Quality Control and Productivity in Oak Timber - From Forest to the Primary Processing

João P. F. Carvalho [1], José A. Santos [2], Joana Santos [2,3]

[1] University Tras-os-Montes Alto Douro, Dep. Forestry, CITAB, PO Box 1013, Vila Real, Portugal, jpfc@utad.pt
[2] Laboratório Nacional de Energia e Geologia, Estrada do Paço do Lumiar 22, 1649-038 Lisboa, Portugal, jose.santos@ineti.pt [3] joana.santos@ineti.pt

ABSTRACT

Oak timber is valuated for its beauty, good mechanical properties and natural durability and may have multiple uses.

An understanding of the factors that affect oak timber quality is essential. It is important to have quality control of physical, mechanical and technological wood characteristics in order to define the better primary processing and end-use.

Silviculture may significantly impact wood quality and final stand value. Specific prescriptions will depend on species, site conditions, desired end product and management options. An appropriate silviculture with optimized technological operations allows a well use of wood even with small diameters. Adequate wood classification is required in order to optimize industrial processes and improve product quality. Quality criteria and procedures for round and sawtimber are referenced.

Key-words: Oak timber, round wood, sawtimber, quality control, silviculture.

INTRODUCTION

Indigenous Portuguese forests are dominated by oak species with both broadleaves (*Quercus faginea, Q. pyrenaica, Q. robur*) and evergreen oaks (*Q. rotundifolia, Q. suber*) included in the subsections *Quercus*, *Ilex* and *Cerris*. Broadleaves species occur in the northern and centre region with Atlantic and sub-Mediterranean climate influences. Portuguese oak (*Q. faginea*) and evergreen oaks are disseminated in centre and southern regions where Mediterranean and continental climate are predominant. Other native oak species with minor representation are *Q. canariensis, Q. coccifera* and *Q. lusitanica*. In addition to the indigenous species, there are other exotic oak species used in plantations. The most used is the northern-red oak (*Q. rubra*) which covers a residual surface area in different regions of north and central Portugal.

This article concerns to the related species pedunculate-oak (*Q. robur*) and pyrenean-oak (*Q. pyrenaica*). Pedunculate-oak grows in more temperate conditions in the piedmont and middle hill up to 800 – 1000 m. It is spread in the nor-western provinces of Minho, Douro and Beira. Pyrenean-oak occur in northern and interior regions, usually between 400 – 1200 m (Carvalho, 2005). Nowadays, broadleaved oak forests cover a surface area of 117,900 ha (IFN, 2005).

Oak forests provide ecological, environmental, economical and social functions. They are important for climate regulation, water and soil conservation and biodiversity. Because of its less combustibility they provide firehazard prevention. In addition, oak forests are relevant for aesthetics, recreational, historical and cultural activities.

These forests provide wood for multiple uses as well other non-wood products like medicinal plants and mushrooms. Hunting and pastoral activities are also developed in some oak forest areas. Many of the natural oak territory have been progressively exploited through time with environmental, ecological and socially negative impacts. An adequate revenue and valuation that promotes a good management are essential to ensure those functions and goods.

Oak timber is appreciated for its beauty, good mechanical properties and natural durability. Oak wood has a high moderate density, providing a good axial compression and static shear resistance. Heartwood is naturally resistant to rot and insect damage without need of chemical preservative treatments. It has multiple uses such as firewood, carpentry, furniture and cooperage. In addition, the wood can be used for decorative or finishing purposes such as panelling, window and door, flooring and furniture manufacture, and as a building construction material, for stairs, beams, decks and other inside and outside structural elements.

According to FAO predictions, world forest area will decrease in the future and simultaneously timber consumption will increase for both firewood and sawtimber. The problems connected with tropical hardwoods, economical and ecological factors have increase interest in oak.

Different studies have defined applications that allow an increment value to oak wood. Optimized wood processing and quality control criteria were developed too.

SILVICULTURE AND WOOD QUALITY

Silviculture is essential to produce wood material with appropriate characteristics. Procedures that evaluate the wood quality in the forest and primary wood processing are important in order to stimulate better use and value.

Wood quality is a relative concept defined by end-use requirements and existing technology. This means that it may be suitable for one purpose but not for another. There are different attributes that can be used to define the wood quality. They can be wood intrinsic characteristics and other more related with tree anatomy. Since wood is a biological material its formation is dependent on a wide variety of factors, both internal and external to the tree (Larson, 1969).

Forest managers that want to maximize forest values need to know features that determine wood quality. Although wood quality characteristics are inherent to particular species, they can be influenced by tree growing conditions. This gives foresters opportunity to choose rotation length, stocking control on some sites, thinning and pruning.

Different wood uses require different material characteristic specifications. Better wood with less or no abnormalities is used in more demanding applications such as veneer while wood with more features is selected for carpentry and rustic applications. Wood quality depends on tree genetics, site conditions and silvicultural practices. Physical and mechanical properties vary widely between trees and inside each tree. Different studies showed that there is an important genetic variability inside each population for site factors and wood quality (Nepveu, 1993). Wood density has a major influence on lumber behaviour and affects other quality characteristics (strength, durability, shrinkage). Usually, higher densities lead to higher shrinkage and processing hardness. Average ring density is positively correlated with latewood density. Studies showed great individual variability, and explaining an important fraction of the existing variability related to wood characteristics (Becker, 1979; Nepveu, 1984).

Growing speed depends on site conditions, genetic characteristics and silviculture. From a silviculture and technology point of view growth improvement must be compatible with quality and wood use. For more demanding uses such as veneer trees with thin rings are more valuable (Bartot, 1988). Heartwood density at a certain age is influenced by site conditions. Evaluations with pedunculate-oak illustrates that density increases from neutral - hygrophilous to acid – mesophilous sites.

For applications of higher value, oak wood with less shrinkage, without cracks, lower proportion of sapwood, pleasant colour and grain are required. It is also important to look for regular growing for technological and aesthetic purposes. Thinning should also eliminate those trees with tension wood. Irregular shaped crowns lead to high levels of tension and wood of lower quality, cause instable wood and deformation in veneer.

Management has traditionally maintained stands with high stocking to produce wood with narrow growth rings. Slower growth was believed to be necessary to produce timber for better quality uses. Trees with medium to larger diameters, clear boles and wider growth rings will be sought. Where economic return is important, systems to produce valuable crop trees will be required and integrated with a multiple outputs management systems.

For veneer larger diameters are usually required although different techniques may be used to valuate medium diameters (> 40 cm). Veneer products demand high quality trees which require the right silviculture. Bole length it's also a quality criteria. Surface appearance, colour and presence of small spots are important in aesthetic quality (Mazet and Janin, 1989). Growth ring width and regularity can be controlled by silvicultural practices besides the existing individual variations and processing technique. In general, wood with light colour, fine to medium grain, no important defects, hardiness and mechanical strength not to high is preferred. Veneer colour variations can appear due to the presence of different anatomical elements, ring width, processing techniques as well as individual variability.

Cooperage is another important activity for quality wines and brandy. Oak wood is appreciated for storing and aging because of its mechanical properties, permeability, porosity, polyphenolic and aromatic substances content. Wood characteristics for barrel-making vary according to species and origin. Provenance is important and there are some preferences. Sensorial compounds characteristics are important. In general, there are not a strong relationship between grain and extractives. There are variations between species and locations. Studies show that pedunculate-oak tend to have a higher content in tannins and sessile-oak more aromatic; however, there are big individual variations (Guimbertreau, 1987). Pyrenean-oak has structural and chemical characteristics ideal for barrel-manufacturing. Its chemical characteristics (polyphenols, tannins and volatile compounds) are quite similar to other species which are of recognized enological quality.

Wood texture is an important characteristic for barrel for wine and brandy. Straight trees, with regular growth, without spiral grain and rich in aromatic compounds are desirable. Pedunculate-oak trees with large growth, rich in tannins and higher permeability are appropriate for brandy aging. Nowadays, valuation of small diameter trees (35 – 40 cm) is also sight as well stands submitted to a more dynamic silviculture even for brandy with fewer requirements. Some defects and singularities are excluded. Grade A is assigned to the better wood quality while grade B tolerate some features.

Furniture usually requires good boards. The outer surface demands wood absence of defects while the inner pieces tolerate their occurrence. However, the presence of small knots and other features are appreciated since it gives a more natural appearance.

Lumber dimensions and small defects for carpentry do not affect so greatly the product quality. Flooring allows the use of different timber dimensions which lets oak wood be profitable.

Considering its high natural durability oak wood presents advantages in outside products such as building and garden structures and furniture, without need for chemical preservatives. Because of its resistance to radiation, climatic and biological agents it’s also of great interest in building construction along the coast. Those applications tolerates a large amount of knots and so a valuation of oak wood material. Wood colour and grain are appreciated and their features provide a natural beauty.

Depending on the type of management, oak forests can provide different kind of wood products. Wood quality can be influenced by silvicultural practices. Management strategies may change product quantity, quality and value (Courraud, 1987; Montgolfier, 1988). Log quality declines with the presence of some characteristics such as poor form (sweep, ovality, taper), large branch size, spiral grain and juvenile wood. An increase of size can mitigate the impact of some of these characteristics.

Silviculture attempts to regulate tree growth and avoid or reduce certain defects or features. However, the presence of certain wood singularities is appreciated by consumers (Marchal and Mothe, 1992) because it gives a more natural appearance.

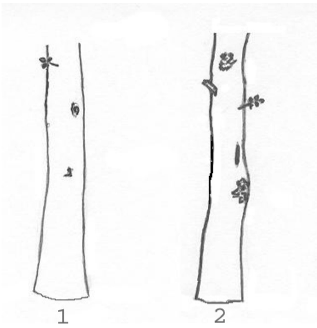
Stocking control and pruning are two important aspects concerning stand management. Silvicultural practices may have different goals depending on the ecological and site conditions and the stand development stage. Interventions may change tree growth rate, stand yield, stand stocking and structure.

The goal of high-quality oak silviculture is to produce a proportion of quality lumber. A dynamic silviculture can be applied and optimize stem quality and high productivity. A positive selection of the best phenotypes, collective and individual culture with selective thinning from the pole stage might be followed. This allows a reduction in stand rotation which has economical benefits. High-quality wood is the production target with oaks with diameters of 60 cm or larger at breast height, suitable as veneer and sawtimber. High-forest for timber production is the best system to pursue which can extend to 80 – 120 years or more with large target diameters. Many coppices are a thoughtless resource and high-forest is desirable wherever possible both for economical and ecological reasons. It will also allow the accomplishment of other ecosystem functions. High-forest may render compatible timber production and firewood supply.

Unlike other forest species, like poplar, oak forests cannot be established as clonal commercial plantations because of its impact on natural processes and ecosystem functioning.

Thinning regimes should be designed to optimize the value of the stand synthesizing diameter increment, stand stocking and volume growth, enhancement of bole quality, and species composition. In general, the heavier the thinning the greater the diameter growth response of individual trees; however, heavy thinning may reduce stand yield and degraded bole quality of residual trees. Crown height and branch persistence may increase (Miller, 2000). Many epicormic shoots may develop as a result of non-appropriate thinning operation. Currently it is accepted that dominant trees have fewer epicormic shoots than suppressed trees. However, some studies reports no significant differences between tree size classes and its presence may occur in some situations due to different physiological response, environment conditions, provenance and silvicultural history. In general, vigorous upper-crown trees are less likely to produce epicormic branches. Meadows and Goelz (1998) showed in oak stands that new epicormic branches increased significantly after different levels of thinning and that it was greater on low-vigor trees. A survey performed by Stubbs (1986) with oak showed that different log grades may be improved in the absence of epicormic branches. Log grade A may be improved 97%, grade B 68% and grade C logs may be reduced by 167%. Because log grade has a major influence on the value of hardwood sawtimber, log grade reduction caused by epicormic shoots, particularly on butt logs, greatly reduces the value of the stand.

Response to thinning varies with species, site, age and stand condition. Oak forests benefit from thinning but must be applied at time, type and intensity. Thinning favours the best crop trees in order to obtain vigorous and large trees, well formed, without branching and important defects up to 6 – 8 m. The presence of an accessory stand is important to obtain well formed trees. Bole quality and grade are determinant for its value. The value of a log decreases quickly as grade declines. Any cultural practice that results in a bole classification reduction significantly reduces the value of the stand (Figure 1).



Bole 1	Bole 2
. Grades (% bole volume): A (67%) and B (33%) . Total bole value: 240 €	. Grades (% bole volume): A (44%) and C (56%) . Total bole value: 170 €

Figure 1 – Differential grading and value for two example boles with the same volume. Silviculture has a major influence on bole quality and value.

Shake may appear in oak trees and there are references that might be frequent in some geographical areas like in England with *Q. robur* and *Q. petraea* (Savil, 1986). Trees with earlywood larger than average are likely to have greater predisposition to shake. Large cells can cause fractures to cell walls locally, extending the flaw and leading to fracture. Like other wood characteristics, there is much variation among individuals. Vessel size characteristics are highly heritable which means that breeding programs may produce less shake-prone trees (Kleinschmit, 1986). There are some indications that soils influence the frequency of shake, and that sound oak is normally found in soils with a reasonable proportion of clay (Brown, 1945). There are no significant relationship between vessel area and ring in the adult wood, which means that growth has no effect on vessel area. However, in the juvenile wood of adult trees there is a strong and negative correlation between ring width and vessel area (Huber, 1993).

In the early stages growth deviations and forks must be corrected. Pruning is necessary to promote stem form and branch-free length. Pruning promotes straightness of young trees and stimulates height growth. Forks must be suppressed from early stages when trees are 1.5 – 2 m tall. Pruning reduces the number and size of knots and the amount of juvenile wood which are depreciative to quality. More tapered stems are formed under the influence of the live crown. Incidence of branches will have implications on log use and quality depending on their location (Figure 2). Large knots drastically reduce strength and are a major cause of downgrade in timber. Pruning must be progressive, frequent and moderate in order to avoid dead knots, reduce decay hazard and not affect tree growth.

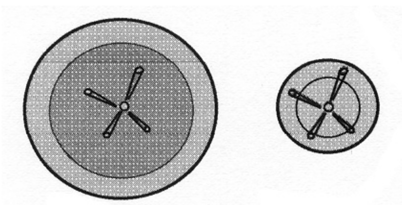


Figure 2 – Incidence of features on the bole depending on height location (left: stem butt; right: upper stem near base crown).

The history of the present oak stands affects their current status responses to treatment and potential for producing goods and services. Silvicultural practices are needed to determine which density level produced the greatest yield and affects tree quality. Research has provided yield tables which gives information about conditions for producing high-value oak timber on suitable sites (Carvalho and Parresol, 2001).

Wood productivity of oak forests may change widely according to species, site and management options. According to evaluations and studies performed in national territory annual increment of oak stands may range between 2 – 8 $m^3.ha^{-1}$ for pyrenean-oak and 4 – 8 $m^3.ha^{-1}$ for pedunculate-oak. Oaks are slow to medium growing trees, but the quality of the wood generates an added value that largely compensates for growth. Moreover, it is necessary to assure supply of certain raw-material. An adequate wood and industrial valuation can be obtained even with lower yield oak stands with an appropriate silviculture and timber processing technology. This allows higher revenue for existing resources even in more limiting environments.

Different studies in Portugal and other countries present oak wood valuation including small diameters and more Mediterranean species (Groome *et al*., 1988; Janin *et al*., 1989; Marchal and Mothe, 1992; Carvalho *et al*., 2004). Several efforts have been made with different species for a better use of small to medium timber such as panels (Thibaut, 1993; Ciccarese and Pettenella, 1993; Triboulot and Leban, 1998). Future consumption perspectives for this type of timber are increasing which valuates small woods (ECE/FAO, 1990).

CRITERIA FOR OAK TIMBER QUALITY EVALUATION

Grading rules were developed to segregate wood according to quality requirements in specific uses. Standardized rules ensure that the same grade will represent the same characteristics and value, and can be used for the same purpose.

Strength and stiffness of timber are main concerns in the construction industry, pallets and containers. In decorative uses, appearance is the major factor. Different grading rules apply in these situations. This article relates with grading rules appropriate for non-structural timber.

In factory lumber grades defects limit the dimensions (length and width) of clear-face cuttings. Log diameter is important since large logs produce wide boards that can be ripped to eliminate lumber defects. For round wood and sawtimber limits are established for certain characteristics (e.g., spiral grain, crack dimension).

Round Timber

Loggers need basic criteria of hardwood timber quality. Defects influence in most log grade specifications.

Round timber classification gives a common utilization and valuation reference for producers and users. It answers primary processing industry requirements and timber quality normalization. A better mutual trust between producer and industrial is also achieved.

Log classification is useful for a proper log processing. Classification considers log size, abnormalities and features. Classification is obtained with 4 grades (A, B, C, D) and a different value is related. A potential use may be assigned for each grade. Log length and minimal diameter are defined for each grade.

Round wood classification considers size and qualitative features (Table 1). These features are structure and form irregularities and chemical wood alterations.

Table 1 – Classification features for oak round timber.

Size Classification
. Mean log diameter.
Qualitative Classification
. Structural characteristics
colour; sapwood and heartwood proportion; growth ring width.
. Structural singularities
knots type, number and size; epicormic shoots; bark pocket; burl;
gall; buckle; spiral grain; eccentric pith; back pocket; included sapwood.
. Shape singularities
sweep; ovality; bulge; shake (top, ring, heart, seam, frost, lightning).
. Deterioration by fungus
rot; stain, heart.
. Deterioration by insects
holes; boring.
. Other degradations
carbonized wood; scar; strange objects.

A survey study performed in oak forests (*Q. pyrenaica*) located in the north region throughout exploitation activities provided round wood classification. Table 2 presents top diameter and relative proportion for each grade of the timber stock.

Table 2 – Oak (*Q. pyrenaica*) round timber classification. Log top diameter, volume proportion and value for each grade are presented.

Grade	A	B	C	D
d_{min} (cm)	45	35	30	25
% (v)	8,8	23,7	39,4	28,1
€/m^3 (road side)	350	220	120	60

The following preferential end-use was defined for each grade: A – furniture; B – furniture, flooring, carpentry (window and door manufacture); C – carpentry, flooring; carpentry (structural wood); D – construction (structure); palette.

Sawn Timber

Classification describes timber quality for industrial use. Surface aesthetics, mechanical behaviour and durability are valuated. Lumber classification is important for a good technological processing and obtaining of uniform lumber and components.

The recognition and evaluation of lumber characteristics are done considering its final use. Classification of dried lumber must be realized with objective criteria based on timber abnormalities and singularities and possible defects introduced during the primary processing like drying. Sawing interacts with log form and size and the geometry of boards is defined. A bad drying process can produce defects (fissure, tension, and warp). Drying evaluations and studies for each species and material sizes are important.

Hardwood lumber grades are delineated on the basis of the minimum yield of free defect material contained in each board. Classification considers size and qualitative appearance characteristics on the visible face (Table 3).

Lower grades admit larger defects. Larger defects are tolerated in larger sized pieces. The best grades are likely to be used with a clear finish while the poorer grades may be painted or concealed. Small knots are preferred to large knots, and intergrown knots are more acceptable. Wane and warp is more controlled while a moderate slope of grain can be tolerated. A board of one species may be quite clear while oak might have considerable decorative figure.

Table 3 - Classification features for oak sawn timber used to determine quality of appearance.

Size Classification
. Length and width.
Qualitative Classification
. Sapwood: presence.
. Knots: number, size, type, adherence.
. Fissures: shake type, width, length, depth.
. Inclusions: presence of strange elements (bark, carbonized wood, objects).
. Pith: presence.
. Bark pocket: presence.
. Spiral grain: slope of grain.
. Deformations: wane, cup, bow, twist, thickness irregularities.
. Biological deterioration (insects and fungi): holes, spots, rot, stain.
. Spots: colour variations, presence of spots.
. Moisture content: final moisture content.
. Drying tensions: presence of deformation, compression and tension wood.
. Moisture content gradient: moisture content differential between inside and outside.

The quality classification on sawn boards for other final uses than structural may be found in the European standard concerning sawn timber appearance grading of hardwoods. According to this standard, individual selected boards and bolues grading is made on the faces. Only in special cases the grading is made also in edges. The size, position and frequency of features, sawing defects and deteriorations are taken into account. Non-conformity with the conditions applicable to any one of these elements is sufficient to downgrade the piece. Dimensional variation is not taken into account for quality grading and may be covered by other standard or requirements defined contractually.

In order to consider variation of pieces dimensions a quality of appearance classification system was developed based on the European standard that considers additional stripe sizes. This allows a valuation of potential boards that presents a higher presence of certain features such as knots which may be obtained from less managed forests. Different dimensions are considered for application and qualification criteria according to the size of the individual boards are used. This principle is also used by the American Hardwood Export Council (AHEC).

Classification is defined by a set of symbols, one concerning piece dimension (S1 to S6) and another to appearance quality (Q1 to Q3). Appendix I presents the criteria used to define dimension and quality of appearance classification. Two length sizes (80 and 200 cm) and three width sizes (8, 12 and ≥ 22 cm) are considered. Quality characteristics are the same as the European standard and consider structural features, sawing characteristics, warp, biological degradations and stains (Appendix I). Priority must be given to longer stripes and for each length dimension to the larger width. Thus, on the same board two classifications may be obtained for different stripe's length and width (Figure 3).

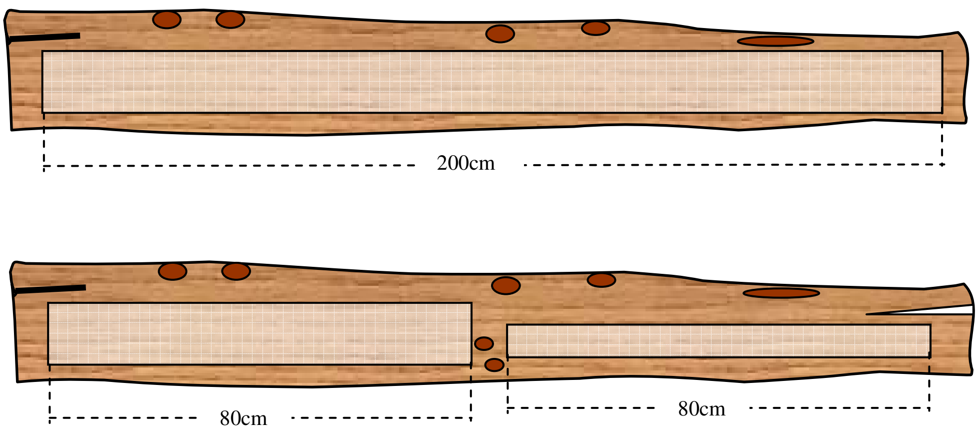


Figure 3 – Choice of stripes for classification on oak boards depending on length and width. Different widths (8, 12 and ≥ 22 cm) may be obtained for each length class (200 and 80 cm).

On a survey performed on oak boards, classification was carried out considering two designations, one for size and another for qualitative attributes. Figure 4 shows the classifications results for oak (*Q. pyrenaica*) boards.

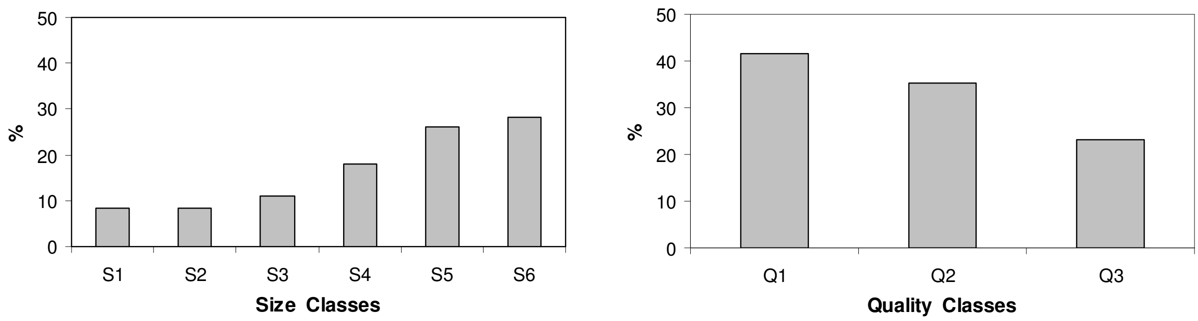


Figure 4 – Oak sawn timber classification by size and qualitative attributes.

Size of the smaller boards (length of 80 cm and width of 8 and 12 cm) are the most representative in the sample. Considering qualitative characteristics, 42% belongs to the better grade (Q1), 35% to the intermediate grade (Q2) and 23% to the lower grade (Q3). Boards without sufficient quality for carpentry and furniture were discarded and represent only 2%.

Additional primary processing technical aspects related with oak timber quality

Physical and mechanical properties of native oak wood were evaluated (Carvalho *et al.*, 2004; Santos *et al.*, 2005). Quality assessments and technological processes were carried out in order to optimize procedures and manufactured quality products. Native oak timber presents an excellent machinability. Wood planning is easy and produces perfect surface finish.

Operations like moulding, drilling and polishing are simple with fine work and no abnormal tool wearing. Gluing of wood components provides good joints and a well reception of painting products. Log sawing is done without difficulty with conventional equipment. Sawing can be done with different patterns determined by log diameter and quality characteristics. It is convenient that the first cut follows the log centre to avoid warp. An optimization of sawing is only practical with logs over 35 cm of diameter.

The main concern is to control drying so as to minimize any degradation. Drying must be done with controlled air temperature and humidity. Rate of drying must be slow and adequate air circulation is necessary. If air-drying is used timber stacking must be done according to the good rules with good aeration. Air-drying will take about 4 – 5 months to reach a moisture content of 16% for timber with 30 – 35 mm thickness. Kiln-drying is necessary if drying to low moisture content. Accurate control of the drying elements should reduce the amount of degrade in the stack. With a conventional dryer and following a soft drying schedule it's possible to dry timber with 45 mm thickness to a moisture content of 10% in about 45 days.

Veneer requires the establishment of a cutting plane and technique adapted to the veneer quality. New processing technologies allow the use of timber with wider growth rings and smaller log diameters. This means that a better wood valuation can be achieved. For barrel-making it's desirable that air-drying is used because it provides good wood characteristics.

CONCLUSIONS AND FINAL REMARKS

Wood is a renewable resource and one of the most important construction materials. Wood retains carbon, is biodegradable, allows a variety of applications and requires less energy to manufacture.

Past-land activities, fire and livestock grazing have caused severe oak growth and regeneration problems. Oaks have been and currently are extremely important forests systems throughout European countries.

Oak forests provide important environment, ecological, social and economic functions. An appropriate oak management and valuation are essential in order to ensure good revenue and simultaneously provide a sustainable development.

Interest in both economic and ecological value of oaks will continue and probably increase in the future. Their relevance for multiple-purpose forest management as well high value timber supply is of great importance.

The economic benefit of producing large-sized timber of high-quality is of great interest. For this, suitable ecological conditions and proper silviculture have to be taken into account. It is not possible to generalize about oak silviculture because oaks grow under a wide range of conditions. Silviculture of oaks must fit to species, site, stand characteristics, market and land-owner.

Oak wood is very appreciated and widely used in many applications because of its heritage, beauty, strength and natural durability. Limitations in using certain chemicals for timber preservation create a better opportunity for hardwood species with a high natural durability especially for outside applications.

Appropriate oak silviculture and timber processing techniques for small diameters are necessary for better economical returns.

Grading of timber may be view too as a marketing strategy ensuring buyers appropriate quality timber for their needs. Material grade is usually determined visually and in some situations a more objective method would be desirable. Some techniques such as optical image analysis can determine wood features offering an improvement in efficiency.

A good timber use must consider manufacture product purpose and processing technologies in order to reduce wood loss. An appropriate timber processing is advisable to obtain lumber with a good dimensional stability, avoiding cracks and warping. Ideally timber should be dried to the moisture content approximately to the service moisture content. All primary processing operations must be monitorized to ensure product quality.

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APPENDIX I – APPEARANCE GRADING OF OAK SAWN TIMBER.

Table I.1 presents length and width sizes considered for each class and Table 2 presents qualitative characteristics for classification.

Table I.1 – Quality class according to different reference sizes.

Dimension class	Length (cm)	Width (cm)
Longest size		
S1	200	≥ 22
S2	200	12
S3	200	8
Shortest size		
S4	80	≥ 22
S5	80	12
S6	80	8

Table I.2 – Classification based on qualitative characteristics.

Features	Q1	Q2	Q3
Sapwood	Not permitted	Permitted if ≤ 20mm width	Permitted if sound
Knots	Sound and intergrown; Diameter ≤ 2 mm Number ≤ 2	Sound and intergrown; Diameter ≤ 4 mm Number ≤ 5	Sound and intergrown; Diameter ≤ 6 mm Number ≤ 5
Checks	Closed fissure Length ≤ 5 mm Depth ≤ 2 mm	Width ≤ 0,5 mm Length ≤ 10 mm Depth ≤ 2mm	Width ≤ 0,5 mm Length ≤ 10 mm Depth ≤ 4 mm
Internal fissures	Not permitted	Not permitted	Not permitted
Inclusions	Not permitted	Not permitted	Not permitted
Pith	Not permitted	Not permitted	Not permitted
Spiral grain	≤ 2 mm in 100 mm	≤ 4 mm in 100 mm	≤ 8 mm in 100 mm
Biological degradation	Not permitted	Not permitted	Not permitted
Spots	Not permitted	Slight colour variation permitted	Slight colour variation permitted
Final moisture content	12% ± 2%	12% ± 3%	12% ± 4%
Drying tensions	Not permitted	Not permitted	Not permitted
Moisture content gradient	≤ 1,5%	≤ 2%	≤ 3%
Warp	Not permitted if derived from growth tensions, drying tensions or spiral grain	Slight warp permitted	Permitted when planing for final dimension specifications
Thickness irregularities	Minimal thickness ≥ target thickness + 2.5 mm	Minimal thickness ≥ target thickness + 2.5 mm	Minimal thickness ≥ target thickness + 1 mm