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New insulation fiberboards from sunflower cake with improved thermal and mechanical properties

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Introduction

- Biorefinery of sunflower (*Helianthus annuus* L.) whole plant can be conducted in a co-rotating Clextral BC 45 (France) twin-screw extruder [1].
- The cake generated is largely composed of lignocellulosic fibers (more than 50%). Actually, it is a lixiviated matter where soluble molecules (proteins, pectins) and lipids are partly removed. At the same time, molecules from plant skeleton are not extracted.
- As a natural composite, it is successfully processed into dense boards by thermo-pressing [1,2]. Proteins ensure the agromaterial cohesion, and fibers entanglement also acts like reinforcement.
- Thermal insulation fiberboards can be also produced [3]. But, their ability for thermal insulation of buildings would have to be improved.
- This study aimed to manufacture by compression molding at ambient temperature new insulation fiberboards with improved thermal and mechanical properties by adding to the cake different natural binders at different contents (Fig. 1).
- The influence of molding conditions on board density, flexural properties, and heat insulation properties was examined.
- Molding conditions included binder type (starch-based binder, casein or gelatin) and binder content (10%, 15%, 20% and 25%) (Table 1).

Results and discussion

- The starting material was a powder consisting of inhomogeneous particles (Fig. 2), and fibers (i.e. the largest particles) represented 51.6% of its dry matter.
- All fiberboards were cohesive mixtures of a natural binder and lignocellulosic fibers (i.e. filler), in what could be considered as a natural composite (Fig. 3).
- Board density increased with increasing binder content: 338-375 kg/m^3 for S, 266-439 kg/m^3 for C, and 255-315 kg/m^3 for G.
- The mechanical properties increased at the same time (Fig. 4).
- Conversely, heat insulation properties improved with decreasing board density, and the lowest thermal conductivity was obtained for each natural binder tested with the least dense fiberboard (Fig. 5).

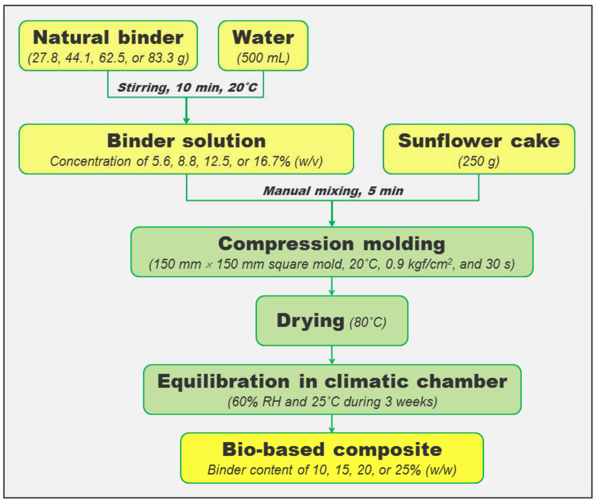

Fig. 1. Process for bio-based composite manufacturing.

Table 1
Molding conditions for the manufacture of the twelve fiberboards.

Board number	S1	S2	S3	S4	C1	C2	C3	C4	G1	G2	G3	G4
Binder type	S	S	S	S	C	C	C	C	G	G	G	G
Binder content (%)	10	15	20	25	10	15	20	25	10	15	20	25

S, starch-based binder; C, casein; G, gelatin.

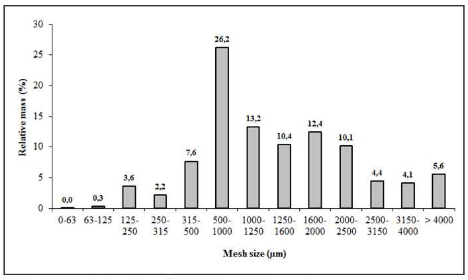

Fig. 2. Particle size distribution in the cake.

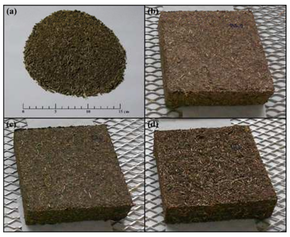

Fig. 3. Photographs of the cake (a) and of the three fiberboards with 25% binder content (b, board S4; c, board C4; d, board G4).

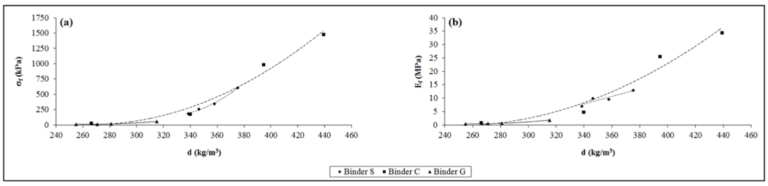

Fig. 4. Flexural strength at break (a) and elastic modulus (b) of the twelve fiberboards manufactured by compression molding, as a function of their density.

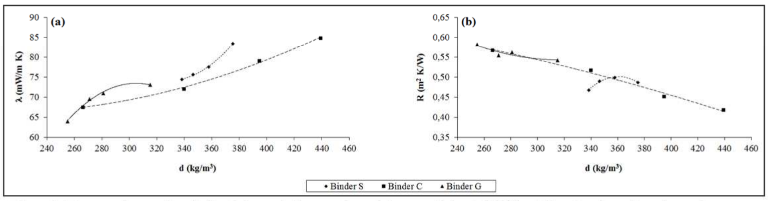

Fig. 5. Thermal conductivity (a) and thermal resistance (b) at 25°C of the twelve fiberboards manufactured by compression molding, as a function of their density.

Conclusion

- New insulation fiberboards from sunflower cake with improved thermal and mechanical properties were produced by pressing at ambient temperature.
- Best compromise between mechanical and heat insulation properties (λ = 77.6 mW/m K at 25°C) was a starch-based board with 20% binder content.
- Because of its promising heat insulation properties, this new fiberboard could be positioned on walls and ceilings for thermal insulation of buildings.
- The bulk cake was an even better insulation material (only 62.0 mW/m K for thermal conductivity at 25°C): usable as loose fill in the attics of houses.

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