

## The diversification of chemical composition of pine wood depending on the tree age

BOGUSŁAWA WALISZEWSKA<sup>1</sup>, WŁODZIMIERZ PRĄDZYŃSKI<sup>2</sup>, MAGDALENA ZBOROWSKA<sup>1</sup>, AGATA STACHOWIAK-WENCEK<sup>1</sup>, HANNA WALISZEWSKA<sup>1</sup>, AGNIESZKA SPEK-DŹWIGAŁA<sup>1</sup>

<sup>1</sup>- Institute of Chemical Wood Technology, Faculty of Wood Technology, Poznań University of Life Science

<sup>2</sup>- Institute of Wood Technology, Poznań,

**Abstract:** *The diversification of chemical composition of pine wood depending on the tree age.* The chemical composition of pine wood at different ages was studied. Sapwood and heartwood were divided into two zones depending on growth rings. Variation in the content of the main components of wood was observed. With age, the content of cellulose in the tree increases, while the content of holo-cellulose decreases. Irrespective of tree age a greater amount of lignin was found in pine heartwood than in sapwood.

**Keywords:** scot pine, chemical composition, sapwood, heartwood

### INTRODUCTION

Forests play many important roles, such as environmental, production and social. They influence not only the local but also the global climate. They produce oxygen and absorb carbon dioxide, which influences the greenhouse effect. The wood harvested from the forest is the most important basic raw material for mankind. It is used in many industries such as: construction, furniture industry, the pulp and paper industry. Finally, it is used as fuel.

The dominant species of the Polish forests is the scots pine *Pinus sylvestris* L.. Pine is represented by about 80 species of trees or shrubs. It occurs mainly in the temperate zone of the northern hemisphere. In Poland four species grow in the wild state: scots pine (*Pinus sylvestris* L.), stone pine (*Pinus cembra* L.), dwarf mountain pine (*Pinus mugo* Turra) and mountain pine (*Pinus mugo nothosubsp. rotundata*). *Pinus sylvestris* is the most important tree accounting for about 70% of the state forests. Pine wood is differentiated into sapwood and heartwood. Annual growth rings are clearly visible and have different width depending on tree age and habitat. The share of earlywood of the annual growth rings is approximately 60-70% and differs from latewood in anatomical structure and chemical composition.

Scots pine is one of the most important coniferous species, which apart from its high wood technical characteristics provides also significant amount of resinous substances. In the form of sawn timber scots pine is used as construction material in versatile ways, while in the naturally round timber state – it is mainly used as pit timber. Pine wood is used to manufacture fiberboard, particleboard and pulp. It is also a potential raw material for the wood hydrolysis industry.

The aim of the study was to investigate the impact of the pine tree age on its chemical composition taking into account the division into sapwood and heartwood.

### MATERIALS AND METHODS

Material for the study was obtained from two different sites:

1. 75 year old pine from forest division Oborniki Śląskie, forest district Pęgów, working circle Pęgów; forest habitat type - fresh mixed coniferous forest;
2. 104 year old pine from forest division Łopuchówko, borough Murowana Goślina, forest habitat type - fresh beech-hornbeam-oak forest;

Four discs with a thickness of 5 cm were cut from each trunk at the breast height and seasoned in laboratory conditions. Each disc was divided by hand into four parts by means of a chisel. The 75 years old pine was divided into sapwood: up to the 20<sup>th</sup> growth ring and from the 20<sup>th</sup> to the 40<sup>th</sup> growth ring. Heartwood was divided: from the core to the 15<sup>th</sup> growth ring and from the 15<sup>th</sup> to the 29<sup>th</sup> growth ring. The 104 year old pine was divided into sapwood: up to 28<sup>th</sup> growth ring, and from the 28<sup>th</sup> to the 56<sup>th</sup> growth ring. Heartwood was divided: from the core to the 21<sup>st</sup> growth ring and from the 21<sup>st</sup> to the 42<sup>nd</sup> growth ring. Next, the wood was grounded with a Pulverisette 15 laboratory knife mill and the fraction 0,5-1,00 mm was isolated by means of sieves.

Chemical analyzes were done separately for sapwood and heartwood taking into account the division into growth rings and according to PN-92/P-50092 standard. The following parameters were determined:

- content of extractives with a Soxhlet extractor and the use of ethyl alcohol;
- cellulose content by means of the Seifert method;
- lignin content by TAPPI method;
- holocellulose content with sodium chlorite.

## RESULTS

The chemical composition of wood depends on many factors for example the tested wood zone (sapwood or heartwood), age and part of the tree, the climate zone and the habitat in which it grew (Prosiński 1984, Fengel and Wegener 1984, Rowell 1984). In the conducted study the cellulose content in the sapwood of the 75 year old pine ranged from 46.3% to 47.3%, and was lower than in the same part of the 104 year old pine in which it varied from 48.1% to 49.7% cellulose, depending on the growth ring layer. Thus it can be concluded that the older tree contained more cellulose in sapwood (Fig. 1). Similar cellulose content in 60 year old pine was reported by Wróblewska and Sława-Neyman (1995).

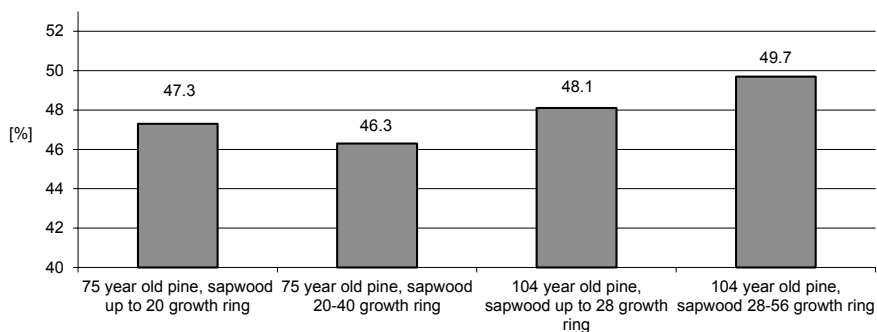


Fig. 1. The content of cellulose in pine sapwood with division into growth ring zones

When analyzing results concerning cellulose content in the heartwood of the 75 year old pine it can be observed that the amount of this component was at 45.0% in growth rings in direction from the core and 44.2% in growth rings between 15 and 29 (Fig. 2). Similar quantity - 46.3% and 47.4% of cellulose in a 60 year old pine are reported by Wróblewska and Sława-Neyman (1995). The older, 104 year old tree, contained much more of this basic component in the heartwood, i.e. 49.3%, in growth rings from the core to the 21<sup>st</sup> growth ring. In further growth rings, i.e. from 21<sup>st</sup> to 42<sup>nd</sup>, the cellulose content in the heartwood was 46.9% (Fig. 2).

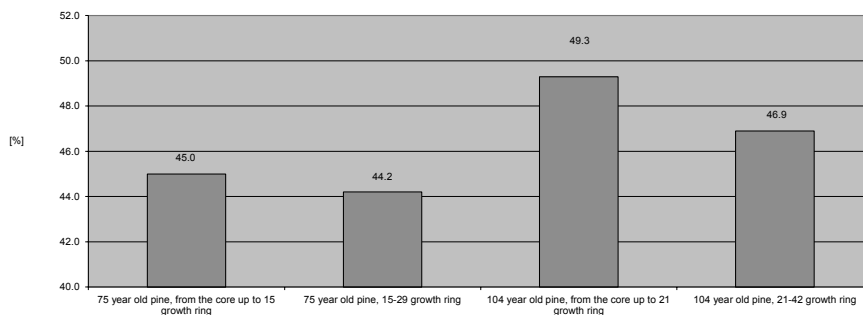


Fig. 2. The content of cellulose in pine heartwood with division into growth ring zones

The amount of holocellulose in pine sapwood remained at a similar level of approximately 65% in the 75 year old pine regardless of the division into growth rings. Approximately 10% more of holocellulose was determined in sapwood of the 104 year old pine. It accounted for 73.8% and 74.7%, depending on the growth ring zone (Fig. 3).

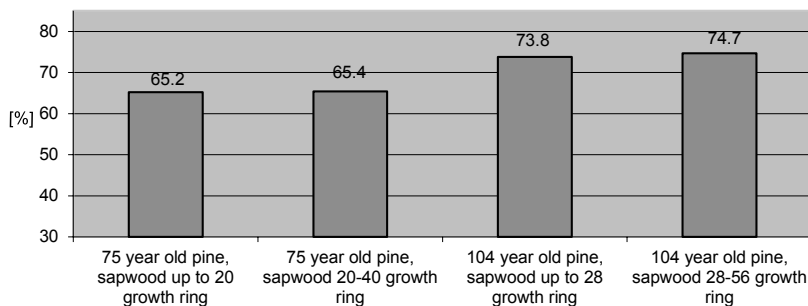


Fig. 3. The content of holocellulose in pine sapwood with division into growth ring zones

In heartwood, regardless of pine tree age, a lower content of holocellulose was observed in the core zone ranging from 67.2% to 69.5% than in the growth ring zone between the 15<sup>th</sup> and 29<sup>th</sup> growth ring (75 years old pine) as well as between the 21<sup>st</sup> and 42<sup>nd</sup> growth ring (104 year old pine). The amount of holocellulose in these areas was 78.4% and 75.6% (Fig. 4).

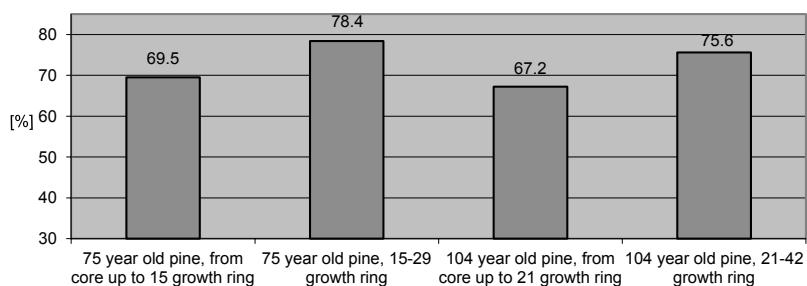


Fig. 4. The content of holocellulose in pine heartwood with division into growth ring zones

Fig. 5 shows the lignin content in selected sapwood areas of the surveyed trees. The amount of this component, regardless of the growth ring zone and tree age was on a similar level and ranged from 26.5% to 27.2%.



Fig. 5. The content of lignin in pine sapwood with division into growth ring zones

In the heartwood of the 75 year old pine a similar content of lignin of approximately 28% was found (Fig. 6). Slightly higher amount of lignin was determined in heartwood of the 104 year old pine, i.e. 30.2% in the zone from the core to the 21<sup>st</sup> growth ring and 29.2% for the area between the 21<sup>st</sup> and 42<sup>nd</sup> growth ring.

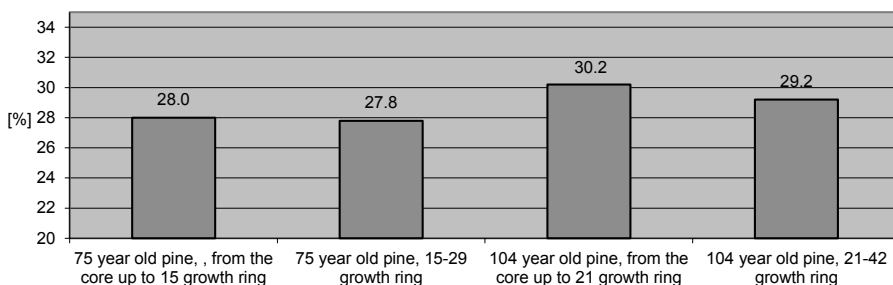


Fig. 6. The content of lignin in pine heartwood with division into growth ring zones

In the pine sapwood a low amount of substance extracted with ethanol were found. In the zone up to the 20<sup>th</sup> growth ring of the 75 year old pine, the amount was 2.7% and in the zone between 20<sup>th</sup> and 40<sup>th</sup> growth ring - 2.3%. However, in the zone up to the 28<sup>th</sup> growth ring in the 104 year old pine, the amount of extractives soluble in ethanol was 3.4%, and in the zone from the 28<sup>th</sup> to 56<sup>th</sup> growth ring - 2.8% (Fig. 7).

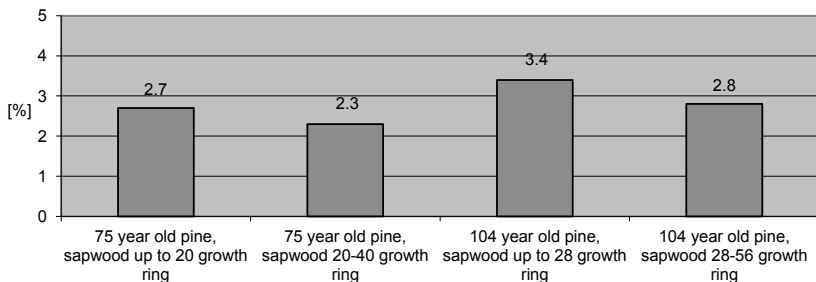


Fig. 7. The content of extractives in pine sapwood with division into growth ring zones

In the heartwood of the 75 year old pine in the zone between the core and the 15<sup>th</sup> growth ring, the amount of extractives was 13.3% (Fig. 8). Nearly half less, i.e. 6.8% of the compounds were observed in the zone between the 15<sup>th</sup> and 29<sup>th</sup> growth ring. Similar relationships were found by Krutul (1998), who states that the content of extractives decreases from the core to the pine wood trunk periphery.

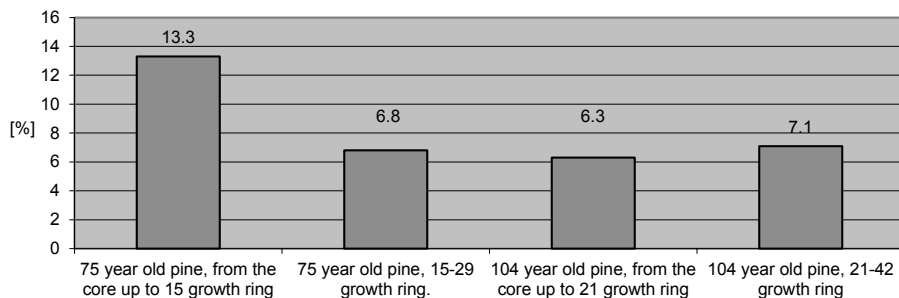


Fig. 8. The content of extractives in pine heartwood with division into growth ring zones

However, in the 104 year old pine the content of compounds extracted with ethanol, irrespectively of the selected growth ring zone, was similar and accounted for 6.3% in the core zone and 7.1% in the zone between the 21<sup>st</sup> and 42<sup>nd</sup> growth ring (Fig. 8).

## CONCLUSIONS

1. Heartwood contains much more substances extracted with ethanol than sapwood.
2. Regardless of the tree age, it was observed that the pine heartwood zone contains a higher amount of lignin than pine sapwood.
3. The older the tree, the content of cellulose increases and of lignin slightly increases, while the amount of holocellulose decreases.

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**Streszczenie:** *Zróżnicowanie składu chemicznego drewna sosny w zależności od wieku drzewa.* Najbardziej popularnym drzewem polskich lasów jest sosna zwyczajna (*Pinus sylvestris* L.). Celem pracy było określenie wpływu wieku drzewa na skład chemiczny – jak zmienia się zawartość celulozy, ligniny, holocelulozy w bielu i twardzieli. Część bielastą i twardzielową podzielono na dwie strefy w zależności od przyrostów. Stwierdzono zróżnicowanie w zawartości głównych komponentów drewna. Wraz z wiekiem drzewa, wzrasta zawartość celulozy, a maleje holocelulozy. W części twardzielowej oznaczono większą ilość ligniny, niż w części bielastej drewna sosny, niezależnie od wieku drzewa.

Corresponding author:

Bogusława Waliszewska  
Institute of Chemical Wood Technology, Faculty of Wood Technology,  
Poznań University of Life Sciences  
ul. Wojska Polskiego 38/42,  
60-637 Poznań, Poland  
email: bwaliszewska@up.poznan.pl  
phone: +48 61 848 74 65