VOL II

Estudos em Ciências Agrárias e Ambientais

Eduardo Spers
(Organizador)

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2024

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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

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THE CHOICE OF OPTIMAL TECHNOLOGY FOR EXTRACTING WOOD GREENERY FROM FOREST DENDROMASS

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ABSTRACT: Forests and forest land in Bosnia and Herzegovina encompass an area of 3,231,500 ha out of which 1.28 mill. ha is in the Republika Srpska (RS) entity and the rest in the B&H Federation entity. In the forests of RS each year are cut down around 2.94 mill. m^3 of dendromass. Of these, about 15-20% or 127,500 to 170,000 m^3 makes wood greenery - twigs with needles or leaves, with 10 mm diameter at thick end, measured with bark. Based on the experience of others, first of all from Russia, the Baltic and Scandinavian countries, it is known that wood greenery represents valued raw material in different sectors of economy: agriculture, pharmaceutical and cosmetics industry and others. The entire annual attack of wood greenery remains unused, with us. There are at least two reasons for this: a) because there are still no elaborated and proven practices of rational collection and concentration of raw materials to processing plants; and b) because we are not familiar enough with the methods of wood greenery processing. A detailed analysis of the technology of wood assortment production in our forestry practice has been carried out. Based on these findings, a model of integrated forest utilization was conceived, including wood greenery. Then, the technology of wood greenery processing was analyzed in the following sense: mechanical drying and fractionation processes, chemical extraction processes, thermal processes by classical heating and energy use of the microwave electromagnetic field and their combinations: mechanical-chemical methods and thermo-chemical methods. Finally, such technology of wood greenery processing has been selected to optimally matches with the integrated use of forest resources, in terms of the following

[1] An earlier version of this article was published in the South Florida Journal of Environmental and Animal Science, Miami, v.2, n.2, p. 87-101, apr./jun., 2022. ISSN 2769-3252

criteria: minimal negative environmental impact, maximum safety at work, low energy consumption, primarily from renewable sources, maximum quality of final products.
KEYWORDS: Wood greenery. Processing technology. Forest dendromass.

LA ELECCIÓN DE LA TECNOLOGÍA ÓPTIMA PARA LA EXTRACCIÓN DE MADERA VERDE DE DENDROMASA FORESTAL

RESUMEN: Los bosques y las tierras forestales de Bosnia y Herzegovina abarcan una superficie de 3.231.500 ha, de las cuales 1,28 millones de ha se encuentran en la entidad de la República Srpska (RS) y el resto en la entidad de la Federación de ByH. En los bosques de la RS se talan cada año unos 2,94 millones de m^3 de dendromasa. De ellos, alrededor del 15-20%, es decir, entre 127.500 y 170.000 m^3, son de madera verde, es decir, ramitas con agujas u hojas, con un diámetro de 10 mm en el extremo grueso, medido con corteza. Basándose en la experiencia de otros, en primer lugar, de Rusia, los países bálticos y escandinavos, se sabe que la madera verde representa una materia prima valiosa en diferentes sectores de la economía: agricultura, industria farmacéutica y cosmética y otros. La totalidad del ataque anual de madera verde permanece sin utilizar, con nosotros. Esto se debe al menos a dos razones: a) porque todavía no existen prácticas elaboradas y probadas de recogida racional y concentración de materias primas para las plantas de procesamiento; y b) porque no estamos suficientemente familiarizados con los métodos de procesamiento de la madera verde. Se ha llevado a cabo un análisis detallado de la tecnología de producción de surtido de madera en nuestra práctica forestal. Sobre la base de estos resultados, se concibió un modelo de aprovechamiento forestal integrado que incluye la madera verde. A continuación, se analizó la tecnología de procesamiento de madera verde en el siguiente sentido: procesos de secado y fraccionamiento mecánicos, procesos de extracción química, procesos térmicos por calentamiento clásico y uso de energía del campo electromagnético de microondas y sus combinaciones: métodos mecánico-químicos y métodos termoquímicos. Finalmente, esta tecnología de procesamiento de madera verde ha sido seleccionada para que coincida de manera óptima con el uso integrado de los recursos forestales, en términos de los siguientes criterios: mínimo impacto ambiental negativo, máxima seguridad en el trabajo, bajo consumo de energía, principalmente de fuentes renovables, máxima calidad de los productos finales.
PALABRAS CLAVE: Madera verde. Tecnología de procesamiento. Dendromasa forestal.

1 INTRODUCCIÓN

Wood greenery (WG) consists of branches with needles or leaves with a diameter of up to 10 mm measured over bark from the butt end (Figure 1); it is also referred as technical greenery. WG is made from brushwood of coniferous and hardwood trees, whereby brushwood we mean dendromass less than 7 cm thick, mesured over bark, while branchwood is thicker than 7 cm, mesured over bark.

WG is a raw material for the production of several products with a variety of usable values such as: vitamin-mineral flour, chlorophyll-carotenoic paste, essential oils, fitoinsecticides, plant growth regulators, phytopharmaceuticals, primary forms of medicinal preparations in human medicine etc.

Figure 1: Wood greenery of fir (*Abies alba* Mill.); (photo: S. Ljubojević)

Forests and forest land in Bosnia and Herzegovina encompass an area of 3,231,500 ha out of which 1.28 million ha is in the entity of Republika Srpska (RS) and the rest in the entity of Federation B&H. In the forests of RS about 2.94 mil. m^3 of dendromass are cut down every year. Of these, about 15-20% or 127,500 to 170,000 m^3 makes WG (Ljubojević *et al*., 2007). Apart from forest records, the determination of the amount of logging residues can also be done using dendrometric formulas (Daniš *et* Neruda, 2021). For now, the entire annual attack of WG remains unused. There are at least two reasons for this: a) because there are still no elaborated and proven practices of rational collection and concentration of raw materials to processing plants; and b) because we are not familiar enough with the methods of WG processing.

The aim of the paper is to analyze the technology of production of wood assortments in our forestry practice and based on this knowledge, to propose the concept of integral forest exploitation, which includes WG. Then to analyze the technologies of WG processing and to choose the solution that most completely satisfies the given criteria.

2 MATERIAL AND METHODS

The subject of research is WG of domestic conifers: fir (*Abies alba* Mill.), spruce *(Picea excelsa* Link.), Scots pine (*Pinus silvestris* L.) and black pine (*Pinus nigra* Arnold). In comparison to the raw material of the broadleaf (deciduous) species, the coniferous raw materials are of no seasonality and can be used throughout the year.

Table 1: The basic characteristics of the observed objects.

Basic characteristics	Observed objects			
Location	Industrial plantations „INCEL“	Forest estate „Borja“ Teslić	Forest estate „Gostović“ Zavidovići	Forest economy region Kneževo
Type of ownership	Joint-stock company	State-owned enterprise		Private property
Forest type	Pine plantations	High mixed beech, fir and spruce forest	High forest and plantations of pines	High forest of spruce
Means of work	Working phase - harvesting			
	Harvester FMG Lokomo 990	Chainsaw		
	Working phase - wood bunching and extracting			
	Skidder LKT- 81	Skidder LKT-80	Ackja and Gantner HSW 20 winches joined in a cableway system	Winch TPS TUN 40 mounted on tractor Ursus C360
Harvesting system	Assortment method	Assortment method	Full-tree method	Full-length method
Appearance form of wood greenery (WG)	WG integrated with branchwood - at felling site	WG integrated with branchwood - at felling site	WG integrated with branchwood - at timber yard	WG integrated with branchwood - at felling site

An analysis of the production technology of wood assortments in our forestry practice was carried out by monitoring four felling areas in different harvesting season. According to the time of realization, there are winter felling (from October 1 to March 31) and the summer felling (from April 1 to September 30). The basic characteristics of the observed objects are given in Table 1.

Harvesting and processing technology was observed using method of continuous timing during one full working day per felling area. In this way, a chronological sequence of work elements was established, from the moment when the cutting begin until the moment when the timber assortments are dispatched to the timber yard.

Along with this, not disturbing the regular production process, three organizational solutions were tested.

1. WG was separated from the branchwood and brushwood at felling sites using simple garden tree shearing scissors, then put in 70-liter bags, loaded on pack- horses and carryed to the storage place along the truck road.
2. Brushwood was separated from the branchwood at felling sites using axes and strong bypass lopper and then stacked in small bundles. From here the raw material was handed over to the iron baskets arranged along the skid road. In regular production these baskets are used for the transportation of stacked wood. Baskets were mounted on the front and rear of the skidder and forwarded to the storage place, where the final separation of WG from brushwood was carried out.
3. The third variant involves specific felling operation, which is rarely encountered in our forestry practice. It is a strip clear cut in Scots pine plantation on a steep terrain, where it is not justified to build permanent roads (skidding trucks and forest roads). Trees were cut and hauled as a whole or split by half, using pair of winches (Figures 2-5). WG was separated from the branchwood and brushwood by hand tools at the end of the ropeway.

To better understand the working conditions on preparation of WG, the average moisture content by the tree species and the felling season was determined, in the usual way and based on small samples ($n_i \leq 30$). For the same reasons, the bulk density of WG was evaluated as well. With that regard, a wooden container of 1 x 0.5 x 0.5 m was made. It was filled with material to the top and weighed on the field scale, with a reading of 0.1 kg. The obtained values are converted to the standard unit kg/m^3.

By inspecting the scientific and professional papers, technical documentation and patents, processing technologies of WG have been analyzed and a solution that satisfies the following criteria has been selected: a) a mass-usable product made without further fractionation, b) waste that is generated during production is usable, c) production takes place without use of chemical agents, d) production is flexible with respect to raw material origin - it is possible in mobile and stationary plants, e) selected solution is proven in practice. Also, chosen solution does not adversely affect the environment, provides all the necessary safety at work and requires low energy consumption, primarily from renewable energy sources.

Figures 2-5: Whole trees haulage using pair of winches - Ackja winch for skidding from stupms to theropeway and Gantner HSW 20 winch for extraction down the mainline (photo: S. Ljubojević).

Fig. 2: Sledge winch Ackja	Fig. 4: A view at the clear cut strip in Scots pine plantation	Fig. 5: Load attached to the carriage with clamping device
		
		
Fig. 3: Sledge winch Gantner HSW 20		

3 RESULTS

To make WG a kind of raw material, it is necessary to conduct several working operations: to collect branchwood from the felling site, to separate WG from the branchwood and to gather it in a form suitable for transportation, to transport it to the processing site. In doing so, we distinguish between internal transport, on a move from stumps to the storage place, and external transport, from the storage place to the processing plant.

Collecting WG from standing trees is not reasonable for reasons that need not to be specifically explained. On the contrary, the only possible solution is the separation of the tree's greenery immediately after the tree felling in any situations: regular felling, sanitation felling, random yield etc.

Possible negative ecological impacts induced by the crown mass removal, can be reduced by appropriate timing of operations, minimizing the nutrient removals from the forest sites and recycling of ash from the combustion installation (Ghaffariyan, 2010; Kuiper, 2006).

3.1 MANUAL PREPARATION OF WOOD GREENERY

In a typical case, manual preparation of WG involves the following work elements:

- collecting branchwood left behind after cutting the trees,
- separation of WG from branchwood,
- carrying of WG to the containers for transport,
- stacking of WG at the containers for transport.

The following average working time structure was determined for the implementation of the described work elements in the eighth hours working day (WD):

- Effective working time (EWT) = 6 h (75% of WD)
- Delay time (DT) = 2 h (25% of WD),

where under the EWT we mean a period of useful work, and under the DT allowed breaks in work, such as: mealtime, rest and personal time, interference time.

The following average structure of EWT was determined:

- Preparatory time = 14.4 min (4% of WT)
- Time of transition (from tree to tree) = 24.8 min (8% of WT)
- Separation of WG from branchwood = 277.2 min (77% of WT)
- Disposal and stacking of WG at the container = 39.6 min (11% of WT)

The following average production rate per worker was determined: 161.4 kg ofWG per WD, with variation interval between 134 - 189 kg of WG per WD. These resultspoint to the conclusion that manual preparation of WG is not economically justified due to the low productivity of manual labor.

3.2 INTERNAL TRANSPORT

Relatively high moisture content in fresh WG and its low bulk density (Table 2) make it difficult to find rational solutions with the transport means currently in use in our forestry, whether the raw material is carrying from the forests in bags on pack-horses, or in iron baskets mounted on the skidder. The only economically viable solution is to transport entire trees using wire-rope systems (Figures 2-5). However, this technological solution rarely meets our forestry practice, and as a such, it does not have a decisive significance in the eventual organization of mass production. Conversely, mechanical hauling of whole trees or parts of them is not acceptable due to the high pollution and damage of raw material (Ljubojević, 2008).

Table 2: Moisture content in fresh wood greenery and its bulk density.

Harvesting season	Tree species			
	Scots pine	Black pine	Fir	Spruce
Moisture content (%)				
Winter	51	51	50	48
Summer	51	53	50	47
Bulk density (kg/m^3)				
Winter/summer	57,6	82	142	173,2

3.3 CONCEPT OF PRIMARY COLLECTION AND CONCENTRATIONS OF WOOD GREENERY TO THE PROCESSING SITE

An applicable techno-economic solution assumes the mechanized gathering and palletizing of forest residues in the form of biomass bundles and their delivery to the processing plants (Illustrated table 1, production lines 1 & 2). In this way, it significantly shortens the time of primary collection and concentration of the raw material to the processing site, ensures better raw material quality and at the same time increases the bulk density of the load. Two-stage separation of biomass is performed at the processing site. In the first step, branchwood and brushwood are separated by a light hydraulic crane. Branchwood is directed to the production of solid biofuels (woodchips, briquettes, pellets). Brushwood is mechanically separated into ligno-cellulose skeleton and wood greenery (Figure 6).

Illustrated table 1: Production lines for bundling of logging residues in regular felling.

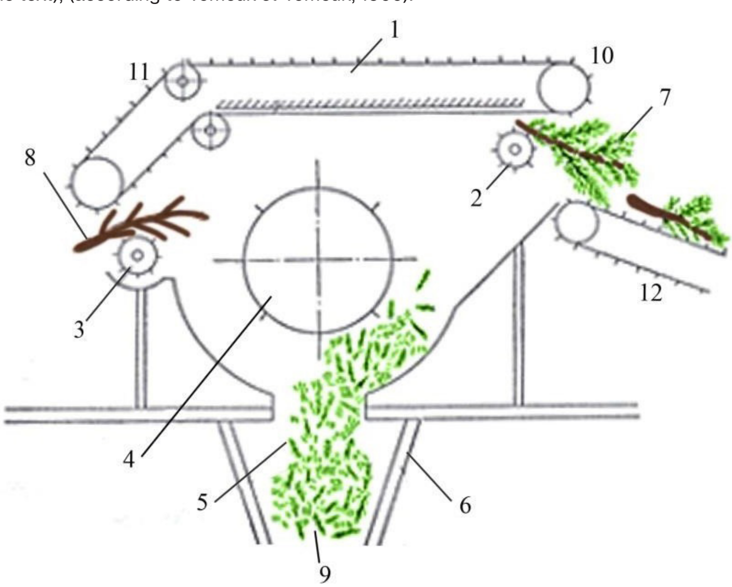
1	Logging residues at the felling site	Making bundles with the slash bundler at the felling site	Collecting bundles over felling site and transfering to the storage place	Transporting bundles to the processing plant
				

2	Logging residues at the felling site	Collecting and transporting forest residues to the storage place	Making bundles with the slash bundler at the storage place	Transporting bundles to the processing plant
				

(source: Ljubojević, 2016).

Separation of WG from the wooden skeleton is the most important operation in the phase of WG preparation. By switching from manual to mechanized production, it significantly increases productivity and reduces production costs (Hakkila, 1989; Levin *et al*., 1984; Nikitov, 1985). Separator "ODZ-12A" (ODZ is an acornym of "Отделитель древесной зелени" [in Russian]) is an automatic machine constructed and introduced into regular production in the former USSR. The Separator consists of five basic parts and mechanisms mounted on a rigid chassis: 1. Belt conveyor (internal), 2. Roller inserter, 3. Roller ejector, 4. Separation drum with blades, 5. Bunker for receiving WG, 6. Chassis (Figure 6).

Figure 6: Separator of wood greenery "ODZ – 12A": 7. Brushwood, 8. Bare branches, 9. WG, 10. Powered pulleys, 11. Tensile rowels, 12. Belt conveyor (external) for the delivery of WG in front of the separator (positions 1- 6 are described in the text); (according to Tomčuk *et* Tomčuk, 1966).



Automatic feeding of separation drum with WG and discharge of bare branches is carried out by Belt conveyor /1/. Top layer of belt consists of metal rolls with welded ribs- a thin cylinder in the form of non-head nails. Its working position and strength are regulated by Tensile rowels /11/. Drum with blades /4/ is the main part of Separator. It divides green parts from wooden skeleton by means of knives fixed with clamps. Rubber shock absorbers prevent collisions during rotation. External belt conveyor /12/ inserted WG in a shape of brushwood into the Separator, piece per piece with a thicker end forward.

Main technical characteristics of the Separator are: capacity - 1.5 t WG/h, separation purity - 98%, power - 3.8 kW, drum speed 500 – 650 rotations /min, working volume of bunker - 0.5 m^3.

3.4 CHOICE OF OPTIMAL WOOD GREENERY PROCESSING TECHNOLOGY

WG serves as a raw material for obtaining a large number of products with a wide usage value, for which various technological processes have been developed (Table 3). Otherwise, fresh (unprocessed) branches with needles are used as a protective cover for young agricultural crops, soil protection from moisture loss, as an addition to fodder and as a raw material for compost production (Duryea *et* Edwards, 1997; Daugavietis *et al*., 2015). When domestic animals and poultry are fed, a previous smoothing with water vapor is practiced.

When the simplified review of processing technologies is filtered through the set of criteria, the production of vitamin-mineral flour (VMF) comes out as an optimal solution. VMF can be produced in mobile facilities and in stationary plants, both of which operate according to the same principles (Hakkila, 1989; Levin *et al*., 1984; Nikitov, 1985; Tomčuk *et* Tomčuk, 1966). Figure 7 shows the technological scheme of VMF production. The exception is only WG of fir, which due to the high content of essential oil requires additional technological intervention, combining hydrodestillation with short-term processing of the raw material by high pressure steam (so-called steam cracking) (Levdanskij *et al*., 1992).

Table 3: Simplified review of wood greenery processing technologies.

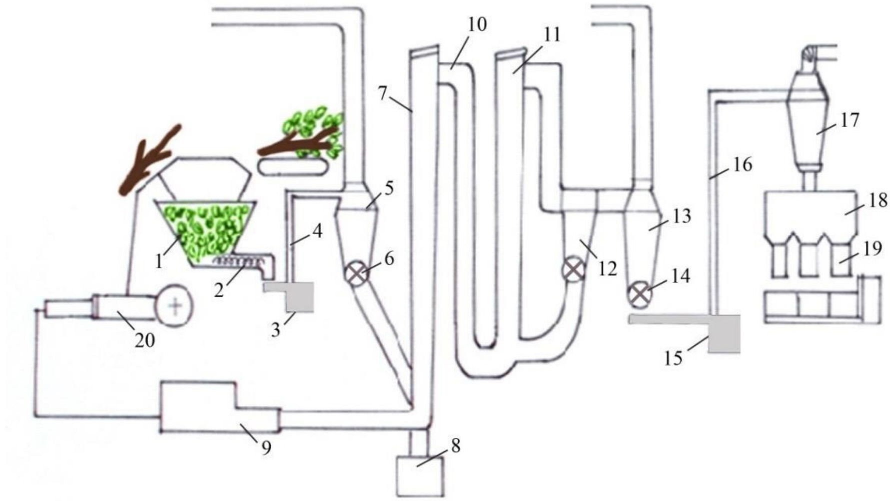
Products obtained from wood greenery	Essence of the processing technology	Source
Vitamin-mineral flour	Thermal and mechanical treatment by combining drying, sorting and grinding processes	Hakkila (1989), Levin (1984) Nikitov (1985), Tomčuk (1966)
Essential oils	Hydrothermal treatment by aqueous distillation	Daugavietis (2014), Tomčuk (1966)

Biologically active compounds (BAC) of law molecular weight	Chemical treatment by extraction with aqueous sodium hydroxide solution/*/	Karmanova (2005), Terenteva (2016), Šanina (2004)
BAC of high molecular weight	Thermochemical treatments	Karmanova (2005), Terenteva (2016)
Chlorophyll-carotenoic paste	Thermochemical treatment by gas extraction process in combination with distillation of essential oils	Levin (1984), Tomčuk (1966)
Primary forms of medicinal preparations in human medicine	An infusion in water or in diluted ethanol; coniferous therapeutic extract	Levin (1984), Paršikova (2015)

/*/ This process yields more useful products. Lipids are used in perfumes, medicine and other industries. Concentrate of neutral ingredients (provitamin concentrate), separated by emulsion extraction, can be used as a bioactive additive in the perfumery and cosmetic industry and as an additive in domestic poultry and cage breeding fur animals.

Production of VMB is carried out according to the following procedure (Figure 7): WG from the Collecting bunker /1/ drops onto the Screw conveyor /2/ which brings it to the Crusher /3/. Rough chips come out of the Crusher as a mixture of needles and particles of wood and bark. It is carried through Conveying duct /4/ by compressed air into the Bunker /5/. At the bottom of the Bunker there is a Dosing unit /6/ by which rough chips is evenly distributed to the First drying column /7/. A mixture of greenery and particles of wood and bark floats in the column space. Stream of hot air is programmed so that only the hardest fraction (particles of wood) can fall down. This fraction is collected into the Container below the First drying column /8/, from where it is periodically inserted into the Furnace /9/. From the First column, the dried material goes to the Second /10 / and the Third column /11/ for further drying. A part of the material that is not sufficiently dried and, therefore is heavier, is separated /12/ and via feedback sent for redrying. Completely dried material goes through the Cyclone /13/ and the Dosing unit /14/ to the Mill /15/ in which it turns into flour. It passes through a Sieve of 1.5-2 mm diameter and through Conveying duct /16/ goes to the Cyclone /17/ with WMF Bunker /18/ and with Line for filling and sewing bags with VMF /19/. Bare branches fall into the Press for briquettes /20/ which are intended for market or are used on-site for own needs.

Figure 7: Technological scheme for the production of vitamin-mineral flour: 1. Bunker for receiving WG, 2. Screw conveyor, 3. Crusher, 4. Pneumatic conveyor, 5. Bunker for receiving rough chips, 6. Dosing unit, 7. First drying column, 8. Bunker for receiving waste material from the first drying column (wood and bark particles), 9. Furnance, 10. Second drying column, 11. Third drying column, 12. Separator of residual wet material, 13. Cyclone, 14. Dosing unit, 15. Mill, 16. Pneumatic conveyor, 17. Cyclone, 18. Bunker of VMF, 19. Line for filling and sewing bags with VMF (according to Tomčuk *et* Tomčuk, 1966).



Compared with the above-mentioned plant, Hakkila (1989) describes a slightly smaller, more compact and more mobile chip sorter SIKO-2. Recently, processing of WG into VMF using the energy of the microwave electromagnetic field, have been described by Posmetjev *et* Latiševa (2018). The essence of this process is to convert the energy of the microwave electromagnetic field into the heat. According to the authors, with applying their solution one can achieve separation purity of 90-95 % by weight without prior mechanical processing (as made by „ODZ 12A“ separator). Unfortunately, this solution has not yet lived in practice, inspite the fact that it has been officially presented in April 2006.

4 CONCLUSIONS

To become a raw material, it is necessary to conduct several operations over WG: to gather branchwood over felling site, to separate WG from branchwood, to gether it in a form suitable for transport and to deliver it to the processing site.

Manual preparation of WG is not economically justified due to the low productivity of manual labor - 161.4 kg of WG per worker and WD, with variation interval between 134 - 189 kg of WG.

Relatively high moisture content in fresh WG and its low bulk density make it difficult to find rational solutions with the transport means currently in use in our forestry, whether the raw material is carrying from the forests in bags on pack-horses, or in the iron baskets mounted on the skidder. The only economically viable solution is to transport entire trees using wire-rope system. However, this technological solution rarely meets our forestry practice, and as a such, it does not have a decisive significance in the eventual organization of mass production.

An applicable techno-economic solution assumes the mechanized gathering and palletizing of forest residues in the form of biomass bundles and their delivery to the processing plants. In this way, it significantly shortens the time of primary collection and concentration of the raw material to the processing site, ensures better raw material quality and at the same time increases the bulk density of the load.

Separation of greenery from the wooden skeleton is the most important operation in the phase of preparation. By switching from manual to mechanized production, it significantly increases productivity and reduces production costs.

Of the many products that can be obtained from WG, VMF is especially distinguished as a mass-consumable product in the feeding of domestic animals. Its production is flexible in relation to the source of raw materials - it is possible in mobile and stationary plants, and waste generated during production is usable. Production takes place without the use of chemicals and without negatively affecting the environment.

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SOBRE O ORGANIZADOR

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ÍNDICE REMISSIVO

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