Studying the anatomical, chemical, and mechanical properties of the wood of Acer cinerascens Bois maple trees growing in Mount Cara and determining its suitability for the paper and pulp industry.

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Abstract

The current study included a Identification study of maple trees (*Acer cinerascens* Bois) using wood anatomical properties and determining their suitability for paper and pulp industries based on the Runkel ratio. Four Aspects (northern, eastern, southern, and western) were used in northern Iraq (Mount Kara). As this species grows naturally in these areas located within the Jamanki district / Amadiya district of Dohuk Governorate, the study samples were determined at a rate of (6) replicates for each interface, so that the total number of samples would be (24) samples selected to cover all . The study area for all studied areas was 197.62 km2 and at different heights above sea level. The wood samples were taken at the chest height of the trunk of the studied trees from the same face of all samples, which is the northern face of the tree. The results of the anatomical study revealed a significant environmental influence on the variation in anatomical characteristics of the studied wood of this maple species. The results related to the Runkel ratio also indicated the suitability of the studied maple wood for the paper and pulp industry.

Keywords: Maple, Acer cinerascens Bois anatomical characters. paper pulp

Introduction

Maple (Acer) is a plant genus of approximately (125) species, most of which are trees or shrubs. It grows in the northern regions of Russia, Europe, Canada, and elsewhere. It belongs to the Sapindaceae family according to the angiosperm phylogeny. Most maple species range in height from 10 to 40 meters, abundant water to grow and thrive [21] The importance of this research lies in highlighting the importance of maple wood found in Mount Kara, Amadiya District, Dohuk Governorate, northern Iraq, which could help improve wood quality.

The research aims to study the effect of interfaces, slope, and hill shadows on the anatomical properties of wood. It also aims to determine the effect of soil composition and type on the anatomical properties of wood. It also aims to identify the wood of this species of maple tree using anatomical characteristics. The most important species found in Iraq is (common maple *Acer cinerascens* Bios). Maple wood is used in the manufacture of furniture, flooring and doors due to its hardness and high quality. In addition, maple syrup is extracted from some types of maple trees, such as the sugar maple, which is a popular syrup in the United States and Canada. Some types of maple trees are also used as ornamental trees in public gardens and parks, due to the beauty and colors of their leaves in the fall. Some parts of the maple tree are also used in alternative medicine to treat certain ailments [17].

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[14] conducted a study on the influence of both topography and land use on woody plant species composition and biodiversity in arid landscape across the Himalayas of Nepal. Two slopes of different orientations. In [7] on the anatomical characteristics of the walnut genus, and [6] on the characteristics of the wood of the Pistachio tree growing in northern Iraq, the study of both of them is related to the different elevations and the presence of a difference in the characteristics of the wood for each elevation above sea level. [15] studied the effect of locations and the diagnosis of two species of the genus Quercus that grow naturally in the Atrush area of Dohuk Governorate, northern Iraq, using the anatomical characteristics of the wood. The study showed that the locations and altitude above sea level had an effect on the anatomical properties of the wood.

Material and Methods

This study was conducted on Mount Kara, located within the Jamanki sub-district/Amadiya district of Duhok Governorate, northern Iraq. The mountain lies between longitudes (43.292518°-43.317600°) east and latitudes (37.016558°-37.018344°) north. These forests are characterized by their biological diversity; as many types of trees and forest shrubs grow in them, such as needle-leaved and broad-leaved trees, to form a distinct and independent ecosystem for centuries. The study samples were determined at a rate of (6) replicates for each interface, so that the total number of samples would be (24) samples, optionally to cover all interfaces, for the study area located in Kara Mountain, in the northern part of Iraq, covering the four Aspects (northern, southern, eastern, western) at different elevations above sea level.

All samples were taken from the same Aspect on the northern side of the trees at the chest height of the trunk of the studied trees, according to the method mentioned by [19] and [16] and followed by [4] by taking a cubic section of the tree trunk at chest level with a side length of 5 cm.

1. The first site is located in Mount Kara (northern face), with an average elevation of 1299 meters above sea level, latitude (37.018344º), longitude (43.317600º), an average slope of (19.1%), and an average tree diameter of (18) cm.
2. The second site is located in Mount Kara (southern face), with an average elevation of 1277 meters above sea level, latitude (37.016661º), longitude (43.317746º), an average slope of (12.8%), and an average tree diameter of (19) cm.
3. The third site is located in Mount Kara (eastern face), with an average elevation of 1144 meters above sea level, latitude (37.018216°), longitude (43.319533°), an average slope of (16.5%), and an average tree diameter of (12) cm.
4. The fourth site is located in Mount Kara (western face), with an average elevation of 1294 meters above sea level, latitude (37.019681°), longitude (43.316794°), an average slope of (15.8%), and an average tree diameter of (16) cm.

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Table (1) Symbols of the studied geographical locations, interfaces, shadow, heights above sea level, longitudes and latitudes.

Latitude circles	longitude lines	Height above sea level (m)	Aspect	Sample code
37.018344º	43.317600º	1299	N	P1
37.016661º	43.317746º	1277	S	P2
37.018216º	43.319533º	1144	E	P3
37.019681º	43.316794º	1294	W	P4

Preparing and coding the samples:

Six trees were selected in each of the Aspects studied, so that the number of samples became (24) study samples. Six trees were taken from each Aspect and at different heights according to the location and Aspect, as shown below: The code (P1) was given to the sample in Mount Kara at the first site with the northern Aspect N. The code (P2) was given to the sample in the second site of Mount Kara with the southern Aspect S. The sample at the third site of Mount Kara with an eastern face (E) was given the code (P3). The sample at the fourth site of Mount Kara with a western face (W) was given the code (P4). Healthy, defect-free trees with straight trunks were selected; samples were taken at breast height (b.h) at a height of 1.3 m.

Above ground level. The anatomical study was conducted in the Wood Science Laboratory/Department of Forestry Sciences, College of Agriculture and Forestry, University of Mosul. Chemical and mechanical separation of wood cells of the studied species was performed.

Wood cell separation by the chemical method, Maceration:

The wood cells were separated chemically by taking a wood sample at the level of the chest height (b.h) of the trunk of the studied tree according to the method mentioned by [19] and [16],. This method is summarized by taking a cubic section of the tree trunk at (b.h) with a side length of (5) cm, then the process of chemically separating the wood cells was carried out on this sample according to the method [12]

The quantitative and qualitative characteristics of the chemically separated wood cells were then studied.

Runkel Ratio:

It is worth noting that the relative value of Runkel has a positive effect when it is low, as it significantly affects the quality of paper and pulp and the mechanical properties of wood, as confirmed by numerous researchers. iincluding [1],[4]. The Runkel ratio was calculated using the following equation:

Runkel ratio = twice the fiber wall thickness / fiber cavity diameter

Mechanical separation of wood cells using a microtome:

Wood samples were taken from the trunk of the studied trees at the chest level (b.h), then cut into wooden models in the form of a rectangular parallelepiped with dimensions (2x1x1 cm), after which they were placed in a beaker containing distilled water to soften the wood samples by boiling them in this water until they are saturated and completely submerged. After reaching the point of fiber saturation with water, the samples are stored, and then they were placed in the refrigerator. After that, very thin slices were made for microscopic examination with a thickness of 15-20 micrometers for the three faces of the wood (radial face, transverse face, tangential face) using a rotary microtome at a knife angle of 10-15º according to the method [20], then the wooden chip is taken and placed on a microscope slide and covered with a cover slide, and it is

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examined using the developed microscope equipped with a camera and connected to the previously mentioned laptop computer, and (20) readings were taken for each of the studied anatomical wood characteristics, and the properties of the three wood faces were studied.

Results and Discussion

Vessels Elements Length:

It was noted from Table (2) that there is a variation in the length of vessel elements according to the Aspects, as it was found that the southern Aspect S and western Aspect W contained vessel elements with average values lower than the average values of these Aspects. As for the characteristics of the northern Aspects (N) and the eastern Aspects (E), it is known, according to surface analysis, that the southern and western Aspects receive a much greater amount of solar radiation than the northern and eastern Aspects. The average values of the length of the vessel elements in the southern and western Aspects were 854.871 and 859.412 micrometers, respectively. While the average values of the vessel elements in the northern and eastern Aspects were 869.331 and 877.065. Micrometers respectively. It is worth noting that the Aspects that receive a greater amount of solar radiation have less moisture in the soil of these Aspects, and therefore the trees deliberately reduce the length of the vessel element, in order to increase the opportunity to deliver water, nutrients and salts to all parts of the tree. This result was consistent with what [2] found, who showed that the southern and western Aspects had shorter vessel elements.

According to [4],and [10], this variation in the lengths of the vessel elements of the wood of the studied maple trees growing in Mount Kara, and according to what [8] mentioned, may be attributed to the difference in the water conductivity of the stomata in the leaves and in the speed of transpiration, as humidity plays a large and effective role in influencing the lengths of the elements. Vessels and their diameters, as longer vessels are ideal in humid areas, while short vessels are in dry or less humid areas. [18] stated that the lengths of vessel elements are greater in forests that grow near water compared to the length of these elements in forests that grow far from rivers. Thus, these results showed that There is an environmental influence and an influence of sites. This result was consistent with what was found by [2], who stated that sites properties play a role in influencing the dimensions of vessel elements. Figure (1) shows the length of vessel elements for the maple studied at 10X magnification.

Figure (1) Vessel element length for maple wood at 10x magnification

Vessel element diameter:

It was noted from Table (2) that there were variations in the dimensions of this characteristic regarding the diameter of the vessel elements, as the average values of the vessel element diameters on the southern and western Aspects were much lower than the average values. For the same characteristic in the northern and eastern Aspects, which indicates the presence of an effect of the Aspects on the characteristic of the diameter of the vessel elements, as the average diameter of the vessel elements in the southern and

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western Aspects reached (364.810 and 395.412) micrometers, respectively. While the average in the northern and eastern Aspects reached (437.476 and 413.243) micrometers, respectively. According to the surface analysis, it is known that Trees growing in dry areas have narrower, more diffused vascular elements than those growing in humid areas. As a physiological necessity, trees narrow the diameter of vascular elements in areas receiving greater solar radiation due to the low moisture content of the soil in these areas, thus providing hydraulic security. This result is consistent with the results of [2] Although [11] stated that vessel elements have a functional and adaptive interpretation and are related to plant growth environments, water availability, and other variables, when explaining the diameter of the vessel element between different environmental conditions and locations, it is closely related to the conditions of the location. [9] indicated that the species Those exposed to less solar radiation and more humidity had larger vessel elements. He also explained that vessel diameters are greatly affected by the amount of water flowing through the tree, increasing with increasing humidity and decreasing with drought or low humidity. Regarding the dimensions, they were the opposite of the length of the vessel elements, as they were larger in diameter on the northern and eastern Aspects, while the lengths of the vessel elements were larger on the southern and western Aspects. Thus, it is clear that the Aspects play a role in influencing the dimensions of the diameter of the vessel elements. This result was consistent with the result of A study by [2] found that the eastern and northern Aspects had larger diameters than the western and southern Aspects. The reason for the Aspect's influence on vessel diameter rates may be attributed to differences in the amount of moisture present in the soil. while trees tend to narrow the diameters of vessel elements to increase pressure and ensure water delivery in areas with low or dry soil. These results are consistent with what was found by [2] and what was mentioned by [5] and with the findings of [9] who showed that surfaces exposed to greater humidity and less solar radiation had larger vessel element diameters than those exposed to greater solar radiation and less humidity.

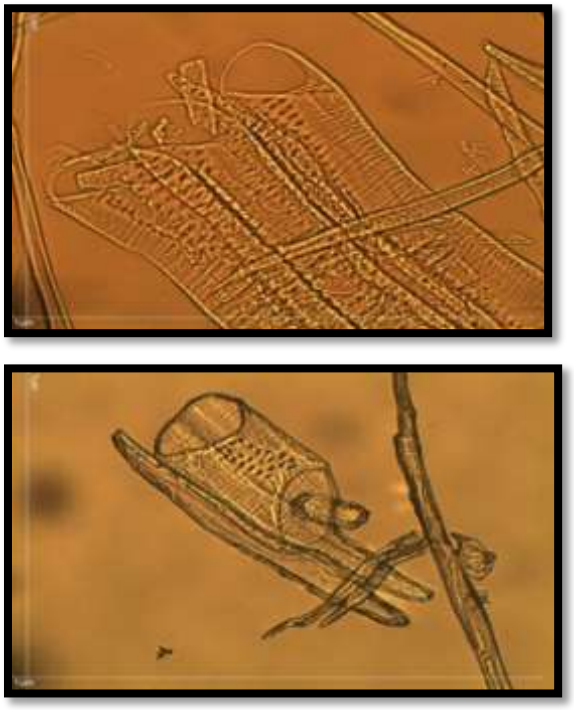

Figure (2) Diameter of the vessel elements of the studied maple wood at 40X magnification.

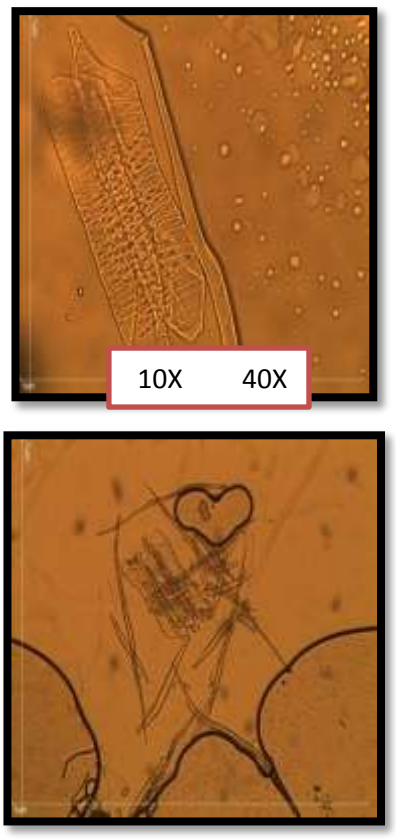

Figure (3) Length and diameter of vessel elements at 10X and 40X magnification

Table (2) Average length and diameter of vessel elements and the ratio between them

Diameter of vessel elements (micrometer)	Length of vessel elements (micrometers)	Interfaces
437.476	**869.331**	**N**
364.810	**854.871**	**S**
413.243	**877.065**	**E**
395.412	**859.412**	**W**

Fiber Length:

From Table (3), we find that the dimensions of the chemically separated wood cells varied among themselves and according to the four surfaces from which the samples were taken. Regarding fiber length, we note that the average values reached their highest percentage in the eastern surface (E), followed by the northern surface (N), where the average fiber length reached and (1802.751) micrometers respectively, while the values of both the western W and southern S Aspects for this characteristic reached (1631.749) and (1617.973) micrometers respectively. From observing these values, we find that the

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average fiber length values for both the eastern and northern Aspects were close and gave the highest length values, while the average fiber length for the western and southern Aspects were also close and gave values. Indicating that fiber length is inversely proportional to the amount of radiation reaching the area. Fiber cell length plays a role in wood strength; the longer the fiber, the stronger the tree and other physical properties, as found by [13].

The results obtained for fiber length clearly indicate that the interface, environmental conditions, and soil properties have a significant impact on fiber length. This is consistent with what was found by [2].

Medium fibers, whose lengths range between (0.90-1.90) mm, and long fibers, whose lengths exceed (1.90) mm. Hence, according to this classification, the studied maple tree fibers fall within the group of medium-length fibers. Figure (7) indicates the length of the fibers.

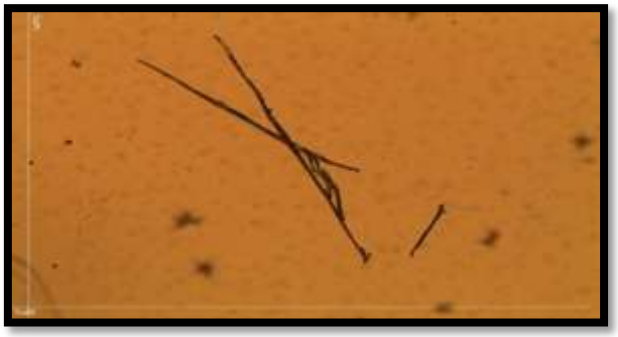

Figure (4) Fiber length 4x

Fiber Diameter:

As for the fiber diameter characteristic, the Aspects had a significant impact on this factor. The southern and western Aspects showed a significant decrease in fiber diameter, reaching (129.488) and (132.200) micrometers, respectively. Meanwhile, the northern and eastern Aspects had the same value. High values, reaching (149.595) and (141.788) micrometers, respectively. As is known, the southern and western Aspects are the two Aspects that are exposed to high solar radiation, which leads to dry soil and low humidity in these two Aspects. Therefore, under such conditions, trees tend to form fibers with small diameters and larger lengths, and this is consistent with what was found by Both researchers [3], and [2]. The situation is reversed for the northern and eastern Aspects, where the fibers have larger diameters. This is due to both Aspects containing a higher moisture content, due to the lower solar radiation incident on these Aspects. It is worth noting that increasing fiber diameter reduces bonding points, which constitutes a weakness in paper industries.

Fiber wall thickness:

Regarding fiber wall thickness, the Aspects showed a significant variation in the average values for this characteristic. The southern and western Aspects showed the highest average wall thickness values, reaching (42.429) and (42.321) micrometers, respectively. Meanwhile, the northern and eastern Aspects showed a variation in the average value of this

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characteristic (fiber wall thickness), reaching (37.151) and (34.315) micrometers, respectively. It is well known that the larger the fiber diameter, the smaller the wall thickness, and vice versa. These results are consistent with what was stated by [4], and [7], who stated that there is an inverse relationship between fiber diameter and wall thickness, and that the stiffness of fiber cells is closely related to their walls. Thick walls make trees more resistant to collapse. Thus, it is clear that wall thickness is affected by Aspects, environmental conditions, and properties.In. The results of the anatomical study of the wood of the studied maple trees showed the presence of septate fibers, which were recorded for the first time in this study, as septate fibers are an important diagnostic characteristic, and this was confirmed by [7], [6], and [2]. Figure (6) shows the septate fibers in the wood cells of the studied maple trees.

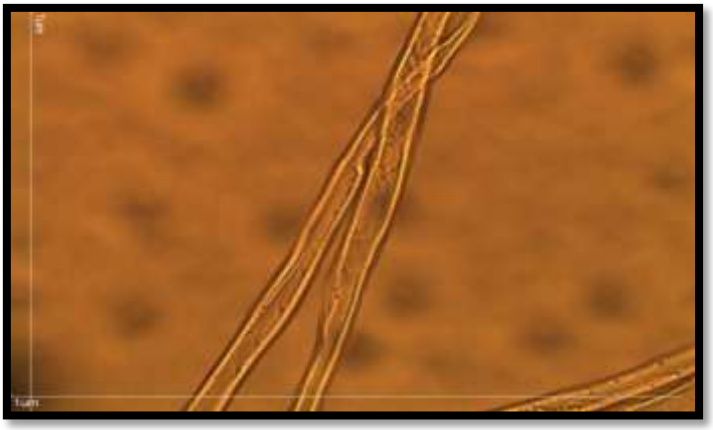

Figure (5) Fiber wall thickness 10 X

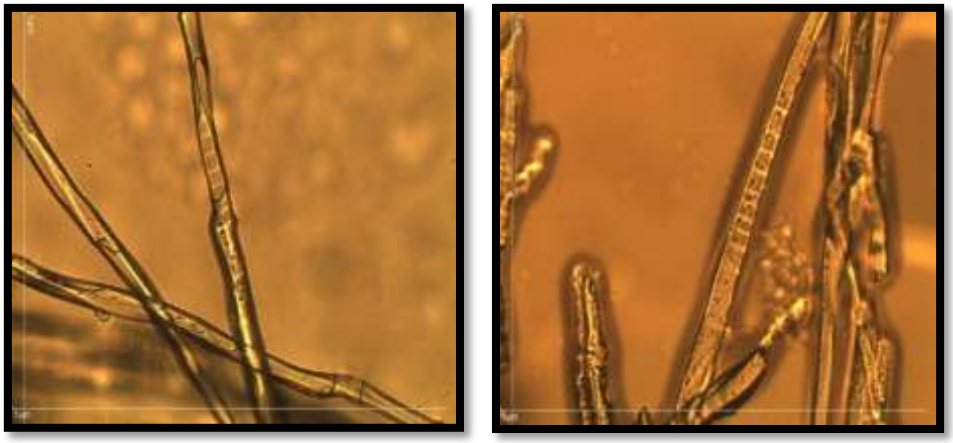

Figure (6) The divided fibers in the wood cells of the studied maple trees 10X

Runkel ratio:

The Runkel e ratio is one of the ratios used to determine the suitability of wood for the type from which it is extracted. observing Table (3), we find that there are environmental effects on the average Runkel ratio, but in general, all Aspects had values for the Runkel ratio within the acceptable limits for the industry. This ratio is used for the manufacture of paper pulp. The best types of wood for this use are those in which the value of the ratio falls between (1.5-0.25). From Paper pulp, that is, all the wood of the type under study was suitable for making paper pulp, with variations in the quality of use between the four Aspects, as the eastern Aspect had the best value for the Runkel

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ratio, which amounted to (0.965); while the northern Aspect came after it with a ratio of 0.989, then the southern and western Aspects followed it with (1.303) and (1.376), respectively. It is worth noting that the quality of the wood For the paper industry, according to the results of this study, it is linked to the low solar radiation reaching the region and the local climate of each tree, as well as to the increase in humidity. Whereas the southern and western Aspects, which have a greater amount of radiation and a lower humidity percentage, had a higher Runkel ratio, than the northern and eastern Aspects. That is, their suitability for this purpose is less. This was confirmed by both [7]. The results above, related to the Runkel ratio, indicate that the wood of the studied maple trees is suitable for the manufacture of paper and pulp. The Runkel ratio of this type of maple was affected by the Aspect, with its value being lower in the northern and eastern Aspects with higher humidity and lower temperatures, the higher the Runkel ratio. Altitude above sea level: As for altitude above sea level, there was no clear relationship between this characteristic and the anatomical characteristics of the wood.

Table (3) Average fiber length, fiber diameter, fiber wall thickness, fiber cavity diameter, braided groove diameter, and Rankel ratio.

Aspects	Fiber Length (µm)	Fiber Length (µm)	Fiber Length (µm)	Runkel ratio
N	1802.751	149.595	37.151	0.989
S	1617.973	129.488	42.429	1.303
E	1803.630	141.788	34.315	0.965
W	1631.749	132.200	42.321	1.376

Anatomy study of mechanically separated wood cells (microtom):

The results of the current study showed, as shown in Table (4), the quantitative characteristics of the wood of maple trees growing in Mount Kara **Analyzed using the mechanical method (Microtom).**

Table (4) Quantitative characteristics of the mechanically separated cells from the wood of the studied *Acer cinerascens* Bois trees.

Interfaces Attributes	North Aspect	Southern Aspect	Eastern Aspect	Western Aspect
Height of ray cells in the tangential face (micrometer)	137.058-117.516 (127.993)	140.631-109.658 (124.880)	135.959-112.004 (125.241)	146.217-106.780 (129.349)
Number of single-layer ray cells in the tangential face in height	15-37 (26.000)	19-44 (29.300)	13-28 (21.700)	20-44 (30.100)

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Height of transverse ray cells in the radial face (micrometer)	410.000-111.585 (305.175)	305.655-143.799 (258.535)	243.775-145.197 (208.102)	346.888-144.665 (194.665)

*Values within parentheses indicate the average, and values without parentheses indicate the largest and smallest range.

Regarding the height of the ray cells on the tangent face, it was found that the highest average was recorded on the western face, which amounted to (129.349) micrometers, while the lowest average was recorded on the northern face, which amounted to (127.993) micrometers. As for the eastern and western faces, the average height of the cells was. In them (124.880) and (125.241) micrometers, respectively. This indicates that there is an effect of sunlight on the Aspects, and consequently an effect of the Aspects on the characteristic of the height of the ray cells in the tangential face, as shown above, and this was confirmed by [2]. As for the number of single-layer ray cells in the tangential face in height, it was shown from the results of Table (5) that there is a clear effect of both the location and the topographical face.

In this capacity, the highest value was recorded on the western Aspect, where the number of cells ranged between (20-44) cells, with an average of (30,100) micrometers, followed by the southern Aspect, where the number ranged between (19-44) cells, with an average of (29,300) micrometers. As for the northern Aspect, the number ranged between (15-37) cells, with an average of (26,000) micrometers, while the eastern Aspect recorded the lowest values, where the number ranged between (13-28) cells, with an average of (21,700) micrometers, thus showing a clear effect of the Aspects on the number of single-layer ray cells. As for the height of the transverse ray cells in the radial face, the northern and southern Aspects recorded the highest average, which ranged between (410-000-111,585) and (305,655-143,799) with an average of (305,175) and (258,535) micrometers, respectively, then The eastern Aspect followed them with an average cell height ranging between (243.775-145.197) and an average of (208.102) micrometers, while the western Aspect was characterized by the lowest average cell height, which ranged between (346.888-144.665) and an average of (194.665) micrometers, which indicates the presence of an effect of the Aspects on the characteristic of the height of the transverse rays cells, and this result was consistent with the results of [2]. In general, the results related to the quantitative characteristics of wood cells, which are among the anatomical characteristics of wood, showed that the characteristics of maple wood have taxonomic and diagnostic importance. These differences also highlighted an important role in understanding the anatomical characteristics of wood and comparing them with other maple species spread across different countries, as indicated by previous studies.

Conclusion

The results of this study could have significant future implications for the optimal and efficient use of the studied maple wood in various economically viable industries.

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The study found that the surface area of the maple wood has an effect on the nutrient content of the soil. The surface area has an effect on the dimensions of the vessel elements of the studied maple wood. The surface area has an effect on the fiber dimensions of this type of wood. Septated fibers were recorded in this type of maple wood, a significant diagnostic characteristic. According to the results of the Rankel ratio analysis, the studied maple wood is suitable for the manufacture of paper and pulp, with the surface area influencing the Rankel ratio. Altitude above sea level has no effect on the anatomical characteristics of this type of wood. The study demonstrated the importance of qualitative and quantitative characteristics, separated by mechanical and chemical methods, in identifying and distinguishing the studied maple wood growing naturally in northern Iraq.The combination of girdling and 10 $g.L^{-1}$ with either cultivar was superior treatment with most of parameters compared to the control of both cultivars.

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