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BASIC DENSITY OF HARDWOODS DEPENDING ON AGE AND SITE

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ABSTRACT

It is of essential importance for the practical experts to know the basic density, which is used as factor „ATRO tons/m^3". It expresses, how much is the dry timber content of live wood or freshly logged wood (above the net moisture content of ~30 %). Knowing this value the dry substance production of stands and the „attroweight" (dry weight) of timber freights can be determined. In the research the basic density of the wood and bark of sessile oak, turkey oak and beech was defined. The samples separated according to age have derived from younger and older stocks from 3 sites of different quality. The wood of the beech species can be stated as 0.568 ATRO tons•m^{-3} on the average, that of the sessile oak is 0.586 ATRO tons•m^{-3}, that of the turkey oak is 0.627 ATRO tons•m^{-3}. The basic density of the bark of oaks is less than that of the wood, while it is approached for beech.

KEYWORDS: Sessile oak, Turkey oak, beech, basic density, ATRO tons•m^{-3}, bark.

INTRODUCTION

Tree species, site type and silviculture largely determine the basic density of wood. This is defined as the amount of dry matter present in a solid cubic metre of timber at 0 % moisture content (Kofman 2010). In case of the bark wood additional to the wood species the age and the wood-bark ratio play an important role among others. The bark thickness depends on the species of wood, the age and ecologic factors. With the same diameter the young tree has a thinner bark and the older tree has a thicker one (Sopp 2000). Because on a good site the trunks can earlier reach a certain diameter, in case of similar diameter they provide smaller bark thickness than on worse sites.

Bark thickness varies on different parts of the stem. Thicker bark is commonly found near the base of the stem and decreases in thickness with increasing height up the stem. Not only is bark thickness affected by the height up the stem, but also by the age of the individuals (assuming age is related to size) (Shekholeslami et al. 2011).

We have to distinguish between the wood and the bark density. Many studies have reported that bark has lower density than wood (Knige and Schultz 1966, Požgaj et al. 1997, Klašnja and Kopitovič 1999), and soft broadleaf species have registered the lowest wood density, followed by coniferous and hard broadleaf species (Jamnická et al. 2014). In case of some wood species there is a great difference within the bark between the density of suberised outer bark and that of the inner bark, so the average density is defined by their volume ratio. It can be also observed that in case of certain wood species the density of outher bark exceeds the wood (e.g. Norway spruce) and for others it is significantly less (e.g. black locust, oaks, poplars). The inner bark is generally denser than wood and the trees with smooth bark have mainly an outer bark of high density (e.g. beech, red oak, birches).

The wood density can vary also according to its location in the tree. Generally going outwards from the pith it continuously increases in the juvenile section, afterwards the average density reaches the highest value in the mature wood. In case of the wood species with high cutting age in the older age (80-150 years) a slight density fallback can be observed, while in case of trees with definitely coloured heartwood (e.g. oak, turkey oak) the density of sapwood is of 5-8 % less than that of the heartwood. For this reason the effect of age is more significant than the distance of wood from the pith (Grekin and Verkasalo 2010). Besides the effect influencing the annual ring width shall not be negligible as well (Přemyslovská et al. 2007).

The goal of the present study is the examination of the effects of the age and site on the basic density in case of wood and bark. The defined values help the timber vendors to specify the conversion factors which are used during the takeover and point out the difference between the two main wood parts.

MATERIAL AND METHODS

During the research we have taken breast height disk samples from totally 180 trunks of 3 wood species (Tab. 1) [3 wood species x 3 site groups (good, mean, weak) x 2 age-classes (younger, older) x 10 trunks]. The mixed deciduous forests are situated at an altitude of 280-570 m; the average annual temperature ranges between 9.0-11.0°C, and the longterm total annual precipitation is approx. 678 mm. The properties of each 10 pcs. disc were evaluated for the wood species and for every site based on the following examinations: Macroscopic anatomical examinations (age, wood-bark ratio), Density examination.

Tab. 1: Marking of the examined wood species according to site and age.

Wood species	**Age**	**Site quality (G-good; M mean; W-weak)**	**Code of samples arising from different subcompartments**		
SOK-sessile oak	younger (Y)	good	${}_{Y}QUPE_{G}$	${}_{Y}QUCE_{G}$	${}_{Y}FASY_{G}$
(*Quercus petraea* L.)		mean	${}_{Y}QUPE_{M}$	${}_{Y}QUCE_{M}$	${}_{Y}FASY_{M}$
QCE-Turkey oak		weak	${}_{Y}QUPE_{W}$	${}_{Y}QUCE_{W}$	${}_{Y}FASY_{W}$
(*Quercus cerris* L.)	older (O)	good	${}_{O}QUPE_{G}$	${}_{O}QUCE_{G}$	${}_{O}FASY_{G}$
BE-beech		mean	${}_{O}QUPE_{M}$	${}_{O}QUCE_{M}$	${}_{O}FASY_{M}$
(*Fagus sylvatica* L.)		weak	${}_{O}QUCE_{W}$	${}_{O}QUPE_{W}$	${}_{O}FASY_{W}$

Because the moisture content of the sample disks was above the fibre saturation point, they already had the maximum volume. The volume measurement was performed by flooding the disks in a manner that those were dipped in a bowl filled with water placed on a scale in a manner that those were held under water by a pin fixed to a bracket. With this measuring method operating with the principle of the buoyant effect the value read from the scale has indicated the sample volume. Because the green moisture content of the specimen was above the fibre saturation point, the quick dipping did not cause any volume change and water absorption respectively.

After the volume and mass measurement the disks were disbarked and then we redefined the volume without bark. For the indication of the basic density of the bark it is required to define the volume, which was provided by the volume difference of the samples in the bark, then that of the disbarked samples.

In the next phase the disks and barks were put in a drying cabinet, where – controlled by measurements of mass – those were dried to absolute dry condition and their weight was measured after drying.

Basic density was calculated by dividing the oven-dry mass by the saturated volume of sample, determined using the water displacement method (Eq.):

$$\rho_b = \frac{w_0}{v_s}$$

where: ρ_b - the basic density (kg•m^{-3}),
w_0 - the dry mass (kg),
v_s - the saturated volume (m^3).

The results were evaluated by a computerized statistical program composed of analysis of variance and following Duncan tests at the 95 % confidence level.

RESULTS AND DISCUSSION

Based on the average age of the 10 disks taken from the individual forest parts egyes the younger and older age-classes can be well separated (Tab. 2). Between the identical site types a difference of 20-30 years can be observed in case of the sessile oak and the turkey oak based on age, while in case of the beech a difference of 30-40 years.

Tab. 2: Average age of the wood species.

Sessile oak	Age (years)	Turkey oak	Age (years)	Beech	Age (years)
$_Y$QUPE$_G$	49	$_Y$QUCE$_G$	30	$_Y$FASY$_G$	42
$_Y$QUPE$_M$	42	$_Y$QUCE$_M$	31	$_Y$FASY$_M$	43
$_Y$QUPE$_W$	40	$_Y$QUCE$_W$	34	$_Y$FASY$_W$	30
$_O$QUPE$_G$	68	$_O$QUCEG	59	$_O$FASY$_G$	78
$_O$QUPE$_M$	67	$_O$QUCE$_M$	55	$_O$FASY$_M$	69
$_O$QUPE$_W$	58	$_O$QUCE$_W$	56	$_O$FASY$_W$	69

The percentage volume rates defined by dipping into liquid properly reflect the differences of the individual wood species resulting from the morphology of their barks (Fig. 1).

The explanation of the deviation of some percentages observable at the average wood-bark rates of the sessile oak samples shall be primarily searched in the age, because with the increase of age the bark rate reduces. For the influencing effect of the site quality an unambiguous tendency cannot be shown regarding the main wood parts. In case of the Turkey oak a higher bark rate could be measured than in case of the sessile oak. The site effect cannot be stated unequivocally also in case of this sort of wood.

In case of the beech resulting from the morphology of the bark the bark rates are significantly lower than in case of oaks. The values between 2.5-3.5 % are less then the ones in the literature (Shekholeslami et al. 2011, Miles and Smith 2009, Sarikhani 1984). Due to the thin, smooth bark the influencing effect of age arises even less. The site quality practically does not play an important role in this case.

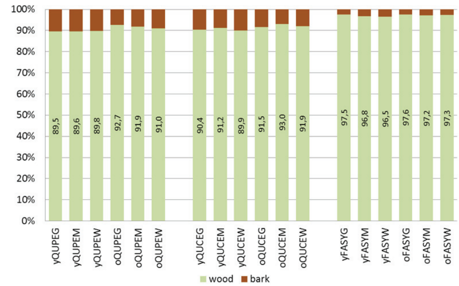

Fig. 1: Wood-bark volume rates.

Corresponding with the deterioration of the site quality the average ages show a reducing tendency except for one exception (turkey oak of younger age). For the basic density of wood it can be stated independent from the wood species, that allowing for the same exception the highest density values can be measured on the best sites (Figs. 2-3). From 3 wood species independent from the forest subcompartment and the site the basic density of the turkey oak wood is the highest. While in case of the older age-class it is followed by the sessile oak, then by beech, in case of the younger ones the values of both wood species alternate. The results received are smaller in case of beech (-4.5 %) and sessile oak (-1.5 %), however in case of turkey oak these are 5.3 % higher for example than the conversion factor applied in one industry branch (Papierholz Austria). According to the publication by Miles and Smith (2009) the average general density by genus regarding oaks is 594 kg•m^{-3} in case of wood, and 579 kg•m^{-3} in case of bark. Regarding sessile oak, these values are similar to our measurement in case of wood part, but 18 % higher in case of bark. Regarding turkey oak these values are similar to our measurement in case of bark, but 5 % less in case of wood part.

In case of the bark this sequence changes. The sessile oak has the lowest values in every case, followed by the turkey ok, then by the beech.

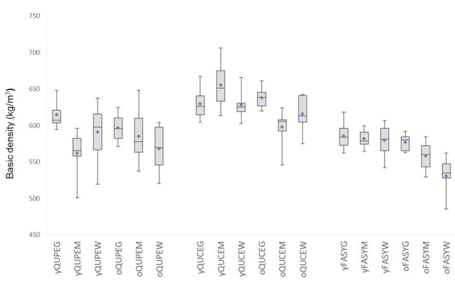

Fig. 2: Basic density of wood.

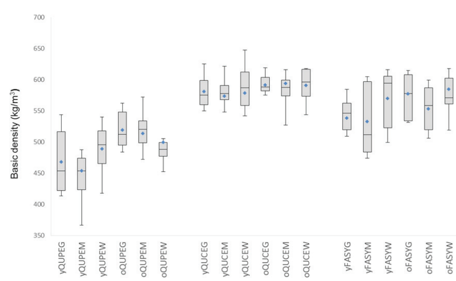

Fig. 3: Basic density of bark.

The basic density of the bark is lower than that of the wood, independent from the wood species. The difference between both major tree parts is the biggest in case of sessile oak, which moderates in case of the older age-class to its half or third compared to the younger age-class. In case of the turkey oak the values are lower and in case of beech there is a smaller difference between the basic density of wood and bark compared to oaks. In case of the barks the standard deviation is about twice as high compared to the woods.

CONCLUSIONS

Basic density of wood

The ATRO tons•m^{-3} factor between the sessile oak, turkey oak and beech shows significant differences. The three wood species in sequence from the lowest to the highest: beech, sessile oak, turkey oak. The wood of beech can be stated in 0.568 ATRO tons•m^{-3} on the average, that of the sessile oak in 0.586 ATRO tons•m^{-3} and that of the turkey oak in 0.627 ATRO tons•m^{-3}.

Basic density of bark

From oaks the basic density of the bark of sessile oak is 10-20 % lower than wood depending on the forest subcompartment. Regarding the age, that of the older age-class is higher. In case of the turkey oak the deviation is lower, under 10 % on the average, but the older ones of this sort of species have a higher basic density.

The basic density of the thin bark of beech occasionally reaches that of the wood. It can be observed first of all in case of the older samples, while in case of the young ones a slightly bigger difference can be seen in favour of the wood.

Effect of age and site to the basic density of wood

In case of woods between sites considered as of identical quality in case of the sessile oak samples a basic density difference of 3-4 % can be experienced, while the age difference was 15-20 years. Within both different forest subcompartments the highest quality sites have reached the highest values, while the ones resulting from the mean and weak areas alternate depending on the forest part. The growing age does not result a definitely higher or lower density, because it can be significantly modified by the site quality.

Between the sites corresponding with identical quality in basic density values a significant deviation can be shown only in case of mean quality. The highest basic denstiy value was reached by the wood of mean quality belonging to the younger age-class, while the lowest value was reached by the wood of also mean quality belonging to the older age-class.

In case of beech contrary to oaks a more definite coherence can be observed both in relation with age and with site. In both forest parts the basic density gradually increases from the weaker site quality towards to better site quality. In case of the older age-class it can be sharply seen, while in case of the young one less.

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