

UTILIZATION OF GRAPEVINE RODS AS RAW MATERIAL FOR PRODUCTION OF BOARDS

Julia MIHAJLOVA

University of Forestry, Faculty of Forest Industry
Blvd. Kliment Ohridski nr. 10, 1797 Sofia, Bulgaria
Phone: +359 291 907/260, Cell: +359 888 770 216, E-mail: jmihajlova@itu.bg

Hülya KALAYCIOĞLU

Karadeniz Technical University, Faculty of Forestry
Department of Forest Industry Engineering
61080 Trabzon, Turkey
Phone: +90 462 377 1522, Cell: +90 542 535 4266, E-mail: khulya@gmail.com

Marius-Catalin BARBU

Department of Forest Products Technology and Timber Construction
Salzburg University of Applied Sciences, Kuchl, Austria
Faculty for Wood Engineering, University Transilvania, Brasov, Romania
Cell: 00 40 741 580 000, E-mail: marius.barbu@fh-salzburg.ac.at

Abstract:

The paper presents the results of studies relating to the utilization of the grapevine rods remaining at the pruning of the vineyards.

The main objective of the present research was to compare and analyze the obtained values of physico-mechanical indicators of different types of wood-based panels with the participation of grapevine rods in their composition.

To be fulfilled the goal of the study in laboratory conditions were produced:

- 7 different types of single-layer particleboards from grapevine particles based on UFR and PFR, the binder content varying between 8 u 12%, boards density was from 700 to 840kg/m³, at press temperature – 190°C;

- 7 types fiberboards from grapevine fibers - with 10% PFR, boards density was 900kg/m³, at varying the percentage of grapevine fibers from 0 to 30% and press temperature – 190°C;

- 3 types three-layered particleboards with a face layer from wood particles and a core layer from grapevine particles, at ratio of FL:CL=40:60, based on PFR, the binder content varying between 8 u 12%, boards density was 700kg/m³, at press temperature 170°C;

- 4 types three-layered combined boards with a face layer from wood fibers and a core layer from grapevine particles (0; 15; 30 u 45%), based on 10% UFR in FL and 10% UFR in CL, at press temperature 170°C.

The summarized results for the physical and mechanical indicators of the manufactured boards with various participation of grapevine particles respectively grapevine fibers are presented in Tables 1 – 4.

The results obtained within the present research demonstrated that the grapevine rods can be utilized as raw material for production of different type of boards – particleboards, fiberboards, combined boards. Increasing the content of this type of lignocellulosic material in the composition of the various types of boards leads to a deterioration in their physico-mechanical indicators, which can be offset to a certain extent by an increase in the binder content or a change in the type of binder. This, of course, must be done after taking into account the future use of the respective type of wood boards.

Key words: grapevine rods; raw material; particleboards; fiberboards; combined boards.

INTRODUCTION

The needs of wood raw material and wood-based materials increases proportionally to the rate of population growth. The world population increases by about 90 million persons annually (Cooper and Balatinecz, 1999). Moreover, on a world-wide scale, more than 3.5 million tons of wood are consumed per year, which corresponds to about 0.7 t per capita. If the consumption of wood and the population growth remained constant, then the need of wood would increase by 60 million tons each year. Therefore, emergence of big unbalance between the wood supply and demand is inevitable. The above presented clearly shows the shortage of forest resources and the impact of the increased wood consumption. Therefore, the lack of forest resources necessitates partial or full replacement of wood with other lignocellulosic raw materials in the production of wood materials (Mihajlova and Savov 2017).

The grapevine rods are abundant and renewable annually. Every season, large quantities of grapevine rods remain as by-products in the field, and unfortunately not utilized properly in related industries, although, the grapevine rods are excellent alternative sources to replace wood particles and wood fibers. Moreover, it is an environmentally friendly practice due to disposal methods. In general, mostly grapevine rods are destroyed by fire.

The grapevine (*Vitis vinifera* L.) is a perennial plant, expanded in the temperate zone of the Earth, covering a broad area of approximately 10 million hectares. The stem of the grapevine usually develops shortly and ends in rambling, of which shoots develop in spring. The mature shoots, called grapevine rods, are pruned every year. The generation of absolutely dry lignocellulose substance by a hectare is from 1.5 to 2.0 tons, i.e. the minimum amount of annually generated potential raw material in the world is beyond 15 million tons.

From an economic point of view, the use of the grapevine rods as a raw material in board's production correlates mainly with their price free warehouse of the board's manufacturer, i.e. of reducing the raw material collecting and transport costs to minimum. Therefore, it is more efficient as raw material sources to use larger grapevine plantations, where the implementation of mechanization is economically justified. For the reduction of transport costs, it is recommended the plants for wood boards based on grapevine raw material to be built in regions abundant in large amounts of that raw material, which in reality is utterly attainable in numerical wording – above 50 thousand tons raw material in diameter of 60 km. Besides, it is more rational to transport the raw material in crushed state, which is achieved by special mobile cutting machines at the spot of collecting the raw material.

The grapevine rods are a seasonal raw material, thence it is necessary to secure its preserving throughout the year. That can be carried out at best in open areas for storing, because the grapevine rods crushed in a form of splinters are stored better in piles of technological cuts. In addition, it is ascertained that the grapevine wood stuff rots harder, i.e. the wood stuff loss while keeping it in open throughout the year is below 10 %. The substance does not heat spontaneously (the temperature inside the piles does not exceed 50°C). The destructive phenomena manifest mainly on the surface layers of the piles at a depth to 270 mm. The balanced humidity of the stuff in the piles is 15-18 %, irrespective of the climatic conditions (Yosifov et al. 2001).

The utilization of the grapevine raw material for wood boards has several alternative solutions in terms of applying one or other method of production, as well as the type and the quality of the manufactured product.

OBJECTIVE

The main objective of the present research was to compare and analyze the obtained values of physico-mechanical indicators of different types of wood-based panels with the participation of grapevine rods in their composition.

MATERIAL, METHOD, EQUIPMENT

In the laboratory experiments grapevine rods of such kinds as Pamid and Dimjat which are common in Bulgaria, have been used. Incidentally, it is necessary to remark on the ascertainment (Yosifov et al. 2001) that the kind of the grapevine rods not shown any essential influence on the boards properties.

To be fulfilled the goal of the study in laboratory conditions were produced:

- 7 different types of single-layer particleboards from grapevine particles based on UFR and PFR, the binder content varying between 8 и 12%, boards density was from 700 to 840kg/m³, at press temperature – 190°C;

- 7 types fiberboards from grapevine fibers - with 10% PFR, boards density was 900kg/m³, at varying the percentage of grapevine fibers from 0 до 30% and press temperature – 190°C;

- 3 types three-layered particleboards with a face layer from wood particles and a core layer from grapevine particles, at ratio of FL:CL=40:60, based on PFR, the binder content varying between 8 и 12%, boards density was 700kg/m³, at press temperature 170°C;

- 4 types three-layered combined boards with a face layer from wood fibers and a core layer from grapevine particles (0; 15; 30 и 45%), based on 10% UFR in FL and 10% UFR in CL, at press temperature 170°C.

The obtaining of the particles has been performed through a two-stage crushing of the grapevine rods. The initial crushing has been performed on a disc-cutting machine, and the obtained particles in length of 25-30mm have been further fractioned on a centryfugal-rotary cutting machine (mill) for the synthetic resins based boards or on a hammer mill for the wood fiber boards. By means of the cutting machine the generated particles had a thickness of 0.3-0.6 mm and a dispersed structure in fractions as follows: 10/5 – 13.4%; 5/2.5 – 32.6%; 2.5/1 – 40.5%; 1/0.7 – 9.5%; 0.7/0 – 4%'. The dispersed structure of the particles after the hammer mill was: 10/5 – 28.3%; 5/0.7 – 65.1%; 0.7/0 – 6.6%. The high percentage of small fraction (0.7/0) in the both

ways of crushing is mainly due to the anatomy structure of the grapevine rods, i.e. the structure of pith and bark husks.

Before mixing the particles with the proper binding agent, it is subjected to desiccation up to thorough moisture 3 – 5%. By using the binding agent based on synthetic water soluble UFR and RFR, the following basic parameters have been projected: board thickness 16mm, board density $770 \pm 70 \text{ kg/m}^3$, dry resin content in the boards - $10 \pm 2\%$. The compressing has been performed by means of a laboratory hydraulic press with the temperature of the plates of 190°C and the pressing time 0.5min/mm. Depending on the board density the maximum pressing pressure has been within 1,8 – 2,6MPa.

For the obtaining of fiberboards with different quantity of grapevine fibers at content from 0 to 20% industrially manufactured wood-fiber mass was used with the following composition: beech – 57%, oak – 35%, poplar – 8 %. The mass was stored in the laboratory and was dried to water content of 11%. The degree of its defibration, determined after the Schopper-Riegler method, is 11° . Its bulk density is 32 kg/m^3 .

With a view to eliminating mineral inclusions and ash from the grapevine rods, as well as increasing their water content, they were soaked in a water bath for 72h. The grapevine rods were cut in advance. The grapevine rods pieces thus prepared were placed in a laboratory defibrator with additional amount of circulating water. The defibration's duration was 2min. Grapevine fibers obtained after mechanical method were subjected to sorting and subsequent drying under atmospheric conditions (Fig. 1).



Fig. 1.
Mass of grapevine rods.

Phenol-formaldehyde resin with initial concentration of 48% and concentration of the glue solution of 30% was used for the manufacture of the boards.

Gluing was done in a laboratory mixer with the glue feed by forced injection using an air gun and a compressor. The pressing was carried out in a hydraulic press type Manni № T 0376-449541 (Fig.2).



Fig. 2.
Laboratory hydraulic press type Manni.

All laboratory boards were sized 500x500mm and thickness respectively for particleboards and for combined boards 16mm, and for fiberboards - 6mm.

The physical and mechanical indicators of all laboratory boards were determined after methods pursuant to valid standards.

RESULTS AND DISCUSSION

The summarized results for the physical and mechanical indicators of the manufactured boards with various participation of grapevine particles respectively grapevine fibers are presented in Tables 1 – 4.

Table 1

Single-layer particleboards from grapevine

Board No	Kind of binder - Binder content, %	Density, kg/m ³	Water absorption, %	Thickness swelling, %	Bending strength, N.mm ⁻²	Internal bond, N.mm ⁻²
1.	UF - 8	770	53.1	17.8	10.6	0.33
2.	UF - 10	700	74.1	15.3	11.8	0.35
3.	UF - 10	770	45.0	14.2	18.2	0.49
4.	UF - 10	840	32.4	12.5	22.9	0.57
5.	UF - 12	770	39.3	11.0	19.8	0.57
6.	PF - 8	770	42.6	14.9	18.8	0.46

Table 2

Fiberboards from grapevine fibers with 10 % PFR

Board No	Grapevine fibers content, %	Density, kg/m ³	Water absorption, %	Thickness swelling, %	Bending strength, N.mm ⁻²	Internal bond, N.mm ⁻²
1.	0	915	38.3	13.7	56.4	-
2.	5	920	37.8	14.0	54.0	-
3.	10	925	50.2	20.3	48.2	-
4.	15	935	52.0	24.9	45.5	-
5.	20	940	53.3	27.6	42.8	-
6.	25	920	57.0	28.8	32.6	-
7.	30	930	61.0	28.9	29.0	-

Table 3

Three-layered particleboards with a FL from wood particles and an CL from grapevine particles

Board No	Kind of binder - Binder content, %	Density, kg/m ³	Water absorption, %	Thickness swelling, %	Bending strength, N.mm ⁻²	Internal bond, N.mm ⁻²
1.	PF - 8	700	85.1	36.9	13.0	0.27
2.	PF - 10	700	79.0	32.6	13.0	0.40
3.	PF - 12	700	67.0	19.1	18.0	0.48

Table 4

Three-layered combined boards with a FL from wood fibers and an CL from grapevine particles

Board No	Grapevine particles content in CL, %	Kind of binder - Binder content, %	Density, kg/m ³	Water absorption, %	Thickness swelling, %	Bending strength, N.mm ⁻²	Internal bond, N.mm ⁻²
1.	0	PF - 10	700	97.1	29.0	18.0	0.48
2.	15	PF - 10	700	104.2	30.4	17.8	0.32
3.	30	PF - 10	700	106.9	31.8	17.0	0.30
4.	45	PF - 10	700	114.0	32.9	16.8	0.28

From the data presented in Table 1 concerning the physical and mechanical properties of single-layer particle boards at 10% UFR, it can be seen that an increase in density from 700 to 840kg/m³ leads to a reduction in water absorption from 74.1 to 32.4% and in thickness swelling from 15.3 to 12.5%. The bending strength and internal bond of the same type of boards increases from 11.8 to 22.9N.mm⁻² and from 0.35 to 0.57N.mm⁻², respectively, with increasing the boards density. When choosing a density in the production of boards with the participation of grapevine particles, an account must be taken of their future use. With regard to values for indices for the thickness swelling, bending strength and internal bond (EN 319) all the obtained boards with 10% UFR content and densities of 700, 770 and 840kg/m³ respectively meet the requirements of EN 312 for Type P1 – Requirements for general purpose boards for use in dry conditions and for Type P2 – Requirements for boards for interior fitments (including furniture) for use in dry conditions. The boards with density of 770 and 840kg/m³ have shown in the tests values for bending strength, internal bond and swelling in thickness, 24h suitable for boards Type P3 according EN 312 – non load-bearing boards for use in humid conditions.

Increasing the percentage of binder in the board composition can be traced if the values of the physical and mechanical indicators of board type 1, 3 and 5 in Table 1 are compared. It can be seen that the increase in the board binder content has a positive effect - water absorption and thickness swelling are reduced, and bending strength and internal bond of the boards are increased. When selecting the percent of the binder content, it is necessary to consider both the future use of the boards, i.e. the desired values for properties of the obtained boards, as well as economic efficiency as the higher percentage of binder increases the cost of the boards. All three types of boards - respectively with 8, 10 and 12% UFR in their composition correspond to requirements of EN 312 for Type P1 – Requirements for general purpose boards for use in dry conditions, and the boards with 10 and 12% UFR in their composition meet the requirements against these indicators for Type P2 – Requirements for boards for interior fitments (including furniture) for use in dry conditions and for Type 3 according EN 312 – non load-bearing boards for use in humid conditions.

As can be seen in Table. 1, boards 1 and 6 were obtained with the same parameters but with a different type of binder - respectively UFR and PFR. When comparing the obtained values for the physical and mechanical indicators, it is clear that better indicators have the boards with PFR – 42.6% water absorption, 14.9% thickness swelling, 18.8N.mm⁻² bending strength and 0.46 N.mm⁻² internal bond, which are respectively with 10.5% lower water absorption, with 2.9% lower thickness swelling, with 8.2N.mm⁻² higher bending strength and 0.13N.mm⁻² higher internal bond compared with the boards with UFR. Of course, when choosing the type of binder, future use of the boards should be considered.

From the data presented in Table 2 can be seen how does the increase of the fiber content from grapevine rods in the FBs composition affect their indicators. Under the conditions of the study, the water absorption of FBs varies from 61% to 38,3%. That is, the water absorption of the boards with 30% participation of grapevine fibers is by 22,7% worse, respectively higher, than that in the reference board that is without participation of grapevine fibers. Under the conditions of the study, the thickness swelling of FBs varies from 28,9% to 13.7%. That is, at 30% grapevine fibers content, the thickness swelling is with 15.2 % worse, i.e. higher, than that of the reference board that is without participation of grapevine fibers. With the addition of up to 30% of grapevine fibers to the composition of FBs, decrease in the bending strength of the

boards from 56 to 29N.mm⁻². The boards with grapevine fibers content of 5% to 20% meet the requirements of the highest strength classes, respectively FBs with increased load-carrying capacity for bearing structures and for outdoor use, respectively with required bending strength of 44 and 40N.mm⁻². This shows that the grapevine rods as a waste lignocellulosic raw material from the agriculture may be successfully, without violating the requirements to the bending strength, utilized in the composition of FBs in content of up to 20%. The boards with grapevine fibers content of 25% meet the requirements for bending strength of FBs for general purpose and for use in dry environment. And FBs with 30% grapevine fibers content do not meet the requirements to the studied indicator. Attention should be paid to the fact that the boards were manufactured with high PFR content – 10%. This makes the utilization of grapevine fibers in their composition of more than 20% unjustified with respect to the bending strength. In conclusion, the following main recommendations may be made: The amount of grapevine fibers shall not exceed 20% of the composition of FBs manufactured after dry method, and when there are increased requirements to the boards with respect to the performance indicators, the amount of grapevine fibers shall not exceed 5%. In subsequent studies, the effect of the grapevine fibers content within the range 5% to 10% and 10% to 20% should be studied (with lower increment).

In Tab. 3 are presented data on the physicomechanical indicators of three-layer particleboards with the face layer from wood particles and core layer from grapevine particles with different participation of PFR in board composition. From the results obtained in testing the physicomechanical properties of the boards, the tendency to improve them with an increase in the binder content – reduce water absorption with 18,1% and thickness swelling – with 17,8%, as well as increasing the bending strength with 5.0N.mm⁻² and the internal bond with 0,21N.mm⁻². All three types of three-layer boards - with 8, 10 and 12% PFR in their composition, respectively, meet the requirements of EN 312 for Type P1 – Requirements for general purpose boards for use in dry conditions, and boards with 10 and 12% PFR in the composition and the requirements against these indicators for Type P2 – Requirements for boards for interior fitments (including furniture) for use in dry conditions. Three-layer boards with 12% PFR participation in the composition meet the requirements for these indicators for Type 3 according EN 312 – non load-bearing boards for use in humid conditions.

In Table. 4 the values obtained for the study for physicomechanical indicators of the three-layer composite boards, which are obtained with a density of 700 kg/m³ and the participation in the composition of the boards - 10% of the PFR, are presented. From the obtained results there is a tendency to deteriorate the physicomechanical indicators of the boards with increasing the percentage of grapevine particles in the core layer – for example, water absorption increases by 16.9% with the gradual increase of the grapevine particles content in CL from 0 to 45%; respectively, the thickness swelling increases from 29 to 32.9%, i. e. with 3.9%; the bending strength decreases by 1.8N.mm⁻² (from 18.0 to 16.8 N.mm⁻²) and the internal bond also decreases from 0.48 to 0.28N.mm⁻² (with 0.2 N.mm⁻²) for the boards with 45% grapevine particles in CL. By comparing the values obtained for the physicomechanical indicators on the three-layered combined boards with those of the three-layer particleboards with CL from the grapevines particles and 10% PFR in their composition, it is clear that the combined boards have better mechanical indicators (bending strength 16,8N.mm⁻² and internal bond 0,28N.mm⁻²) even at 45% grapevine particles content in CL, but worse physical properties (water absorption 114% and thickness swelling 32,9%). This is most likely due to the face layer, which is obtained from wood fibers at a density 700kg/m³.

CONCLUSIONS

The studies conducted confirm the results of a number of colleagues working in this field (Yeniocak et al. 2014; Ntalos et al. 2002, Kalaycioğlu and Nemli 2006; Alma et al. 2005). The results obtained within the present research demonstrated that the grapevine rods can be utilize as raw material for production of different type of boards – particleboards, fiberboards, combined boards. Increasing the content of this type of lignocellulosic material in the composition of the various types of boards leads to a deterioration in their physicomechanical indicators, which can be offset to a certain extent by an increase in the binder content or a change in the type of binder. This, of course, must be done after taking into account the future use of the respective type of wood boards.

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