VOL II

Estudos em Ciências Agrárias e Ambientais

Eduardo Spers
(Organizador)

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APRESENTAÇÃO

O campo das Ciências Agrárias e Ambientais desempenha um papel fundamental na compreensão e solução dos desafios contemporâneos relacionados à produção de alimentos, à conservação ambiental e ao bem-estar animal. Em um mundo em constante transformação, questões como a sustentabilidade dos agroecossistemas, o manejo eficiente dos recursos naturais e a saúde pública se tornam cada vez mais relevantes. É com este espírito que apresentamos o volume II da coletânea "Estudos em Ciências Agrárias e Ambientais", que reúne pesquisas de autores de diversas partes do mundo, cada um contribuindo com sua perspectiva e expertise únicos.

Os quinze artigos que compõem este volume abordam uma variedade de tópicos, refletindo a riqueza e a diversidade das Ciências Agrárias. Desde práticas conservacionistas que buscam melhorar e manter agroecossistemas, até investigações sobre o uso de fitohormonas e fertilização na produção vegetal, o uso de tecnologias de processamento de madeira e a promoção do bagre armado - cada estudo traz à tona questões cruciais que impactam tanto a produção agrícola quanto a saúde ambiental.

Neste volume, também exploramos a crescente relevância dos produtos agrícolas locais, especialmente em tempos desafiadores como os que vivemos, marcados pela pandemia da COVID-19. A importância de circuitos curtos de proximidade se torna evidente, promovendo não apenas a segurança alimentar, mas também a resiliência das comunidades.

Além disso, as contribuições da veterinária destacam a importância do cuidado animal e da saúde pública, ilustrando a interconexão entre os seres humanos, os animais e o meio ambiente.

Esperamos que esta coletânea não apenas informe, mas também inspire debates e colaborações futuras entre pesquisadores, profissionais e estudantes da área. Juntos, podemos avançar em direção a um futuro mais sustentável e equilibrado, em que conhecimento pesquisa sejam os pilares para soluções efetivas.

Agradecemos a todos os autores e colaboradores que tornaram este trabalho possível. É nossa esperança que os estudos aqui apresentados contribuam para um entendimento mais profundo das questões agrárias e ambientais, e que possam servir de base para novas investigações e práticas inovadoras.

Eduardo Eugênio Spers

SUMÁRIO

SUSTENTABILIDADE E PRÁTICAS CONSERVACIONISTAS

CAPÍTULO 3

STRUCTURAL AND CHEMICAL CHARACTERISTICS OF WOOD GREENERY ORIGINATING FROM BOSNIA AND HERZEGOVINA

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ABSTRACT: The subject of research is wood greenery of beech (*Fagus sylvatica*), sessile oak (*Quercus petraea*), black pine (*Pinus nigra*) and Norway spruce (*Picea abies*) which remains at cutting areas after regular felling in forests of Bosnia and Herzegovina. For each species were analyzed structural relations of main components: wooden twigs, bark that covers twigs and green leaves/needles. In addition were analyzed: crude nutrients, macro and micro elements, physiologically active matters and amino acids. The length of a basic twig is one of the features that characterizes wood greenery as raw material. The greatest absolute and average length has wood greenery of beech, followed by oak, spruce and then black pine. In a broader sense, wood greenery of deciduous trees is longer than that of conifers. Most leaves/needles in relation to the weight of the basic twig has spruce, then black pine, oak and beech. In deciduous trees, oscillations in chemical composition were observed in spring and summer. As a rule, the content of chemical elements and compounds takes higher values in spring compared to those in summer, observing that with vitamins, these differences are not large, while with carotene they are emphasized. In conifers, this regularity is less pronounced, when winter and spring are taken as reference seasons. Most parameters have higher values during spring, however, not a negligible number of those whose values are higher during the winter, such as carotene. The highest concentration of amino acids was recorded in oak, followed by beech. Significantly less amino acids were detected in wood greenery of spruce, and least in black pine. Individually, the most

abundant amino acid was glutamic acid in the wood greenery of the oak, followed by valine in the wood greenery of the beech. The least represented amino acid in all samples was methionine. From the aspect of production continuity, coniferous wood greenery is of somewhat greater importance because it is available throughout the year, and deciduous wood greenery only during the vegetation season. In practice, these differences can be mitigated by choosing the right schedule of felling operations.
KEYWORDS: Wood greenery. Structural characteristics. Chemical composition. Conifers. Deciduous trees.

1 INTRODUCTION

Every year in our forests the cut down is around 4.45 mil. m^3, from which 3.70 mil. m^3 is of different forest assortiments, which means the difference between gross and net mass is about 750,000 m^3. Each year this biomass remains unexploited in our felling areas (Ljubojević, 2016). The thinnest portion of unused biomass makes so-called wood greenery (WG). It is also referred as „muka“, tree foliage, tree verdue, technical foliage and techinical greenery (Keays, 1971; Tait *et al*., 1982; Young, 1976). Three basic components of WG are: woody twigs, bark that covers them, and leaves or needles grown on them. The architecture of WG consists of one, more or less accentuated, main twig with lateral twigs. A twig consists of an axis with leaves attached in certain arrangement, including buds (terminal and axillary), lenticels, stipules and stipule scars. It is considered that the most physiologically active substances are found in green mass (leaves/needles), much less in bark and the least in twig wood. If twigs are younger, they still haven't gotten woody, so they contain a larger amount of physiologically active matters. With thicker branches, participation of undesirable ligno-cellulose component increases at the expence of physiologically active complex (Tomčuk *et* Tomčuk, 1966, 1973, Terzić, 1970; Terzić *et al*., 1979).

The age of WG, primarily of its green components, has direct repercussions on the quality and quantity of raw materials and future products. Old leaves have to fight with younger leaves for water. They have a lower intensity of photosynthesis and lower nitrogen content per unit mass compared to younger or shorter leaves. However, plants with long-lived leaves are usually associated with nutrient-poor soils (Midgley *et* Enright, 2000). Unlike deciduous trees, where some species retain their leaves for only a few months to one year, conifers are known for their longevity. Pines retain needles for over three years and spruce for about five and a half years (Gower *et al*., 1993; Midgley *et* Enright, 2000; Pensa *et* Sellin, 2002). These moments should also be taken into account when organizing regular production.

Early studies of chemical composition of conifers have shown that 1 kg of dry spruce needles contains up to 4,000 international units of vitamin C, up to 600 mg of beta-carotene (provitamin A), between 920 - 2600 mg of flavonoids and up to 560 mg of vitamin E, in the form of alpha-tocopherol (Valdman, 1955). Subsequent research has shown that conifers also contain chlorophyll, free amino acids, fatty acids, sterols, including beta-sitosterol, sugars, macro- and micronutrients, as well as substances essential for animal nutrition (Kalninsh *et al*., 1978). The same source states that WG of conifers also contains some undesirable ingredients, such as: tannins and resin acids, and a large amounts of lignin, which limit its use mainly to poultry and piglets. Research in USA has given affirmative judgments about the possibilities of feeding rabbits and small livestock with WG of poplar (*Populus* spp.) and black locust (*Robinia pseudoacacia*), provided that polyethylene glycol, or otherwise, cancels the negative effects of tannins (Ayers, 1992).

WG is a raw material for a larger number of products: vitamin-mineral flour (VMF), chlorophyll-carotene paste (CCP), vitamin concentrate, ß-carotene, essential oils and their fractions, coniferous wax and balsamic paste, other products (cineole, sodium chlorophyllin, iodine phytalisin, camphor), (Ebele *et* Kalninsh, 1954; Ievins *et al*., 1986; Solodky, 1947; Solodky *et* Agranat, 1971; Tomčuk *et* Tomčuk, 1966, 1973; Fisher, 1971). It is interesting to note that the first preparations from WG were consumed by humans and only then by animals. Namely, in the late 1930s, in the Kolyma prison within northern camps of Gulag system (USSR), *coniferous soup* was used as a prophylactic agent and remedy (Gorbatov, 1989). Somewhat later, in the same country, *coniferous water* was developed as a remedy for scurvy during the siege of Leningrad (today St. Petersburg) in World War II. Throughout 872 days of the siege, inhabitants of Leningrad called the *coniferous water* the *elixir of life*. And the third, by the volume of production, the most massive product from WG was created in the former Soviet Union. It is a vitamin-mineral flour (VMF), a preparation for feeding domestic animals. VMF is formed by short-term drying of WG at a high temperature without the presence of oxygen, and then by grinding it to the consistency of flour. The production and application of VMF began in the 1950s. With the production of VMF, agriculture was given a completely new product, also forestry found placement for large quantities of hitherto unused raw materials. In cirlces of scientific and professional public of that time, the value of VMF was considered to be equivalent to a grass meal (Kalninsh *et al.* 1978).

First industrial plant for production of VMF was built in 1956 in Latvia as part of Forestry Company „Volcano" in area of Kuldiga. The applied technology was developed at the Latvian Academy of Sciences and the Latvian Academy of Agriculture under the leadership of Kalninsh and Abolinsh (Tomčuk *et* Tomčuk, 1966). The capacity of the plant was 45t of product per year. By the end of 1980s, the production of VMF in USSR reached 190,000 tons per year (Daugavietis *et al*., 2015). Parallel to the development of VMF, CCP production technology was developed at the Leningrad Forestry Academy under the leadership of Solodky. Unlike VMF, the use of CCP is not unambiguously determined. Tomčuk and Tomčuk (1966, 1973) quoted Solodky who writes that positive results were obtained in the treatment of the following human diseases: diseases due to A-hypovitaminosis, thermal and chemical burns, ulcers of various etiologies, eczema, *Trichomonas colpitis*, pseudo-erosion, folliculitis, boils, hydradenitis, trichophytosis, lichen planus, chronic atrophic rhinitis. Moreover, in animal diseases such as: cow endometritis, gastrointestinal diseases of calves and lambs, surface wounds and some skin diseases. However, Daugavietis *et al*. (2015) state that CCP was widely used as a feed ingredient in the amount of 0.3-0.4% from the animal feed base. CCP efficacy has been substantiated by extensive laboratory trials and in production conditions, referring to: Ebele *et* Kalninsh (1954), Solodky *et* Hinich (1969), Fisher (1971).

Considering the number of plants built and volume of production in them (until 1970, there were over 250 plants for processing WG in USSR alone), it is quite logical that the structure and chemical composition of raw materials be regulated by local standards. However, the first standard (GOST 21769-76) was adopted only in 1976 (Anon., 1978). Among other things, it prescribed a thickness of basic branch of 8 mm, measured with the bark. Second standard (GOST 21769-84) was passed in 1984 (Anon., 1984). This standard refers to WG as a raw material for the production of VMF, as well as for freshly prepared food additives for domestic animals and poultry. The standard stipulates, among other things, that VMF must not be made from WG of: *Corylus* sp., *Cytisus* sp., *Daphne mezereum*, *Fagus* sp., *Juglans* sp., *Quercus* sp., *Rhamnus* sp., *Rhus* sp., *Sambucus nigra*. Depending on the content of leaves/needles, bark, wood, inorganic and organic impurities, WG was classified into three classes. Class I included raw materials in which the proportion of leaves/needles, buds and non-woody shoots is not less than 80% and the mass fraction of bark and twigs is not more than 15%. Class II included raw materials in which the share of the first component is not less than 70% and the second component is not more than 25%, while in class III these components took values above 60% and below 35%. For all three classes it was prescribed that the mass fraction of other organic impurities may not exceed 5%; nor that the mass fraction of inorganic impurities may exceed 0.2%.

The aim of this paper is to determine the morphological, structural and chemical characteristics of wood greenery originating from four widely distributed tree species in Bosnia and Herzegovina (B&H). The obtained results can usefully serve as one of the strongholds in the eventual decision-making on the production and processing of this, for the domestics conditions, new forest wood assortment.

2 MATERIAL AND METHODS

This research includes four species of trees, which inhabit significant areas of forests and forest lands in B&H. These are European beech (*Fagus sylvatica* L.), sessile oak (*Quercus petraea* (Matt.) Lieblein [Syn.: *Q. sessiliflora* Salisb.]), black pine (*Pinus nigra* Arnold) and Norway spruce (*Picea abies* (L.) Karsten [Syn. *P. excelsa* (Lam.) Link]).

In the introductory part, we quoted the Russian standard GOST 21769-84, which even prohibits the use of beech and oak WG for the production of VMF. The long-standing domestic livestock tradition, as well as numerous scientific and professional papers, affirm the use of WG of beech and oak, either as browse or as tree hay (tree fodder) in the years of crop failure (Bahtijarević, 1982; Ivanković *et al*., 2005; Mackie, 1903; Nikolić, 1967; Rajkumar *et al*., 2015; Topić *et* Šupe, 1996; Wessely, 1879). Therefore, we included these two species in our research.

Samples for the analysis were taken from three localities, situated in the northwestern part of the country. Beech and oak WG were taken from the high beech and oak forests on deep acid brown and ilimerised solils in Forest District "Gozna", Forest Economic Area "Donjevrbasko". Spruce WG was taken from high spruce forest on deep acid brown and ilimerised solils in Forest District "Cvrcka", Forest Economic Area "Čemerničko". Black pine WG was taken from Forest enterprise "Industrial plantations" A.D., Banja Luka, Management unit "Kunova".

The materials for the structural analysis of beech and oak WG were taken in the second week of May and in the second week of August 2018, while the material for the structural analysis of black pine and spruce WG, were taken in the second week of February and the second week of May 2018. Samples were taken from freshly felled trees by using portable electric pruning saws to separate branches 2-2.5 cm in diameter (thick to coarse branches). Afterwards, using a hand pruner and a caliper gauge, 10 mm thick twigs measured over bark, were separated; in older North American sources, a maximum WG twig thickness of 6 mm (0.24 inches), is recommended (Keays, 1971; Tait *et al*., 1982). From each tree, 15 pieces of WG were taken, five pieces from the upper third of the canopy, five pieces from the middle of the canopy and five from the lower part of the canopy. In this way, an aggregate sample was formed with 45 pieces of WG of each species.

The structure of the basic twig of WG was analyzed using the sectional method, so that each twig was divided into five sections: the first section (I): twig thickness of 0.1-2.0 mm, II: 2.1-4.0 mm, III: 4.1-6.0 mm, IV: 6.1-8.0 mm, V: 8.1-10.0 mm. In each section, three basic components were carefully separated: the green part (leaves/needles), bark and wood, and weighed on a digital scale with a reading accuracy of 0.1 g.

The examination of chemical composition of WG was carried out in two phases. Crude nutrients, macro and micro elements and physiologically active matters were analyzed on the basis of material collected in 2018. The analysis of amino acids in WG of the investigated species was performed on the basis of material collected in spring of 2021, from the same locations as in 2018. In all samples, chemical analysis began no later than third day after collection, *i.e.* harvesting.

Individual chemical components were determined by classical methods of analysis. Total protein was determined by Kjeldahl. Fat determination was performed by the Soxhlet method. Crude fiber were determined according to Wende`s method. The ash was determined by burning the material at a temperature of 550 °C. Nitrogen-free extract (NFE) was determined as a supplement of up to 100% in relation to the total amounts of crude protein, fat, crude fiber and ash. The concentration of total chlorophyll and total carotenoids was determined by spectrophotometric measurements on a UV/VIS spectrophotometer and calculations according to the Lichtenthaler (1987) formulas. Vitamins C (ascorbic acid) and E were determined by reversed-phase HPLC on a C_{18} column. Vitamin B_2 (riboflavin) was determined fluorimetrically and vitamin K using a fluorescence detector. The content of macro and microelements was determined by inductively coupled plasma atomic emission spectroscopy (ICP-AES) technique. Analysis of amino acids contents were performed by L-8800 High-speed Amino Acid Aanalyzer (Hitachi), using appropriate syringe filters and standard amino acid solutions. The content of essential oil in the WG of black pine and spruce was determined using the Clevenger-type distillation apparatus, with flat-bottomed flask of 5,000 cm^3. The weight of one batch was 300 g of raw material filled up with 3,000 cm^3 of water. The distillation lasted 4 hours. The amount of essential oil was read in cm^3. In order to be able to determine the percentage oil content, the cubic oil content was multiplied by the specific weight of the oil, as follows: for black pine - 0.863 and for spruce 0.883 (Kapetanović *et al*., 1988).

3 RESULTS AND DISCUSSION

The length of basic twig is one of many features that characterizes WG as a raw material. Results proved that greatest absolute and average length had WG of beech, followed by oak, spruce and then black pine (Tab. 1). In a broader sense, the WG of deciduous trees is longer than the WG of conifers (Fig. 1).

Table 1: The length of the basic twig of woody greenery.

Tree species	Average length of twig (cm)	Range (cm)	
		min	max
Beech	84.5	61	114
Oak	82.2	58	101
Black pine	39.9	21	50
Spruce	70.6	53	89

Two branch architectures predominate in beech: wider and narrower. In oak, the differentiation is more pronounced in the longitudinal than in the transverse view, so that we distinguish between longer and shorter branching. Black pine is also dominated by two types of arrangements: shorter and denser twigs and longer twigs with sparse needles. The main feature of spruce are laid and well-arranged twigs, which results in a large and dense coverage.

Figure 1: The appearance of wood greenery of beech (below) and black pine (above); (photo S. Ljubojević).

Mass structure of wood greenery by thickness of sections is shown in Table 2. Most leaves/needles in relation to the weight of basic twig has spruce - 76%, then black pine - 74%, oak - 50% and beech - 49%. Similar descending sequence was established by Terzić (1970) for the area of Maoča, in Krivaja river basin, in central B&H: spruce -78%, black pine - 74%, oak - 59% and beech - 55%. On average, spruce has the heaviest WG twig - 285.1 g, and the lightest beech - 125.9 g. On average, the heaviest WG (twig with Ø 10 mm at the thickest end) is discarded by spruce - 285.1 g, followed by WG of oak - 193.9 g, then WG of black pine - 170.8 g and finally of beech - 125.9 g.

An indicative parameter of structure of WG is a relative representation of WG components by thickness of sections (Tab. 3). In all observed species except spruce, with increasing of twig thickness, relative share of *green component* (leaf /needle) decreases. Also, in all observed species, the smallest reduction in the share of *green component* is between the fourth and fifth sections. This means that reducing the thickness of the basic twig from 10 mm to 8 mm does not contribute to a significant increase in the quality of WG. On the other hand, the inclusion of 8 -10 mm section in WG increases the degree of biomass utilization and reduces production costs. The most favourable structure of WG is found in spruce. With increasing thickness of the basic twig of spruce, there is no decrease in the relative share of the *green component*, but it even slightly increases at the expense of the other two components (bark and wood).

Table 2: Mass structure of wood greenery by thickness of sections and its components.

Thicknees of sections (mm)	Components of WG				Components of WG			
	Leaf/ needle	Bark	Wood	Σ	Leaf/ needle	Bark	Wood	Σ
	Beech (g)				Oak (g)			
0.1 - 2.0	16	0.2	0.3	2.1	2.8	0.5	0.3	3.6
2.1 - 4.0	6.3	1.5	2.0	9.8	9.0	3.0	2.2	14.2
4.1 - 6.0	12.6	4.4	7.0	24.0	18.0	6.3	6.2	30.5
6.1 - 8.0	18.0	6.9	13.9	38.8	28.4	17.2	17.2	62.8
8.1 - 10.0	23.4	9.7	18.1	51.2	39.8	20.6	22.4	82.8
Σ	61.9	22.7	41.3	125.9	98.0	47.6	48.3	193.9
%	49	18	33	100	50	25	25	100
	Black pine (g)				Spruce (g)			
0.1 - 2.0	-	-	-	-	-	-	-	-
2.1 - 4.0	12.4	2.1	0.7	15.2	18.1	3.8	2.6	24.5
4.1 - 6.0	27.7	5.1	3.0	35.8	52.0	11.0	7.8	70.8
6.1 - 8.0	37.5	8.2	6.8	52.5	64.0	9.3	8.0	81.3
8.1 - 100	49.2	9.0	9.1	67.3	83.2	13.3	12.0	108.5
Σ	126.8	24.4	19.6	170.8	217.3	37.4	30.4	285.1
%	74	14	12	100	76	13	11	100

Table 3: Relative representation of wood greenery components by thickness of sections.

Thickness of sections (mm)	Components of WG				Components of WG			
	Leaf/ needle	Bark	Wood	Σ	Leaf/ needle	Bark	Wood	Σ
	Beech (%)				Oak (%)			
0.1 – 2.0	76.0	9.0	15.0	100	77.8	13.9	8.3	100
0.1 – 4.0	66.4	14.3	19.3		66.3	19.7	14.0	
0.1 – 6.0	57.1	17.0	25.9		61.7	20.3	18.0	
0.1 – 8.0	51.5	17.4	31.1		52.4	24.3	23.3	
0.1 – 10.0	49.2	18.0	32.8		50.5	24.6	24.9	
	Black pine (%)				Spruce (%)			
0.1 – 2.0	-	-	-	100	-	-	-	100
0.1 – 4.0	81.6	13.8	4.6		73.9	15.5	10.6	
0.1 – 6.0	78.6	14.1	7.3		73.6	15.5	10.9	
0.1 – 8.0	75.0	14.9	10.1		75.2	13.8	11.0	
0.1 – 10.0	74.0	14.0	12.0		76.0	13.0	11.0	

The chemical composition of WG of beech, oak, black pine and spruce, originating from B&H, is shown in tables 4-7. Most proteins contain WG of oak during summer –56.4 g/kg $_{F.W.}$ and the least WG of black pine during spring - 37 g/kg $_{F.W.}$ Conifers contain more than twice as much fat as deciduous trees. The least amount of moisture has WG of spruce during the winter, and the highest WG of black pine during the spring - 54.5%. It is interesting to note that a similar moisture content was registered in the WG of eastern white pine (*Pinus strobus*) in British Columbia – 53.2 % (Keays, 1971).

Table 4: Crude nutrients in beech, oak, black pine and spruce wood greenery originating from B&H (values are based on fresh weight – F.W.).

Components	Beech		Oak		Black pine		Spruce	
	Spring	Summer	Spring	Summer	Spring	Winter	Spring	Winter
Protein (g/kg $_{F.W.}$)	44	49.7	49.2	56.4	31	37	38	34.6
Fat (g/kg $_{F.W.}$)	16	14	16.5	15.9	54	56	49	54
Crude fiber (g/kg $_{F.W.}$)	155	188	159	177	193.3	220.6	214	230.1
NFE (g/kg $_{F.W.}$)	289.7	269.4	235.5	186.9	166.4	186	201.1	210
Ash (g/kg $_{F.W.}$)	19.9	20.4	23.6	29.8	10.3	12.4	15.9	18.8
Dry matter (g/kg $_{F.W.}$)	524.6	541.5	483.8	466	455	512	518	547.5
Moisture (%)	47.5	45.8	51.6	53.4	54.5	48.8	48.2	45.2

In terms of physiologically active matters, WG of oak and beech contain significantly more carotene and chlorophyll than that of conifers. The highest concentration of vitamin C is found in WG of black pine during spring – 10.9 g/kg $_{F.W.}$ and the lowest in WG of spruce during winter - 2.0 g/kg $_{F.W.}$ In both conifers, concentration of vitamins are lower in winter than in spring. These seasonal differences are particularly pronounced in the case of vitamin E (Tab. 5).

Table 5: Physiologically active matters in beech, oak, black pine and spruce wood greenery originating from B&H (values are based on fresh weight – F.W.).

Physiologically active matters	Beech		Oak		Black pine		Spruce	
	Spring	Summer	Spring	Summer	Spring	Winter	Spring	Winter
Carotene (mg/kg $_{F.W.}$)	101.2	52.5	112.3	96	42.9	63.3	54.6	86.1
Vitamin B_2 (mg/kg $_{F.W.}$)	13	11.2	13.5	11.1	8.8	5.1	9.9	6.5
Vitamin C (g/kg $_{F.W.}$)	4.9	3.7	4.5	3.1	10.9	5.1	4.2	2.0
Vitamin E (mg/kg $_{F.W.}$)	128.1	127.5	155.5	162.9	161.4	14.1	111	44.4
Vitamin K (mg/kg $_{F.W.}$)	21.3	19.9	27.2	24.8	20.3	8.4	28.3	10.8
Chlorophyll (g/kg $_{F.W.}$)	17.3	13.4	18.3	16.4	12.7	9.1	12.5	9.9

When it comes to the mineral composition of WG, the observed species contain more phosphorus in summer than in other seasons. The same is the case with calcium content in deciduous trees, while the situation is reversed in conifers. Deciduous species are significantly richer in Fe, Mn, Zn and Cu compared to conifers. Wood greenery of oak has by far the most cobalt, while the concentration of molybdenum is more or less balanced (Tab. 6).

Table 6: Macro and micro elements in beech, oak, black pine and spruce wood greenery originating from B&H (values are based on fresh weight – F.W.).

Elements	Beech		Oak		Black pine		Spruce	
	Spring	Summer	Spring	Summer	Spring	Winter	Spring	Winter
Ca (g/kg $_{F.W.}$)	6.9	9.1	7.7	9.4	12.8	5.5	5.3	4.6
P (g/kg $_{F.W.}$)	1.2	1.9	0.9	1.6	1.4	1.8	0.9	1.3
Fe (mg/kg $_{F.W.}$)	951.4	606.6	798.5	488.5	566.6	53.4	159.5	78.1
Mn (mg/kg $_{F.W.}$)	1818.5	1286.4	995.5	753.2	52.8	33.3	252.9	233.5
Zn (mg/kg $_{F.W.}$)	181.6	142.2	231	134	31.4	62.5	90.9	44.5
Co (mg/kg $_{F.W.}$)	17.1	9.6	39.0	23.2	18.4	17.1	9	10.1
Cu (mg/kg $_{F.W.}$)	10.1	6.9	10.1	5.1	5.8	1.3	4.1	1.2
Mo (mg/kg $_{F.W.}$)	0.5	0.3	0.7	0.5	0.3	0.2	0.3	0.2

The highest concentration of amino acids was recorded in WG of oak, a total of 47.32 g/kg $_{F.W.}$, followed by WG of beech – 41.64 g/kg $_{F.W.}$. Significantly less amino acids were detected in WG of spruce - 33.72 g/kg $_{F.W.}$ and the least in WG of black pine - 31 g/kg $_{F.W.}$ (Tab. 7). Similar relationships are described by Terzić *et al*. (1979) on material from site of

Maoča, in Krivaja river valley in central B&H, with the note that they analyzed samples from two other seasons, summer and autumn. In our case, individually, the most represented amino acid is glutamic acid (in WG of oak), followed by valine (in WG of beech). The least represented amino acid in all samples is methionine (Tab. 7).

Table 7: Aminoacids in beech, oak, black pine and spruce wood greenery, during spring season, originating from B&H (values are based on fresh weight – F.W.).

Aminoacids	Beech	Oak	Black pine	Spruce
	g/kg $_{F.W^*.}$			
Alanine	2.47	2.92	1.62	2.13
Arginine	2.32	4.57	1.58	1.93
Aspartic acid	4.41	5.60	2.86	3.29
Glutamic acid	5.00	5.89	3.03	3.95
Glycine	2.28	1.95	1.58	1.90
Histidine	1.10	1.40	0.62	1.13
Isoleucine	2.22	2.65	1.64	2.69
Leucine	3.67	4.35	2.78	3.38
Lysine	2.12	2.51	1.36	2.82
Methionine	0.06	0.19	0.04	0.06
Phenylalanine	2.54	3.01	1.88	2.11
Proline	1.77	2.10	1.23	1.70
Serine	2.18	2.58	1.43	1.77
Threonine	2.13	2.27	1.54	1.63
Tyrosine	1.54	1.64	1.00	1.13
Valine	5.83	3.69	1.99	2.11
$\sum$	41.64	47.32	26.12	33.73

Woody greenery of black pine is richer in essential oil than WG of spruce. Average yield of pine oil during winter was 0.45% and during spring 0.39%. At the same time, average yields of spruce oil were 0.17% and 0.11%, respectively.

4 CONCLUSIONS

On average, the heaviest WG is discarded by spruce, followed by oak, then black pine and finally beech. At the same time, the greatest absolute and average length has WG of beech, followed by oak, spruce and then black pine. Most leaves/needles in relation to the weight of the basic twig has spruce, then black pine, oak and beech.

In all observed species except spruce, with increasing of twig thickness, the relative share of the *green component* (leaf /needle) decreases. In spruce, with increasing thickness of the basic twig, the relative share of the *green component* slightly increases at the expense of the other two components (bark and wood). In deciduous trees, this decline is the largest between the first and second sections, while in black pine the largest decline is between the third and fourth sections. In all observed species, the smallest reduction in the share of the *green component* is between the fourth and fifth sections. This means that reducing the thickness of the basic twig from 10 mm to 8 mm, does not contribute to a significant increase in the quality of WG. On the other hand, the inclusion of 8 -10 mm section in WG increases the degree of biomass utilization and reduces production costs.

In deciduous trees the content of chemical elements and compounds takes higher values in spring compared to summer, noting that with vitamins these differences are not large, while with carotene they are emphasized. In conifers, this regularity is less pronounced, when winter and spring are taken as reference seasons. Most proteins contain WG of oak during summer and the least WG of black pine during spring. Conifers contain more than twice as much fat as deciduous trees. The least amount of moisture has WG of spruce during winter, and the highest WG of black pine during spring. WG of oak and beech contain significantly more carotene and chlorophyll than that of conifers. The highest concentration of vitamin C is found in WG of black pine during spring and the lowest in WG of spruce during winter. In both conifers, concentration of vitamins is lower in winter than in spring. These seasonal differences are particularly pronounced in case of vitamin E. Observed species contain more phosphorus in summer than in other parts of the season. The same is the case with calcium content in deciduous trees, while the situation is reversed in conifers. Deciduous species are significantly richer in Fe, Mn, Zn and Cu compared to conifers. Wood greenery of oak has by far the most cobalt, while the concentration of molybdenum is more or less balanced. The highest concentration of amino acids was recorded in WG of oak, followed by beech. Significantly less amino acids were detected in WG of spruce, and the least in WG of black pine. Individually, the most represented amino acid is glutamic acid (in WG of oak), followed by valine (in WG of beech). The least represented amino acid in all samples is methionine. Woody greenery of black pine is richer in essential oil than WG of spruce, either in spring or winter.

From the aspect of production continuity, coniferous wood greenery is of greater importance because it is available throughout the year, and deciduous wood greenery only during the vegetation period. In practice, these differences can be mitigated by choosing the right schedule of felling operations, by cutting down forest stands with deciduous tree species during spring and summer and those with conifers during autumn and winter.

The obtained results can serve as a part of background material in case of new facilities establishment for processing of wood greenery on industrial scale. In this way, an entirely new product (or more of them) is offered for agriculture, while forestry is finding placement of raw material that has not been exploited until now.

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ÍNDICE REMISSIVO

A

B

C

D