Influence of Sessile Oak Log Characteristics on the Efficiency in Veneer Cutting

Adela-Eliza Dumitrascu,[a] Elena-Camelia Musat,[b] Dorin-Ion Dumitrascu,[c] Valentina Doina Ciobanu,[b] and Emilia-Adela Salca [d,]*

The sessile oak tree represents 10.5% of the forest area in Romania and is the most widespread indigenous oak species. To select the most suitable domain of use for sessile oak wood, certain dimensional and qualitative criteria were taken into consideration. The aim of the present study was to highlight the influence of some log characteristics (wood diameters and quality) on the efficiency in sessile oak veneer cutting. The authors used a group of sessile oak logs purchased from Targoviste in Southeast Romania. The results analysis indicates the influence of sessile oak log diameters on the veneer efficiency comparative with decorative veneer efficiency by estimation of the cumulative density function (CDF). Analyzing the quality of sessile oak logs, it was found that buds and insect holes were the most important defects that appeared. Also, the regression analysis indicates an acceptable level of the present defects and did not have a significant influence to the veneer cutting efficiency, upon the number of obtained veneer sheets and the surface area of special veneer sheets, respectively.

Keywords: Sessile oak; Veneer efficiency; Cumulative density function; Defects; Regression analysis

Contact information: a: Department of Manufacturing Engineering, Transilvania University of Brasov, Mihai Viteazul 5, 500174, Brasov, Romania; b: Department of Silviculture and Forest Engineering, Transilvania University of Brasov, Sirul Beethoven 1, 500123, Brasov, Romania; c: Faculty of Mechanical Engineering, Transilvania University of Brasov, Politehnicii 1, 500024, Brasov, Romania; d: Faculty of Wood Engineering, Transilvania University of Brasov, Universitatii 1, 500068, Brasov, Romania;
** Corresponding author: emilia.salca@unitbv.ro*

INTRODUCTION

The sessile oak wood species (*Quercus petraea* (Mattuschka) Liebl.) is located in wide areas across Europe. Its population spreads from the Iberian Peninsula to Norway, going East to Crimea and Caucaz, passing to Minor Asia and reaching North of the Mediterranean Sea (Kremer and Zanetto 1997; Şofletea and Curtu 2007; Alberto *et al.* 2011).

In Romania, the oak wood species represent 18% of the country’s forest area. Oak trees can have large dimensions, and the wood itself presents specific and valuable physical, mechanical, and aesthetic properties (Kruch and Nicolescu 2010; Knorn *et al.* 2012; Petrițan *et al.* 2012). It is worth mentioning that at the national level, the sessile oak represents 10.5% of the forest area, it is the highest spread indigenous oak species, and it occupies 56% of the *Quercus* species area (Şofletea and Curtu 2007).

Moreover, the economic importance of this wood species is highlighted by the numerous publications that approached problems related to the wood structure and its quality, the specific defects that appeared, the efficiency in veneer cutting, the genetic variations, the genetic control of various characteristics, and the influence of the manufacturing features on the efficiency in veneer (Raczkowska and Fabisiak 1991; Savill *et al.* 1993; Zhang *et al.* 1994; Mosedale *et al*. 1996; Feuillat and Keller 1997; Kremer and Zanetto 1997; Doussot *et al.* 2002; Le Moguédec *et al.* 2002; Mercker and Hopper 2004; Alberto *et al*. 2011; Kruch 2011; Moldovan 2011; Moroşanu 2012; Dumitrascu *et al*. 2013; Musat *et al.* 2016; Rohumaa *et al.* 2016; Denes *et al.* 2017; Pangh and Doosthoseini 2017).

The geographical forest repartition in Romania, the wood species ratios and their grouping on the forest land, in the case of important wood species, are expressed through the following data: 30% softwoods, 30% beech, 20% oak species, 15% diverse hard hardwoods, and 5% diverse soft hardwoods. The functional location of forests is another important criterion used for their allocation on the land. In Romania, from that point of view, the group of forests having special functions of protection and that one having functions of production and protection are similarly allocated on the land, that means with equal ratios.

The wooden mass quality, which is yearly valued, depends on: wood species, health of marked trees, forest age, and the nature of the products. The economic value of the exploited forest species mainly depends not only on the wood quality, but also on the possibilities to capitalize the processing industry. As regard to the later aspect, the sessile oak tree is mainly used to obtain structural and decorative veneers. To increase the veneer diversity and to capitalize the small-sized veneers, the so-called reconstructed veneers are produced.

A complete and efficient use of the wood resource is needed in the wood products industry. Therefore, each piece of wood must be economically used and valued according to its quality. To select the most suitable domain of use for sessile oak wood, dimensional and qualitative criteria are taken into consideration. The raw wood is graded based on various quality classes, which have undergone changes over time. There are three quality classes for an oak log used in various industries, the F class for veneers and classes I and II for timber and other wood products.

The economic importance of the sessile oak wood is influenced by the compliance with the quality standard (ISO 1316-1 (2013)). Four quality classes (Q-A, Q-B, Q-C, and Q-D) are specified within SR EN 1316-1 (2013), out of which the first two provide restrictions regarding the sapwood radial width. All of the details and defects are defined within the European standard mentioned above, with respect to common oak and sessile oak, including also the quantified sapwood width for logs quality classification. The major difficulty hindering the high-efficiency marketing of such wood species is the fact that most of the features and defects newly introduced into SR EN 1316-1 are not reflected in the Romanian standards, such as the frequency of spreading, size, and log distribution (Dumitrascu *et al.* 2013).

This paper aims to highlight the effects that certain wood characteristics have on the efficiency of sessile oak veneer cutting. Such wood species provide high quality wood with special physical-mechanical properties and aesthetic qualities that make it a valuable wood resource for the furniture industry.

The wood of sessile oak used for decorative veneers is not currently mass-produced, and it is spread in different ratios within the forest area. The forest areas in which such sessile oak trees were identified presented a large number of good quality trees over 120 years old. In Romania, in most of the cases, the official buyer is the one who decides which trees in the forest will be purchased.

The present research focuses on the qualitative and quantitative analysis of the sessile oak raw materials from Targoviste Region (Romania) in accordance with the imposed criteria and evaluation standards. This research analyzed the influence of the sessile oak logs diameter and their quality upon the efficiency in veneers and decorative veneers cutting. Based on the obtained data, diagrams specific to each diameter category were represented. The cumulative density function (CDF) that allows one to estimate the probability of obtaining the veneer efficiency when compared to the one of decorative veneer was determined. From the qualitative point of view, the most important types of defects were identified. The defects with the highest influence upon the efficiency in veneers and decorative veneers considering the number of obtained veneer sheets and the surface area of special veneer sheets were identified by using the regression analysis.

EXPERIMENTAL

Materials

This research used a group of sessile oak logs purchased from the Silvic Division of Targoviste, Romania to obtain veneers and decorative veneers as well. Both quantitative and qualitative criteria were taken into consideration for the logs selection (Table 1).

Table 1. Quantitative and Qualitative Criteria of Logs for Veneers Cutting according to SR EN 1316-1 (2013)

<table>
<tr><th>Grade</th><th>Minimum Diameter (cm)</th><th>Length of Logs According to Their Grades (m)</th><th>Non-accepted Defects</th></tr>
<tr><td>A</td><td>60</td><td rowspan="3">2.70 – 2.80
2.80 – 2.90
2.90 – 3.20
3.20 – 3.30
3.30 – 3.40
3.40 – 3.50
3.50 – 3.60</td><td rowspan="3">Diameters lower than 40 cm without sapwood at the thin end.
Shape defects: taper > 1 cm/m; curvature > 15%; ovality > 8%; excentricity > 0.6 mm/m.
Major structural defects: knots; burls; rot; insect holes; ring shake; spiral grain; end splits; splits; buds; double alburnum; discolorations;
Minor structural defects: frequency of annual rings (less than 3 rings/cm); frost cracks; ingrown bark.</td></tr>
<tr><td>B</td><td>51</td></tr>
<tr><td>C</td><td>40</td></tr>
</table>

Table 2 presents the classification of sessile oak logs based on their grades and diameters.

Table 2. Distribution of Sessile Oak Logs Based on Diameter Category

Diameter Category		Number of Pieces Per Diameter Category	Total Number of Logs
Class No.	Diameter (cm)		
I	40 to 55	69	217
II	56 to 70	128	
III	71 to 85	19	
IV	>85	1	

The main statistical parameters, which refer to the raw material characteristics investigated, are presented in Table 3. It is worth noting that the average values were close to the median values determined for the entire group of logs. Such an observation indicated that the values of each studied parameter were normally distributed.

Table 3. Main Characteristics of Sessile Oak Raw Material for Veneers

Characteristics	Statistical Parameter					
	Minimum	Maximum	Mean	Median	Standard Error	Standard Deviation
Diameter (cm)	48	86	60	60	0.48	7.06
Length (m)	2.3	3.9	3.0	2.9	0.03	0.37
Volume (m^3)	0.489	1.864	0.880	0.820	0.02	0.26
Veneer Efficiency (m^2/m^3)	39.33	1602.08	771.70	771.34	14.97	220.53
Decorative Veneer Efficiency (m^2/m^3)	0	1332.41	655.01	677.20	16.12	237.52
Surface (m^2)	52.47	1707.16	645.71	612.13	18.88	278.06
Number of Sheets	385	4100	1617	1645	30.01	442.02

Methods

The data analysis focused on the efficiency in the veneer and decorative veneer cutting, the veneer surface, and the number of resulted veneer sheets. Therefore, some statements regarding the technological process are needed. Moreover, each oak log presented a unique bar code that was set and identified along the entire process, *i.e.*, at the final processing step, the above-mentioned parameters of each log were known and used (Moroșanu 2012).

The technological process began with the log transfer from the log yard to the cutting sector, where it was cut into two, three, or four spliwoods as a function of its size (Cassens 2003; Mercker and Hopper 2004). Each piece received the same identification bar code to the log it belonged to (original log). These log parts were stacked in such a way to rebuild the initial log, and they were transferred through the basins for a heat treatment. The heat-treated material was cut into veneer sheets that were later stacked and each of the stacks received the same identification bar code to the original log. The veneer drying was followed by the conditioning and sizing of veneer sheets (*** 2000; Cassens 2003), which included the defects removal. Lastly, the veneer sheets were classified according to their quality and dimensions.

The research methodology was based on the analysis of log characteristics as a function of the quantitative and qualitative conditions, and the reference of sessile oak log parts to their log diameter category. By using the specific cumulative density functions (CDF) applied to each diameter category, the efficiency in veneer cutting compared to decorative veneer cutting was analyzed. The influence of the sessile oak log quality on the efficiency of veneer cutting consisted in the identification of the main categories of the defects.

RESULTS AND DISCUSSION

Influence of Sessile Oak Log Diameter on the Efficiency in Veneer Cutting

The repartition of the sessile oak logs under investigation as a function of the diameter category (Fig. 1) indicated that the best pieces corresponded to the A and B classes (Table 1), such as 30 logs having the diameter of 54-55 cm and 31 logs having the diameter of 60-61 cm, while only a few pieces belonged to the III and IV classes (Table 2).

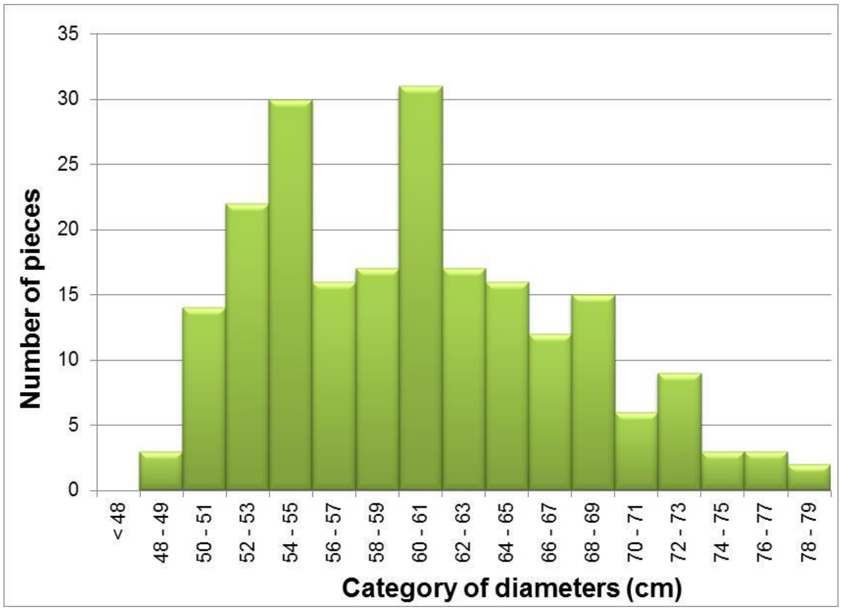


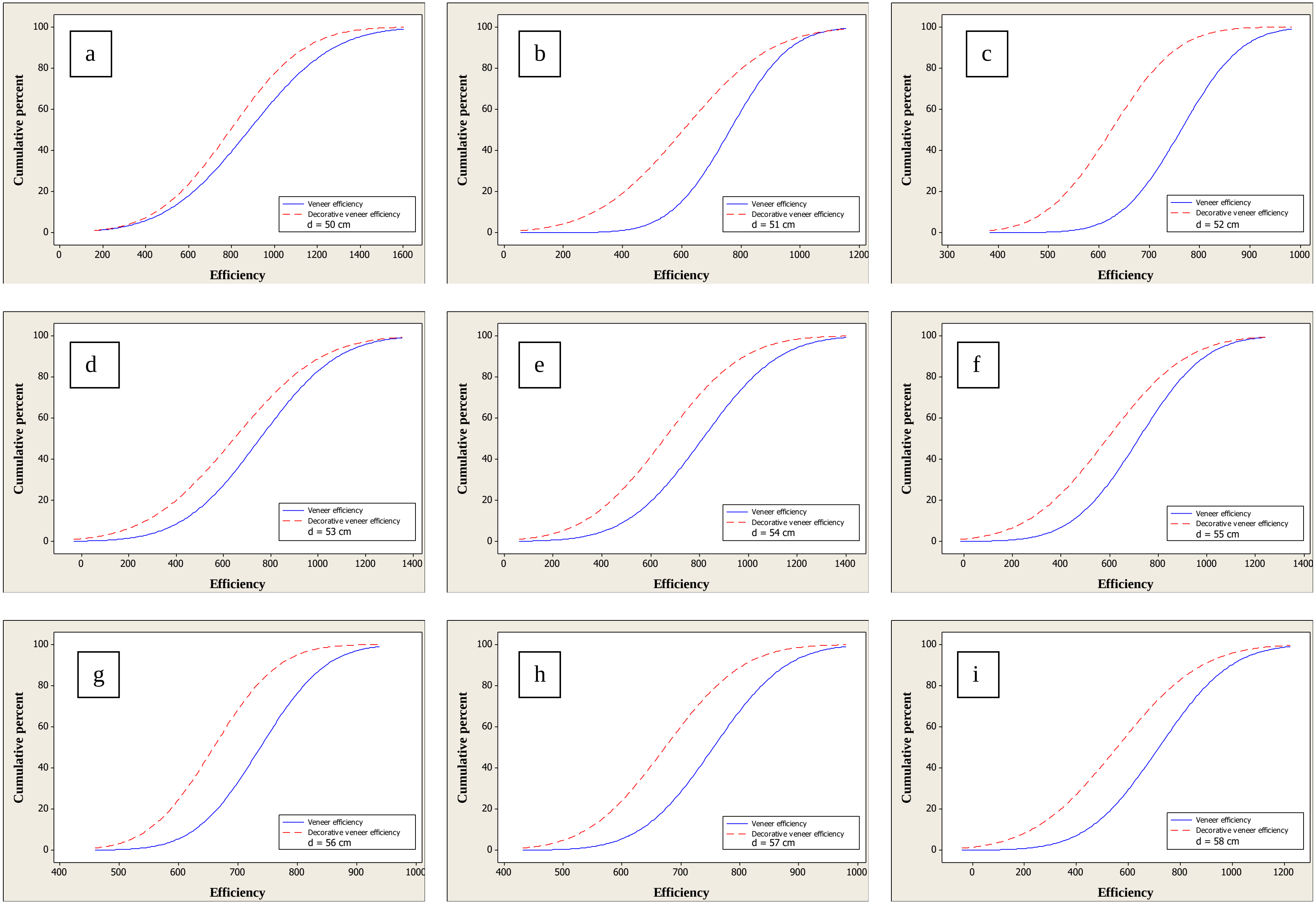
Fig. 1. Distribution of raw material as function of diameter category

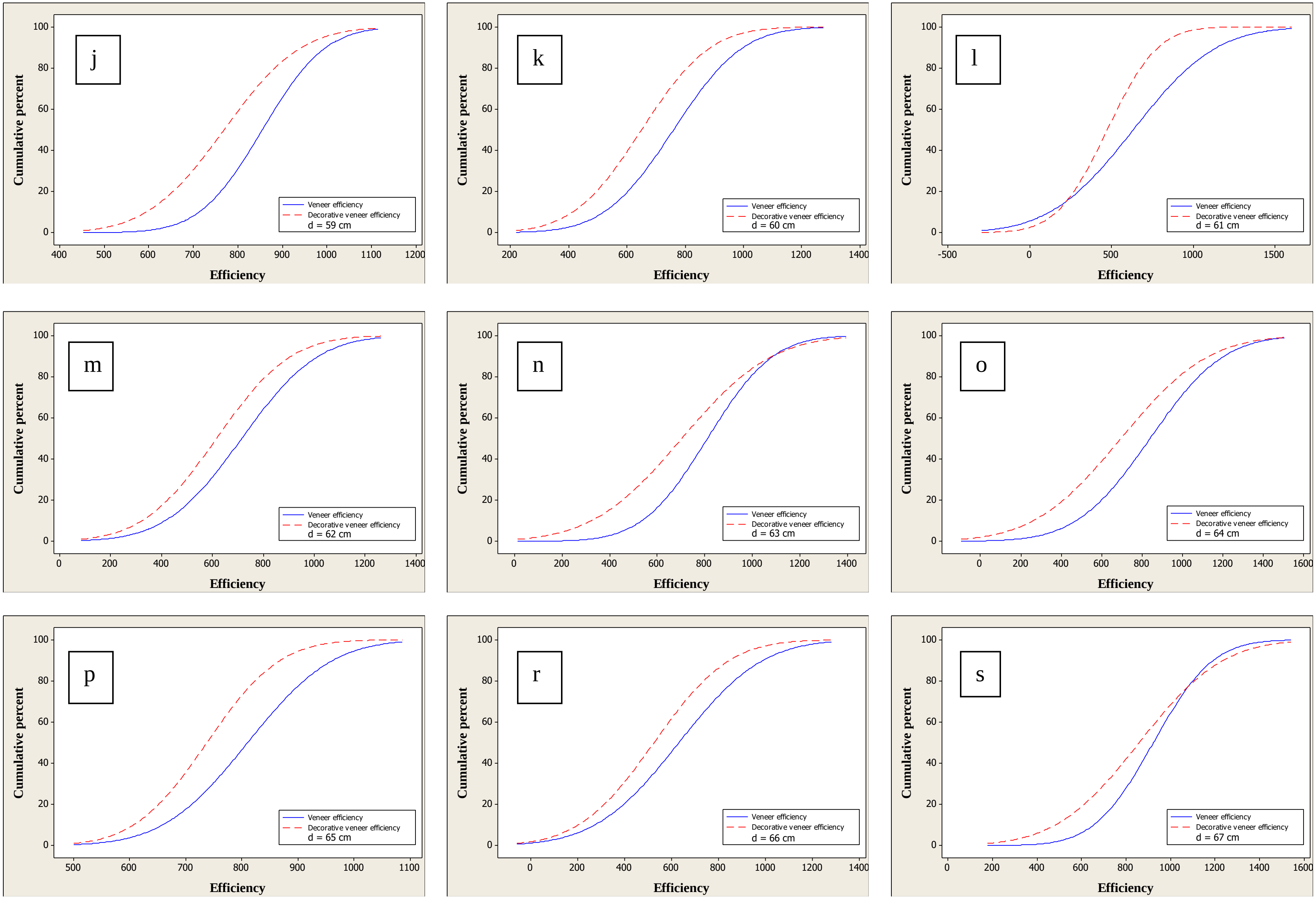
The statistical analysis of data was performed by using Minitab. The program allows the graphically representation of the experimental data points overlapped by the curves. In this respect, the statistical analysis was applied to each diameter category from 50 cm to 73 cm. This study focused on the probability to obtain efficient veneer and decorative veneer cutting, based on the cumulative density function (CDF). Figure 2 (a to z) illustrates the cumulative probability distributions specific to each log diameter category.

The results expressed by the cumulative density functions (Fig. 2) show the probability to obtain efficient veneer cutting compared to decorative veneer cutting. To highlight the influence of the log diameter upon the veneer cutting efficiency, a minimum probability of 80% and 90% for veneer cutting and decorative veneer cutting were considered, respectively. The comparative results are shown in Figs. 3 and 4.

For the probability of 80%, the best efficiency in veneer cutting was obtained for the logs having the diameter of 50 cm (Fig. 3). A special and distinct situation appeared for the logs having the diameter of 67 cm when the efficiency in veneer cutting was equal with that one of decorative veneers of about 1100 m^2/m^3.

For the probability of 90% the best efficiency in veneer cutting was obtained for the logs having the diameters of about 50 and 64 cm (Fig. 4), while the maximum value of the efficiency in decorative veneer cutting corresponds to the logs having a diameter of 67 cm. For that category maximum values of the efficiency in veneer cutting and decorative veneers as well, for the probability of 80%, were obtained.


a
Cumulative percent
Efficiency
Veneer efficiency
Decorative veneer efficiency
d = 50 cm
b
Cumulative percent
Efficiency
Veneer efficiency
Decorative veneer efficiency
d = 51 cm
c
Cumulative percent
Efficiency
Veneer efficiency
Decorative veneer efficiency
d = 52 cm
d
Cumulative percent
Efficiency
Veneer efficiency
Decorative veneer efficiency
d = 53 cm
e
Cumulative percent
Efficiency
Veneer efficiency
Decorative veneer efficiency
d = 54 cm
f
Cumulative percent
Efficiency
Veneer efficiency
Decorative veneer efficiency
d = 55 cm
g
Cumulative percent
Efficiency
Veneer efficiency
Decorative veneer efficiency
d = 56 cm
h
Cumulative percent
Efficiency
Veneer efficiency
Decorative veneer efficiency
d = 57 cm
i
Cumulative percent
Efficiency
Veneer efficiency
Decorative veneer efficiency
d = 58 cm


j
Cumulative percent
Efficiency
Veneer efficiency
Decorative veneer efficiency
d = 59 cm
k
Cumulative percent
Efficiency
Veneer efficiency
Decorative veneer efficiency
d = 60 cm
l
Cumulative percent
Efficiency
Veneer efficiency
Decorative veneer efficiency
d = 61 cm
m
Cumulative percent
Efficiency
Veneer efficiency
Decorative veneer efficiency
d = 62 cm
n
Cumulative percent
Efficiency
Veneer efficiency
Decorative veneer efficiency
d = 63 cm
o
Cumulative percent
Efficiency
Veneer efficiency
Decorative veneer efficiency
d = 64 cm
p
Cumulative percent
Efficiency
Veneer efficiency
Decorative veneer efficiency
d = 65 cm
r
Cumulative percent
Efficiency
Veneer efficiency
Decorative veneer efficiency
d = 66 cm
s
Cumulative percent
Efficiency
Veneer efficiency
Decorative veneer efficiency
d = 67 cm

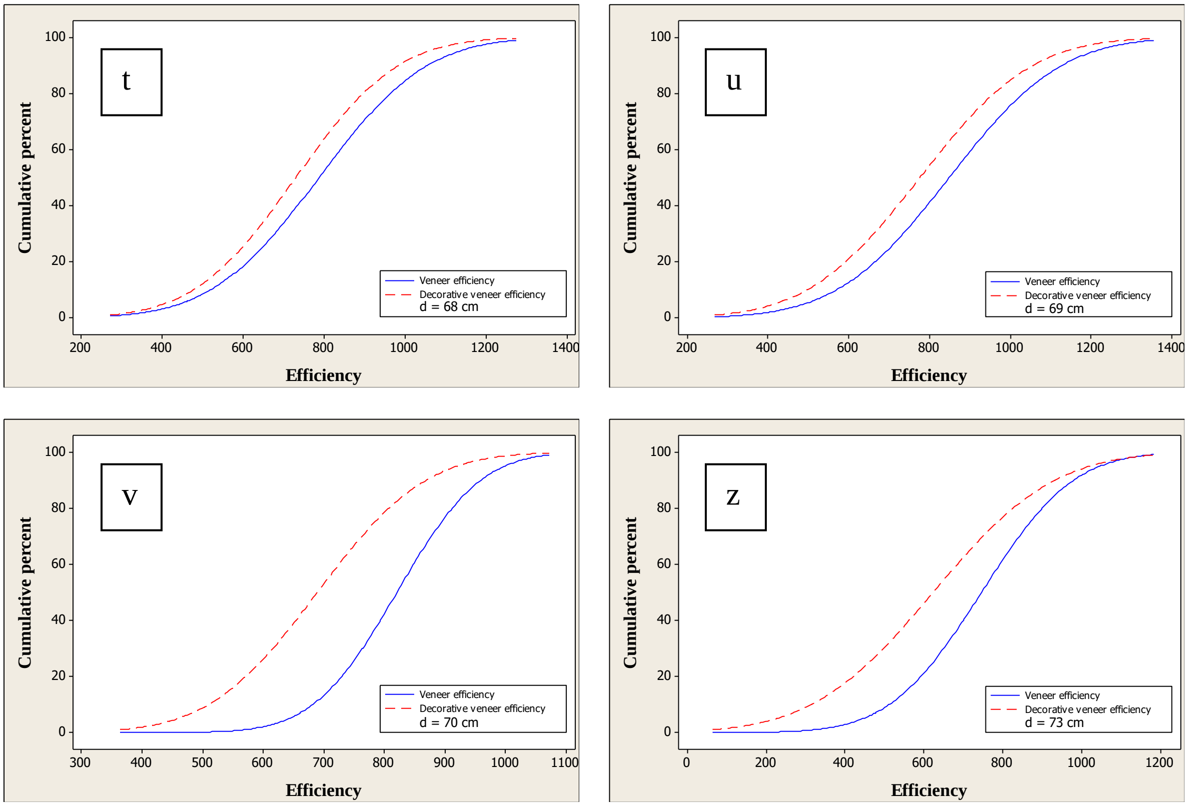


Fig. 2. Cumulative density functions (CDF) for veneer efficiency as function of log diameter: 50 cm (a), 51 cm (b), 52 cm (c), 53 cm (d), 54 cm (e), 55 cm (f), 56 cm (g), 57 cm (h), 58 cm (i), 59 cm (j), 60 cm (k), 61 cm (l), 62 cm (m), 63 cm (n), 64 cm (o), 65 cm (p), 66 cm (r), 67 cm (s), 68 cm (t), 69 cm (u), 70 cm (v), and 73 cm (z)

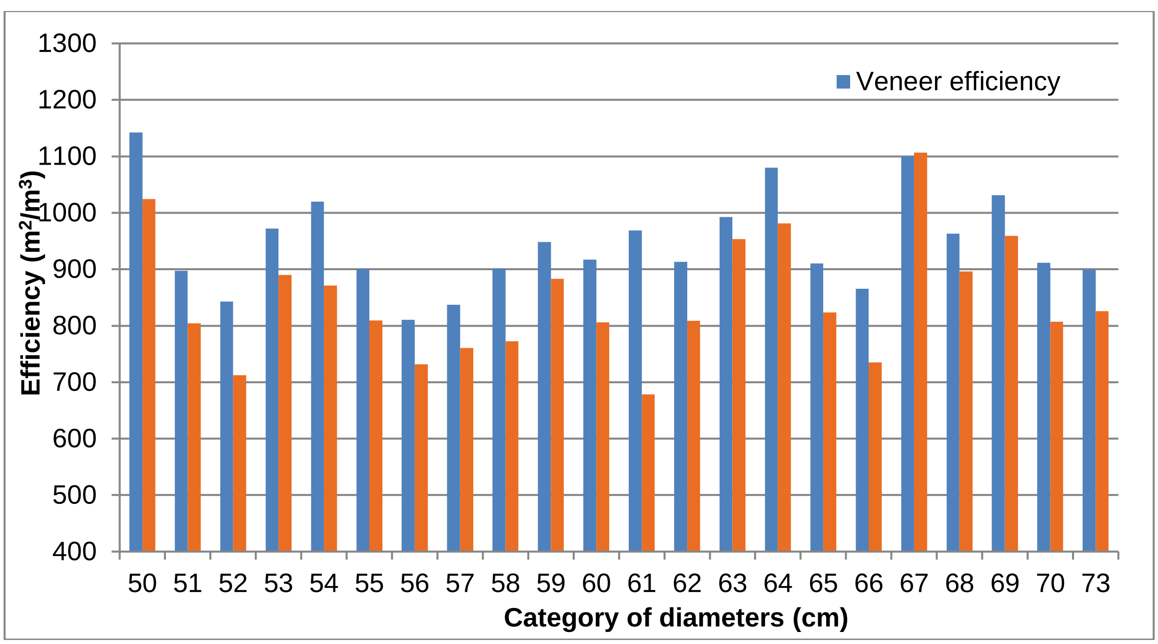


Fig. 3. Comparative analysis of the efficiency in veneer and decorative veneer cutting corresponding to a probability of 80%

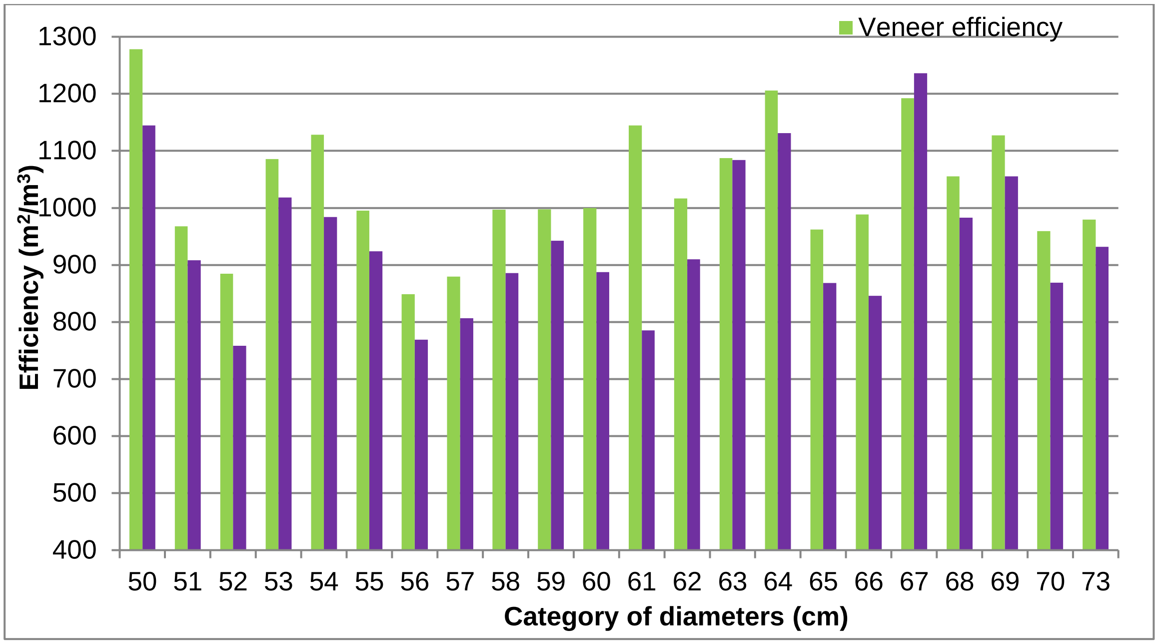


Fig. 4. Comparative analysis of the efficiency in veneer and decorative veneer cutting corresponding to a probability of 90%

Influence of Sessile Oak Log Quality on the Efficiency in Veneer Cutting

To emphasize the importance of the raw material quality for decorative veneers, several analyses based on the acceptable defects, such as taper, sprawl, buds, wood studs, and insect holes, were performed. The data are shown in Fig. 5. The pieces were classified according to the defects that appeared.

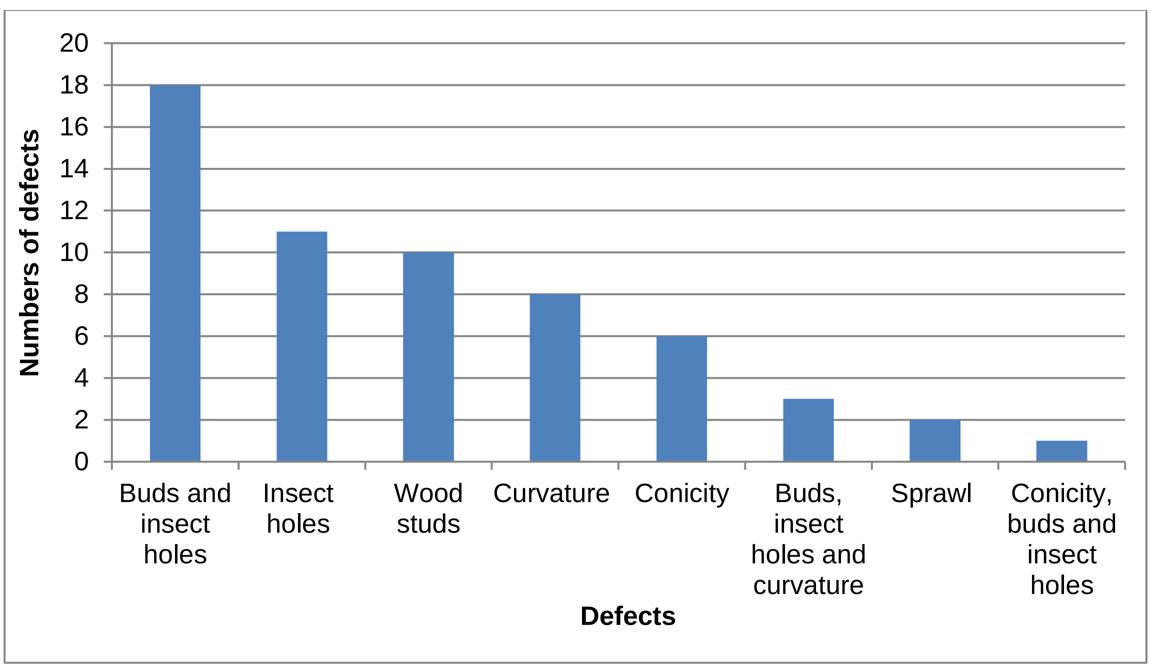


Fig. 5. Types of defects that appeared within the group of sessile oak logs

One acceptable defect (wood studs, buds, curvature, sprawl, taper or insect holes) or two (buds and insect holes, curvature and buds, or wood studs and insect holes) and even three defects (buds, insect holes and curvature, and taper, wood studs and insect holes) could be identified on the same log.

Out of the 217 logs sampled, 97 logs presented some type of defect. The acceptable defects had approximately 27% frequency. The most frequent defects were buds and insect holes (18 pieces), followed by insect holes (11 pieces), and wood studs (10 pieces). The linear regression method was applied for each one of the defects, and the results indicated an acceptable level of the present defects. Therefore, no remarkable influence was noticed for the obtained efficiency in veneer cutting (Table 4).

The results obtained after regression (Table 4) indicate a certain influence of buds and insect holes, curvature and wood studs upon the efficiency in veneer and decorative veneer cutting, and upon the surface area of special veneers, respectively. On the other hand, the number of obtained veneer sheets is influenced only by the curvature, even at a very low ratio. Moreover, the influence of such defects (curvature, insect holes, taper, knots and rot) upon the veneer quality and the efficiency in veneer cutting, are well known (Lutz 1977; Mercker and Hopper 2004).

Table 4. Analysis of Quality Defects

Characteristic	Buds and Insect Holes		Curvature		Insect Holes		Wood Studs	
	r	R^2	r	R^2	r	R^2	r	R^2
Veneer Efficiency (m^2/m^3)	0.20	0.04	0.17	0.03	0.53	0.28	0.15	0.02
Decorative Veneer Efficiency (m^2/m^3)	0.24	0.06	0.14	0.02	0.45	0.20	0.24	0.06
Surface of Decorative Veneer (m^2)	0.14	0.02	0.16	0.03	0.36	0.13	0.17	0.03
Number of Sheets	0.05	0.00	0.15	0.02	0.16	0.03	0.04	0.00

CONCLUSIONS

1. To select the sessile oak logs for veneer production, quantitative and qualitative criteria were applied according to regulation standards. The raw material quality has an important influence on the efficiency of veneer and decorative veneer cutting.
2. The influence of the sessile oak log diameter on the efficiency of veneer and decorative veneer cutting could be estimated based on the cumulative density functions.
3. The most important defects identified in sessile oak logs purchased from Targoviste region in Romania are buds and insect holes, but they are acceptable and do not noticeably influence the efficiency of veneer cutting. Out of the identified defects, the buds, the insect holes and the wood studs have influenced at a certain extent the cutting

efficiency of veneers and special veneers, the surface area of special veneers, respectively, while the curvature is the single defect that influenced all the four parameters here analyzed.

4. The analysis of the obtained results after regression indicates that the insect holes were the defects having the highest influence upon the efficiency in veneers and special veneers, upon the number of obtained sheets and the surface area of special veneer, respectively.
5. Decisions can be made with regard to the acceptance or removal of defects that appeared in logs from certain geographical regions. Also, the negotiation of their price depends on the future benefits that they provide.

ACKNOWLEDGMENTS

The authors are grateful for financial support of the Transilvania University of Brasov.

REFERENCES CITED

Alberto, F., Bouffier, L., Louvet, J. M., Lamy, J. B., Delzon, S., and Kremer, A. (2011). "Adaptative responses for seed and leaf phenology in natural populations of sessile oak along an altitudinal gradient," *Journal of Evolutionary Biology* 24(7), 1442-1454. DOI: 10.1111/j.1420-9101.2011.02277.x

Cassens, D. L. (2003). "Manufacturing fine hardwood face veneers," Purdue University. Forestry and Natural Resources, *FNR* 240.

Denes, L., Lang, E. M., and McNeel, J. F. (2017). "Development of veneer-based corrugated composites, Part 1: Manufacture and basic material properties," *BioResources* 12(1), 774-784.

Doussot, F., De Jéso, B., Quideau, S., and Pardon, P. (2002). "Extractives content in cooperage oak wood during natural seasoning and toasting. Influence of tree species, geographic location, and single-tree effects," *Journal of Agricultural and Food Chemistry* 50(21), 5955-5961. DOI: 10.1021/jf020494e

Dumitrașcu, A. E., Ciobanu, V. D., and Lepădătescu, B. (2013). "Valorization of wood resources for the cutting of decorative veneer in the context of sustainable development of Romanian forests," *BioResources* 8(3), 4298-4311. DOI: 10.15376/biores.8.3.4298-4311

Feuillat, F., and Keller, R. (1997). "Variability of oak wood (*Quercus robur* (L.), *Quercus petraea* (Liebl.)) anatomy relating to cask properties," *American Journal of Enology and Viticulture* 48, 502-508.

Knorn, J., Kuemmerle, T., Radeloff, V. C., Keeton, W. S., Gancz, V., Biriș, I. A., Svoboda, M., Griffiths, P., Hagatis, A., and Hostert, P. (2012). "Continued loss of temperate old-growth in the Romanian Carpathians despite on increasing protected area network," *Environmental Conservation* 40(2), 182-193. DOI: 10.1017/S0376892912000355

Kremer, A., and Zanetto, A. (1997). "Geographical structure of gene diversity in *Quercus petraea* (Matt.) Liebl. II. Multilocus patterns of variation," *Heredity* 78(5), 476-489. DOI: 10.1046/j.1365-2540.1998.00313.x

Kruch, J., and Nicolescu, V. N. (2010). "The particularity of sapwood in industrial sorting of sessile oak (*Quercus petraea* (Liebl.)) and oak (*Quercus robur* (L.)) logs [*Particularitatea alburnului in sortarea industrial a bustenilor de gorun*]," *The Journal of Forests [Revista padurilor]* 1, 3-9.

Kruch, J. (2011). "The double alburnum, the most severe defect for oak (*Quercus robur* (L.)) and sessile oak (*Quercus petraea* (Matt.) Liebl.) logs in industrial sorting [*Lunura, cel mai sever defect pentru bustenii de stejar si gorun in sortarea industriala*]," *The Journal of Forests [Revista padurilor]* 126(5), 37-45.

Le Moguédec, G., Dhôte, J. F., and Nepveu, G. (2002). "Choosing simplified mixed models for simulations when date have a complex hierarchical organization. An example with some basic properties in Sessile oak wood (*Quercus petraea* (Liebl.))," *Annals of Forest Science* 58(8), 847-855. DOI: 10.1051/forest:2002083

Lutz, Jh. F. (1977). "Wood veneer: Log selectiond, cutting and drying," Forest Service, U.S. Department of Agriculture. *Technical Bulletin* 1577, 137 p.

Mercker, D., and Hopper, G. (2004). "PB1744 Quality Hardwood Veneer," *Forestry, Trees and Timber* 5, 12 p.

Moldovan, I. C. (2011). *Evaluarea variabilităţii genetice a stejarului pedunculat (Quercus robur L.) şi a gorunului [Quercus petraea (Matt.) Liebl.] în populaţii din estul României cu ajutorul markerilor ADN. (Genetic Variation of Pedunculate Oak (Quercus robur L.) and Sessile Oak [Quercus petraea (Matt.) Liebl.] in Eastern Romanian Populations Using DNA Markers),* Doctoral Thesis, Transilvania University of Brasov, Romania.

Moroşanu, C. (2012). *Studiul calităţii lemnului de stejar şi gorun, destinat debităţii furnirelor estetice. (Study Regarding the Quality of Wood from Pedunculate Oak and Sessile Oak Cut for Decorative Veneers),* Doctoral Thesis, Transilvania University of Brasov, Romania.

Mosedale, J. R., Charrier, B., and Janin, G. (1996). "Genetic control of wood colour, density and heartwood ellagitannin concentration in European oak (*Quercus petraea* and *Quercus robur*)," *Forestry* 69(2), 111-124. DOI: 10.1093/forestry/69.2.111

Mușat, E. C., Salcă, E. A., Dinulică, F., Ciobanu, V. D., and Dumitrașcu, A. E. (2016). "Evaluation of color variability of oak veneers for sorting," *BioResources* 11(1), 573-584. DOI:10.15376/biores.11.1.573-584

Pangh, H., and Doosthoseini, K. (2017). "Optimization of press time and properties of laminated veneer lumber panels by means of a punching technique," *BioResources* 12(1), 2254-2268.

Petrițan, A. M., Biriș, I. A., Merce, O., Turcu, D. O., and Petrițan, I. C. (2012). "Structure and diversity of a natural temperate sessile oak (*Quercus petraea* (L.))- European beech (*Fagus sylvatica* (L.)) forests," *Forest Ecology and Management* 280, 140-149. DOI: 10.1016/j.foreco.2012.06.007

Rohumaa, A., Yamamoto, A., Hunt, C. G., Frihart, C. R., Hughes, M., and Kers, J. (2016). "Effect of log soaking and the temperature of peeling on the properties of rotary-cut birch (*Betula pendula* Roth.) veneer bonded with phenol-formaldehyde adhesive," *BioResources* 11(3), 5829-5838.

Raczkowska, L. H., and Fabisiak, E. (1991). "Radial variation and growth rate in the length of the axial elements of sessile oak wood," *IAWA Journal* 12(3), 257-262. DOI: 10.1163/22941932-90001254

Savill, P. S., Kanowski, P. J., Gourlay, I. D., and Jarvis, A. R. (1993). "Genetic and intratree variation in the number of sapwood rings in *Quercus robur* and *Quercus petraea*," *Silvae Genetica* 42(6), 371-375.

SR EN 1316-1 (2013). "Hardwood round timber-Qualitative classification. Part 1: Oak and Beech," (In Romanian: *Lemn rotund de foioase. Clasificare calitativă. Partea 1: Stejar şi fag*), Romanian Society for Standardization, Bucharest, Romania.

Şofletea, N., and Curtu, L. (2007). *Dendrology [Dendrologie]*, Transilvania University Publishing House, Brasov, Romania.

Zhang, S. Y., Nepveu, G., and Eyono Owoundi, R. (1994). "Intratree and intertree variation in selected wood quality characteristics of European oak (*Quercus petraea* and *Quercus robur*)," *Canadian Journal of Forest Research* 24(9), 1818-1823. DOI: 10.1139/x94-235.

*** (2000). "Descriptions of manufacturing processes". A FAO Corporate Document Repository. Available at: http://www.fao.org/docrep/t0269e/t0269e03.htm accessed on 2017, February 3.

Article submitted: November 29, 2016; Peer review completed: January 28, 2017; Revised version received and accepted: February 6, 2017; Published: February 17, 2017.
DOI: 10.15376/biores.12.2.2579-2591