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EFFECT OF PARTICIPATION OF VINE FIBRES ON SOME PHYSICAL AND MECHANICAL PROPERTIES OF FIBREBOARDS

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ABSTRACT

Wood is a raw material in short supply both in Bulgaria and worldwide. In Bulgaria, vine twigs are widespread lignocellulosic waste from agricultural production.

In this study, the effect of inclusion of vine fibres in the composition of fibreboards on their properties is presented. Vine fibres were obtained by means of defibration with a defibrator laboratory mill. For the purpose of the study, fibreboards were produced under laboratory conditions with inclusion of vine fibres at a content from zero to twenty percent in increments of five percent. The main physical and mechanical properties of the boards were determined. On this basis, analysis was made and respective conclusions were drawn.

Key words: fibreboards, lignocellulosic waste, vine fibres.

INTRODUCTION

Fibreboards (FBs) find many-sided application because of their good physical and mechanical properties. They find application in furniture production and construction, being used in manufacture of furniture, doors, linings, coverings. Hard FBs manufactured after wet method and especially those manufactured after dry method (high-density FBs) also find application as a substitute of veneer plywood.

One of the main advantages of FBs under the conditions of shortage of large-sized wood raw material both in Bulgaria and in the world are the reduced requirements to the raw material (Donchev, G. 1982; Xing, C. *et al*. 2006) Small-sized wood, as well as technological wood with reduced requirements in comparison with those in particleboards manufacture, is used as a raw material for FBs. Another main advantage of FBs with respect to the raw material for production is the possibility of utilization, although partially, of the residual lignocellulosic products obtained from agriculture (Mehmed Akgül *at al*. 2010; Mo, X. Q. et al. 2003; Halvarsson, S. *et al*. 2010).

In Bulgaria, a considerable number of studies of the possibility of utilization of the residual lignocellulosic raw materials in the composition of FBs manufactured after wet method were performed (Tzolov, V. *at al*. 1987), but no recent studies of the effect of such type of raw materials on the indicators of FBs manufactured after dry method, and more particularly of raw material made of vine twigs, were found.

Vine plantations in Bulgaria are considerable in terms of size and although vine twigs are seasonal waste, their amount may not be ignored (www.mzh.government.bg).

Main disadvantage of such type of raw material is the presence of mineral substances in its composition (Shehata, S. 2016; Markessini, E et al. 1997).

This may be overcome through washing the vine twigs, which will be also favourable to their defibration because of the increase of the water content in the raw material.

This justifies the topicality of this study related to the determination of the effect of vine twigs content on the performance properties of FBs.

Object of this study is the possibility of utilization of residual lignocellulosic products from agriculture in the composition of fibreboards manufactured after dry method.

Subject of the study is the effect of vine twigs content in quantity of up to 30% on the performance indicators of fibreboards manufactured after dry method on the basis of phenol-formaldehyde resin (PFR).

MATERIALS AND METHODS

The matrix of the experiment is presented in Table 1.

Table 1: Matrix of the experiment

No.	FB density ρ, kg/m^3	Vine twigs content *Px*, %	Wood-fibre mass content, %
1	920	0	100
2	920	5	95
3	920	10	90
4	920	15	85
5	920	20	80
6	920	25	75
7	920	30	70

To realize the study's goal, industrially manufactured wood-fibre mass with the following composition: beech – 57%, oak – 35%, poplar – 8%, was used. The mass was stored in the laboratory of pressed materials at the Department of Mechanical Wood Technology of the University of Forestry 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/m3.

The vine twigs were refined in a laboratory defibrator and were dried to water content of 11%.

With a view to eliminating mineral inclusions and ash from the vine twigs, as well as increasing their water content, they were immersed in a water bath for 72 h. The vine twigs were cut in advance. The vine twigs pieces thus prepared were placed in a laboratory defibrator with additional amount of circulating water.

The defibration's duration was 2 min. Vine fibres obtained after mechanical method were subjected to sorting and subsequent drying under atmospheric conditions (Fig. 1).

Figure 1: Mass of vine twigs

Phenol-formaldehyde resin with initial concentration of 48% and concentration of the glue solution of 30% was used for the manufacture of the boards. The proportion of resin relative to absolutely dry fibres was 10%.

The boards were produced at a temperature of hot pressing of 190º. The pressure was as follows: Ist stage – 3.0 MPa in duratioan 15% of whole cycle; IInd stage – 1.8 MPa in duration 25 % of whole cycle; IIIrd stage 0.6 MPa in duration 45% of whole cycle and IVth stage 1.2 MPa in duration 45% of whole cycle. The press factor was 30s per millimeter of board thickness. The set board thickness was 8 mm.

The physical and mechanical properties of FBs were determined after methods pursuant to valid standards (BDS EN 310; BDS EN 317; BDS EN 323:2001).

RESULTS AND ANALYSIS

The summarized results for the physical and mechanical properties of the manufactured boards with various participation of vine twigs are presented in Table 2.

Table 2: Results for some properties of boards at various vine fibres content

Board number No.	Vine fibres content P_x, %	Density ρ, kg/m^3	Bending strength *fm*, N.mm^{-2}	Water absorption *A*, %	Swelling in thickness *Gt*, %
1	0	915.03	56.43	38.34	13.65
2	5	919.86	54.03	37.78	14.01
3	10	927.32	48.18	50.21	20.32
4	15	936.19	45.48	51.96	24.94
5	20	938.22	42.78	53.33	27.60
6	25	919.11	32.55	57.02	28.81
7	30	932.59	29.00	60.97	28.87

The difference in the density of the individual boards is considerably below the permissible limits (BDS EN 316), on account of which this factor should not lead to considerable dispersion in the output results of the study.

The variation of the bending strength at the various vine fibres content is presented graphically in Figure 2.

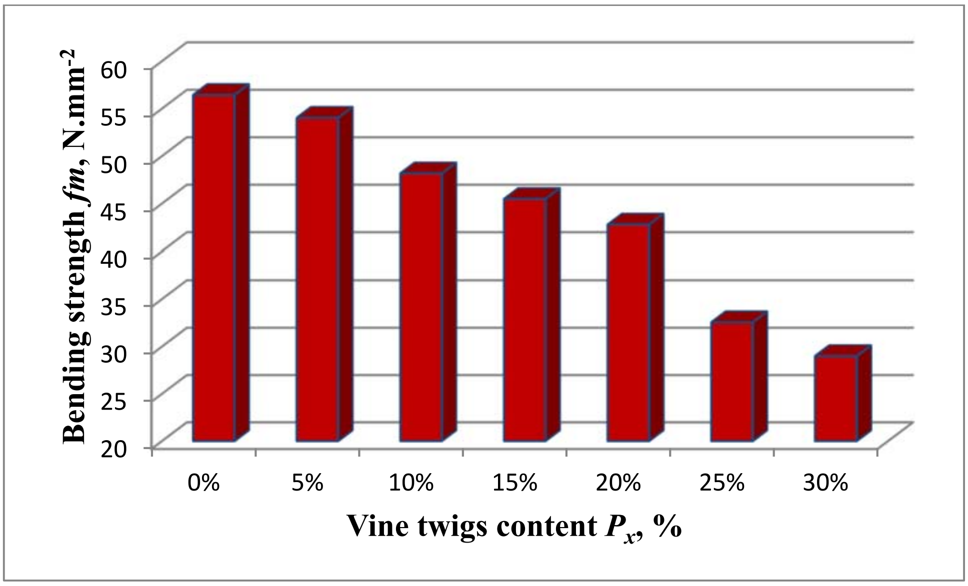

Figure 2: Variation of the bending strength of boards at various vine fibres content

With the addition of up to 30% of vine fibres to the composition of FBs, decrease in the bending strength of the boards from 56 to 29 N.mm^{-2}, or decrease of the studied indicator by 1.9 times, is observed.

In case of addition of up to 5% vine fibres, the variation of the bending strength is negligible, within the statistical error. This shows that up to 5% addition of vine fibres will not decrease the bending strength and they could be added to the composition of the boards, with the boards being manufactured according to the modes used for manufacture of boards from wood raw material. Difficulties from technological point of view would rather emerge because of the necessity of various modes for cutting and from the risk of separation of the mass of vine fibres in the pneumatic conveying installations.

The first significant drop of the studied property is observed in the vine fibres content above 10%. Here, decrease by 8 N.mm^{-2} or decrease by 11% in comparison with the property value in the reference board. In case of increase of the vine fibres content from 10% to 20%, uniform decrease in the value of the bending strength is observed, with the bending strength in the board with 20% participation of vine twigs being 75% of that of the reference board.

Very significant is the drop in FBs with 25% and 30% vine fibres content. With the increase of the vine fibres content by 25%, decrease by 10 $N.mm^{-2}$ or by 24% in comparison with the bending strength of boards with 20% participation of vine fibres is observed. This shows that, in view of the strength of FBs, the addition of more than 20% of vine fibres to their composition is unjustified.

The boards with vine fibres 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 40 $N.mm^{-2}$. This shows that the vine twigs 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 vine fibres content of 25% meet the requirements for bending strength of FBs for general purpose and for use in dry environment (BDS EN 622-5). And FBs with 30% vine fibres content do not meet the requirements to the studied property. Attention should be paid to the fact that the boards were manufactured with high PFR content – 10%. This makes the utilization of vine fibres in their composition of more than 20% unjustified with respect to the bending strength.

The variation of the water absorption of FBs at various participation of vine fibres is shown in Figure 3 in graphic form.

Under the conditions of the study, the water absorption of FBs varies from 61% to 38%. That is, the water absorption of the boards with 30% participation of vine fibres is by 62% worse, respectively higher, than that in the reference board that is without participation of vine fibres.

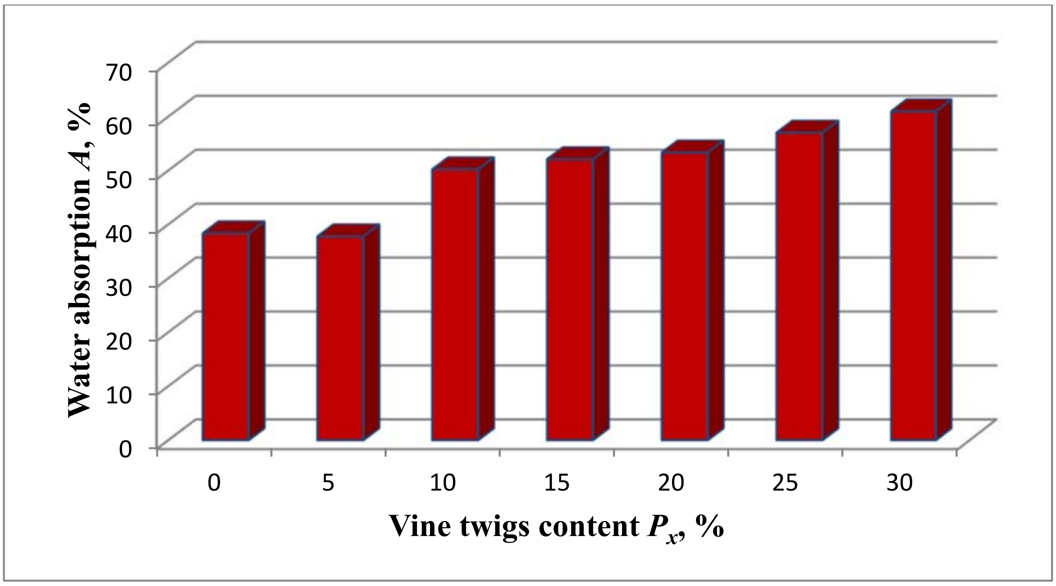

Figure 3: Variation of the water absorption of the boards at various vine twigs content

In case of addition of 5% vine fibres, no increase in the studies properties is observed in practice. Very significant is the deterioration, i.e. the indicator value increases, in case of increase of the vine fibres content from 5%

to 10%. Here, the relative deterioration of the property is by 31.5%.

In case of increase of the vine fibres content from 10% to 20%, uniform, at low rate, increase of the property is observed. The water absorption at 20% vine fibres content is only by 1.09% higher than that in boards with 10% vine fibres in the composition. Therefore, within this range of variation, the studied factor does not exercise significant influence.

The next significant increase of the property is when going beyond the limit of 25% vine fibres in the composition of the boards. Therefore, with a view to obtaining better water absorption of FBs, the increase of the vine twigs content in the composition of the boards to more than 20% is unjustified.

The variation of the swelling in thickness of FBs at various participation of vine fibres is shown in Figure 4 in graphic form.

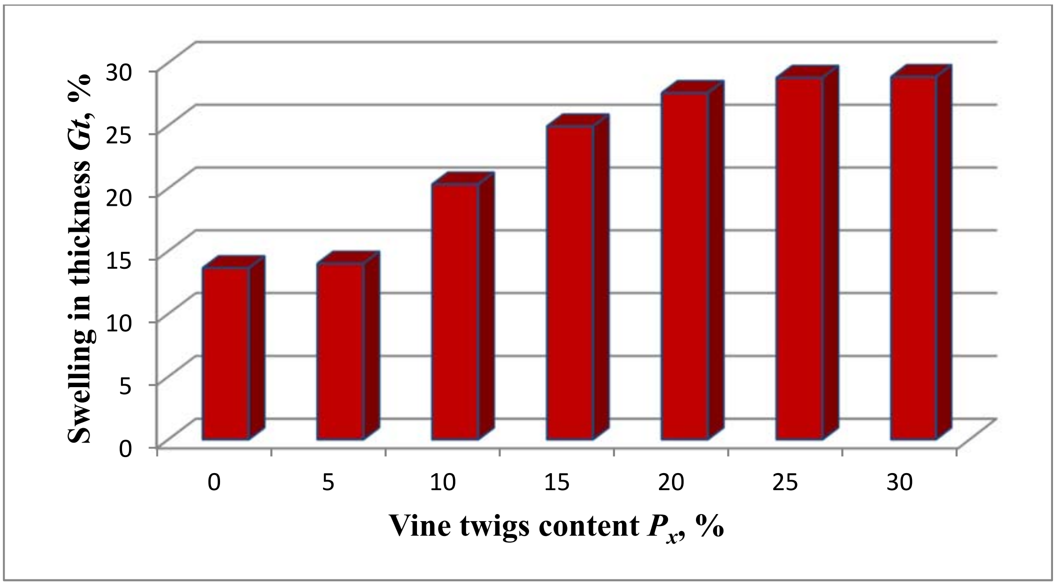

Figure 4: Variation of the swelling in thickness of boards at various vine twigs content

Under the conditions of the study, the swelling in thickness of FBs varies from 29% to 13.6%. That is, at 30% vine fibres content, the swelling in thickness is by 2.13 times worse, i.e. higher, than that of the reference board that is without participation of vine fibres.

In case of addition of 5% vine fibres, no significant variation in the swelling in thickness of the boards is observed. Big increase (deterioration) is observed in FBs with participation of vine fibres in quantity of 10% and more. The difference in the swelling in thickness between the boards with 5% and 10% participation of vine fibres is 6,12 %, i.e. the relative increase of the property is 42%. In the case of this property, the next significant deterioration is with the increase of the vine fibres content from 10% to 15%. Explanation may be sought here in the fact that vine twigs, in comparison with wood, have higher amount of hemicelluloses, mineral and ashy substances in their composition. And although the boards have absorbed approximately equal amounts of water, the bonds, adhesive and cohesive, between the fibrous elements at 15% vine fibres content are considerably worse than those at 10%, which leads to higher swelling.

In case of increase of the vine fibres content from 15% to 30%, uniform, at constant gradient, increase of the swelling in thickness is observed.

With respect to the swelling in thickness, the boards with more than 20% vine fibres content do not meet the requirements of the standard for minimum permissible value of swelling of 25%. Therefore, in order to utilize this raw material in quantities of more than 20% of vine fibres, modifications in the technological and mode factors in the manufacture of FBs should be introduced.

The boards with 10% and 15% vine fibres content meet the requirements to swelling in thickness in case of use of boards in dry environment. Under the conditions of the experiment, only the board with 5% vine fibres content meets the requirements with respect to the swelling in thickness for use in moist environment.

CONCLUSIONS

As a result of the conducted study of the effect of participation of vine fibres on the performance indicators of FBs manufactured after dry method, the following main conclusions may be drawn:

1) The participation of vine fibres up to 5% of the composition of FBs manufactured after dry method does not lead to significant change in their properties;
2) In case of increase of the vine fibres amount from 5% to 10% in the composition of FBs, significant deterioration in the studied properties of the boards is observed. The next significant deterioration is in case of addition of vine fibres more than 20% of the composition of FBs manufactured after dry method;
3) With respect to the bending strength, FBs with vine fibres content of up to 20% meet the most rigorous standardized requirements, viz. for boards with increased load-carrying capacity for bearing structures;
4) In case of application of FBs in moist environment, the vine fibres content should not exceed 5%, with the boards with vine fibres content of up to 20% meeting the requirements for use in dry environment;
5) Vine fibres, in quantities up to 20%, may be successfully utilized in the composition of FBs.

In conclusion, the following main recommendations may be made: The amount of vine fibres 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 vine fibres shall not exceed 5%. In subsequent studies, the effect of the vine fibres content within the range 5% to 10% and 10% to 20% should be studied (with lower increment).

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