According to the results of the study, the lowest biological efficiency rate was found in *P. djamor* mushroom growing in chestnut wood sawdust with 38.22%. The highest biological activity rate was found in *P. citrinopileatus* mushroom growing in beech wood sawdust with 70.93% (Table 4). In a study, three species of *Pleurotus*, *P. sajor-caju, P. platypus*, and *P. citrinopileatus* mushrooms were grown on various agricultural wastes such as rice straw, corn stalk, sugar cane pulp, coconut fiber and a mixture of these wastes. Biological activity varied between 25.18% and 38.63% (Ragunathan et al., 1996). In another study, three species of *Pleurotus, P. sajor-caju, P. platypus* and *P. citrinopileatus* were grown on different agricultural wastes (cotton stalk, coconut fiber, sorghum stems and mixtures of these wastes). Biological activity ranged from 26.11% to 41.42% (Ragunathanand and Swaminathan, 2003). In a different study, oyster mushroom that produced from coffee waste and wheat straw have been studied. Salmones et al. (2005), found the biological efficiency rate between 30.5 and 80.5%. Industrial paper waste was investigated in the production of *P. citrinopileatus* mushrooms. Biological efficiency ranged from 3.3% to 94.5% (Kulshreshtha et al., 2013). As seen in the studies, the biological efficiency rate varies between a wide scale depending on the type of mushroom to be produced and the growing substrate. Therefore, it is seen that the results of this study also support the literature studies.

5. Conclusion

In this study, physical properties and quality analyses of the oyster mushrooms species produced in the different composts and under the specified conditions were investigated. . When oyster mushrooms want to be consumed as food, the cap part is especially consumed. It is known that the stipe part is not consumed much in general. Considered the size of the cap, the white oyster grown on beech compost can be recommended as food.

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ECONOMIC ANALYSIS OF TOY INDUSTRY TODAY AND THE IMPORTANCE WOODEN TOY IN TURKEY AND ITS COMMERCIAL VOLUME

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Abstract

With the influence of organic life and ecological approach, which is becoming widespread in the world, the use of wood materials is increasing in toy production. This situation was noticed in the transition from the plastic toy, which contains the social changes and the negative health elements, to the wooden toy with healthy materials. In this study, the studies on the development, definition, importance of the toy industry, the market data it created in years 2014-2018, its economic analysis, raw material properties and the application of these principles in the subgroup wooden toy were conducted.

As of 2018, 46.27 billion dollars of exports and 124.9 billion dollars of imports actualized worldwide. In Turkey, in general of the toy industry in 2018 despite the production of $ 97.6 million with down 34%, level of 262.9 million dollars imports, 32.8 million dollars exports with decline of 21% was realized. The EU countries are seen to be the most important foreign market for Turkey and they are targeted as market. On the other hand, for Turkey that appears to be a lower share of the world market in terms of production and trade of wooden toys, the situation of this sector that is open to investment and development creates the reasons of the research. With the data obtained as a result of the economic analysis and literature research, forecasts have been developed in order to raise the awareness of wooden toys in our country, to develop market conditions and to increase their qualifications.

This study, which is carried out by emphasizing the meaning, quantity and value of the wooden toy industry and also by determining its share in the toy industry, but also by associating it with the intra-sector market share, is capable of meeting the deficiency in the field.

Keywords: Toy, wooden toy, healthy toys, economic analysis

1. Introduction

Today, it is very important to increase awareness by ensuring functionality and continuity in wooden toy production and to contribute to the sector in the long term by improving design and innovation capability. In addition to this, with the importance of toys for child development and education, the use of healthy materials is extremely important. Therefore, healthy wooden toys should be preferred instead of toys being plastic etc. which may have the risk of having carcinogenic active substances in raw materials and dyestuffs.

Information from the earliest dates shows that the history of toys is as old as human history (Jackson, 2001). It is known that the first toys belong to Egyptians and there is a rich variety of toys (Yalçınkaya, 2004). After Anatolia which has a rich toy culture, was conquered by the Turks in the 10th century, the toy tradition has survived to the present day through cultural transfer (Akbulut, 2009). It can be said that toy making first appeared in Eyüp in the 17th century as an organized industry in Anatolia (Onur, 2005). Toy production based on wood has undoubtedly been the source of the toy industry (Demircan, 2005).

The re-rise of sustainability practices in wooden toys has been realized with the introduction of environmentalist approaches (Aydın, 2012). Therefore, they are preferred by processing its nature-friendly features, which are connected to its environmentalist structure, as they provide a safe and healthy game life (Tunç and Adıgüzel, 2020). Developing alternative strategies based on environmental and social principles with a multidisciplinary approach will be able to make wooden toys more effective in terms of sustainability.

In addition, social and economic conditions are also related to materials and production processes that are reflected through toys (Onur, 1991). Wood is generally an easy-to-use natural raw material. Various types have been used in the toy industry for many years because of its natural aesthetic structure, elasticity module and comfortable touch feeling (Friso et al., 2015). In addition, behaviors such as new consumption patterns, reuse and recycling in the sustainable design phase of wooden toys should be applied in life (Manzini and Vezzoli, 2002).

Different materials have been used in toy production since the earliest times and today plastic has taken its place as the most used material (Ak, 2006). However, the most striking factor about plastic toys was the detection of excess lead ratios in the paint on the outer surface of the toy (Bapuji and Beamish, 2007). For this reason, the suitable material to be selected for the toy must first of all be appropriate to the quality and quantity of the model it is used, to identify the material, to be used with other materials and to know its physical and chemical properties and its properties (Elibol et al., 2006).

The amount of harmful substances such as lead and cadmium in the structure of plastic etc. toys should be limited and determined according to standards (Aslan, 1997). Water-based paints used in coloring on exterior surfaces are more permanent and do not have flammable properties (Sönmez, 2000). At this point, more water-based paints should be preferred for coloring wooden toys (Elibol et al., 2006). In addition, it is stated that wooden toys can be colored with natural root dye and buckthorn, which are harmless with appropriate painting techniques, and also some colored tree species can be used (Koyuncu, 2017).

The sense of touch is important in discovering and learning and in this context, wood is superior to plastic due to the chemical coldness of plastic. At the same time, wood is accepted as a warm material as the manual connection of the wooden toy changes over time (Barthes, 1998). In recent years, due to the efforts of people to create healthy living conditions, a negative approach is seen in the market for plastic toys that damage the nature and adversely affect the environment with their reactions. As a result of these developments, the reflection on the wooden toy industry has been positive, depending on the philosophy of healthy life in the society and it has come to the fore as it is preferred in the market.

It was pointed out that the toys in the past supported the development of children more and that the materials used in this were especially natural (Metin et al., 2017). Wood, which is a natural material, is an organic-based material with fibrous and porous texture and an easily processable material with aesthetic structure due to its organic structure (Usta, 2016). Hardwoods are the best choice in the production of toys rated as educational, especially due to their high density, better wear resistance and good handling (Ebner and Petutschnigg, 2007; Wood Handbook, 2010). In addition, wooden toys survive through mass production techniques, reinterpretation of foreign forms, various ornaments and adapt to changing market conditions (Akbulut, 2009).

A good toy is a solid, durable, useful, easy-to-care toy that does not come off quickly, does not have sharp, sharp corners and can be cleaned easily (Çamur et al., 2008). It is also important that the toy is qualified, not multiplicity. Toys to be given to children should be preferred starting from the simple level to the difficult (Arıkan and Karaca, 2004). Another important issue in toy selection is the safety issue of the toy (Özmert, 2006).

In accordance with the Toy Safety Regulation, sector companies have very serious responsibilities. The Ministry of Commerce made a new regulation and determined the usage limits of some chemicals used in toys and children's equipment. In our country, amendments regarding chemical restrictions will come into effect after a year, with the regulation of the Ministry of Commerce and the industry manufacturers will comply with the usage values until December 2020.

According to the findings of the competitiveness research of the Turkish toy industry conducted on the basis of market data for the period 2007-2018, the competitive power of the Turkish toy industry is low today (Tunç and Adıgüzel, 2020). Low toy consumption compared to developed countries shows that the potential demand for toys in Turkey is too much. When Turkey's toys import and export prices are examined, it appears that the price of import is lower than the price of export and while Turkey imports expensive toys while exports value-added exports. Turkey has 0.04% share of total World imports of toys in 2108. Turkey has 0.01% share of the World total toy exports in 2018 (Pageva, 2019).

The world market in the toy sector consists of brand owner companies, national branded companies, that include contract firms, distributors and toy sales points at which production is carried out. Toy stores and supermarkets are important points for sales in meeting the toy with the consumer. However, today, toys are meeting with consumers via informatics from the Internet (Pagev, 2019).

2. Materials and Methods

Using the content analysis study, Toy World and Turkey Sector, Turkey Wooden Toys and Toy Industry production volumes, export and import volumes were examined collecting both valid data and field qualitative data. The obtained data are classified and summarized within the framework of a specific problem or purpose, and primarily the collected data are conceptualized. It was ensured that the theme explaining the data was determined by making a logical arrangement according to these concepts. The necessary comparisons and proportions are given. The reason for the world in general and Turkey's toys and wooden toys worth taking the examination, the results making comparisons is to identify both perspectives.

3. Results

In order for companies operating in the toy industry to reach new markets and customers, it will be of great benefit to develop appropriate plans and strategies together with the conditions in the market in order to make realistic economic analyses.

3.1. Status and Trade of Toy Market in the World

In order for companies operating in the toy industry to reach new markets and customers, it will be of great benefit to develop appropriate plans and strategies together with the conditions in the market in order to make realistic economic analyzes. Examining at the World Toy Trade, the world toy trade volume, which was 56 billion 775 million dollars in 2007, reached 96 billion 484 million dollars in 2018 and increased by approximately 70% (Trademap, 2019).

The import and export figures expressing the world market distribution and size for the period of 2014-2018 are shown in Table 1. When Table 1 is analyzed by years, it is seen that the total exports and imports of the world increased continuously during the period.

Table 1: Worldwide toy import and export values (Trademap 2019).

Years	2014	2015	2016	2017	2018	Variation%)
Import	45.23	45.23	46.68	49.12	50.21	11.01
Export	34.5	34.91	37.74	43.92	46.27	34.11

Total exports, which were 34.5 billion dollars worldwide in 2014, increased by 34.11% in 2018 and reached 46.27 billion dollars. In addition, total imports, which were 45.23 billion dollars worldwide in 2014, rose to 50.21 billion dollars in 2018 with an increase of 11.01%. The toy industry is seen as a growing market in the world.

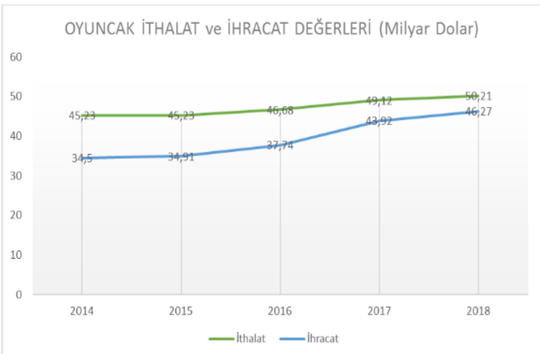

Figure 1: The status of the world toy market over the years

As seen in Figure 1, an increase rate of 11.01% in imports and 34.11% in exports is observed between 2014-2018. Considering the last 5 years, it is seen that especially in 2017, toy imports increased by 5% and exports by 14% compared to the previous year. However, compared to previous periods, 2018 shows a more steady increase and the rate is 2% in imports and 5% in exports.

The import and export figures of the 5 countries that make excessive import and export around the world in the period of 2014-2018 are included in Table 2. Considering the world in general, Europe, which has high import and export rates according to the volume ratios they create in the toy market, is the leading country, followed by the Far East countries. The USA follows these countries with the volume they create.

Table 2: Import and export countries for the world toy industry (Pagev 2019, Trademap 2019).

IMPORTER COUNTRIES			EXPORTER COUNTRIES		
Country	Value(billion$)	Share(%)	Country	Value(billion$)	Share(%)
The USA	34.4	27.6	CHINA	56.7	47.3
GERMANY	8.9	7.1	HONGKONG	7.2	6.0
JAPAN	6.4	5.1	The USA	6.8	5.7
ENGLAND	6.4	5.1	GERMANY	6.0	5.0
FRANCE	5.4	4.3	Czech Republic	3.6	3.0
Total of other countries	124.9	100	Total of other countries	119.9	100

Total toy import in the world was realized as 124.9 billion dollars in 2018 and 49.2% of the total imports were made by 5 countries USA, Germany, Japan, England and France. In the first place of the importer countries, the USA has a 30% share in the world total imports with its import of 14.75 billion dollars in 2018. Exports were realized as 119.9 billion dollars in 2018, 61% of total imports were made by 5 countries. China realized this export with a figure of 56.7 billion dollars and a high rate of 47.3%. China is also followed by the Far East country, Hong Kong.

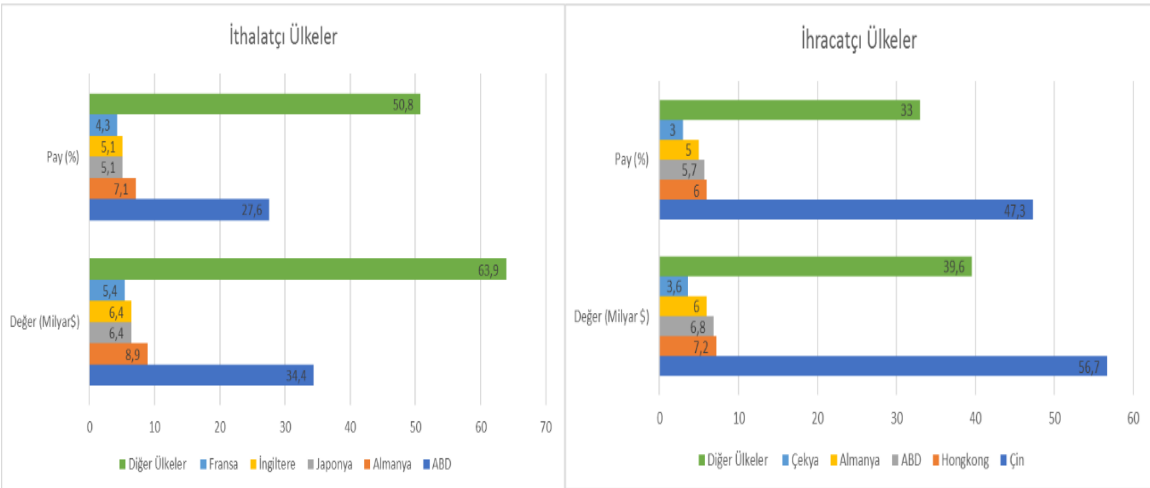

Figure 2: The toy market of the countries in the world market

As seen in Figure 2, the USA and Germany are the highest importers in terms of import and export value in the toy industry in the world, and they are in the 2nd and 3rd place after China, which has the highest export rate in the toy sector in terms of export value. On the other hand, other countries except Japan are in the European continent in the top 5 of the importing countries.

The data show us that Europe is the continent with the highest import rate and is the biggest potential buyer for our country's producers. Due to the position of Turkey, especially as logistics and quality processes are expected to receive a significant share of this market.

It is seen that the highest exporting countries in the world are China and Hong Kong in the Far East, these countries have reached these numbers with low raw material and labor costs, but they maintain their position despite their disadvantage in terms of logistics and quality.

3.2. Toy Industry Foreign Trade of Turkey

The most export from 10 countries during the period 2014-2018 exports by Turkey are set out in Table 3. Turkey's toy industry, taking into account countries with export and import data based on years 2014 and 2018 were examined.

Table 3: Turkey's toy exports by countries as of (Tredemap 2019; Bronze and Adıgüzel 2019)

	Export Cost (Thousand Dollar)										
Country	England	Iraq	Greece	Cyprus	Serbia	Iran	Italy	RF	Arabia	Germany	Total
2014	1419	2781	1.966	-	1324	523	1446	1735	848	788	41838
2018	2221	1935	1.871	1849	1559	1439	1412	1350	1322	1219	32829
Difference (%)	56	-31	-4.9	185	18	175	-2	-22	55	55	-21

As seen in Table 3; The export figure, which was 41.8 million dollars in 2014, was 32.8 million dollars in 2018, and a decrease of 21% is observed in exports. Considering the countries, there was no export for Cyprus in 2014, but it reached 1849 million in 2018 with an increase of 185%. When we look at the data of the UK in 2014 and 2018, it is observed that it is at the highest rate with an increase rate of 56%. Arabia and Germany follow England with an increase rate of 55%. As seen in the table,

European countries rank first in exports, followed by Middle Eastern countries. While making evaluations, it is observed that there is a fluctuating course in exports, as well as European countries lead the way.

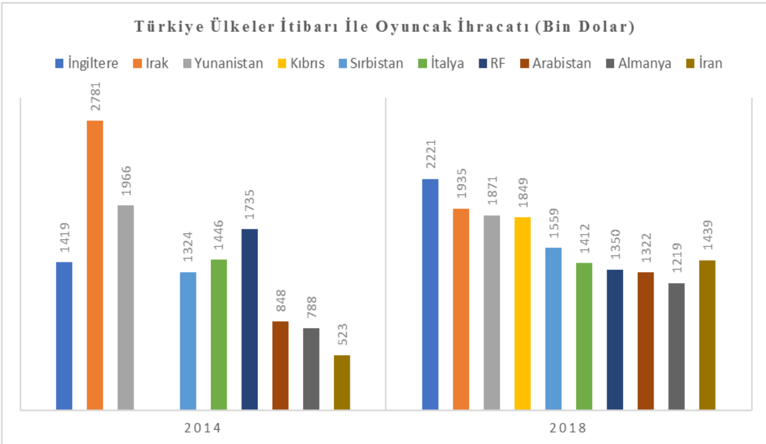

Figure 3: Toy export value of the country's reputation with Turkey

As stated in Figure 3; Turkey's toy industry exports 2014-2018 reputation is to be seen whether any country featured, $ 2.2 million with England in 2018 in total exports is the highest value of the first countries respectively Iraq, Greece, followed by Cyprus and Serbia.

Most of the imports carried out by 10 countries during the period 2014-2018 import figures as the value of Turkey are set out in Table 4. Turkey's toy industry for 2014 and 2018 based on the exchange rates are expressed examining their import rates.

Table 4: As of toy imports with countries Turkey (Trademap 2019; Bronze and Adıgüzel 2019)

	Import Cost (Thousand Dollar)										
Country	China	Indonesia	Vietnam	Czechia	Italy	Denmark	Hungary	Malesia	Tailand	Germany	Total
2014	3510 72	3264	2572	1045	4288	2854	288	2897	1390	2376	400600
2018	2306 90	6573	4337	4150	2742	2289	1686	1610	1385	886	262085
Difference (%)	-34	100	68	297	-36	-19	485	-44	-0,03	-62	-34

As seen in Table 4; Turkey's total imports during the period 2014-2018 has fluctuated. The toy import, which was 400.6 million dollars in 2014, was realized as 226.2 million dollars in 2018, and there is a decline in imports with a significant decrease of 34%. Turkey's total imports, China stands out as the most active countries. As of 2018, 230.69 million dollars of imports have been made from China. Another point that stands out in the table is that among the top 10 countries with the highest number of imports, apart from China, there are 4 Southeast Asian countries, namely Indonesia, Vietnam, Malaysia and Thailand.

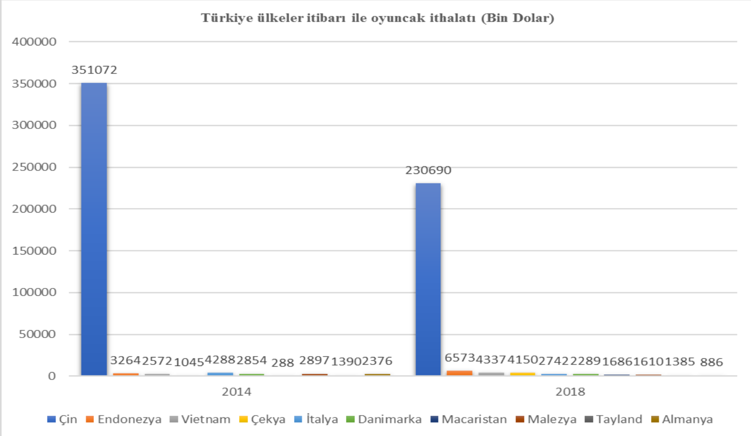

Figure 4: Turkey's toy import values with other countries

As indicated in Figure 4; In 2018, there was a 34% decrease in imports from China, but an increase in Indonesia and Vietnam, other Far Eastern countries. In addition, there was an increase of 297% in the Czech Republic and 485% in Hungary. it is seen that Turkey imports mainly in the Far East. A decrease is observed in the amount of imports from European countries, Italy, Denmark and Germany. The increase in imports from Far Eastern countries, which are said to be low in terms of quality and price, and the decrease in imports from European countries indicate that the move is price-oriented.

In 2018 due to shortage of negative economic indicators and problems related to rate, the toy market in Turkey has experienced some decline in both quantity and value. After the recession period it experienced, it had a tendency to grow again in 2019, and it is expected to slow down due to the world pandemic process and Kovid-19 disease experienced at the beginning of 2020.

The market grew by an average of 6 percent per year between 2013 and 2019. In 2018, toy production amounted to 19 thousand tons in quantity and 98 million dollars in value. 2019 was the year to make up for the losses in the sector. Production in the first half of the year was 11.7 thousand tons and 58.2 million dollars.

4. Discussion

4.1. Economic Situation of Toy Industry in Turkey

Turkey's inability to achieve throughout the toy industry production in specialized areas, away from scattered production structure clustered without predominantly carries out its activities as a sector based on imports in the domestic market because of technological infrastructure and branding are not at the desired level. Despite the high import rate in recent years in Turkey, the expected value of the find began development trend in the toy industry for the last 5 years, the value and quantity of the production, import, export and domestic market sales data with foreign trade deficit and market share are shown in the statistics in Table 5.

Table 5: Turkey Total Toy Production, Market and Supply-Demand Balance (Pagev 2019; TÜİK, 2019)

Years	2014		2015		2016		2017		2018	
	Quantity (Ton)	Million ($)	Quantity (Ton)	Million ($)	Quantity (Ton)	Million ($)	Quantity (Ton)	Million ($)	Quantity (Ton)	Million ($)
Production	20.9	158	18	126.1	19.4	135.3	19.7	145	18.9	97.6
Export	7,3	41,8	6.3	31.9	6.8	33.2	6.9	34.9	6.6	32.8
İmport	28.3	400.6	26.9	350.1	32.7	422.7	28.6	392.1	28.1	262.9
Foreign Trade Deficit	-21	-358.8	-20.6	-318.2	25.9	389.5	-21.7	-357.2	-21.5	-230.1
Domestic Consumption	41.9	516.8	38.6	444.3	45.3	524.8	41.4	502.2	40.4	327.7
İmport/ Domestic Cons. (%)	67.5	77.5	69.6	78.7	72.1	80.5	69	78	69.5	80
Domestic market share(%)	32.5	22.5	30.4	21.3	27.9	19.5	31	22	30.5	20

Turkey's toy production as shown in table 5; While the amount was 20.9 tons in terms of amount and 158 million dollars on value basis in 2014, the amount decreased to 18.9 tons in 2018 and decreased to 97.6 million dollars. We can associate this decline with the economic crisis in 2018, which caused contraction in all sectors in the world. However, a total of 400.6 million dollars in 2014. Turkey imports the toy industry, exporting 41.8 million dollars and 516.8 million dollars in the domestic market consumption is realized, the industry has 358.8 million dollars in the foreign trade deficit. In 2018, 262.9 million dollars of imports, 32.8 million dollars of exports and 327.7 million dollars of domestic market consumption were realized, and the sector showed a foreign trade deficit of 230.1 million dollars and decreased in value.

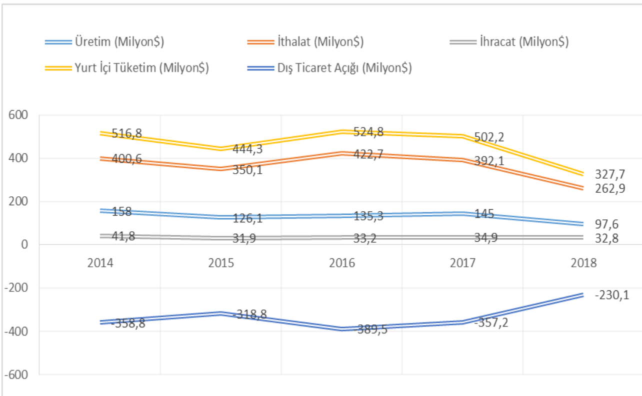

Figure 5: Turkey Total Toy Production, Market and Supply-Demand Balance (US $ Million)

As seen in Figure 5, despite the production of 158 million dollars in the toy industry in 2014, 401 million dollars of imports were realized. Domestic sales volume was 517 million dollars, while exports of 42 million dollars were made and production gained a share of 26% in the domestic market. In 2018, production declined to 98 million dollars and imports to 263 million dollars.

While the domestic sales volume decreased to 328 million dollars, the export amount was realized as 33 million dollars. Turkey's toy industry is a sector based mainly on imports. It is observed that it is in a process that increases its export-oriented activities with its infrastructure in international markets

4.2. Economic Analysis of Turkey's Wooden Toy Industry

The characteristics, preference reasons and technological processability of each of the raw materials from which the toy is made are very important for the sector. Accordingly, the manufacturer companies active in the world toy industry are named and classified according to the type of raw material they use in production. We can list these as plastic, fabric, plush, metal and wooden toys. Each of the toys separated according to the type of raw material used in production also has a commercial market.

The number of toy manufacturers operating in Turkey is seen as an industrial as 19 pieces. Among these companies, it manufactures wooden toys in the branded factory, which is established only in Düzce, for the market in industrial scale, as well as with the contract working principle in medium and large size workshops. In addition, it is observed that wooden toy manufacturers do not focus on certain regions throughout the country.

The total production of plastic toys in the toy industry in Turkey, imports and domestic consumption market, about 70% of the total toy production and imports, while exports accounted for approximately 90% (Pageva, 2019). Among the total toy industry, wooden toys come with the highest rate after plastic toys. Wooden toy production, import and domestic market consumption constitute approximately 25% of the total amount of toys, and approximately 8% of the total amount of exports. These ratios were determined based on field and literature studies for toys other than plastic toys.

To be rich in tree species can be used as raw materials in manufacturing wooden toys in the wood sector in Turkey and grew up with wide infrastructure and manpower capabilities began to find the expected value. For these reasons, the statistics of production, import, export and domestic market sales as well as foreign trade deficit and market shares in the last 5 years in terms of quantity and value of the toy industry, which is in the development trend, are shown in Table 6.

Table 6: Turkey Wooden Toy Production, Market and Supply-Demand Balance

Years	2014		2015		2016		2017		2018		2014-2018 (%)	
	Quantity (Ton)	Million ($)	Quantity (Ton)	Million ($)	Quantity (Ton)	Million ($)	Quantity (Ton)	Million ($)	Quantity (Ton)	Million ($)	Quantity (Ton)	Million ($)
Production	5.22	39.5	4.5	31,52	4.85	33.82	4.92	36.25	4.72	24.4	-9.5	-38.2
Export	0.58	3,34	0.50	2.55	0.54	2.65	0.55	2.79	0.52	2.62	-10.3	-21.5
İmport	7.07	100.15	6.72	87.52	8.17	105.67	7.15	98.02	7.02	65.72	-0.01	-34.3
Foreign Trade Deficit	-6.49	-96.81	-6.22	-84.97	-7.63	103.02	-6.60	-95.23	-.6.50	-63.10	-0.01	-34.8
Domestic Consumption	10.47	129.20	9.65	111.07	11.32	131.2	10.35	125.55	10.10	81.92	-3.5	-36.5
İmport/Dom. Cons(%)	67.5	77.5	69.6	78.7	72.1	80.5	69.0	78.0	70.0	80.0	3.7	3.2
Domestic Market Share(%)	32.5	22.5	30.4	21.3	27.9	19.5	31.0	22.0	30.0	20.0	-7.6	-11

As seen in Table 6, imported toys have a share of 77.5% and locally produced toys have a share of 22.5% in the domestic market consumption in the wooden toy industry, which produced 5.22 tons and 39.5 million in 2014 in our country. In 2018, a decline was observed in the wooden toy industry in our country with a value of 4.72 tons and 24.4 million. Imported toys have a share of 80% and locally produced toys have a share of 20% in value from the domestic market consumption

It is observed that the production value of wooden toys has decreased over the years, albeit a little, and the import amount has increased. Between the years of 2014-2018, there was a decrease of 9.5% in terms of quantity, 38.2% in value, 10.3% in quantity, 21.5 in value in exports, and 0.01% in quantity and 34.3% in value in imports. However, there is an increase in domestic market consumption with a value of 3.2%.

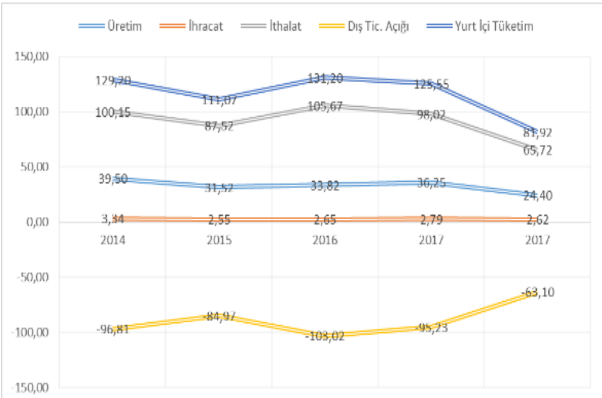

Figure 6: Turkey Wooden Toy Production, Market and Supply-Demand Balance ($ Million)

In Figure 6 as seen in manufacturing wooden toys Turkey, as the value of exports and imports, fluctuations in 2014-2017 but is noticeably seen a case in 2018 shows a decline. At the same time, it is seen that the foreign trade deficit grew at a noticeable level in 2018. In the year 2014-2018 in the amount of exports as compared to production in Turkey have made aint seen an increase.

5. Conclusion

The worldwide toy industry market grows with the development of changing preferences and technologies. It is observed that the toy companies in our country are in the development phase, their competitive power is generally low and they cannot get the desired market share in the world market. Negative consumer movements have occurred in Far Eastern toys due to negative thoughts on safety and health and changing market conditions. Turkey toy industry market is in development that will transform favor with advantages such as sources of raw materials, healthy products, skilled labor and logistics conditions of negative consumer requests that occur in the toy industry market

For the toy industry in the world, while exports were 34.5 billion dollars and imports were 45.23 billion dollars in 2014, exports reached 46.27 billion dollars and imports reached 50.21 billion dollars as of 2018, increasing in both markets. In the toy industry in 2014, Turkey's total imports of 400.6 million dollars, 41.8 million dollars of exports was realized, while in 2018 imports of 262.9 million dollars, it is observed decline in export market with 32.8 million dollars.

The sector in Turkey in 2014 158 million dollars in production, 358.8 million dollars in the foreign trade deficit and 516.8 million dollars the domestic market consumption took place, while in 2018, 97.6 million dollars of production, 230.1 million dollars in the foreign trade deficit and 327.7 million dollars, is the domestic market consumption have occurred, the sector has decreased in value.

In the developing Turkish Wooden Toy sector, 30.5 million dollars of production, 96.81 million dollars of foreign trade deficit and 129.20 million dollars of domestic market consumption were realized in 2014; internal market consumption has decreased in an equivalent sense to the toy industry. There is a contraction of 38.2% in production, 36% in domestic consumption, and the decrease in the purchasing power of individuals in 2018 has been seen as a reason.

The most important problem of the toy industry is that it has a large foreign trade deficit. When the data are examined, the toy industry; In 2018, there was a deficit of 21.5 tons and 230.1 million dollars. A deficit of 6.50 tons and 63.10 million dollars was provided in wooden toys. The reason for the significant foreign trade deficit in the market as the Turkish toy industry is expressed as the lower unit export price compared to the unit import price.

In our study, it has been determined that Turkish toy companies increase their market share not only in the domestic market, but also in European countries, which they consider very important for development and constantly increase their quality. When we look at the data of 2014 and 2018, it is observed that the toy export to England is at the highest rate with an increase rate of 56%. Britain is followed by Germany with a 55% increase rate and Serbia, Greece and Italy at lower rates.

It is seen that Turkey imports mainly in the Far East. A decrease is observed in the amount of imports from European countries, Italy, Denmark and Germany. Looking at 2018 data, China meets 88% of total imports with a value of 230.6 million dollars. When the results are evaluated, it is seen that uncontrolled imports from Far Eastern countries with high capacity and price advantages prevent the development of the domestic toy industry, cause many domestic brands to disappear, loss of employment and increase in the current account deficit.

Although the amount of wooden toys imported between 2014 and 2018 is close to each other, a decrease in the value corresponding to the amount is observed, especially in 2018. One of the factors that may cause this decline is the economic shrinkage process experienced in the world in 2018, and also the low quality that causes the imported toy products to be the same in quantity but low in price.

Along with the recently developed ecological life philosophy in the world toy industry, an important market is the toy market made of natural and healthy products. The most important and preferred one is toys made of wood, and these products have an increasing market share due to environmental and health concerns. The domestic wooden toy industry will not only provide employment and added value to our economy, but also contribute to our culture by gaining traditional production capability.

Low logistics cost should be used as an important advantage in the wooden toy industry, especially due to its proximity to the Middle East and EU markets. The market share will be increased by ensuring rapid adaptation to new models with toys for cultural and religious common values with the Middle East and the Turkic World.

With the fact that the conscious consumer will continue to increase, the number of consumers who demand transparency and expect loyalty to ethical values from the brands they buy their products are increasing day by day. For this reason, it should be ensured that the consumers who turn to wooden toys make the right decisions and have information about the product life cycle with the eco label placed on the product.

As a result, in achieving a healthy and secure quality of life for our children, investing in the production of wooden toys and development in Turkey it has emerged as a clear sector.

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WOOD AND WOOD BASED MATERIALS IN URBAN FURNITURE USED IN LANDSCAPE DESIGN PROJECTS

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Abstract

As wooden material has been used in many different areas in the historical process, today it is frequently used in urban furniture within the scope of landscape applications. It is very important that the materials used should be eco-friendly and compatible with the design. Within the scope of this study, different urban furniture produced from wood and wood-based materials were examined in order to improve the existing designs. In the samples examined, urban furniture designed in accordance with general design principles are considered; Determinations have been made within the framework of elements such as aesthetics, size, form, ergonomics, functionality, construction, material, durability, safety, layout and economy. In addition, various suggestions have been given for the development of urban furniture, which is a part of landscape applications, and the emergence of new designs in harmony with nature, by examining the visually and material types on the sample wooden reinforcements.

Keywords: Urban furniture, wood, landscape, design

1. Introduction

With each passing day, reinforcement elements are increasingly used in landscape projects in cities. Wooden; It is an important reinforcement material for the landscape sector due to its physical, mechanical and technological advantages (Karadag et al., 2017). Today, the reinforcement elements do not serve the purpose fully due to the damage caused by the people using the reinforcement elements and the mistakes made during the planning and design stages. Factors such as cultural levels, accordance with the function in using furniture, the furniture's meeting the functional expectation, being user-friendly, and being correctly placed are effective in ensuring communication between the equipment elements and the people who use it (Sisman and Yetim, 2004).

Akyol (2006) aimed to reveal the urban furniture design process, which includes all the issues of correct placement and regular maintenance. Karadag et al.,(2017), based on the data obtained from people working in landscaping applications in Turkey, identified the problems related to the use of wood and divided them into three groups. These are, respectively, the weakness of the wooden material and its inability to be protected for a long time, the problems caused by the manufacturer, and the application problems especially encountered during the assembly.

These developing areas of use are also reflected in landscape projects. The use of materials with high visual quality at a scale that reflects the identity and symbol of the city in designs realized on a city scale increases the value in design. In this study, it is aimed to reveal various results with suggestions and recommendations by considering the wood and its derivative materials used in landscape designs by raising awareness on the value of the material.

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1.1. Urban Furniture Concept

The importance given to the examples of official or civil architecture in the traditional city concept also reveals the use and importance of these elements in cities. Because the city is not just a phenomenon created by building and building elements. In addition to providing urban function (Aksu, 2012), the most important complementary element can be given as urban furniture (Sagsoz et al., 1997). In order to maintain a healthy life in social environments with urbanization, shopping environments, communication, cultural environment, transportation systems, traffic regulations, entertainment and service units depend on the existence of design objects used in urban integrity (Erhan, 1990). Especially in public spaces, which gain importance as urban common spaces, urban furniture, which has an important place in meeting the real needs of the citizens, is also small-scale urban items, but many of them can affect newly formed-created or renewed environments with the union they create.

Demand for increasing environmental quality or raising spatial standards and the formation of social pressures; directly depends on the establishment of balances such as knowledge, economic power, social and cultural identity (Gursu, 1988).

The design, production, marketing and selection and positioning of the reinforcement elements should provide environmental awareness, visual and architectural integrity. At the same time, humanistic approaches and the use of materials that will tolerate ecological differentiation and multi-dimensional situation evaluations that meet social needs are required for the success of the implementation (Uludag, 1990). Urban furniture; supports and strengthens functions such as living, shelter, protection, siege, counseling, enlightenment, transportation, communication, games and sports in general or private areas of use for recreational purposes such as streets, roads, parking lots, terraces, pedestrian paths and squares around us, they are original design products that facilitate the community life, gain the appreciation and support of the users, and have an impact on the formation of functional, safe and healthy environments in urban and rural areas indoors and outdoors.

The concept of urban furniture is "urban reinforcement elements", "environmental reinforcement elements", "urban accessories", "landscaping elements", "landscape elements" and so on. They can be expressed in terms. However, these terms may differ due to their scope (Gul, 1991).

Landscaping elements are mostly landscape oriented. Urban accessories, on the other hand, have a meaning that includes only decorative elements. In this study, the term "urban furniture" was used primarily and mostly (Gul, 1991).

Criteria that can make a difference in urban furniture design and affect the level of appreciation of the users;

- color matching,
- measure / ratio balance,
- functional fit
- material compatibility,
- being modern,
- referring to history, being different, impressive, interesting,
- being original,
- good position,

It has been determined as being compatible with the environment, being semantic and monumental.

Urban furniture in structured or unstructured urban public open spaces, which are open to everyone and under the responsibility of the public, is elements that define and complement the space (Ozturk, 1991).

1.2. Wood Material Concept

The word wood comes from the word "Hasep", which means "goods made of wood" in Arabic (Eric 1978). Wood material has started to serve people as fuel, weapon and shelter since the early years of humanity, and today its usage area with the developing technology (Sofuoglu and Kurtoglu, 2016) continues to serve humanity by increasing day by day. Today, wood material is known to have 10,000 different uses (Ors and Keskin, 2001). Its widespread use is attributed to the anatomical structure, physical and mechanical properties and chemical composition of the material (Bozkurt and Erdin, 1997). The rational use of materials obtained from wood depends largely on knowing the physical and mechanical properties of the material well (Goker and Bozkurt, 1987). Today, in the detection and diagnosis of the condition of tree, log, timber or wood; Mechanical, electrical, optical, acoustic, thermographic, radiographic, nuclear magnetic, chemical and biological methods or some of these methods can be used together for analysis (Unger et al., 2001; Seckin, 2010).

In addition, wood material, due to its anatomical and chemical structure, although it has sufficient resistance and natural durability against some effects in outdoor conditions, it cannot withstand external weather effects for a long time (Ors and Keskin, 2001). For this reason, human beings, who have historical unity in the use of outdoor conditions, learned that this material should be preserved where it is used (Sonmez, 1989) by experiencing (Ulay, 2018). In order to protect the wood material and increase its aesthetic value, industrial wood varnish and paint systems developed in the early 20th century have been used (Sonmez, 2000) As the studies in the literature are examined, the wood material is completely compatible with nature and is easy to recycle, its strength compared to other building elements is quite good (Batur, 2004). Wood is a sustainable industrial material that is compatible with different building materials and can be very long-lasting when used correctly (Caliskan et al., 2019).

When evaluated from the design framework, the wood and wood-based materials are light, resistant to different climatic conditions, increased fire resistance with special surface materials, protection against rot and insect damage by impregnation (Seckin, 2010). When the structure is dismantled, rebuilding is easy. The properties such as being energy-friendly and earthquake resistant, being used in harmony with steel, concrete, stone and adobe show that the wooden material complies with all ecological design criteria (Bostanci and Birer, 2004). It has been reported that obtaining the material is very related to economic conditions and technology, not to the existing material as before the Industrial Revolution (Yildiz and Seckin, 2019). As a matter of fact, technological developments related to wood materials finally manifest themselves in nanotechnology applications and strategies for designing new wood-based materials (Jiang et al., 2018). Such developed wood-based composite materials are also used in landscape applications.

Landscape and wood material relationship: Landscape architecture is a profession that uses natural and artificial landscape materials together and emphasizes this in planning and design studies. Landscape architects who prepare landscape projects need to know artificial materials as well as natural materials. The harmony of these materials in the environment and design is very important. This is one of the most important factors of sustainability in planned designs.

For the production of urban furniture, solid wood material has a beautiful appearance, superiority in terms of color and texture (being homogeneous), easy processing and smooth surfaces, being suitable for surface treatments, being resistant to plant and animal pests, no bugs and insect holes, knot-free and it is smooth fiber, durable in climatic conditions, and its contraction and expansion percentages are low (Gursoy, 2011).

In general, high resistance properties are sought in kitchen furniture, sports equipment and garden furniture with wood moisture content with 8 ± 2%, 12-16% respectively and air dry in bench construction, good drying properties. The occurrence of narrowing and enlargement in the dimensions of the massive wood material by absorbing moisture is particularly inconvenient. Imperfections such as cracks, color changes, thick and thin parts, pitted joints caused by the absorption of moisture by the solid wood material use difficult, and is not tolerable for eye pleasure (Gursoy, 2011).

Undesirable size changes and deformations in the products can be prevented by releasing it. This is done by selecting the parts to be used in urban furniture in the desired quality class according to the function of the place of use, drying according to the place of use and then combining them according to the technique (Kurtogu, 2006; Dilik, 2008).

When the materials used are examined, it is observed that wood and its derivatives are frequently used and wood material greatly contributes to the creation of natural areas depending on the principle of protecting and using the environment (Ulay and Yeler, 2020). In addition, with the modern and wide range of products that have emerged as a result of the latest technological developments and chemical processes, options where the visuality and quality come into prominence are presented. In this case, it strengthens the basic principles of landscape designs such as color and texture. Considering the easy accessibility of wood and the sufficient processing opportunities in our country, it is easy and sustainable to choose it (Yeler et al., 2017).

2. Materials and Methods

In this study, by defining urban furniture from a general point of view, the values that can create originality with the use of wooden furniture in design are emphasized and some determinations and evaluations have been made by examining the current wooden urban furniture design examples as materials.

This method of examination is carried out by grouping urban furniture according to design principles. Various suggestions were put forward as a result of examinations and evaluations. The most important of these suggestions is; It has been demonstrated that original and innovative urban furniture increases both the quality of use and visual quality in open spaces where they are used with an aesthetic design, and they provide the opportunity to positively affect the urban identity and the psychological status of the users.

3. Results

3.1. Classification of urban furniture according to their functions:

Wooden materials are very important in the use of urban furniture, especially in floor and floor coverings. In addition, it has different uses in many areas according to its functions. Since these materials are densely coated, they contain many active ingredients. In the manufacture of such products, around 30% recycled materials, 60% wood chips, and around 10% binding additives are used. In urban and rural areas, these coating samples are frequently observed in recreational areas that are generally open to human use and similar recreational areas. In the same way, garbage can, pergola, ornamental objects, sculptures and many different uses are observed in Figures 1-11, some of which are listed below with the main headings and wood-derived examples.

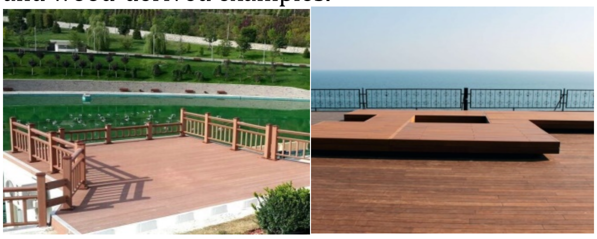

Figure 1: Wooden Floor Coverings (Web-1)

Figure 2: Wooden Seating Units (Web-2)

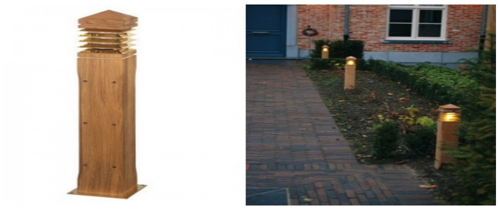

Figure 3: Wooden Lighting Elements (Web-2)

Figure 4: Wooden signs and information (Web-3)

Figure 5: Wooden limiters (Web-4)

Figure 6: Wooden Water Items (Web-5)

Figure 7: Wooden Top Cover Items (Web-6)

Figure 8: Wood Sales Units (Web-7)

Figure 9: Artistic objects (Web-8)

Figure 10: Playing field elements (Web-9)

Figure 11: Other wood items (Web-10, Web-11)

3.2. Wood Derived Materials Used in the Production of Urban Furniture:

3.2.1. Wood Laminated

Lamination technique in wood material; it expands its application area in parallel with technological development with the possibility of obtaining a more stable, perfect and aesthetic material compared to solid wood as well as for the rational use of wood material. As a rule, different wood species, variable number of layers (layers), different sizes and shapes can be applied in lamination (Dilik, 1999). Longer and wider wood material can be produced by clearing the defects (knots, cracks, worm holes, irrigation, etc.) of wood material that is not too long and wide (Percin et al., 2009). Much research has been done in the literature on the physical and mechanical properties of wood laminated materials and their use of different types of wood in Figure 12 (Dilik, 1999; Uysal and Ozciftci, 2004; Ozturk and Arıoglu, 2006; Percin et al., 2009; Zor et al., 2016; Keskin and Togay, 2019). In Figure 12, examples of different uses of wooden laminated beams are given.


Figure 12: Wood Laminate Appearance (Web-1)

3.2.2. Wood / Solid Material

The use of wood as a building material is older than concrete and steel (Bostancıoglu and Birer, 2004). Among the domestic species in Figure 13, which are used in industrial wood reinforcement elements today; beech, chestnut, oak, walnut, hornbeam, scotch pine, fir, spruce, cedar, ash, birch, acacia, maple, foreign species; Examples are iroko, teak, mahogany, sipo, bamboo (Karadag et al., 2016).


Figure 13: Wood / Solid View (Web-12)

3.2.3. Medium Density Fiberboard (MDF)

MDF has been one of the most important board products developed as an alternative to solid wood material (Akgul et al., 2013). Fiberboards are a large-surface board obtained by reshaping fiber and fiber bundles obtained by fiberizing ligno-cellulosic raw materials (Eroglu and Usta, 2000; Istek et al., 2015). It is a wooden product designed in the form of a plate formed with wax and resin glue under high temperature and pressure, after breaking up hard or soft wood residues and turning them into wood fiber. MDF material can be used by painting its raw form for example in figure 14, as well as MDFLam etc. with surface coating materials.

Figure 14: MDF View (Web-12, Web-13)

MDF-Lam (Melamine Coated MDF) Raw MDF board coated with decor paper by impregnating melamine resin and glue with impregnation machines to color, fireproof and waterproof the surface is called MDFLAM. In the literature, many researchers have been done on the technological properties of MDF boards. The effect of fibers belonging to different types of wood used in making MDF on MDF board properties has been studied (Separated, 2000; Winandy et al., 2003; Shi et al., 2006; Ozyhar et al., 2020; Pugazhenthi et al., 2020).

3.2.4. Chipboard

It has found a wide range of use due to its conversion into a large size plate using small size and relatively low value logs. Particleboards are the boards in Figure 15, which are obtained after gluing and shaping dried chips obtained from wood or lignified lignocellulosic raw materials with synthetic resin adhesives under temperature and pressure (Guller, 2001).

Figure 15: Particle Board View (Web-14)

3.2.5. Plywood

It is a material in the form of a large sheet, which is obtained by gluing thin peeling plates (plate, papel) obtained by peeling logs with certain characteristics in special machines and pressing them by placing at least 3 layers or more in an odd number of layers perpendicular to each other for examples in figure 16. Their thickness is between 3-70 mm and they are generally produced in 130 x 220 cm or 170 x 220 cm dimensions (Guller, 2001). They can be classified according to different parameters such as the place they are used, the type of tree they are made of or the sector used.

Figure 16: Plywood View (Web-14)

3.2.6. Oriented Strand Board (OSB)

Produced from low quality thin-diameter logs that cannot be used in plywood production, OSB has been used in many areas, especially it has become a rival to plywood. OSB is a type of chipboard produced by directing specially prepared strands (Ayla, 2001). All kinds of raw materials used in particleboard production can be used in OSB production. The smallest tree diameter that can be used is 5 cm. Bark is not used in the production of OSB. In the production of OSB, fast growing trees with low specificity such as poplar and pine, can be used in Figure 17 (Guller, 2001).

Figure 17: OSB Plate View (Web-14)

3.2.7. Wood Plastic Composite (WPC)

WPC defines a wide range of materials, from polyethylene as a polymer to polyvinyl chloride as a polymer, and from wood flour to natural fibers as a filling material (Ozmen et al., 2014). Today, technological and economic imperatives have made it necessary to research and develop some negative properties and to produce wood polymer composites (Kaymakci et al., 2014), smart bioplastic composites (Ozdemir and Ramazanoglu, 2019) from other wood originated new materials.

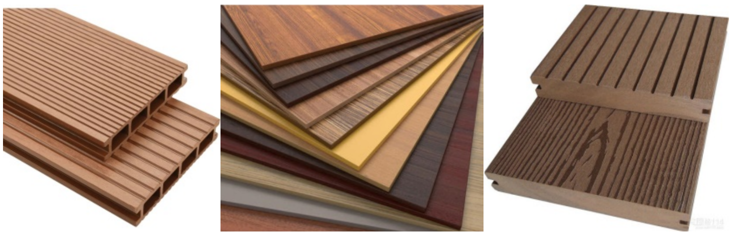

Figure 18: Wood Plastic Composite View (Web-15)

3.2.8. Wood Based Sandwich Panel

Product diversity is increasing day by day in the production of wooden boards and foam (polyurethane)(figure 20), honeycomb (paper and polypropylene, aluminum) (figure 20) or low-density wood types are used as core material in wood-based sandwich boards (Guler and Ulay, 2009; 2010; Ayrildi et al., 2015). Generally, a sandwich layer structure in Figure 19; it consists of two surface layers being covered with a thick middle layer (Ayrilmis et al., 2015).

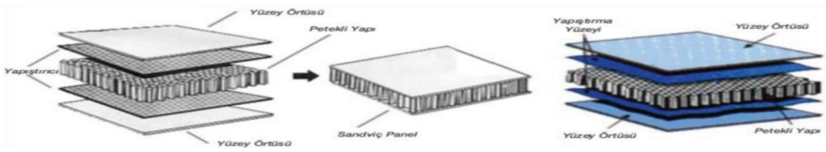

Figure 19: The structure of the sandwich plate (Güler and Ulay, 2009).

Figure 20: Wood-based sandwich plates (Guler and Ulay, 2010).

It has been reported that this type of composite (sandwich) plates are 40-70% lighter, flexible and resistant to water and moisture compared to other composites (Ulay and Guler, 2010). It is thought that such boards are more resistant to moisture, mildew, fungi and the negative properties of wood such as swelling and expansion and are considered suitable for use in urban furniture.

4. Discussion

Urban furniture is important not only for functional purposes but also as visual urban items that complement and define urban spaces. The positive or negative effects of the environment are more visible in places where urban furniture is used extensively and is reflected in the urban landscape.

An urban furniture should be in harmony with the environment it is located in, no matter how well designed. In different environments (historical texture, urban park, streets, focal points, squares, etc.) the same type of material, color, texture, form, etc. Standard urban furniture produced with a sense of design should not be used. However, certain standards should be developed in order to meet certain functions. Factors such as life style, traditions, historical framework and technological development specific to the existing environment and its users that shape an urban furniture should be determined (Aksu, 1998).

It may not be possible to use certain standards in the use of urban furniture. However, certain restrictions may be imposed depending on the space, the size of the space, and the service the space offers to the users. Urban public spaces, which are of great importance for the city, should not be prevented by excessive use of urban furniture. It should be used in line with needs, and efforts should be made to create plain, clean, spacious and open spaces. Aesthetic urban furniture that is related to each other, that can fulfil several functions, suitable for their environment and architecture should be used. In addition, the ready-made urban furniture chosen should be compatible with the tastes and wishes of not only local governments but also all users.

Today, most of the materials are produced by simply imitating them to basic materials (natural stone, wood, etc.). Wall panels made of natural stone-like polyurethane instead of natural stone material, wood-printed vinyl floor coverings instead of wood, steel panel coverings that are close to concrete texture instead of concrete, brick-shaped 3-dimensional wall coverings instead of brick, metal-looking ceramic coverings instead of metal can be examples of imitation materials and often they are used in buildings. However, the correct and appropriate use of the original material will be effective in providing both the real appearance of the final product and a healthier material durability (Yildiz and Seckin, 2019).

Today's technology is very suitable for reproducing imitations of materials with samples. However, imitation materials cannot show the mechanical, acoustic or thermal properties of the original materials, they can only provide the visual comfort of the user. Therefore, it cannot fulfil the functions of original materials. In addition to misleading the user, imitation materials also change the architect's relationship and role in design. These materials, which are marketed with resolved detail and easy application strategy, are added to the projects as finished products, paving the way for the production of uniform building and put the architect in the position of choosing more than the designer. However, the space and material experience of the user is not only realized through visual perception. On the contrary, all its sensory features stand ready to be stimulated. At this point, the experience that the architect wants to give the user while designing a building is established by the relationship of both parties with the material (Yildiz and Seckin, 2019).

Urban furniture, which is a branch of industrial design, should not be considered as a part of a system, it should be considered as one of the city elements that make urban spaces livable, affect the physical structure and appearance of the city, and it should not be forgotten that they are in close relationship with all other urban elements of small and large scale (Aksu, 2012).

In urban furniture design, architects, landscape architects, industrial product designers, furniture manufacturers and material engineering etc. dealing with the livability of urban spaces other than local governments. Such expert groups should first be organized by communicating among themselves and then ensure the participation of the public, who are direct users and effective decision makers.

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