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FEASIBILITY OF OLIVE TREE PRUNING AS ALTERNATIVE RAW MATERIAL FOR CEMENT BONDED PARTICLEBOARD

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Abstract:
Feasibility of olive tree pruning was studied as an alternative raw material for cement bonded particleboard. Experimental cement bonded particleboards had the dimensions of 500×500mm, a thickness of 12mm and an averaged density of 1200kg/m^3. They were manufactured using two different ratios of olive pruning particles with Red pine wood in laboratory conditions. $CaCl_2$, KCl and DARASET 580® were added to the particle cement mixture as accelerator in order to improve board properties. Water absorption, thickness swelling and bending properties of the cement bonded particleboards were evaluated using suitable standard. Results of the study showed that use of olive pruning in the production of cement bonded particleboard significantly influence the properties tested. Bending properties of the tested boards were decreased when $CaCl_2$ was existed in the mixture while water absorption and thickness swelling values were increased. In the presence of KCl, bending strength and thickness swelling of the boards were not altered by the addition of pruning materials but bending stiffness and water absorption values were significantly improved. Use of DARASET 580® in the particle cement mixture improved thickness swelling values while decreasing bending properties. Results indicate that addition of olive tree pruning yields poor board properties which make them unsuitable for structural applications but boards with low mechanical properties may be used as other purposes such as insulation.

Key words*: olive pruning; cement-bonded particleboard; water absorption and mechanical properties.*

INTRODUCTION

Deforestation and increase of demand for wood based materials promote investigation of a wide variety of materials such as agricultural residues, plantation of fast growing and annual plants and recycling of wood products as alternative to wood for the use in the manufacturing of wood based composites. The motive behind these investigations was to develop environmentally friendly building materials based on natural renewable raw materials. During the last few decades, plenty of raw materials have been technically find suitable in the production of wood based composites (Klimek and Wimmer 2017). Although agricultural residues have some advantages such as availability and low density, the properties of composites manufactured from these materials have mostly inferior properties (Sun *et al.* 2013). Collection and transportation of these agricultural residues stand as other obstacles for the utilization of these materials (Guntekin and Karakus 2007).

Cement bonded wood products which may contain a variety of woody forms in the structure with cement, water and some additives (Marteinsson and Gudmundsson 2018) have been in the market in most of the world (Nazerian *et al.* 2018). They have some advantages such as durability, dimensional stability, acoustic and thermal insulation properties and low production cost compared to composites produced with organic resins (Lee 1984; Ramirez-Coretti *et al.* 1998; Savastano *et al.* 2003; Okino *et al.* 2005; Del Menezzi *et al.* 2007). Woody materials which found technically suitable for the manufacture of cement bonded particleboard includes grapevine stalks (Wang *et al.* 2013), some pruning of *Acacia salicina, Ficus altissima, Pithecellobium dulce and Tamarix aphylla* (Abdel-Aal 2014) date palm fronds and pruning of buttonwood (Nasser 2014) and oil palm veins (Ayrılmış *et al.* 2017). Most of the investigations noted above applied pretreatments to the particles such as cold or hot water in order to overcome inhibition.

Olive (*Olea Europea*) trees which are native to the Mediterranean countries are cultivated in more than 40 countries. The area covered by the olive trees was about 10.8 million ha in 2017 (Faostat 2019). Olive tree pruning has been applied just after fruit collection and is a necessary action carried out every two years after harvesting (Fernandez *et al.* 2019). Olive tree pruning which usually less efficiently utilized by burning is abundant source of biomass for Mediterranean countries.

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OBJECTIVE

In this study, utilization of particles produced from olive tree pruning with wood particles was studied in the production of experimental cement bonded particleboard.

METHOD

Cement bonded particleboards had the dimensions of 500mmx500mm, a thickness of 12mm and an average target density of 1200kg/m^3. Coarse wood particles (thickness of 0.3 to 0.7mm and length of 1 to 7mm) with or without pruning particles were mixed with commercial cement (CEM I 42.5), tap water and accelerator in the laboratory conditions. The amount of olive tree pruning particles added to the wood particles was 25 and 50% based on the wood particle weigh. Wood particles/cement ratio was 1:2 and 1:3; water/cement ratio was 1/2.5. 5% of $CaCl_2$ additive based on cement mass was added to the water before mixing. Two other chemical component namely Potassium Chloride (KCl) and DARASET 580® which are used as cement-bond improver and accelerator, respectively were also utilized instead of $CaCl_2$.

Coarse particles of Red pine (*Pinus brutia*) wood were provided from a local particleboard factory. Olive tree pruning which were gathered from a close field were dried and passed through a hammer mill and screened. Particles left between 3-5mm sieves were used in the experiments.

The production of experimental cement bonded boards was carried out as follows: First, wood and pruning particles were mixed and sprayed with water which contains previously dissolved accelerator. Then, cement was added to the mixture until a homogeneous distribution obtained. After mixing, fresh mixtures were spread in a steel frame by hand and cured for 2 days. The mixture which was placed between steel plates was left for curing under the pressure of 1.8-2.0N/mm^2. The cured boards were conditioned in the laboratory climate at approximately +20°C, RH 65%. Samples were cut down after curing to required size in order to determine water absorption, thickness swelling and bending properties.

Water absorption (%) and thickness swelling values (%) after 2 hour and 24 hour of immersion were determined according to TS EN 317 (1999). Bending properties (strength and stiffness) of the boards were determined according to TS EN 310 (1999).

Five replicates were used for each test and obtained data were subjected to an analysis of variance. Experimental results were analyzed using ANOVA tests to identify their statistical significance. Duncan's multiple range tests were performed in order to find the least significant difference between all the variables. The obtained results were also compared to standard values of TS EN 634-2 (2009).

RESULTS AND DISCUSSIONS

Table 1 shows water absorption and thickness swelling properties of cement bonded particleboard samples manufactured using $CaCl_2$. Test results indicate that water absorption (%) values of the manufactured boards after 2 and 24 hours of immersion in water were significantly increased as the amount of olive pruning particle used in the mixture is increased ($P<0.001$; R^2 = 0.88; 0.95). Boards without pruning had the lowest water absorption values than other groups. 24 hour thickness swelling (%) values of the manufactured boards were significantly affected by the proportion of olive pruning used in the study ($P<0.001$; R^2= 0.74). Thickness swelling values after 24 hours of water immersion were the highest for the group containing 25% olive pruning.

Table 2 presents water absorption and thickness swelling properties of cement bonded particleboard samples manufactured using KCl. Analysis of variance (ANOVA) results indicate that addition of olive tree pruning significantly influence the water absorption capacity (2 and 24 hour) of the cement bonded particleboards ($P<0.001$; R^2= 0.98; =0.95). Water absorption (%) values of the manufactured boards after 2 and 24 hours of immersion in water were significantly decreased as the amount of olive pruning particle used in the mixture is increased to 50%. 24 hour thickness swelling (%) values of the manufactured boards were not significantly affected by the proportion of olive pruning used in the study in the presence of KCl.

Table 1

Some physical properties of the cement bonded particle boards manufactured in the presence of $CaCl_2$

Particle/cement ratio	Wood/pruning ratio	WA 2 hour (%)	WA 24 hour (%)	TS 2 hour (%)	TS 24 hour (%)
1/2	100/0	8.6 (0.75)	10.56 (0.69)	3.6 (0.11)	5.58 (0.28)
	75/25	4.89 (1.18)	11.38 (1.19)	3.8 (0.63)	7.7 (0.76)
	50/50	11.41 (0.8)	16.17 (0.68)	3.72 (0.58)	5.6 (1.22)
1/3	100/0	2.8 (1.01)	6.46 (0.78)	2.9 (0.45)	4.9 (0.45)
	75/25	6.59 (1.34)	10.15 (0.29)	7.66 (4.9)	8.1 (1.29)
	50/50	7.95 (1.34)	9.34 (0.18)	3.13 (1.04)	4.8 (0.68)

*Values in parenthesis are standard deviations

Table 2

Some physical properties of the cement bonded particle boards manufactured in the presence of KCl

Particle/cement ratio	Wood/pruning ratio	WA 2 hour (%)	WA 24 hour (%)	TS 2 hour (%)	TS 24 hour (%)
1/2	100/0	23.87 (4.1)	26.4 (1.21)	5.97 (0.98)	7.39 (1.2)
	75/25	35 (2.6)	37.8 (1.75)	6.41 (2.3)	7.85 (1.21)
	50/50	22.18 (1.1)	22.1 (1.1)	5.44 (1.38)	8.08 (1.2)
1/3	100/0	17.7 (0.91)	17.8 (1.03)	3.34 (0.54)	4.1 (1.08)
	75/25	8.85 (0.21)	7.5 (1.25)	3.68 (1.75)	4.48 (0.72)
	50/50	8.77 (0.22)	11.85 (1.27)	4.58 (1.48)	3.7 (1.23)

*Values in parenthesis are standard deviations

Table 3 shows water absorption and thickness swelling properties of cement bonded particleboard samples manufactured using DARASET 580®. Test results indicate that addition of olive tree pruning significantly influence the water absorption capacity (2 and 24 hours) of the cement bonded particleboards ($P<0.001$; $R^2= 0.99$). Water absorption (%) values of the manufactured boards after 2 and 24 hours of immersion in water were decreased almost linearly as the amount of olive pruning particle used in the mixture is increased. Boards without pruning had the highest water absorption values than other groups. 2 and 24 hour thickness swelling (%) values of the manufactured boards were significantly affected by the proportion of olive pruning used in the study ($P<0.001$; $R^2= 0.90$; 0.87). Thickness swelling values after 2 and 24 hours of water immersion were the highest for the group without olive pruning.

Table 3

Some physical properties of the cement bonded particle boards manufactured in the presence of DARASET 580®

Particle/cement ratio	Wood/pruning ratio	WA 2 hour (%)	WA 24 hour (%)	TS 2 hour (%)	TS 24 hour (%)
1/2	100/0	25.7 (0.78)	34.6 (0.97)	12.39 (0.6)	16.5 (0.11)
	75/25	22.5 (1.27)	27.2 (1.2)	7.88 (1.61)	12.1 (1.61)
	50/50	18.1 (0.34)	24.8 (0.47)	8.1 (0.8)	11.6 (0.71)
1/3	100/0	18.14 (0.54)	23.33 (0.69)	4.6 (0.28)	6.46 (0.35)
	75/25	9.09 (0.2)	11.36 (0.25)	5.7 (0.98)	10.2 (0.88)
	50/50	7.28 (0.14)	12.1 (0.24)	5.1 (1.02)	4.42 (0.18)

*Values in parenthesis are standard deviations

Comparing three chemicals used as the accelerator for the mixture; although KCl and DARASET 580® seemingly has decreasing effect on water absorption and thickness swelling, high amount of WA and TS values produced from the experimental boards make them questionable. Higher water absorption and thickness swelling values may also be attributed to chemical composition of the olive pruning. According Fernandez *et al.* (2019) olive pruning contains high percentages of extractives.

In general, higher particle content causes higher water absorption and thickness values (Moslemi and Pfister 1987; Savastano *et al.* 2003; Olorunnisola 2009). Some chemical additives in addition to type of wood particle and wood-cement ratio may also influence water absorption properties (Olorunnisola 2009) and higher cement content in the mixture decreases thickness swelling of cement bonded particleboard (Moslemi and Pfister 1987). Higher thickness swelling ratio may be also attributed to accelerators used which are highly hygroscopic.

It seems that all the experimental boards yielded higher amount of thickness swelling values than those required by the standard (TS EN 634-2). Water absorption and thickness swelling values could be lowered by application of pre-treatment or using fine particles.

The bending properties of cement bonded particleboard are presented in Tables 4-6. Test results indicate that addition of olive tree pruning slightly reduces the bending strength of the cement bonded particleboards ($P<0.001$; $R^2= 0.87$), and greatly decreases bending modulus of elasticity ($P<0.001$; $R^2 = 0.79$) when $CaCl_2$ was used as accelerator. Test results indicate that addition of olive tree pruning do not significantly affect the bending strength of the cement bonded particleboards and slightly increase bending modulus of elasticity ($P<0.001$; $R^2= 0.99$) when KCl was presented in the mixture. Test results indicate that addition of olive tree pruning slightly reduces the bending strength and stiffness of the cement bonded particleboards ($P<0.001$; $R^2= 0.98$) when DARASET 580® was used in the mixture. Overall, the bending properties of boards manufactured with $CaCl_2$ are superior to the other chemicals utilized. Higher cement ratio seemed to yield better mechanical properties for the boards tested.

Table 4

Bending properties of the cement bonded particle boards manufactured in the presence of CACl₂

Particle/cement ratio	Wood/pruning ratio	MOE	MOR
1/2	100/0	4337 (191)	11.5 (0.38)
	75/25	3321 (112)	9.86 (0.33)
	50/50	3665 (173)	10.86 (0.5)
1/3	100/0	4226 (273)	12.4 (0.3)
	75/25	3903 (276)	10.95 (0.11)
	50/50	3389 (249)	9.68 (0.56)

**Values in parenthesis are standard deviations*

Table 5

Bending properties of the cement bonded particle boards manufactured in the presence of KCl

Particle/cement ratio	Wood/pruning ratio	MOE	MOR
1/2	100/0	633 (29)	7.04 (0.65)
	75/25	433 (28)	4.85 (0.46)
	50/50	528 (51)	6.19 (0.58)
1/3	100/0	1354 (26)	5.95 (0.65)
	75/25	1569 (52)	8.66 (0.23)
	50/50	1770 (79)	7.13 (0.23)

**Values in parenthesis are standard deviations*

Table 6

Bending properties of the cement bonded particle boards manufactured in the presence of DARASET 580 ®

Particle/cement ratio	Wood/pruning ratio	MOE	MOR
1/2	100/0	701 (24)	3.7 (0.33)
	75/25	638 (17)	3.5 (0.09)
	50/50	524 (6)	2.9 (0.05)
1/3	100/0	2144 (118)	10.7 (0.7)
	75/25	1635 (126)	8.82 (0.4)
	50/50	1823 (84)	10.1 (0.47)

**Values in parenthesis are standard deviations*

It seems that none of the groups that contains olive pruning provides the minimum standard values of bending stiffness and required by the standard TS EN 634-2 (2009). Bending strength values are satisfied when $CaCl_2$ was used as accelerator. In general, higher bending stiffness (MOE) may be achieved with decreasing particle content for cement bonded boards (Al Rim *et al.* 1999) or density increase (Moslemi and Pfister 1987; Oyagade 1990). According to Bejo *et al.* (2005) better mechanical properties may be attained when densification of the boards increased.

The main reason behind the inadequate physical and mechanical properties of the boards manufactured with the olive pruning could be the density. According to Duzkale *et al.* (2015) the air dry density of the olive wood is $0.86g/cm^3$ which could not be easily compressed resulting some gaps or voids during manufacturing thus yielding undesirable board properties.

It is known that hardwoods contain larger amount of inhibitory components than softwoods (Ronquim *et al.* 2014). A possible contributory factor to the relatively low bending properties of the boards could be higher percentages of extractives compared with softwood/hardwood (Fernandez 2019). Olorunnisola (2007) and Ashori *et al.* (2012) hold water-soluble extractives responsible for inhibition of cement thus, low strength. Reduction in bending properties may be prevented by application of pretreatments which were found acceptable for many lingo-cellulosic materials (Moslemi *et al.* 1983; Lee 1984; Zhengtian and Moslemi 1985; Lee and Short 1989).

CONCLUSIONS

This study explored the feasibility of olive pruning in cement-bonded particleboard production, under laboratory conditions. Based on the results of the study, use of olive pruning in the particle/cement mixture significantly increases water absorption and thickness swelling properties and reduces bending properties of cement bonded particleboard tested in the presence of $CaCl_2$. Only contribution of KCl to wood cement mixture is thickness swelling which seems to be the lowest among all boards manufactured. Although use of DARASET 580® seems to decrease water absorption and thickness swelling values, they are still higher than other groups. Extractives may be hold responsible for the higher water uptake and lower mechanical properties. Inadequate board properties may be improved by application of pretreatments, utilization of fine particle or densification of the boards. Boards with low mechanical properties may be used as other purposes such as insulation.

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