Evaluation of lupin flour (LF)-based adhesive for making sustainable wood materials

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Society of Wood Science and Technology

Geneva, Switzerland

October 11 - 15, 2010

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CONTENTS

1 Masisa company

Our Company was founded in 1960, being the first particleboard manufacturing in Chile.

Currently, Masisa is leadership in Latin America in the production of particleboards (PB) and Medium Density Fiberboard (MDF) for furniture and interior architecture using UF and/or MUF.

Products

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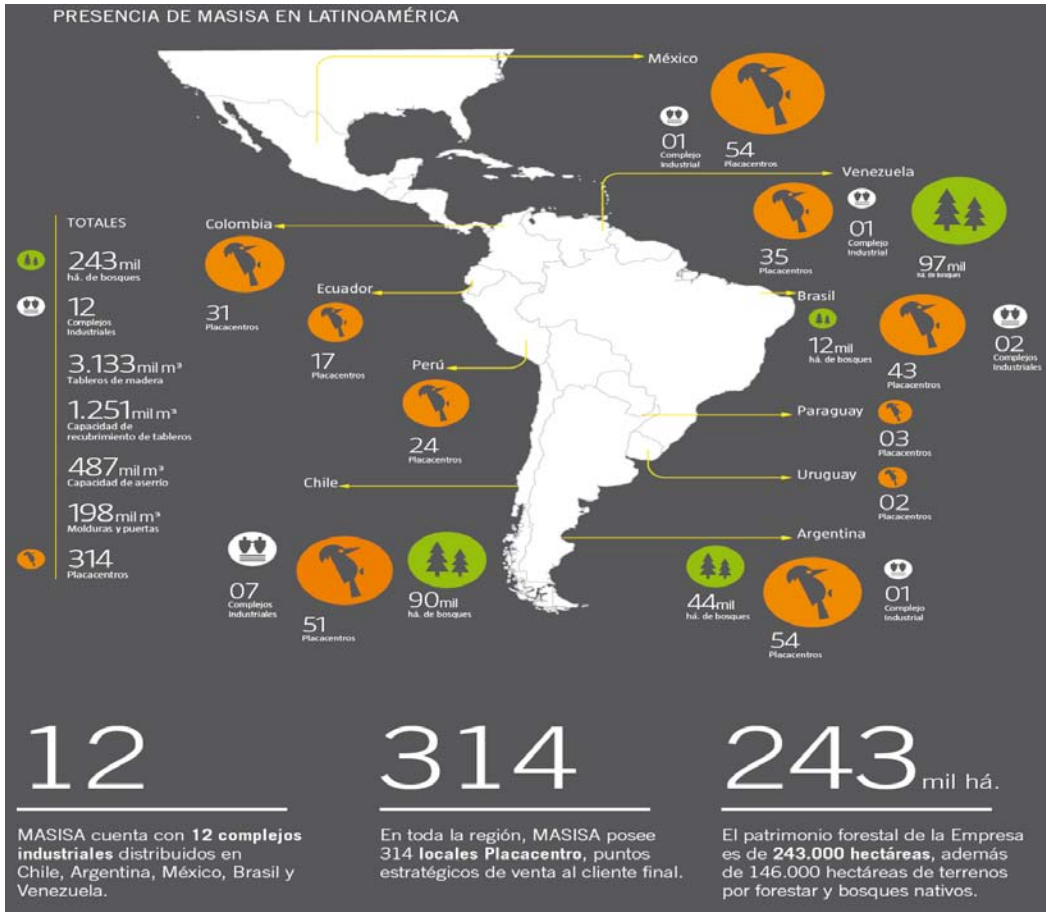
Masisa in South America



Masisa Certification

- ISO 9.001, ISO 14.001 and OHSAS 18.001
- California Air Resource Board (CARB)
- Scientific Certification System (SCS)
- Forest Stewardship Council (FSC)

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2 Introduction

- CARB Phase 1 PB =>0,18 ppm, year 2009

  Phase 2 PB =>0,09 ppm, year 2011

- Availability of Chilean raw material for the manufacture of new adhesive systems

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- The Centre of Bio-Materials and Engineering (CBI-UBB) is carrying out researches for developing bio-adhesives from renewable and sustainable resources in Chile.
- The sectors considered are: agriculture, fishing and forestry.
- Currently, CBI and Masisa are testing lupin seeds for making sustainable products.

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Why lupin?

Component	Lupin (1)(%)	Soy (2)(%)
Moisture Content	10-12	12
Carbohydrates	25-27	30
Protein	35-45	40
Fat	12-14	20
Fibre	10-12	5
Ash	2,5-3,0	5

Adaptation from (1) Fundación Chile, 1978 and INTAL (2)

Cited by Acuña P. (2001)

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Proteins

- Proteins (also known as polypeptides) are organic compounds made of amino acids arranged in a linear chain and folded into a globular form.
- The amino acids in a polymer are joined together by the peptide bonds between the carboxyl and amino groups of adjacent amino acid residues.

Amino acid composition (g amino acid / 16 g N) of lupin and soybean protein

Amino acid	*L. angustifolius*	*L. albus*	*L. luteus*	Soybean
Arginine	11.62	12.20	11.30	5.42
Cysteine	1.36	1.34	2.28	n/a
Histidine	2.57	1.86	3.30	2.46
Isoleucine	3.91	3.80	2.70	4.51
Leucine	6.61	6.90	7.89	6.81
Lysine	4.66	4.75	5.35	5.66
Methionine	0.72	0.66	0.70	1.28
Phenylalanine	3.65	3.85	4.04	3.60
Threonine	3.54	3.29	3.51	3.56
Tryptophan	1.00	0.97	n/a	1.35
Tyrosine	3.66	4.26	3.10	1.67

Source: Glencross B.(2001)

Differences between proteins

- Polarity
- Acidity
- Basicity
- Crosslinking level
- Level to hydrogen bridges
- Chemical reactivity

However…

- Several researches on the use of soy proteins in wood based composites.
- Poor literature regarding the lupin protein as **adhesive**.

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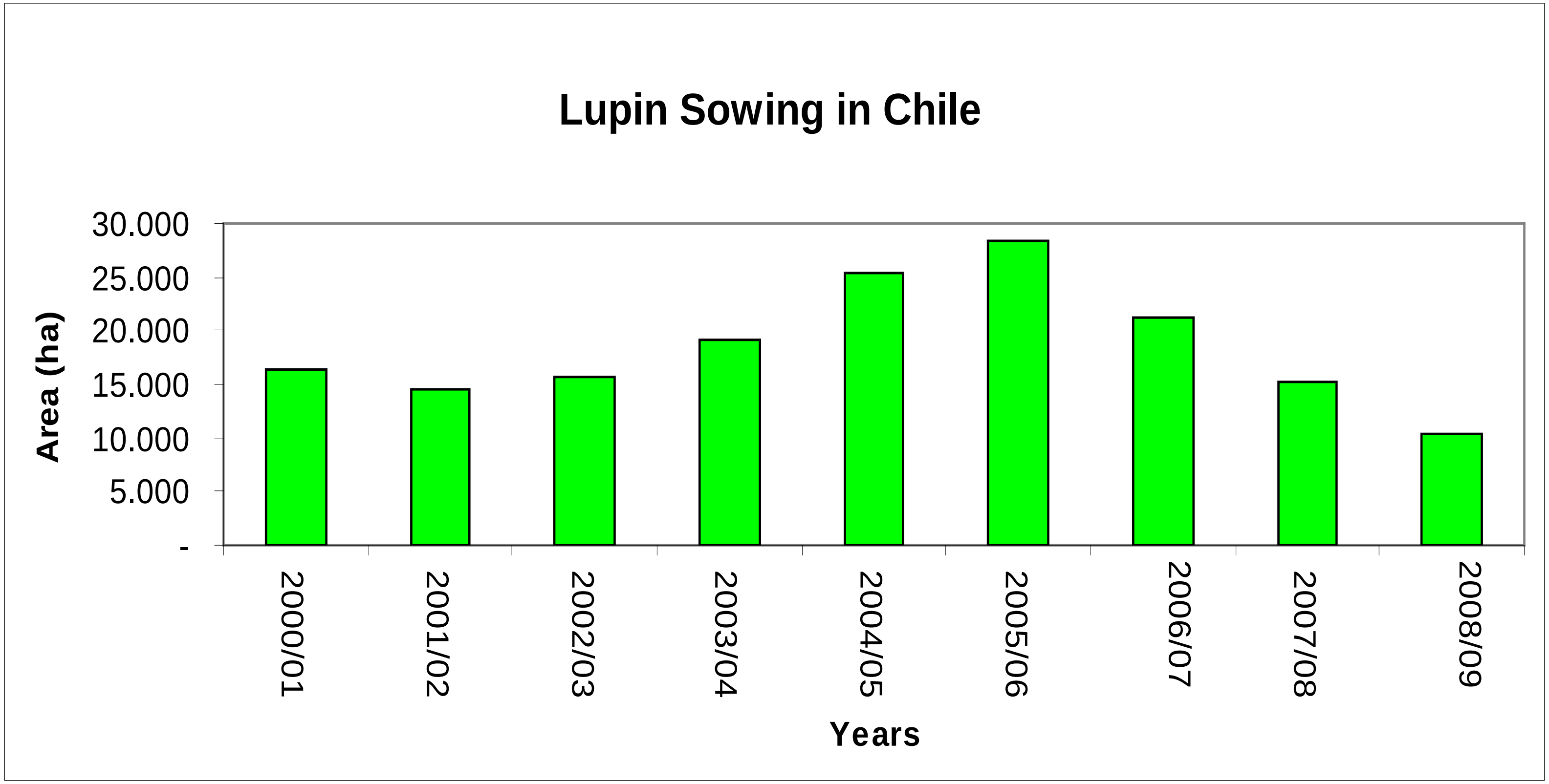
Chilean lupin plantations



Source: Odepa (2010)

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3 Objectives

- To use available Chilean sustainable resources such as lupin for the manufacture of new adhesive systems.

- To compare the physical and mechanical properties of particleboards bonded with of Urea-formaldehyde (UF), Soy Protein Isolated (SPI), Soy Flour (SF), and Lupin Flour (LF) adhesives.

- To evaluate the formaldehyde release of particleboards bonded with Urea-formaldehyde (UF), Soy Protein Isolated (SPI), Soy Flour (SF), and Lupin Flour (LF) adhesives.

4 Materials and Methods

- Particleboards of three layers mat (25/50/25),
- 3 replications for each type of adhesive
- The adhesive levels were set at 7-8 % expressed
- No wax was added
- Applied by atomizing air pressure.

Parameters	Value
Final board size (mm^3)	350 x 350 x 16
Target panel density (kg/m^3)	640
Specific pressure (bar)	32
Platen temperature (C)	190

Adhesives

Four types of formulations were employed:

- Commercial Urea-formaldehyde (**UF**)
- Soy Protein Isolated (**SPI**) from DuPont™ Polymers
- Soy Protein Flour (**SF**) from Contreras y Sánchez Ltda., and
- Lupin Protein Flour (**LF**) from Avelup Ltda.

Characteristics of UF, SPI , SF, and LF

Adhesive type	UF	SPI	SF	LF
Adhesive solid content (%)	65,5	24,0	30,9	32,3
Adhesive Viscosity (cPs)	350	750	800	107,5
Additive(s) used	NH_4CL	NaOH	U[1] and PAE[2]	U[1] and PAE[2]
pH final solution	7,5	9,2	8,6	8,3
Total pressing time (sec)	128	669	325	326

1: Dispersion agent

2: Crosslinker agent

Physical and Mechanical properties

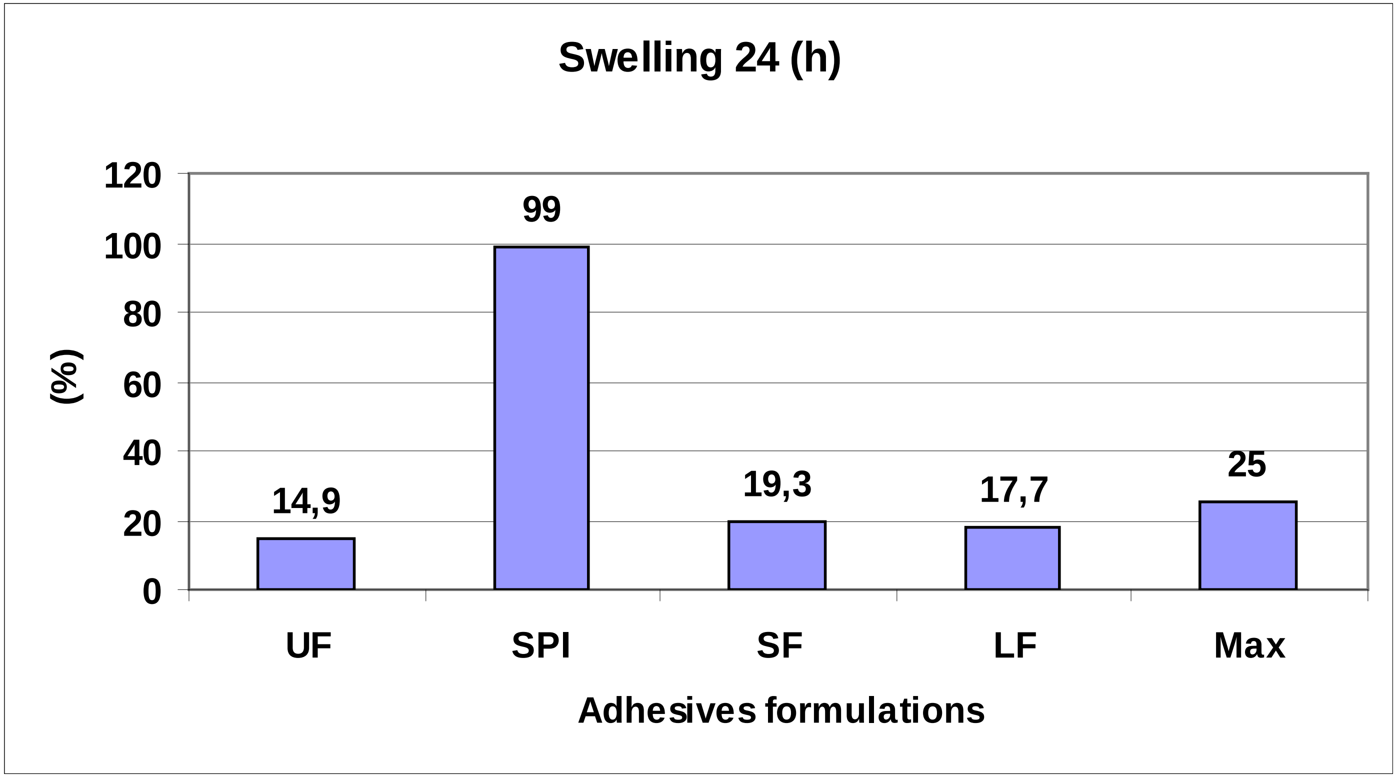
The evaluations were according to:

•UNE-EN 317, 1994 (swelling)

•UNE-EN 319, 1994 (IB), and

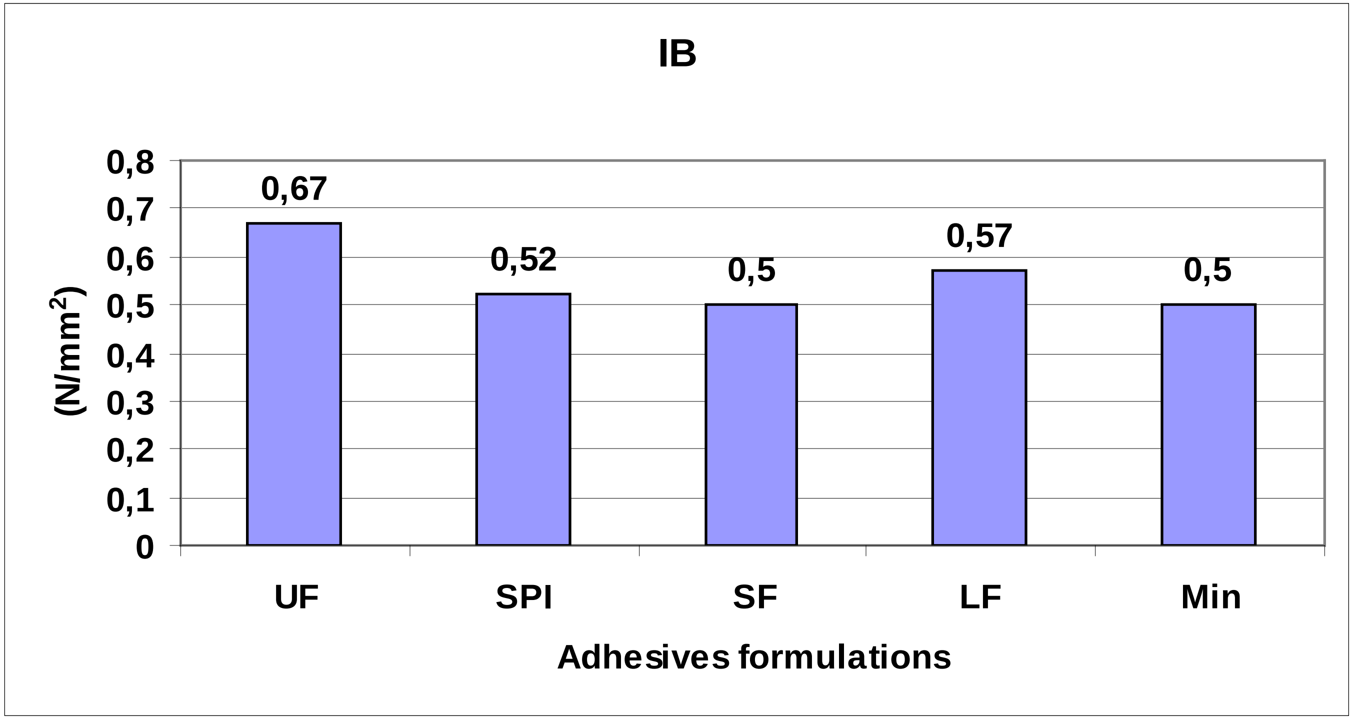
•UNE-EN 120, 1994 (formaldehyde content)

5 Results



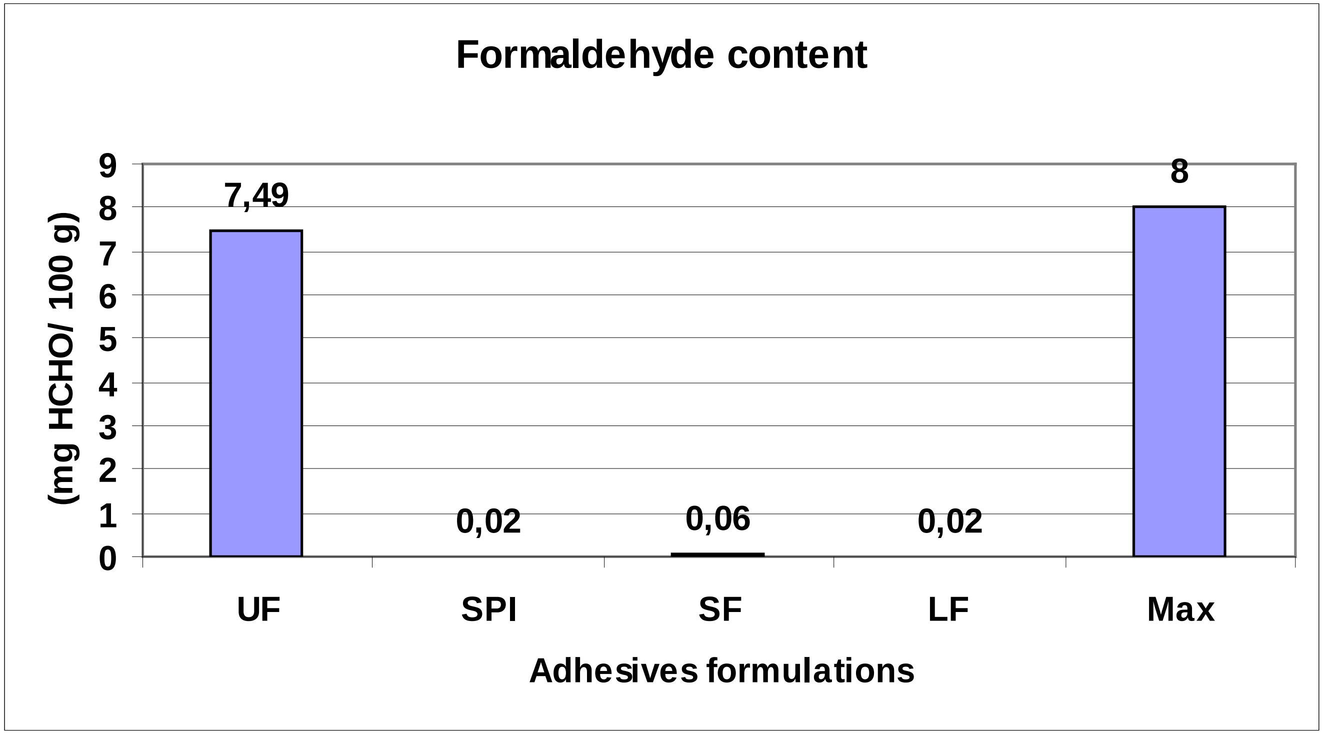
Swelling 24 (h)
(%)
120
100
80
60
40
20
0
14,9
99
19,3
17,7
25
UF
SPI
SF
LF
Max
Adhesives formulations

Results



IB
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
(N/mm2)
0,67
0,52
0,5
0,57
0,5
UF
SPI
SF
LF
Min
Adhesives formulations

Formaldehyde emission



6 Discussions

- Longer pressing times were necessary for soy and lupin based adhesives in comparison to conventional UF.

- SPI had the longest one, while SF and LF were almost similar. It can be attributed to the additives added to the final solution as well as percentage of solids of SPI.

Discussions

- It is a fact that additives used in the cases of SF and LF produce a denaturation of the protein aiding to the dispersion and cross linking of the adhesive.

- On the other hand, low percentage of solids of SPI (24%) indicated that this formulation needs more time to evaporate the high moisture content of the mat before of pressing. It could be corrected by applying catalyst or cross linker additives such as SF and LF adhesives to reduce pressing time.

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7 Conclusions

- This experience employing lupin protein at laboratory scale could produce changes in the Chilean use of this sustainable raw material, especially to satisfy the external regulations about formaldehyde requirement in wood based composites.

- The physical and mechanical properties of particleboards bonded with lupin based adhesive were comparable to those made with soy based adhesive and conventional UF.

Conclusions

- Particleboards bonded with lupin based adhesive had formaldehyde emission comparable to particleboards made with soy based adhesive.

<u>This new adhesive system had the same advantages of the soy adhesive systems: good properties and low formaldehyde emission.</u>

Acknowledgments

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Thank you very much for your attention!

Merci beaucoup!

¡Muchas gracias!

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