HAL
open science

Stems from amaranth (Amaranthus cruentus), an original agricultural by-product for obtaining low-density insulation blocks and hardboards for building applications

Philippe Evon, Guyonne de Langalerie, Laurent Labonne, Othmane Merah, Thierry Talou, Stéphane Ballas, Thierry Véronèse

To cite this version:

Philippe Evon, Guyonne de Langalerie, Laurent Labonne, Othmane Merah, Thierry Talou, et al.. Stems from amaranth (Amaranthus cruentus), an original agricultural by-product for obtaining low-density insulation blocks and hardboards for building applications. Journée de lancement du GDR MBS, Jun 2020, Champs-sur-Marne, France. pp.0, 2020. hal-02648472

HAL Id: hal-02648472

https://hal.science/hal-02648472

Submitted on 29 May 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Open Archive Toulouse Archive Ouverte

OATAO is an open access repository that collects the work of Toulouse researchers and makes it freely available over the web where possible

This is an author's version published in: http://oatao.univ-toulouse.fr/25896

To cite this version:

Evon, Philippe and de Langalerie, Guyonne and Labonne, Laurent and Merah, Othmane and Talou, Thierry and Ballas, Stéphane and Véronèse, Thierry *Stems from amaranth (Amaranthus cruentus), an original agricultural by-product for obtaining low-density insulation blocks and hardboards for building applications.* (2020) In: Journée de lancement du GDR MBS, 16 June 2020 - 16 June 2020 (Champs-sur-Marne, France). (Unpublished).

Any correspondence concerning this service should be sent to the repository administrator: tech-oatao@listes-diff.inp-toulouse.fr

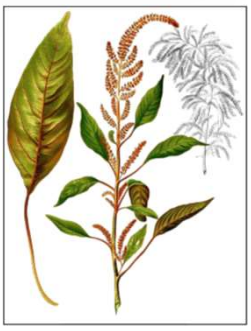
Stems from amaranth (*Amaranthus cruentus*), an original agricultural by-product for obtaining low-density insulation blocks and hardboards for building applications

Ph. Evon[1(*)], G. de Langalerie[1,2], L. Labonne[1] , O. Merah[1], T. Talou[1], S. Ballas[2], T. Véronèse[2]

[1] Laboratoire de Chimie Agro-industrielle (LCA), Université de Toulouse, ENSIACET, INRAE, Toulouse INP, Toulouse, France
[2] Ovalie Innovation, Auch, France
* e-Mail address (corresponding author): Philippe.Evon@ensiacet.fr (Ph. Evon)

Introduction

- *Amaranthus cruentus*, an annual herb native to temperate and tropical regions (cultivated for the nutritional properties of seeds).
- A promising raw material for the biorefinery of whole plant (all parts potentially usable for food and non-food applications).
- Seeds contain: - A lipid fraction (7-8%), rich in squalene of vegetal origin (5-6%) → **FOOD SUPPLEMENT**, **COSMETICS** [1].
  - Proteins (15%) → **BREAD FLOURS**, **BIOCIDAL AND ANTIOXYDANT ACTIVITIES** [2].
  - Starch (up to 55%) → **INJECTION-MOULDING APPLICATIONS**.
- This study especially aims to investigate the possible uses of stems for **material applications**.



Amaranthus cruentus

Results and discussion

- Structure of stems was studied from ten samples: pith fraction was estimated to 24% (w/w).
- Difference in density between bark and pith fractions ⇨ Continuous separation possible through (i) **grinding** and (i) **blowing**.

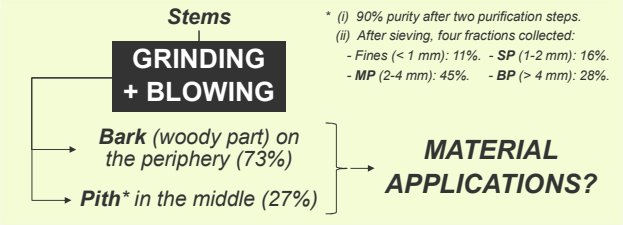
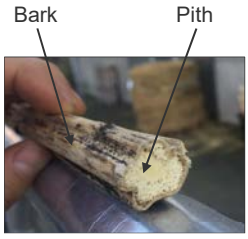


Tableau 1. Characteristics of insulation blocks.

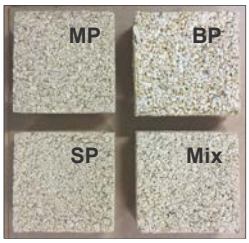
Pith particles	d (kg/m³)	σ_f (kPa)	λ (mW/m.K)
SP	116 ± 1	15.8 ± 1.9	57.5 ± 0.6
MP	100 ± 5	23.0 ± 3.3	54.8 ± 1.5
BP	**89 ± 2**	**84.5 ± 8.2**	**56.0 ± 1.4**
Mix (all fractions)	130 ± 3	59.3 ± 4.5	60.3 ± 1.5

d, density; σ_f, flexural strength ; λ, thermal conductivity.



Cross section of stem

- Alveolar structure for pith particles ⇨ Low bulk density (47 kg/m³ for 4-16 mm particle size) ⇨ Raw material for **thermal insulation**.
- Cohesive materials produced through compression molding (87 kPa, 30 sec, 25 ºC), thanks to the addition of 10% starchy binder.
- **Best compromise between flexural and heat insulation properties with the big pith particles (BP), *i.e.*, > 4 mm (Table 1).**
- High lignocellulose content for the bark (Table 2) ⇨ Potential for the production of **hardboards (HB)** through **hot pressing**.
- From a previously **extrusion-refined bark** using water at a 4.0 liquid/solid ratio, a cohesive HB was obtained with no external binder added (NB) (Table 3) ⇨ Adhesive ability of some chemicals inside bark (free sugars, hemicelluloses and lignins).
- Bending properties much improved with **plasticized cake from amaranth seeds (A)** added ⇨ External binder (starch + proteins).
- **Best flexural properties obtained when adding 20% A (Table 3) ⇨ A2 board is a viable, sustainable alternative for current building wood-based materials, *e.g.*, plywood, chipboard, OSB, MDF, etc.**



Insulation blocks from pith

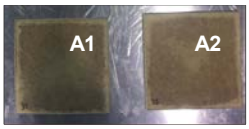
Tableau 2. Chemical composition of bark (% of dry matter).

Component	Cellulose	Hemicelluloses	Lignins	Minerals	Water-solubles
Content	43.6 ± 0.7	17.6 ± 0.4	20.3 ± 0.6	9.3 ± 0.3	14.8 ± 0.9

Tableau 3. Density, flexural properties and water resistance of hardboards produced from extrusion-refined bark using hot pressing (200 ºC mold temperature, 19.6 MPa applied pressure, and 5 min molding time).

Board number	Binder type	Binder content (%)	d (kg/m³)	σ_f (MPa)	E_f (GPa)	TS (%)	WA (%)
NB	No binder	0	1244 ± 35	19.8 ±1.6	2.4 ± 0.2	71 ± 4	56 ± 2
A1	A	10	1279 ± 47	32.4 ±2.6	2.9 ± 0.3	77 ± 4	60 ± 1
A2	**A**	**20**	**1318 ± 47**	**35.8 ± 2.9**	**4.2 ± 0.2**	**87 ± 8**	**69 ± 2**

E_f, elastic modulus; TS, thickness swelling after 24 h immersion in water; WA, water absorption after 24 h immersion in water.



Hardboards from bark

Conclusion

- *Amaranthus cruentus*, a promising raw material for the **biorefinery** of whole plant.
- Stems, composed of (i) a **bark** on their periphery (76% w/w), and (ii) a **pith** in their middle (24% w/w): both usable for **material applications**.
- Possibility to separate mechanically and continuously these two fractions thanks to a fractionation process developed recently: grinding plus blowing.
- Low density for pith particles: usable as **thermal insulating materials** inside buildings (in the form of insulation blocks molded with 10% starchy binder).
- ***Optimal insulation block (BP) ⇨ Light and insulating while preserving good machinability and promising mechanical properties.***
- **Extrusion-refined bark** successfully used for the manufacture of **hardboards** (*i.e.*, dense fiberboards) using **hot pressing**.
- ***Optimal hardboard (A2) ⇨ Viable option for replacing current wood-based building materials, e.g., floor underlayers, interior partitions, etc.***
  - *According to NF EN 312 standard, board already usable for interior fittings (including furniture), in dry environment (P2 type board).*
  - *With much improved water resistance (10% max TS), could be used as a P7 type board (board working under high stress, used in humid environment).*

REFERENCES

[1] Ott C, Lacatusu I, Badea G et al., Exploitation of amaranth oil fractions enriched in squalene for dual delivery of hydrophilic and lipophilic actives. *Ind. Crops Prod.*, 2015, 77, 342-352.
[2] Caselato-Sousa VM, Amaya-Farfán J, State of knowledge on amaranth grain: a comprehensive review. *J. Food Sci.*, 2012, 77, 93-104.

Journée de lancement du GDR MBS
Mardi 16 juin 2020, Ifsttar, Champs-sur-Marne