Comparative content of biologically active substances in wood species of the north of the forest steppe on the example of Lipetsk region

S Yu Shubkin, S S Buneev1 and V L Zakharov
Bunin Yelets State University, 28, Kommunarov Street, the Lipetsk region, Russia

1 E-mail: limes88@mail.ru

Abstract. The wood of 22 of the most common low resinous tree species were studied. The number of polyphenols in the wood of the studied species ranges from 23.6 to 1433.1 mg% (0.02-1.43%). The maximum number is noted in the wood of thorny blackthorn. As the wood of fruit species ages (over 3 years old), the content of polyphenols decreases. The content of organic acids in wood of tree species varied in the range of 0.21-1.08%. The leader in terms of their content was the common rowan tree. The amount of tannins and dyes in wood species ranged from 1.45 to 26.5% and was maximum in the tissues of thorny blackthorn. The tannin level in the tissues of the tree species was 0.83-20.8%. The highest tannin content was in the wood of the rowan tree. With the natural drying of wood of 20 species within 8 months in a ventilated room at an air temperature of 25°C, the moisture content of the wood decreases 1.4-3.83 times and is set at the level of hygroscopicity (11.47-35.6%). In the process of slow drying of wood species, organic acids are not destroyed in them, but are concentrated. The least hygroscopic is the wood of the walnut and pedunculate oak, the most hygroscopic is the wood of the heart-shaped linden.

1. Introduction
Wood of many species is very rich in biologically active substances. For example, oak wood contains flavanols, catechins [1], 5-10% of substances extracted with hot water [17], which are represented by a significant part of tannin and color materials. Wood of different tree species is studied for various purposes: as a raw material for the paper industry, aspen wood [20] and eucalyptus [11], for fuel value - wood from 6 bedrock species of northeastern India [13] and seaside pine [20], as a source tannin - Moroccan acacia bark [20], in winemaking - oak wood [12, 18], in nutrition and cosmetology - wood of pedunculate oak, pine [14], eucalyptus [10] and white poplar [15], as a source of growth stimulants for plants - the bark of the forest beech and common spruce [20] and even for the culture of isolated tissues - the bark of the pedunculate oak [20]. Shoots of sweet cherries growing in places with different pollution were studied for the content of heavy metals in order to use wood as a source of biologically active substances [20]. It has been established that the more polyphenols and tannins in wood, the more durable (resistant to decay) fabrics in gabon walnut [8] and oak [7]. The content of phenolic compounds depends not only on the wood species and the place of growth, but also on the wood layer [20]. There are more volatile substances in wood compared to bark [13]. In the upper part of the crown (younger branches) of white fir, more polyphenols were found than in the old lower part [9]. On the example of pine, the relationship between the content of polyphenols and the quality of smoke when burning its wood was
considered [16]. When wood burns, organic acids are either destroyed or simply carried away with smoke, since the ash pH is much higher (more alkaline) than the wood pH [6].

The purpose of the study is to analyze wood species for the content of biologically active substances most resistant to heat treatment in order to justify the choice of wood species or create an assortment of them in further work on the study of the smoking process.

2. Objects and research methods
The research was carried out in 2019-2020 in the northern forest-steppe zone of the Lipetsk region. The object of research was the wood of 22 of the most common low-resinous tree species. Organs of tree species were collected for analysis in January. The analyzes were carried out in freshly sawn wood. Of the biologically active substances, only the most resistant to heat treatment were determined. Polyphenols were determined as the sum of flavanols and catechins, which were determined photometrically [2]. Since most of the rocks taken for the study belong to the Rosaceae family, the content of organic acids was determined by the titrimetric method in terms of malic acid [5]. Titration was also used to determine the amount of tannins and dyes [4], including separately the proportion of tannin [3].

3. Results of studies
Using 4 fruit species as an example, we have found out how the age of wood affects the content of polyphenols in it (table 1).

| Element              | Apple tree | Dog rose | Sour cherry | Rowan tree |
|----------------------|------------|----------|-------------|------------|
| Annual shoots        | 503.1      | 964.0    | 540.1       | 364.7      |
| 2-3-year-old shoots   | 818.5      | 703.5    | 544.0       | 260.5      |
| 6-12-year-old branches| 62.6       | 71.0     | 65.2        | 45.7       |

The highest content of polyphenols was found in the youngest shoots of fruit trees - 1-3 years old. The 6-12-year-old branches of these breeds contain 6.8-11.7 times less than the 1-3-year-old shoots. We have analyzed perennial fruits from the generative formations of the apple tree. Despite their age, they had a rather high content of polyphenols - 309.8 mg.

When analyzing wood, the weighed portion included annual shoots and multi-year wood. According to the literature data, oak wood can contain up to 15% tannin [1, 19]. According to our research, there were 9.37% of tannin and color materials in oak. Tannin accounted for more than a quarter of this amount (table 2).

| Species               | Polyphenols, mg % | Organic acids, % | Amount of tannin and color materials, % | Tannin, % |
|-----------------------|-------------------|------------------|----------------------------------------|-----------|
| Apple tree            | 423.5             | 0.42             | 12.0                                   | 11.64     |
| Sour cherry           | 542.1             | 0.71             | 1.45                                   | 2.5       |
| Magaleb cherry        | 23.6              | 0.51             | 3.74                                   | 2.5       |
| Nanking cherry        | 698.1             | 0.65             | 2.86                                   | 2.5       |
| Apricot tree          | 352.2             | 0.86             | 4.54                                   | 2.9       |
| Blackthorn            | 1433.1            | 0.56             | 26.5                                   | 3.32      |
| Blood-red hawthorn    | 592.0             | 0.4              | 3.0                                    | 2.9       |
Tree species studied by us, the leader in the content of polyphenols was prickly plum (blackthorn), and the smallest amount of these substances was noted in the wood of antipka (Magaleb cherry). We found a fairly high amount of polyphenols in the wood of common cherry, felt, blood-red hawthorn, common peach, dog rose, common plum, walnut, cherry plum and black alder.

The greatest amount of organic acids was recorded in the wood of the mountain ash, black currant and walnut, the least in the wood of the bird cherry, the common pear and the common plum. The wood of apricot and cherry plum was distinguished by a high content of these substances.

The highest level of the sum of tannins and dyes was noted by us in the wood of thorny blackthorn, and the lowest in the common cherry. A rather high content of these biologically active substances was characteristic of the wood of mountain ash, dog rose, domestic apple and drooping birch.

The content of tannin was the lowest in the wood of black currant and common pear, a characteristic of the wood of mountain ash, dog rose, domestic apple and drooping birch.

After 8 months of storage, the moisture content of the wood decreased 1.4-3.83 times and was established at the level of 25 ° C, the moisture content of the wood decreased 1.4-3.83 times and was established at the level of hygroscopicity. At the same time, the content of organic acids increased by the same factor: from 1.4 (black alder) to 3.83 (pedunculate oak). Thus, in the wood after 8 months of storage in the open air, the content of organic acids ranges from 0.47% in the common plum to 3.78% in the mountain ash. The least hygroscopic was the wood of the walnut and pedunculate oak, the most hygroscopic was the wood of the heart-shaped linden (table 3).

Table 3. Moisture content of organic acids in the wood of studied tree species, %.

| Species        | Organic acids in fresh wood | Organic acids After 8 months of storage | Wood hygroscopicity in fresh wood | Wood moisture After 8 months of storage |
|----------------|-----------------------------|----------------------------------------|----------------------------------|----------------------------------------|
| Apple tree     | 0.42                        | 1.47                                   | 16.32                            | 57.12                                  |
| Sour cherry    | 0.71                        | 1.49                                   | 23.7                             | 49.77                                  |
| Magaleb cherry   | 0.51 | 0.8 | 31.84 | 50.0 |
|-----------------|------|-----|-------|------|
| Nanking cherry  | 0.65 | 1.18 | 27.42 | 49.9 |
| Apricot tree    | 0.86 | 2.98 | 16.44 | 57.0 |
| Blackthorn      | 0.56 | 1.68 | 16.67 | 50.0 |
| Blood-red hawthorn | 0.4  | 0.67 | 23.8  | 40.0 |
| Winter linden   | 0.26 | 0.52 | 35.63 | 71.2 |
| Bird cherry     | 0.21 | 0.65 | 16.13 | 50.0 |
| Silver birch    | 0.28 | 0.51 | 21.67 | 40.0 |
| Pedunculate oak | 0.47 | 1.8  | 12.76 | 48.87 |
| Common pear     | 0.22 | 0.74 | 22.8  | 68.4 |
| White willow    | 0.41 | 0.64 | 26.0  | 40.56 |
| Black currant   | 1.07 | 3.0  | 25.0  | 69.8 |
| Peach           | 0.63 | 2.14 | 16.76 | 57.0 |
| Dog rose        | 0.81 | 2.02 | 20.6  | 51.5 |
| Plum tree       | 0.23 | 0.47 | 28.0  | 57.12 |
| Garden gooseberry | 0.54 | 1.1  | 19.6  | 40.0 |
| Walnut          | 1.03 | 3.6  | 11.47 | 40.1 |
| Rowan tree      | 1.08 | 3.78 | 16.22 | 56.77 |
| Cherry plum     | 0.94 | 2.82 | 19.0  | 57.0 |
| Common alder    | 0.58 | 0.81 | 29.1  | 41.0 |

4. Conclusion
The number of polyphenols in the wood of the studied species ranges from 23.6 to 1433.1 mg (0.02-1.43%). The maximum number is noted in the wood of thorny blackthorn. As the wood of fruit species ages (over 3 years old), the content of polyphenols decreases.

The content of organic acids in wood of tree species varied within 0.21-1.08%. The rowan tree was the leader in terms of their content.

The amount of tannin and color materials in the wood species ranged from 1.45 to 26.5% and was maximum in the tissues of thorny blackthorn.

The level of tannin in the tissues of the tree species was 0.83-20.8%. The highest tannin content was in the wood of the rowan tree.

With natural drying of wood of 20 species for 8 months in a ventilated room at an air temperature of 25 °C, the moisture content of the wood decreases by 1.4-3.83 times and is set at the level of hygroscopicity (11.47-35.6%).

In the process of slow drying of wood species, organic acids are not destroyed in them, but are concentrated.

The least hygroscopic wood is walnut and pedunculate oak, the most hygroscopic is the wood of the winter linden tree.

References
[1] Aksenov P A and Korovin V V 2009 Chemical composition of oak wood used for the production of cognac and brandy Lesnoy Vestnik 1 5-16
[2] Vigorov L I and Tribunskaya A Ya 1968 Methods for the determination of flavonols and flavones in fruits and berries Proceedings of the III All-Union seminar on biologically active (medicinal) substances of fruits and berries (Sverdlovsk) 492-506
[3] 2009 GOST 19885-74 Tea. Methods for determination of tannin and caffeine content. Put into effect by the Resolution of the State Committee of Standards of the Council of Ministers of the USSR dated June 25, 1974 Vol 1539 (M.: Standartinform)
[4] 1981 GOST 24027.2-80 Medicinal plant raw materials. Methods for determination of moisture content, ash content, extractive and tannins, essential oil. Introduced on 01.01.1981 by the Resolution of the USSR State Committee for Standards dated 03/06/1980 Vol 1038 (M.:...
Standartinform)
[5] 1982 GOST 25555.0-82. By-products of fruits and vegetables. Methods for determination of titratable acidity. Approved and put into effect by the Decree of the USSR State Committee for Standards dated December 27, 1982 Vol 5130, 5132, 5133 (M.: Standartinform)
[6] Augusto L, Bakker M R and Meredith C 2007 Wood ash applications to temperate forest ecosystems - potential benefits and drawbacks Plant and soil 306(1-2) 181-98
[7] Baar J, Paschova Z, Hofmann T, Kolar T, Koch G, Saake B and Rademacher P 2020 Natural durability of subfossil oak: wood chemical composition changes through the ages Holzforschung 74(1) 47-59
[8] Bopenga C S A, Dumarcay S, Edou Engonga P and Gerardin P 2020 Relationships between chemical composition and decay durability of Coulaedulis Baill as an alternative wood species in Gabon Wood science and technology doi: 10.1007/s00226-020-01158-5
[9] Brennan M, Fritsch C, Cosgun S, Dumarcay S, Colin F and Gerardin P 2020 Quantitative and qualitative composition of bark polyphenols changes longitudinally with bark maturity in Abiesalba Mill Annals of forest science 77(1) doi: 10.1007/s13595-019-0916-x
[10] Celeiro M, Lamas J P, Arcas R and Lores M 2019 Antioxidants Profiling of By-Products from Eucalyptus Greenboards Manufacture Antioxidants 8(8) doi: 10.3390/antiox8080263
[11] Cetinkol O P, Smith-Moritz A M, Cheng G, Lao J, George A, Hong K, Henry R, Simmons B A, Heazlewood J L and Holmes B M 2012 Structural and Chemical Characterization of Hardwood from Tree Species with Applications as Bioenergy Feedstocks Plos one 7(12) doi: 10.1371/journal.pone.0052820
[12] Coelho E, Teixeira J A, Domingues L, Tavares T and Oliveira J M 2019 Factors affecting extraction of adsorbed wine volatile compounds and wood extractives from used oak wood Food chemistry 295 156-64
[13] Deka D, Sedai P and Chutia R S 2014 Investigating Woods and Barks of Some Indigenous Tree Species in North-East India for Fuel Value Analysis Energy sources part a-recovery utilization and environmental effects 36(17) 1913-20
[14] Drozdz P and Pyrzynska K 2019 Extracts from pine and oak barks: phenolics, minerals and antioxidant potential International journal of environmental analytical chemistry doi: 10.1080/03067319.2019.1668381
[15] Hamad A M A, Ates S, Olgun C and Gur M 2019 Chemical Composition and Antioxidant Properties of Some Industrial Tree Bark Extracts Bioresources 14(3) 5657-71
[16] Jones J, Mitchell E, Williams A, Kumi-Barimah E, Jose G, Bartle K, Hondow N and Lea-Langto A 2020 Examination of Combustion-Generated Smoke Particles from Biomass at Source: Relation to Atmospheric Light Absorption Combustion science and technology 192(1) 130-43
[17] Maga G 1989 The contribution of wood to the flavor of alcoholic beverages Food Rev. Int. 5(1) 39-66
[18] Nikolantonaki M, Daou S, Noret L, Coelho C, Badet-Murat M L, Schmitt-Kopplin P and Gougeon R D 2019 Impact of Oak Wood Barrel Tannin Potential and Toasting on White Wine Antioxidant Stability Journal of agricultural and food chemistry 67(30) 8402-10
[19] Puech J-L 1987 Apport du bois de chene au cours du vieillissement des eaux-de-vie Le bois et la qualite des vins des eaux-de-vie 151-62
[20] Pustynnaya M A, Gusakova M A and Bogolitsyn K G 2015 The Regional and Age-Related Changes of Hardwood Lignin-Carbohydrate Matrix Chemical Composition in Terms of Aspen (Populus tremula) Forestry journal 1