Middle-East Journal of Scientific Research 11 (4): 511-516, 2012
ISSN 1990-9233

Wood Properties Variation along Radial Position in *Quercus castaneaefolia*

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Abstract: Caucasion Oak is a fast-growing light-tending species in north Iranian forests with industrial and exporting value. This study was to determine the exact anatomic characteristics and biometric coefficients of the species along radial direction. The anatomic characteristics were tested using Franklin`s method and statistic analyses were done by means of SPSS and Excel software and then Duncan method was used to compare coefficients. Three normal Caucasion Oak trees were selected in the eastern part of Mazandaran province (Amol city). Discs were taken at breast height and testing samples were prepared in each of rings. For separation of wood fibers was used Franklin method. The results showed that fiber length (Springwood and summerwood woods), fiber diameter (Spring wood and summer wood), lumen width (Springwood and summerwood), cell-thickness of the two walls (Springwood and summerwood), flexibility coefficient (Springwood and summerwood) along radial direction from the pith to bark increase, but slenderness coefficient (Springwood and summerwood) and Runkel coefficient increase slowly so that a meaningful difference was observed in 95% assurance in different growing age (42 Years).

Key words: Caucasion Oak · Slenderness coefficient · Fiber length · Fiber diameter · Thickness of the two walls

INTRODUCTION

The north forests range from Astara, north western part of Gilan province to Gildaghi in Golestan province (800 km long and 20-70 Km wide). The Caspian (Hirkani) woods consist of precious broad-leaved species including, maple, Horn bean, Beech, Ash, Caucasion elm, Alder, Oak and Iron wood covering 1.9 million hectares. The forests cover 12.4 million hectares 7.4 % of total woods of the country [1].

Caucasion oak is among Ring porous and fast-growing, heat-loving, species growing best in deep and medium-dry soil ranging from plain to 2000 meters from the sea level. It has 500-years longevity. The maximum height is 45 meters and its diameter at breast height reaches 3 meters. It includes 8.8% of the live northern woods in the north of Iran. The species have considered medium heavy with specific gravity 0.65-0.8 gr/cm^3. The wood is very valuable for industry and export. It is also used in rail road traverses, Veneering and construction works [2].

Parsapajooh (2003) concluded that the species is a homogeneous, clear heart wood, ring porous one with large vessel holes in Spring wood. The annual rings were different because of diameter difference between spring wood and summer wood. In tangential section, the homocellular rays are monocell or multicell.

Soleimani [3] concluded conducting biometric tests on 16 species in the north of Iran that Caucasian wingnut, alder, beech and horn beam are suitable for paper making because of more fiber length, but Caucasion oak, walnut and Caucasion elm species are not suitable in spite of more than 1 mm fiber length, because they have colorful heartwood and high extractives.

Red oak is from Fagaceae family. It is 38 meters height. The species is creamish sapwood and dark brown heartwood. The wood has dense and heavy fiber and large annual ring. The green specific gravity of this species is 0.99 g/cm^3 and 0.75 g/cm^3 in moisture 12%.

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Raczkkoweka and Fabiseak [4] found studying beam change and growth speed in length cells of sissile oak that fiber length in the mature wood is 10-20% longer than the young.

Safdari (2007) found that in oak family, fir species and ring porous family of hardwood are more sensitive to climate conditions. The ending wood of ring porous will enhance when growth conditions grow.

Parsapajooh [5] found that the width of yearly growth in Caucasion oak species has a meaningful cohision with the ingredients and so with the wood characteristics. So classifying woods according to yearly growth is of importance.

Vinet [6] found that veneering from Oak wood (*Quercus pedonculata*) depends on its growth rings and Oak log with regularly less than 2 mm year growth produce the best veneering.

Doosthosseini and Parsapajooh [7] found while studying Beech that its fiber length in linear section increases from the core to the shell but the fiber length decreases from the bottom to the top.

MATERIALS AND METHODS

After consulting the natural resources experts in Amol, parcel 21 locating in the east of Haraz (Amol, north of Iran) in Zone 53, Zeyaru (Miyantalar) series was chosen. Three normal trees of Caucasion oak species with 42 cm diameter up to the chest, medium age of 42, northern grade, 10%foothill grade,35-40 cm deep organic surface soil and 180 meter height from the sea level were randomly cut down. Then 3 discs were provided with chain saw from chest height. Geographical direction, tree number and disc number were marked on the disk with a sign. The disk were robed with melted Parafin and transferred to the wooden industry lab in Chalous branch, Islamic Azad University, the year rings were determined and analyzed in accordance with the age and year of growth of Spring wood and Fall wood.

To determine biometric coefficients, wood samples were taken with Franklin`s method. In this method, a solution of acetic acid and oxygenized water is used with 100% density and 50-50 relation. Wood samples i.e thin steaks (thinner that match steaks (0.2×0.2×1) were prepared and inserted in test tubes and each sample was given the cod tag. Then, the acetic acid and oxygenized water solution was dispersed on the sample twice as much as their volumes. The samples were put in an oven with 64 ±1heat for 24 hours. After growing pale, the samples were washed (4-5 times) in distilled water so that the solution smell gooff and then the samples were saturated with distilled water so the sample be ready to determine the biometric characteristics with a sudden shake. Then a drop of the solution was place on the glass lum and the lumenl was put on it. Then every sample was put under a microscope and fiber was randomly measured randomly.

Fiber length is significant factor in paper mill and other industrial uses. Research shows the more the fiber length, the more the fiber percentage will be and species grown in ideal conditions will produce longer fiber [8].

Fiber diameter and lumen diameter are influential factors that increase flexibility coefficients, paper resistance against tearing; and interweaving and crack. This coefficient increases with an increase in the lumen diameter. Based on the formula, fiber length have plays an important role in increasing and decreasing of Slenderness coefficient. Runkel coefficient is closely related to thickness of the two walls whose increase will increase paper resistance against tearing.

Flexibility coefficient=lumen diameter/fiber diameter
Slenderness coefficient=fiber length
Runkel coefficient = cell-thickness of the two walls/lumen diameter

Statistical Analysis: In order to determine the relationship between the experimental variable (radial position) and wood properties, all the data measured were subjected to an analysis of variance and Duncan's mean separation test.

RESULTS AND DISCUSSION

Fiber Characteristics: Table 1 shows descriptive statistic results of factors studies about spring wood and late wood of Caucasion oak species. The analysis of variance (Table 2) shows that spring wood and late wood has meaningful differences from pith to bark at 1% reliability. The average fiber length in Spring wood and late wood are 1159.72 and 1146.68 respectively; the average fiber diameter in Spring wood and late wood are 17.30and 16.82 respectively; the average lumen width in Spring wood and late wood were 6.59 and 6.45 respectively; the average thickness of the two walls of fiber in Spring wood and late wood were 10.70 and 10.37 respectively. According to the illustration, the measurements increased from the pith to the bark. The changes are made by the young cambium of the young tree produce cells with less length and diameter via cell divisions. Yet in mature trees, large cells with more thickness are produced by cambium activity [9,10].

Table 1: A comparison of fiber dimension in the most important hardwood species in the north of Iran

	Fiber length (μm)	Fiber diameter (μm)	Lumen width (μm)	Thickness of the two walls(μm)	researcher
Maple	1016.17	22.57	14.69	7.88	Bakhshi *et al.* [12]
Beech	1236.35	23.21	7.61	15.60	Varshoei *et al.* [13]
Horn beam	1763	23.24	9.78	12.10	Solimani [14]
Wing nut	1310	27.21	13.10	18.11	Bakhshi [15]
Sweet locust	1282	32.30	12.9	19.5	Bakhshi and Nouri [16]
Caucasion elm	1325	28.10	16.4	11.5	Bakhshi and Kiaei [17]
Alder	1170	28.13	-	-	Vaysi [18]

Table 2: Descriptive statistics for fiber dimension and biometry properties of Oak wood in North of Iran

	Mean	Max	Min	Std.Deviation
Fiber length in springwood (μm)	1159.72	1600	680	156.24
Fiber length in latewood (μm)	1146.68	1580	620	156.24
Fiber diameter in springwood (μm)	17.30	25.20	9.80	2.77
Fiber diameter in latewood (μm)	16.82	28	7.84	3.01
Lumen width in springwood(μm)	6.59	15.5	2.45	2.12
Lumen width in latewood (μm)	6.45	15.5	1.96	1.97
Two walls thickness in springwood (μm)	10.70	16	0.49	2.03
Two walls thickness in latewood (μm)	10.37	16.5	3.1	2.01
Flexibility ratio in springwood	0.37	0.96	0.16	0.09
Flexibility ratio in latewood	0.38	0.63	0.19	0.08
Slenderness ratio in springwood	68.21	109.14	38.48	12.62
Slenderness ratio in latewood	70.04	149.36	35.44	14.57
Rankel ratio in springwood	1.79	5	0.03	0.66
Rankel ratio in latewood	1.75	4.2	0.59	0.62

Table 3: Analysis of variance between wood properties and fiber features

	Sun of squares	df	Mean square	F
Fiber length in springwood	5035881.084	34	148114.150	7.900**
Fiber length in latewood	3186639.294	34	93724.685	5.617**
Fiber diameter in springwood	1218.118	34	35.827	7.840**
Fiber diameter in latewood	1463.966	34	43.058	8.163**
Lumen width in springwood	489.656	34	14.402	4.231**
Lumen width in latewood	585.997	34	17.235	7.133**
Two walls thickness in springwood	427.846	34	12.584	3.929**
Two walls thickness in latewood	514.150	34	15.122	5.380**
Flexibility ratio in springwood	0.565	34	0.017	2.184**
Flexibility ratio in latewood	0.847	34	0.025	5.200**
Slenderness ratio in springwood	13929.942	34	409.704	3.118**
Slenderness ratio in latewood	26720.950	34	785.910	5.296**
Rankel ratio in springwood	28.232	34	0.830	2.063**
Rankel ratio in latewood	44.471	34	1.308	4.505**

Fiber which very thick walls act like small cellulose bars which bend hard and are not suitable for producing papers; they produce harsh papers that printing ink dots not attach them well. An increasing of fiber diameter thickness had significantly effect on the paper resistance, elasticity and tear strength [11].

The average of fiber dimension some important species in the north of Iran is shown in Table 1, among which Beech, Maple and Alder are significantly important in the Iranian wooden industry.

Fiber lengths in most trees increase from trunk piths to the bark side to the maximum level and after reaching the reaching the maximum frequency stay in balance and then decrease gradually [19].

Wood fiber length is directly related to all mechanical characteristics and fiber diameter is related to qualitative characteristics of wood, but because these two aspects are closely related to the specific gravity of wood and the description is determined by on wood quality by the specific gravity.

The average morphological characteristics of Caucasion oak are shown in Table 2. Analysis of variance (Table 3) shows that Spring wood and late wood have different morphological characteristics from pith to bark in all cases at 0.01 reliability. The average flexibility coefficient in this species in spring wood and late wood is 0.37and 0.38, respectively. The average slenderness coefficient in spring wood and late wood is 68.21 and 70.4 respectively; average Runkel coefficient in both wood are 1.79 and 1.75 respectively.

As the illustration shows, the slenderness coefficient in Spring wood is(R^2=0.002) and in Fall wood is (R^2=0.06), Runkel coefficient is (R^2=0.01) in Spring wood and (R^2=0.03) in late wood decreasing from the pith to the bark. Flexibility coefficient is (R^2=0.004) in spring wood and (R^2=0.04) in late wood, increasing from pith to bark. The changes are made because of the changes in length, diameter and fiber lumen width, so a decrease in lumen width decreases flexibility coefficient: a decrease in fiber lengths decreases slenderness coefficient and a decrease in lumen width and an increase in thickness of the two walls increases in Runkel coefficient. If the slenderness coefficient be more than 33, the paper quality will increase [20]; the average slenderness coefficient in spring wood and late wood is 68 and 70 which is better than normal. Flexibility coefficient are classified in four in accordance with the characteristics suggested by Bektas [21]:

- Super elastic fibers with more than 75 flexibility coefficient.
- Elastic fibers with 50-75 flexibility coefficients.
- Hard fibers with 30-35 flexibility coefficients.
- Very hard fibers with less than 30 flexibility.

Caucasion oak with 37 and 38 flexibility coefficients in Spring wood and late wood respectively is not suitable for paper mill. According to Eroglu [22], Runkel coefficient higher than 1 is not suitable to produce paper because of increasing the thickness of the two walls of cells, but increases resistance against tearing. If the co efficiencies be equal or less than 1, it will be suitable for paper mill because of thinner cell wall; in this study, Runkel coefficients for the spring wood and late wood we measured 1.75 and 1.76 respectively which is suitable for paper mill. According to cambium age Coefficients chart and morphological coefficients (Figure 1 and 2), R^2 shows no relation between the two factors.

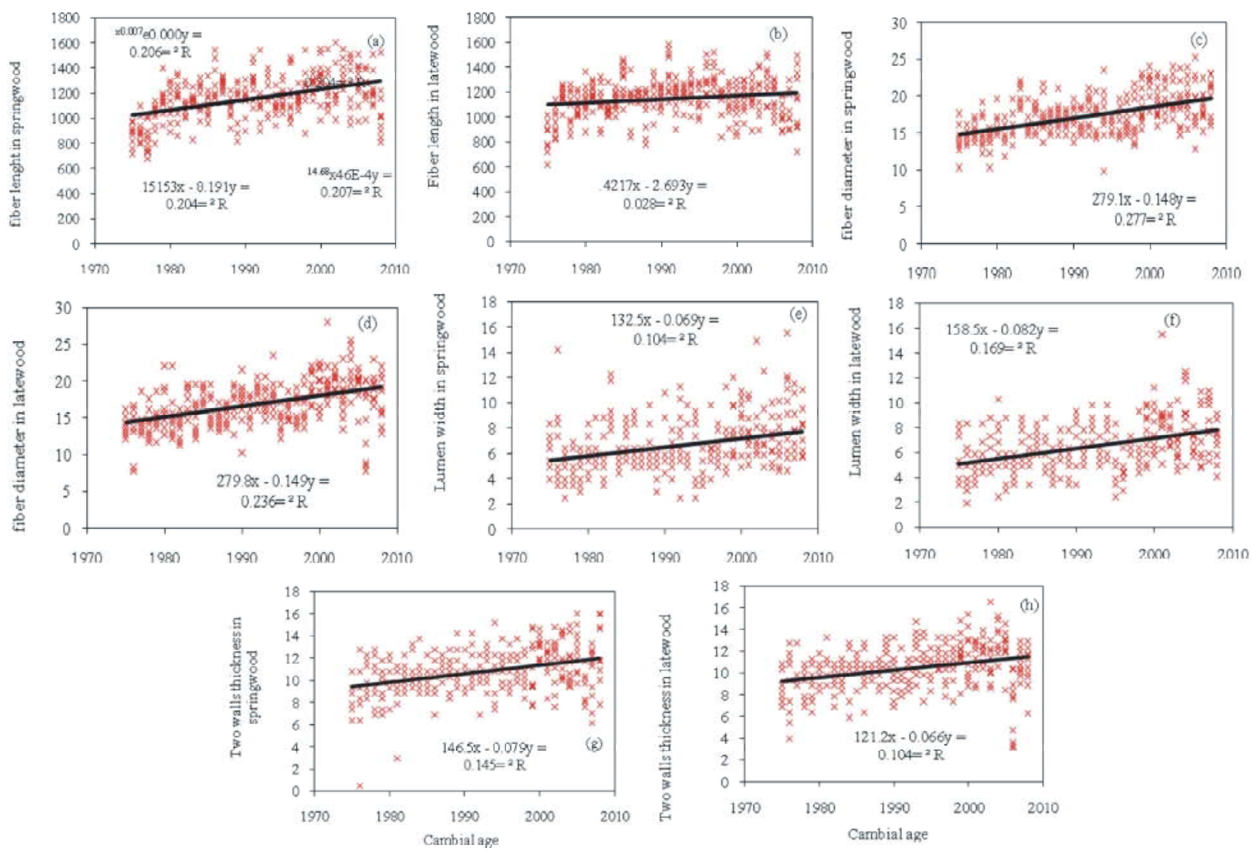

Fig. 1: Variation trend of fiber features along radial position from the pith to the bark, a) Fiber length in springwood, b) Fiber length in latewood, c) Fiber diameter in springwood, d) Fiber diameter in latewood, e) Lumen width in springwood, f) Lumen width in latewood, g) Two walls thickness in springwood, h) Two walls thickness in latewood,

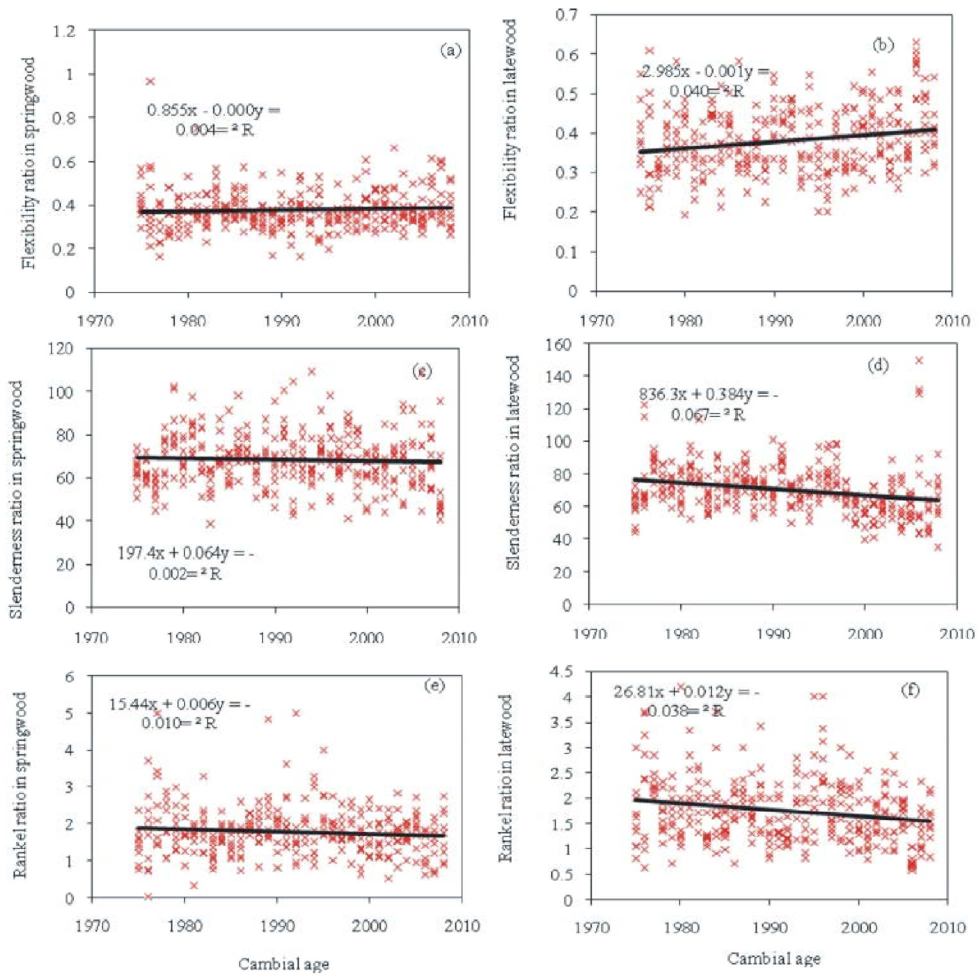

Fig. 2: Variation trend of biometric features along radial position from the pith to the bark, (a) Flexibility ratio in springwood, b) Flexibility ratio in latewood, c) Slenderness ratio in springwood, d) Slenderness ratio in latewood, e) Runkel ratio in springwood, f) Runkel ratio in latewood

REFERENCES

1. Sabti, H., 1994. Forests, Trees and small trees of Iran. Yazd University Publications.
2. Forests organization publication of Iran, 2006. Complete map review, Table 5.
3. Soleimani, P., 1957. Physical and mechanical properties of wood of northern forest, Iran. Nature resource, pp: 5.
4. Raczkkoweka and Fabisiaok, 1991. Radial variation grwth rate in the Length of axial elements of sissile oak wood, IAWA bull. ns., 12(3): 257-262.
5. Parsa pajooh, D., 1973. Correlation between annual ring and technology quality. Nature Resource, 29: 51.
6. Venet, J., 1965. Classement dubois. Cours de technologic du bois, E.N.G.R.E.F., Nancy.
7. Doost hossini, K. and Parsa pajooh, The variation of physical properties and fiber length along longitudinal and radial directions. Nature Resources, 69(5).
8. Parsapajooh, D. and F.H. Schweingruber, 1993. Iranian north woods atlas. Tehran University Publications, pp: 136.
9. Hosseini, S.Z. and R. Naghdi, 2004. Evaluation on juvenile period and fiber length variation of maple wood (*Acer velutinum* Boiss), Journal Agriculture Science Nature Resource, 11(2): 7-15.
10. Panshin, A. and C. Dezeeuw, 1980. TextBook of wood technology. 4th edition, McGraw-Hill, New York.
11. Zobe, L., B.J. Van and J.P. Bujitenen, 1989. Wood variation, Its causes and control, Spring-Verlag, Berlin, Heidelberg, New York.

12. Bakhshi, R., S. Veylaki and M. Kiaei, 2011. The effect of climate on fiber properties of Maple wood. Middle-East journal of scientific research, 8(4): 739-746.
13. Varshoei, A., D. Parsapajouh and A. Sheikheslami, 2007. The effect of site conditions on wood biometric coefficients in Iranian beech (*Fagus orientalis Lipsky*), J. of Agriculture Science, 12(3): 677-684.
14. Soleimani, P., 1957. Biometric properties of *carpinus betulus* and it application in papermaking industrial. Nature resource, 26: 32-35.
15. Bakhshi, R. and M. Kiaei, 2009. A study on anatomical properties and papermaking ratios of wingnut in nowshahr region. The one Iranian coference on supplying raw materials and development of wood and paper industries.
16. Bakhshi, R. and A.A. Nourisadegh, 2010. Climate and anatomical properties sweet locust species wood at tree site altitude in Nowshahr region. Climate change and Dendrochronology in Caspian Ecosystems, 12-14May.
17. Bakhshi, R. and M. Kiaei, 2010. Climate and qualitative properties of Caucasion elm species wood at three site altitudes in Nowshahr. Climate change and Dendrochronology in Caspian Ecosystems, 12-14May.
18. Vaysi, R., 2006. Investigation on fiber length variation and chemical composition in Alnus subcordata.
19. Bhat, K.M., K.V. Bhat and T.K. Dhamodaran, 1989. Fiber length variation in stem and branches of Eleven Tropical Hardwoods, IAWA., B.n.s., 10: 63-70.
20. Xu, F., X.C. Zhong, R.C. Sun and Q. Lu, 2006. Anatomy, ultra structure and lignin distribution in cell wall of Caragana Korshinskii. Industrial Crops and Production, 24: 186-193.
21. Bektas, I., A. Tutus and H. Eroglu, 1999. A study of the suitability of Calabrian pine (Pinus Brutiaten.) for pulp and paper manufacture. Turk. J. Agric. For., 23: 589-599.
22. Eroglu, H., 1980. Investigating possibilities of obtaining wood pulp from wheat straw by O_2-naoh method. Ph.D Thesis, Karadeniz Technical University.