

Influence of knots on the content of chemical substances in knot adjacent oak wood (*Quercus petraea* Liebl.)

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Abstract: *Influence of knots on the content of chemical substances in knot adjacent oak wood (*Quercus petraea* Liebl.).* The research on the content of extractives, cellulose, 1% NaOH soluble substances and lignin occurring in knots, knot adjacent wood, sapwood, heartwood adjacent sapwood and in heartwood was carried out on about 35-years old oak stems from IV Masovian - Podlasie region in Poland. Discs with a height of 150 mm from butt end section, in the half of the stem length and from the top of stem were taken from three oak stems. It was found that extractives content in knots is higher than in the rest of analyzed zones and knots influence this content in knot adjacent wood which is also raised. Lignin content in knots is also the highest in relation to other zones, while cellulose content is the lowest.

Keywords: oak wood, knot, knot adjacent wood, sapwood, heartwood adjacent sapwood, heartwood, extractives, cellulose, 1% NaOH soluble substances, lignin

INTRODUCTION

The presence of knots in wood raw material is acknowledged as the main disadvantage which significantly decrease quality. Knots disturb homogeneity of wood structure, makes its processing and usage more difficult (Pazdrowski i Cybulko 1988). Wood formed and deposited around knot also intensify the heterogeneity because of its structure. Wood around knot is characterized with lower fiber length and higher hardness in relation to wood far from knot. As it arises from papers published earlier (Krutul 1996; Krutul and Sacharczuk 1997; Krutul and Kazem-Bek 1999; Krutul et al. 2000, 2004), knots influence the chemical composition of knot adjacent wood. Apart from examined species, knots cause extractives and lignin content increase (both in knot adjacent sapwood and heartwood), and decrease of cellulose content.

Precise determination of knots influence on knot adjacent wood chemical composition is disturbed because of knots shape and diversity. It is connected with age of analysed wood and knots distribution on cross-section and along the stem height.

According to earlier studies on the influence of healthy knots on some chemical substances content in pine wood (*Pinus sylvestris* L.), change of knots colour takes place along the stem. Dark colour is characteristic for knots with high content of extractives (30-41%) on the stem height between 0.2 and 11.0 m. Knots are bright on the height between 19.5 and 22.5 m and extractives content varies from 4.3 to 5.3 %. Extractives content in knot adjacent heartwood on the height up to 11 m is 2 or 3 times higher in relation to normal heartwood. In knot adjacent sapwood extractives content is even 3, 4 times higher in comparison to normal sapwood. Extractives content in knots adjacent sapwood in top part of the stem varies from 3.5 to 5.3% and does not differ from its content in normal sapwood. On the height up to 19.5 m from the butt-end section lignin content calculated in relation to absolute dry wood after extraction is the highest in knots and knots adjacent heartwood (up to 20m of stem height). In the top part of the stem differences between lignin content in knots adjacent sapwood and normal sapwood are insignificant (Krutul 1996).

According to the paper concerning the influence of knots on the content of extractives and 1% NaOH soluble substances in knot adjacent oak wood (*Quercus robur* L.), raised content was denoted there in relation to wood far from knots (Krutul and Sacharczuk 1997).

In 30 years old oak wood from knots adjacent heartwood extractives content is up to 30% higher in relation to normal heartwood, in knots adjacent sapwood its content is about 20% higher than in normal sapwood. Knots also influence the content of 1% NaOH soluble substances. Their content is higher in knots adjacent wood in comparison to wood far from knots. Lignin content in knots adjacent wood (both sap- and heartwood) is higher in relation to normal sapwood and heartwood. Cellulose content in knots adjacent wood is lower in relation to wood placed far from knots (both sap- and heartwood).

According to data presented above, knots influence particular substances content in knots adjacent wood (Krutul 1997; Krutul and Sacharczuk 1997; Krutul et al. 1999, 2000 and 2004). It was stated that wood of oak *Quercus petraea* Liebl. could be treated equivalent with oak *Quercus robur* L. (Prosiński 1984).

MATERIALS AND METHODS

Samples for analysis were collected from three cca. 35 years old oak stems (*Quercus petraea* Liebl.) which grew up in IVth Mazovia-Podlasie region in Sokołów upper forest district. Disks of 150 – 200 mm height were cut from butt-end section, middle part (half-height) and top part of each stem. Studied trees have grown in fresh mixed forest on the loamy soil.

Cross-section of each stem was divided into heartwood, sapwood adjacent heartwood, sapwood, knot adjacent zone and knots. Wood from 15mm around of knot was acknowledged as knot adjacent. 4mm wide zone on the heartwood and sapwood frontier (2mm of heartwood and 2mm of sapwood) was acknowledged as sapwood adjacent heartwood. Samples from particular zones were collected using drill and chisel then disintegrated in laboratory beater and fractionated with sieves set. The fraction passing 1.2-mm and remaining on 0.49 mm mesh sieve was taken for analysis.

Tab. 1 Knots characteristics in particular discs

stem no.	stem part	height [m]	knots			
			type	diameter [mm]	connection with surrounding wood	health
I	butt-end	0.2	overgrown	78	connate	healthy
	middle	3.5	open	52	connate	healthy
	top	6.0	open	45	connate	healthy
II	butt-end	0.3	overgrown	30	connate	healthy
	middle	4.0	open	42	partially connate	healthy
	top	6.5	open	45	connate	healthy
III	butt-end	0.2	open	45	partially connate	healthy
	middle	4.0	open	50	connate	healthy
	top	6.5	open	38	connate	healthy

Knots characteristics is presented in the Tab. 1. Studied knots formed whole with surrounding wood annual rings on the full perimeter. There was no traces of fungus originated decay so they were acknowledged as connate, healthy knots. The extraction was conducted in Soxhlet apparatus using ethanol-benzene mixture (1:1). Cellulose was analysed with

Kürschner-Hoffer method and lignin according to Tappi T-222 os-74 (Krutul 2002). Additionally, 1% NaOH soluble substances were determined.

RESULTS AND DISCUSSION

Data concerning extractives content in wood of three stems in particular wood zones and in knots on the cross-section and along the stem is presented in figures 1, 2 and 3. According to these figures, knots contain 30-40% more extractives than sapwood and 20-30% more than heartwood in butt-end section of the stem. In the middle section of the stem extractives content is 20-40% higher in relation to sapwood and 5-30% higher in relation to heartwood. Extractives content in knots from the top part of the stem II is about 30% higher in comparison to sapwood and cca. 7% higher in comparison to heartwood. In the stem III these values are correspondingly 25 and 5%.

Extractives content in knots adjacent wood is also higher in relation to sap- and heartwood, as well as in sapwood adjacent heartwood. There are no differences in values obtained for particular sections along the stem. According to Krutul et al. (1999), in 80 years old stems of alder (*Alnus glutinosa* L.) extractives content in knots is almost twice higher in relation to knots adjacent wood and pith adjacent wood (butt-end and middle section). In top part of the stem differences are lower (about 3%).

Knots in cca. 70 years old pine stems contain about 30% of extractives, while knots adjacent heartwood – 24.6% and knots adjacent sapwood - 22.9%. Extractives content in heartwood equals 8.9% and in sapwood – 4.6% (Krutul 1996). Analysed knots contains less extractives in relation to knots from pine wood.

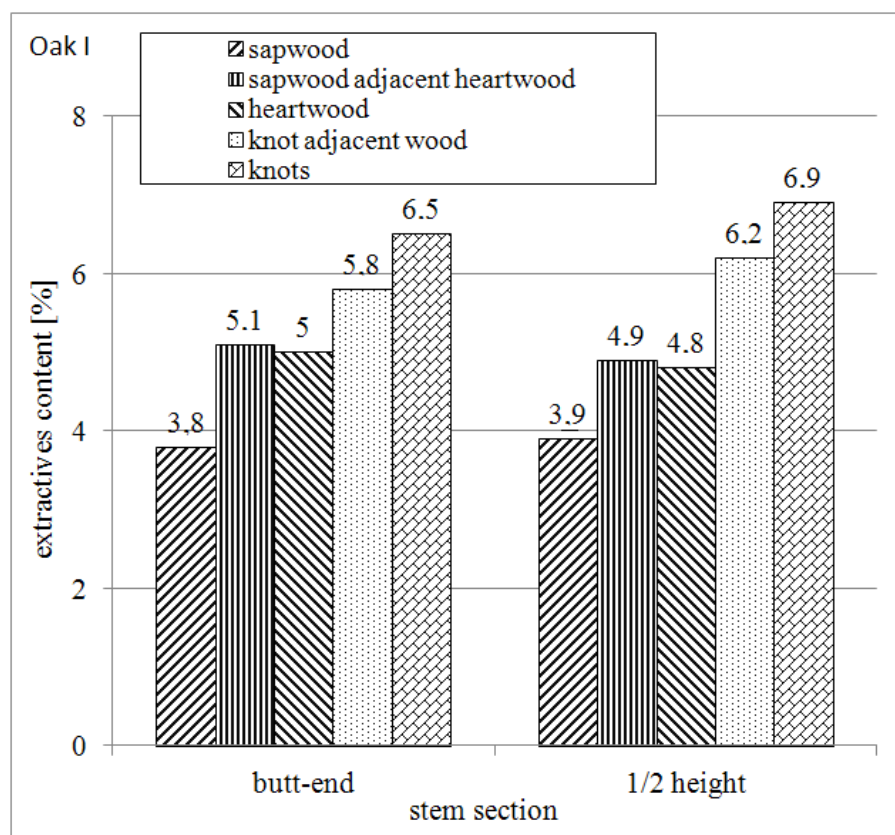


Fig. 1 Extractives content in particular wood zones and knots (stem I)

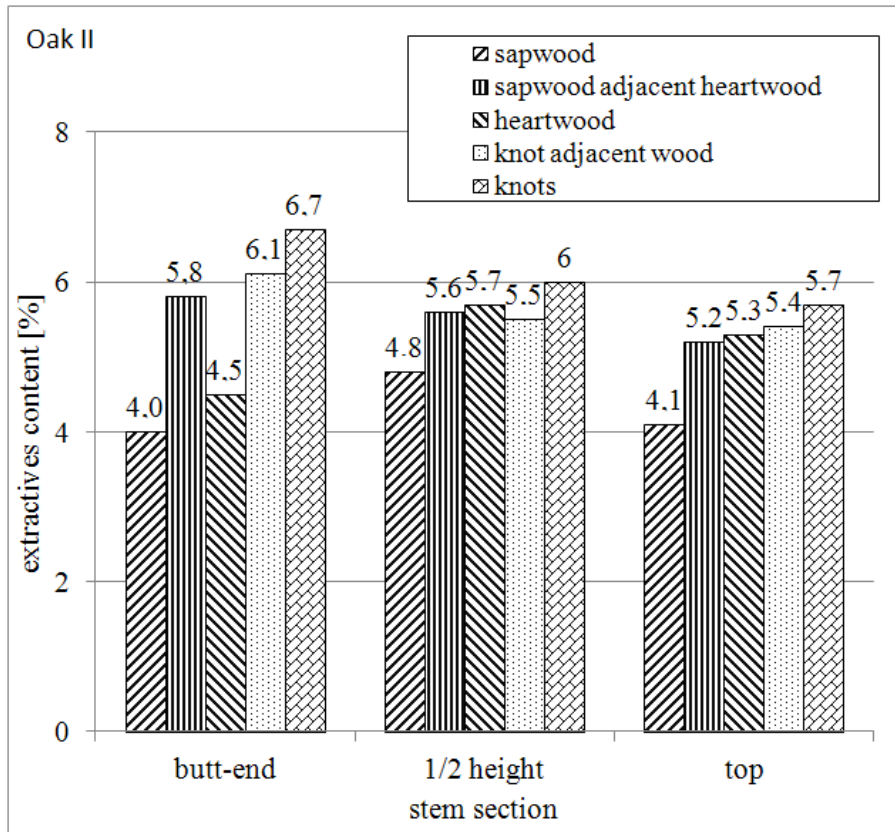


Fig. 2 Extractives content in particular wood zones and knots (stem II)

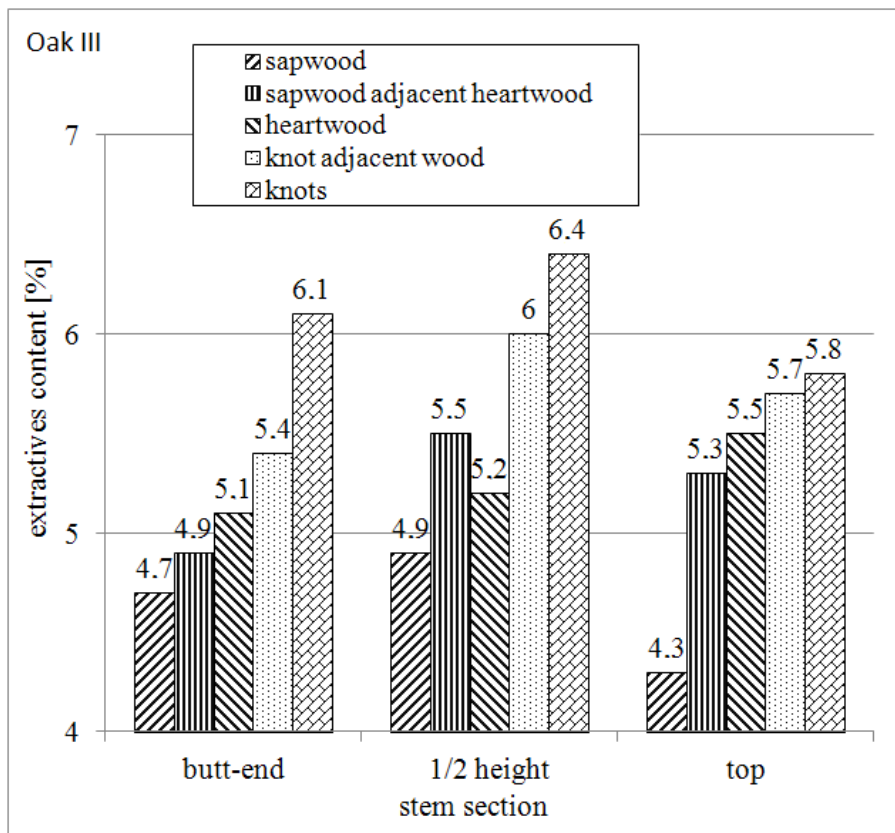


Fig. 3 Extractives content in particular wood zones and knots (stem III)

Extractives content in 30 years old *Quercus robur* L. stems varies from 5.1 to 8.3% whereas in particular wood zones it is similar to results obtained for oak *Quercus petraea* Liebl. (Krutul et al. 2004). Summarizing, knots cause the increase of extractives content in knots adjacent wood.

Figures 4, 5 and 6 present values of cellulose content in particular wood zones and knots on cross-sections in butt-end, half height and top section of the stem. Cellulose content determined with Kürschner-Hoffer method is the highest in sapwood (in all analysed cross-sections) and equals 43.6-44.0%. This content in knots is lower apart from wood section along the stem (14% in butt-end, 13% in middle part, 9% in top part). Obtained results are similar to data denoted in Krutul et al. 2004, concerning cellulose content in particular wood zones of oak (*Quercus robur* L.) Cellulose content in knots adjacent wood is lower in relation to sapwood also in this case.

Summarizing, knots contain the least amount of cellulose from among all of wood zones.

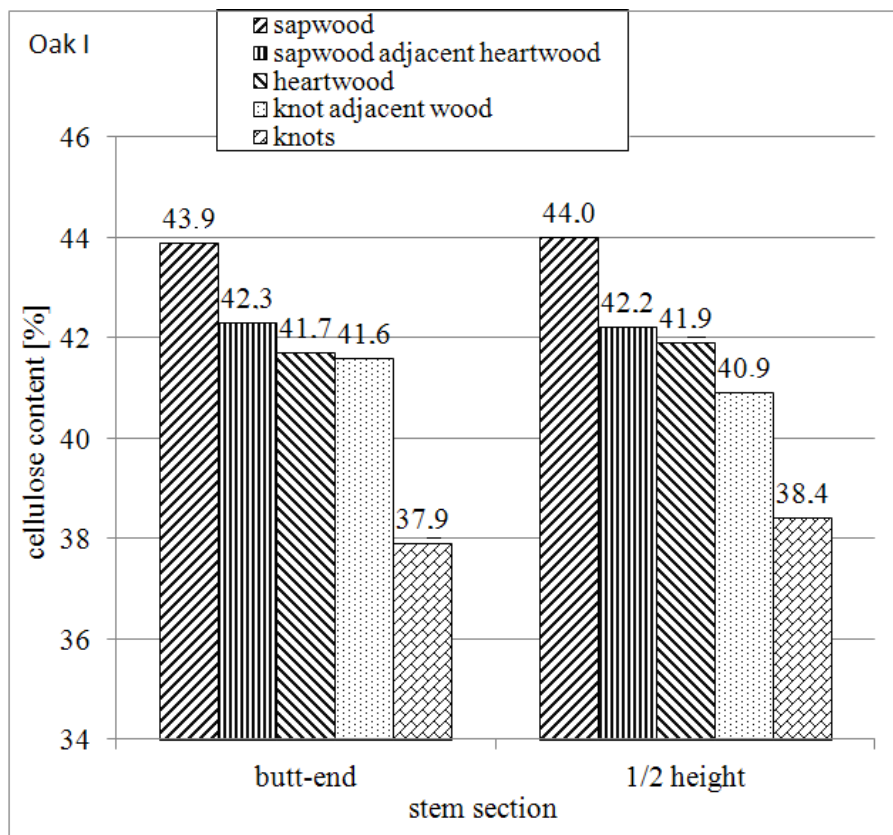


Fig. 4 Cellulose content in particular wood zones and knots (stem I)

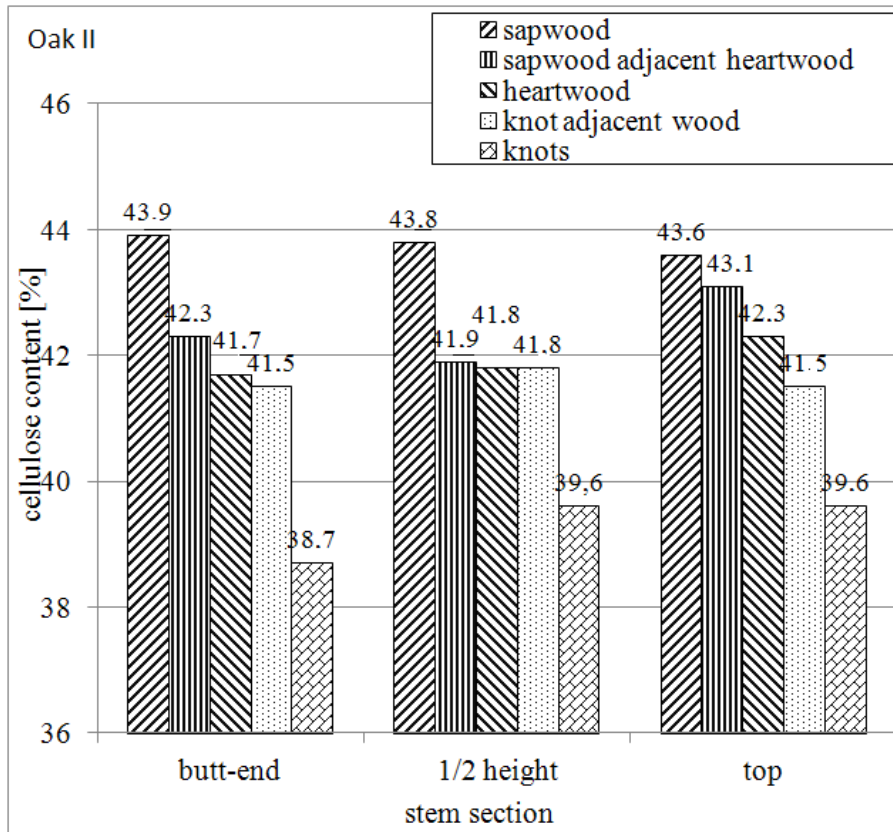


Fig. 5 Cellulose content in particular wood zones and knots (stem II)

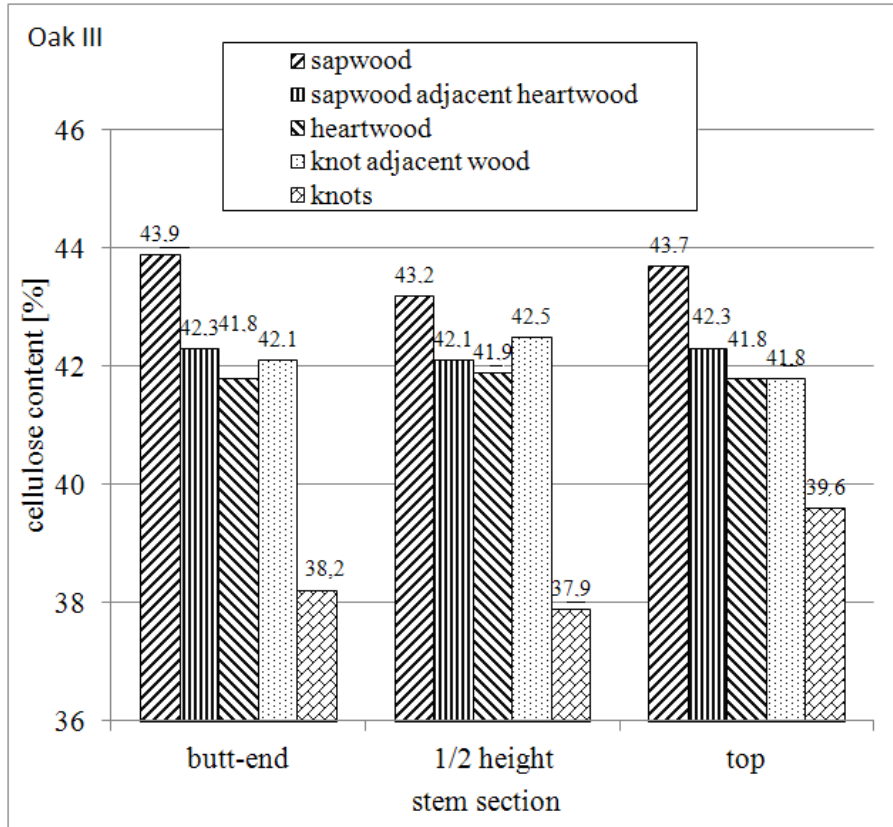


Fig. 6 Cellulose content in particular wood zones and knots (stem III)

Knots are characterized with higher content of 1% NaOH soluble substances in comparison to knots adjacent wood, sap- and heartwood, as it arises from data presented in figures 7, 8 and 9. Only on the cross-section in butt-end part of the stem II these substances content in knots is similar to sapwood adjacent heartwood.

According to earlier studies 1% NaOH soluble substances content in alder (*Alnus glutinosa* L.) is lower apart from tree age. These substances content in knot adjacent wood from butt-end section of 83-years old stem varies from 21.5 to 23.1% (Krutul 1999).

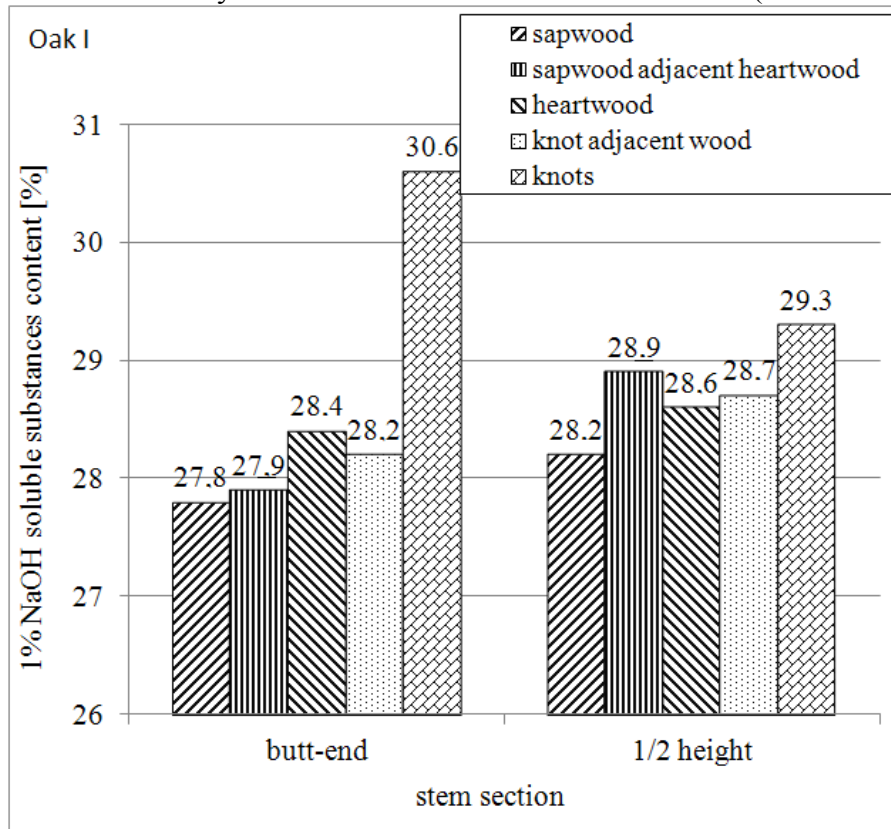


Fig. 7. 1% NaOH soluble substances content in particular wood zones and knots (stem I)

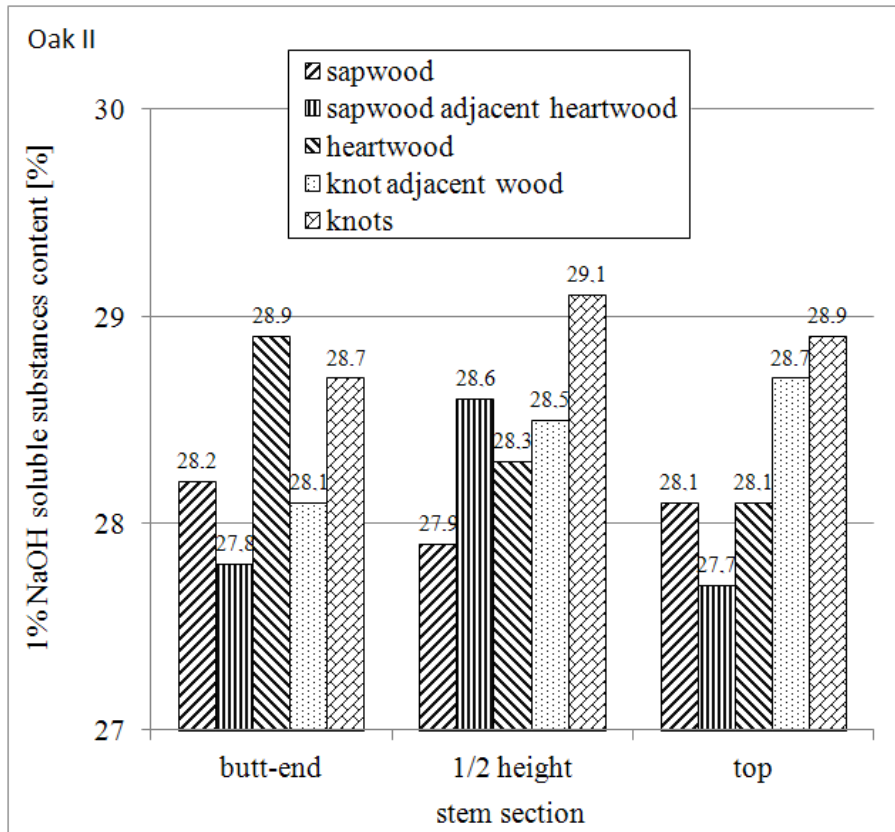


Fig. 8 1% NaOH soluble substances content in particular wood zones and knots (stem II)

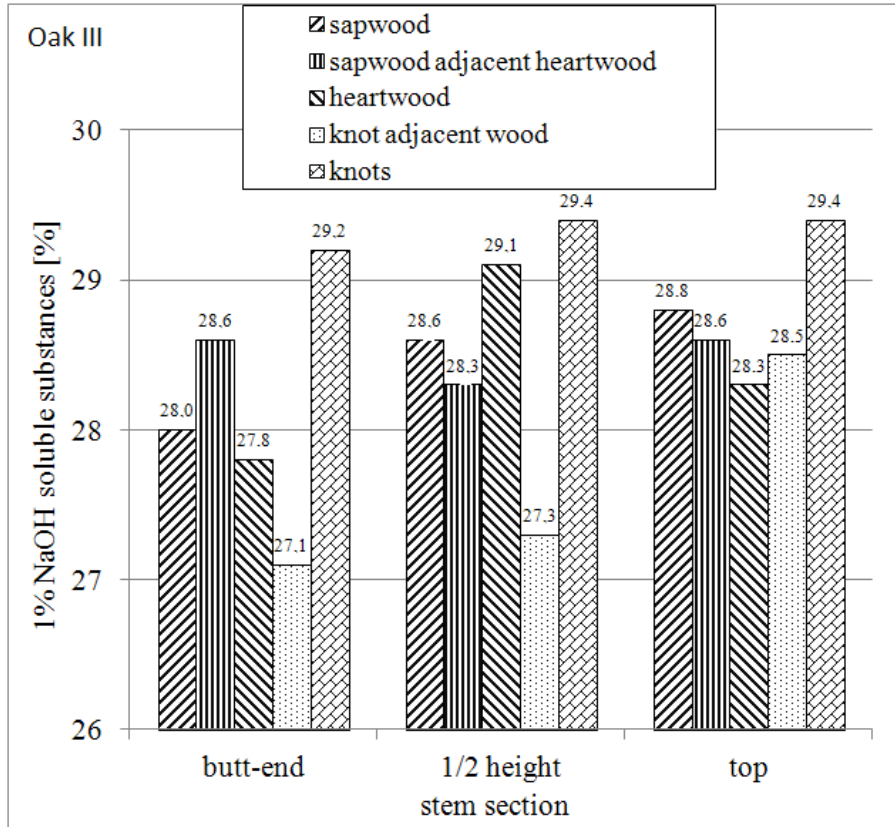


Fig. 9 1% NaOH soluble substances content in particular wood zones and knots (stem III)

According to results of Krutul and Sacharczuk (1997), 1% NaOH soluble substances content in particular wood zones and knots of 25 years old oak stems (*Quercus robur* L.) is more diversified. These substances content in knots from butt-end, middle and top section in stem I are correspondingly 31, 22 and 26% higher in relation to sapwood, in stem II – 20, 22.5 and 15%, in stem III – 20.5, 13 and 12%. In knots adjacent heartwood this content is also higher in comparison to sapwood (Krutul and Sacharczuk 1997).

1% NaOH soluble substances content in knots from analysed oak stems is only 5% higher in relation to sapwood and differences are even lesser in comparison to heartwood.

As it arises from above mentioned comparisons, 1% NaOH soluble substances content in knots and knots adjacent wood and all other analysed zones depends on knots health, trees forest site and their age.

Studied knots contain higher amount of lignin in comparison to other analysed wood zones (Fig. 10, 11 and 12). Lignin content in knots varies from 24.8 to 25.6%, in sapwood from 23.0 to 24.0%. Knots adjacent wood contains more lignin in relation to sapwood and similar in relation to heartwood.

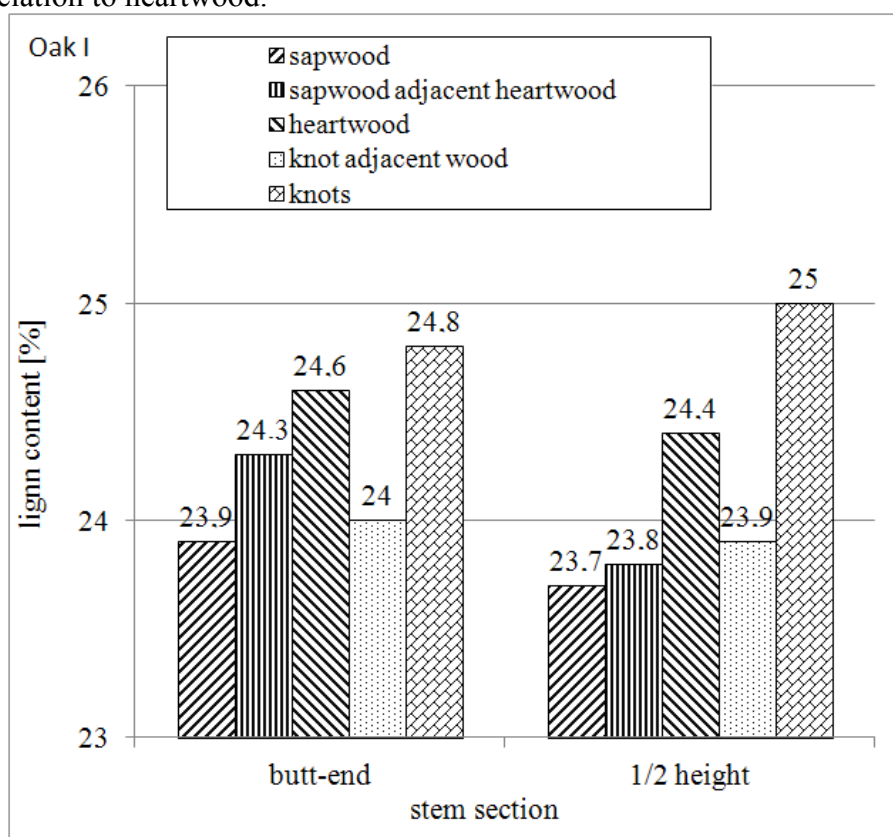


Fig. 10 Lignin content in particular wood zones and knots (stem I)

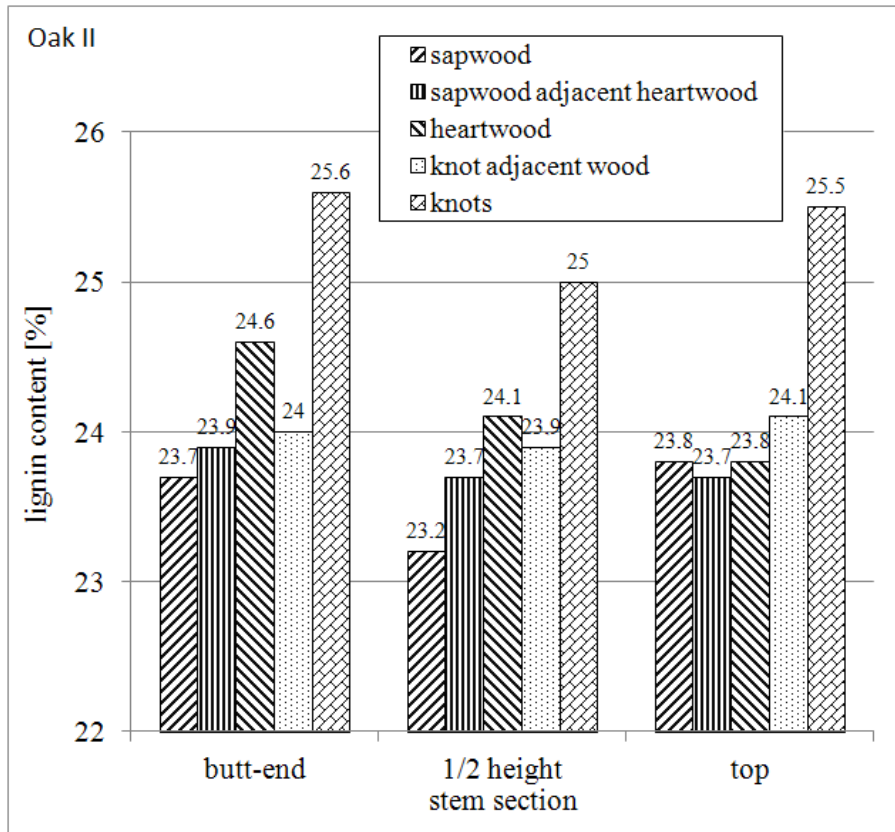


Fig. 11 Lignin content in particular wood zones and knots (stem II)

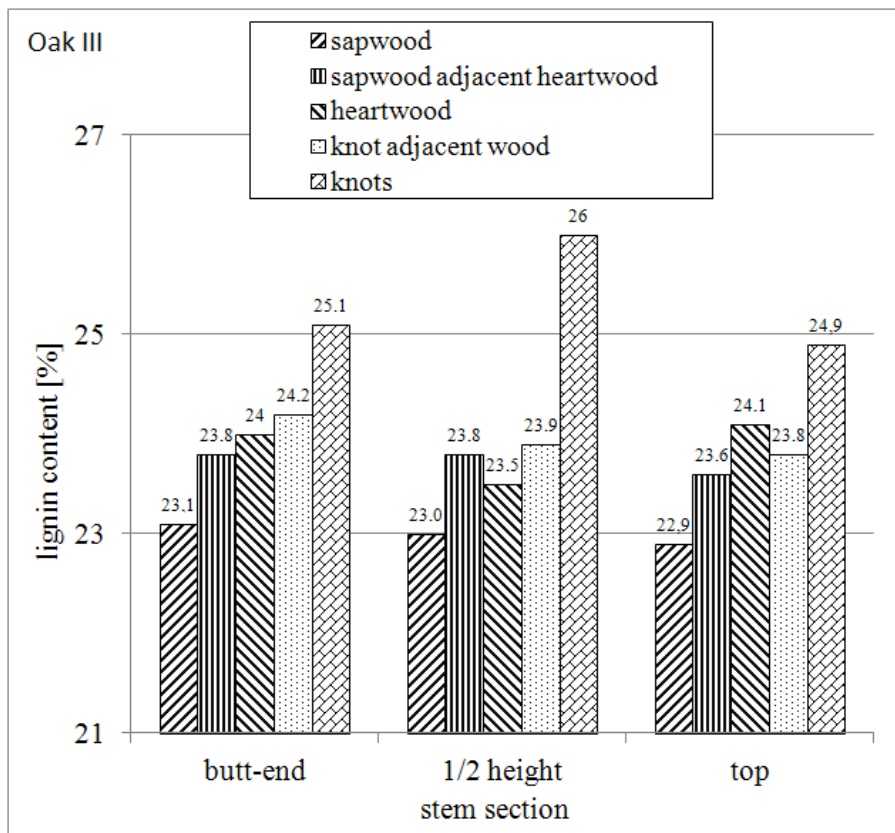


Fig. 12 Lignin content in particular wood zones and knots (stem III)

It must be emphasized that knots in pine stems influence lignin content in knots adjacent wood (both sap- and heartwood) more significantly (Krutul 1996) than knots in analysed oak wood. Studies on the influence of knots on particular components in knots adjacent wood must be performed separately for sap- and heartwood.

CONCLUSION

In cross-sections of butt-end section, middle and top part of the stem knots contain the highest amount of extractives in relation to other studied zones and cause increase of their content in knots adjacent wood.

Apart from the section along the stem cellulose content is the lowest in knots and 1% NaOH soluble substances content is the highest in comparison to other wood zones.

Sapwood adjacent heartwood, heartwood and knots adjacent wood contain similar amount of cellulose, 1% NaOH soluble substances and lignin apart from wood section along the stem.

Sapwood contains higher amount of cellulose in relation to knots and other wood zones and the least extractives amount.

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Streszczenie: *Wpływ sęków na zawartość substancji chemicznych w drewnie przysęczonego dębu bezszypułkowego (Quercus petraea Liebl.). Stwierdzono, że sęki zawierają więcej substancji ekstrakcyjnych w porównaniu z drewnem przysęczonego a obie te strefy zawierają ich więcej niż pozostałe strefy drewna. Stąd wniosek, że sęki wpływają na zawartość substancji ekstrakcyjnych w drewnie przysęczonego. Zawartość substancji ekstrakcyjnych w strefie twardzieli i bielu sąsiadującego z twardzielą jest natomiast zbliżona. Zawartość celulozy w sękach jest najmniejsza w porównaniu z innymi strefami drewna, z kolei zawartość substancji rozpuszczalnych w 1% NaOH jest tam największa. Zawartość ligniny w sękach jest także podwyższona. Badania nad wpływem sęków na zawartość poszczególnych substancji w drewnie przysęczonego powinny być prowadzone oddzielnie dla drewna przysęczonego w bielu i twardzieli.*

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