INFLUENCE OF THE CHEMICAL COMPONENTS OF VINE VARIETIES ON THE PROPERTIES OF PARTICLE BOARDS

[1]FERRÁNDEZ-GARCÍA, Mª TERESA, [2]FERRÁNDEZ-GARCÍA, ANTONIO, [3]FERRÁNDEZ-GARCÍA, BERTA ELENA, [4]GARCÍA-ORTUÑO, TERESA, [5]RUIZ-CANALES, ANTONIO, [6]FERRÁNDEZ-VILLENA, MANUEL

[1]Department of Engineering, Escuela Politécnica Superior de Orihuela. Miguel Hernández University. Ctra. Orihuela-Beniel, km 3.2, 03312 Orihuela (Alicante). Spain
E-mail: chmyck@ccu.edu.tw

Abstract - The use of by-products of agricultural and forestry activity, apart from many other environmental benefits, constitutes an alternative source of income or cost reduction and supports the principles of circular economy. In the Valencian Community, the area devoted to growing vineyards is 73,095 hectares. The periodic maintenance of the crop is carried out through winter pruning from December to March. These prunings are burned or crushed and incorporated into the soil, causing environmental contamination and disease transmission. The aim of this study was to determine the influence of the chemical composition of three vine varieties (Bobal, Garnacha and Monastrell) on the properties of particleboards made with those varieties. In the manufacturing of these boards, grapevine particles without binder with two particle sizes (< 0.25 mm and 0.25-1 mm) and two pressing time cycles (15 min and 15 + 15 min) were used as raw material, obtaining 4 particleboards of each type, hence 48 boards were made. The chemical composition (% tannins and % sugars) of the raw material and the manufactured board were analyzed, as well as the properties of thickness swelling, modulus of rupture, modulus of elasticity and internal bonding strength, following the European Standards applicable to wood particleboards. The best mechanical properties were obtained with the Monastrell variety, since its initial chemical composition has higher percentages of sugars. Therefore, it can be concluded that the higher the amount of sugar, the higher the mechanical properties values are.

Keywords - Bobal, Garnacha, Monastrell, Mechanical Properties, Agricultural Waste.

I. INTRODUCTION

The European Green Deal of December 2019, was designed to respond to climate change and the degradation of the environment to which Europe and the rest of the world are subjected. It establishes a new growth strategy that seeks to transform the European Union into a fair and prosperous society, with a modern economy, efficient in the use of its resources and with the aim of making the European Union the first climate-neutral continent by the year 2050. Within the circular economy strategy, one of the priorities will be the use of waste and bio-intelligent production.

On the other hand, the International Organization of Vine and Wine OIV [1] estimated the world area destined for vine cultivation in 2018 at 7.4 million hectares, of which approximately one million is in Spain. Vineyards generate a large amount of pruning waste every year and traditionally, the two most common forms of disposal have been in situ burning, which produces air pollution, or crushing it with the subsequent incorporation of the pruning waste to the soil, which implies the possible colonization by larvae, parasites and fungi that can be a source of diseases and eutrophication of the water.

A solution to problem would be the transformation of said residues into resources for the elaboration of different products, since it would produce an agricultural and environmental benefit.

There are about 10,000 grape varieties in the world, however, only a few are used in winemaking. Among the best-known varieties in Spain are the Tempranillo, Cabernet Sauvignon, Monastrell grapes and the two most widespread in eastern Spain, which are the Garnacha and Bobal varieties. The objective of the research was to evaluate the influence of the chemical composition of three vine varieties (Bobal, Garnacha and Monastrell) on the properties of the particleboards manufactured with them.

II. MATERIALS AND METHODS

Materials used were residues of vinegar pruning from varieties Garnacha, Bobal and Monastrell. All pruning came from farms in eastern Spain. Water used came from the municipal network.

First, the chemical composition (% tannins and % sugars) of the three varieties was analyzed. Subsequently, pruning residues were left to dry for 6 months and then were trimmed in a blade mill. The particles were sieved and classified according of their size, using for this research particles that passed through the sieve of 0.25 mm (<0.25 mm) and those which passed through the sieve of 1.00 mm and were retained in the 0.25 mm (0.25 to 1.00 mm).

After the classification of the particles, boards were manufactured in a hot press by combining the next variables: 2 particle sizes (<0.25 mm and 0.25-1.00 mm) 3 materials (Bobal, Garnacha and Monastrell), and 2 pressing times (15 and 15+15 min) with 4 repetitions, resulting in 48 particleboards. Any adhesive was used and the particleboards had an approximately thickness of 7 mm. Pressing

temperature and pressure were fixed at 150 ºC and 2.6 MPa respectively. Pressing time was a cycle of 15 minutes or 2 cycles of 15 minutes with a 4 hours pause for cooling at room temperature.

The manufacturing process started with the formation by hand of the mat in a mold of 600x400 mm in which 1.50 kg of particles were sprayed with 10% of water (in relation of the particles weight) over its surface. The mold was then put into the hot press with the parameters mentioned above. In table 1 the processing parameters are shown for each of the particleboards.
After cooling, particleboards were cut for obtaining the samples for the characterization of its physical and mechanical properties and its later classification.
Properties of the particleboards were determined by following the European Standards for wood particleboards [2] and measured according to: density [3], thickness swelling (TS) and water absorption (WA) after 2 and 24 hours under water [4], internal bonding stress (IB) [5], modulus of rupture (MOR) and modulus of elasticity (MOE) [6]. The particleboards were evaluated according to the European standard [7]. The chemical composition (% tannins and % sugars) of the boards made was also analysed.
Mechanical tests were performed in a universal testing machine (Model IB700, Imal, S.R.L., Modena, Italy). Statistical analysis was carried out with the software SPSS v. 26.0 (IBM, Chicago, IL, USA). From the average values, standard deviation was obtained and a variance analysis (ANOVA) for a significance $\alpha < 0.05$ was performed.

III. RESULTS AND DISCUSSION

The chemical composition (% tannins and % sugars) of the vine varieties and their boards is shown in the following table 2.
Table 2 shows that the amount of tannins and sugars got lost or partially lost once the particle board is manufactured.
The density, mechanical properties, thickness swelling and water absorption of the manufactured particleboards are shown in table 3.
The best mechanical properties have been obtained by particle boards of the Monastrell variety with a smaller particle size and two pressing cycles. On the other hand, the board made from the Garnacha variety with the smallest particle size and two pressing times achieved the best results of thickness swelling and water absorption. In addition, it was noted that particleboards made with two pressing cycles obtained higher densities. After the analysis of variance and correlations (table 4), it is observed that the particle size influences all the properties studied, resulting in better values with smaller size. It can also be seen that the pressing time only influences density (the longer the pressing time, the higher the density of the boards). Besides, the variety influences the MOR, MOE, IB and WA; the % of tannins in the WA, in the IB and WA; and the quantity of sugars, in the MOR and MOE (with higher quantity of sugars, better mechanical properties of the boards).

IV. CONCLUSION

It is feasible to manufacture particleboards made from pruning branches of vineyards of the Garnacha, Bobal and Monastrell varieties without any type of adhesive. High-density boards were obtained with the three vine varieties. The boards with the smallest particle size (<0.25 mm) had better mechanical properties, as well as the Garnacha and Monastrell varieties reached higher flexural strength and modulus of elasticity values. Type 1Aa, 1Ab and 3Ba boards met the requirements, specified in the European Standards, for type P1 boards and type 3Ab for type P2 boards.
These results confirm that the variety influence almost all properties of the boards. When the three are compared, the Monastrell had the best mechanical properties. Therefore, the chemical composition of the varieties, in relation to the amount of sugars, does influence the mechanical properties: the higher the MOR, the higher the amount of sugars. However, this was not observed with regard to the percentage of tannins.

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Fig 1. Vinegar particles of size <0.25 mm (left) and from 0.25 to 1.00 mm (right)



Fig 2. Particleboard manufactured with the two particle sizes (<0.25 mm and 0.25-1.00 mm) from the varieties bobal (left), garnacha (centre) y monastrell (right).

Type of board	Variety	Number of boards	Particle size (mm)	Time (min)	Temperature (ºC)	Pressure (MPa)
1Aa	Garnacha	4	< 0.25	15	150	2.6
1Ab	Garnacha	4	< 0.25	15+15	150	2.6
1Ba	Garnacha	4	0.25 a 1.00	15	150	2.6
1Bb	Garnacha	4	0.25 a 1.00	15+15	150	2.6
2Aa	Bobal	4	< 0.25	15	150	2.6
2Ab	Bobal	4	< 0.25	15+15	150	2.6
2Ba	Bobal	4	0.25 a 1.00	15	150	2.6
2Bb	Bobal	4	0.25 a 1.00	15+15	150	2.6
3Aa	Monastrell	4	< 0.25	15	150	2.6
3Ab	Monastrell	4	< 0.25	15+15	150	2.6
3Ba	Monastrell	4	0.25 a 1.00	15	150	2.6
3Bb	Monastrell	4	0.25 a 1.00	15+15	150	2.6

Table 1. Types of board manufactured

	Garnacha	Board of Garnacha	Bobal	Board of Bobal	Monastrell	Board of Monastrell
% Tannins	ND	ND	8.43	ND	11.02	ND
% Sugars	1.48	0.16	< 0.1	< 0.1	4.23	0.24

Table 2. Chemical composition (% tannins and % sugars).

ND: Not detected

Type of board	Density (kg/m^3)	MOR (N/mm^2)	MOE (N/mm^2)	IB (N/mm^2)	TS24h (%)	WA24h (%)
1Aa	988.3 (23.66)	11.50 (1.21)	1454.8 (148.70)	0.57 (0.31)	15.88 (6.82)	49.37 (5.61)
1Ab	999.8 (59.76)	11.40 (0.70)	1717.9 (254,51)	0.96 (0.15)	13.53 (4.35)	48.40 (17.20)
1Ba	901.52 (21.95)	6.26 (1.01)	708.87 (163.87)	0.14 (0.16)	43.57 (7.09)	60.21 (11.40)
1Bb	957.42 (62.45)	9.37 (2.06)	1027.50 (235,16)	0.43 (0.26)	78.72 (8,65)	122.21 (30.43)
2Aa	1060.19 (35.22)	6.25 (0.76)	675.09 (116,34)	0.29 (0.05)	45,83 (4,46)	96,65 (10.01)
2Ab	1118.75 (55.58)	9.84 (1.38)	1281.26 (236.59)	0.29 (0.04)	28.85 (3,70)	62.85 (9.407)
2Ba	819.87 (61.06)	4.12 (0.47)	560.07 (270.31)	0.15 (0.02)	68.31 (7,77)	192.05 (9.32)
2Bb	930.39 (44.40)	4.13 (1.04)	471.15 (134,94)	0.19 (0.03)	66.28 (6,289)	187.16 (27.72)
3Aa	760.55 (54.62)	13.1175 (0.70)	1389.73 (154.21)	0.0925 (0.026)	19.31 (3.34)	83.50 (10.48)
3Ab	1059.81 (31.40)	22.14 (1.70)	2974,4 (481,36)	0.61 (0.045)	24.41 (2.55)	58.84 (4.94)
3Ba	949.28 (19.55)	12.88 (2.35)	1704.9 (256.01)	0.33 (0.12)	72.08 (5.99)	191.10 (8.72)
3Bb	972.74 (21.70)	12.70 (1.48)	1483.81 (153.95)	0.185 (0.013)	67.37 (4.56)	104.57 (10.27)

Table 3. Average results of mechanical, physical and thermal properties.

MOR: Modulus of rupture. MOE: Modulus of elasticity. IB: Internal bonding strength. TS: thickness swelling. WA: water absorption. (..): standard deviation.

Properties	Particle size (mm)	Time (min)	Variety	Tannins (%)	Sugars (%)
Density (kg/m^3)	-0.367^{*}	0.480^{**}	-0.103	-0.054	-0.183
TS 24 h (%)	0.866^{**}	0.013	0.088	0.134	-0.074
WA 24 h (%)	0.692^{**}	-0.122	0.288^{*}	0.379^{**}	-0.087
MOR (N/mm^2)	-0.436^{**}	0.234	0.471^{**}	0.280	0.748^{**}
MOE (N/mm^2)	-0.442^{**}	0.263	0.394^{**}	0.221	0.661^{**}
IB (N/mm^2)	-0.425^{**}	0.322^{*}	-328^{*}	-0.409^{**}	0.040

Table 4. Correlations of the results of the tests.

*. The correlation is significant at the 0.05 level (bilateral).
**. The correlation is significant at the 0.01 level (bilateral).

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