MAIZE COB BOARD (MCB)

Baccalaureate Thesis

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ABSTRACT

This Bachelor Thesis is giving an overview of light wood composites materials, to compare some of these materials, which are already in the trade, with the MCB board.

The MCB boards use the sandwich technology as the Honeycomb panel, gluing a core layer between two surface layers. This board uses maize for the core layer, putting the small cobs cylinders in vertical position between two surface layers of HDF by gluing. The technical characteristics from MCB board are comparable with Honeycomb, Compact light board or Flax board.

With the viability of the MCB board in the trade is found a new use for the cobs, completely different to the traditional uses (as fuel or heating). The MCB board is oriented to serve as indoor wood-door or kitchen furniture.

Diese Bachelorarbeit gibt einen Überblick über Leichtholzverbundwerkstoff, die bereits im Handel sind. Diese werden dann mit der neu entwickelten Leichtbauplatte Maisspindelplatte (MCB) vergleichen.

Das MCB verwendet die „Sandwich Technologie“ die beispielsweise auch beim Honigwabeplatte angewandt wird. D.h. eine Kernlage wird zwischen zwei Oberflächenlagen geklebt. Diese Holzplatte hat Maisspindeln als Kernlage. In der Herstellung werden kleine Maisspindelzylinder in einer vertikalen Position zwischen die HDF-Platten geklebt. Die technischen Charakterisitken sind vergleichbar mit Honigwabeplatte, Spanplatte or Flaxplatte.

Mit dem Erfolg der MCB-Platte im Handel wäre eine neue Verwendung für Maisspindeln gefunden, zusätzlich zu ihren herkömmlichen Verwendungen als Energielieferant. Die MCB-Platte ist als Material für Innen Holz-Tür und Kücheneinrichtung ausgerichtet, wobei andere Verwendungen natürlich nicht ausgeschlossen sind.

KEYWORDS

MCB board, light wood material, indoor wood-door, maize cob board, growing-maize, food-maize.

Maisspindelplatte, Saatmais, Futtermais, Leichtholzverbundwerkstoff, MCB-Platte, Innen Holz-Tür.

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1. INTRODUCTION

The beginning of the history about light wood panels started with the plywood, in 1865 North America, trying to find a new light and thin material. In 1915 were produced the first insulated fiber boards (Michanickl s.a.). The extrusion press in 1797 from Joseph Braham, opened the way to perform wood composite light panels by warm extrusion process. (Drozda s.a. and Avitzur 1987)

Historically, the products from the light wood technology were very expensive and exclusive. They were used in the aeronautic field or in the automotive field. Over the time, the light wood products could be produced cheap, but with a better quality through increased efficiency in production processes, research and development. This trend is very strong in the furniture industry. A clear example is IKEA, which produce low cost furniture with high quality of design using light wood materials. (Michanickl s.a. and Brokovic 2006)

Figure 1: Interior made with wood materials in a luxury car

Figure 2: Dining room table Jämsunda, from IKEA

A light board is commonly known with a density of 450 kg/m³ or lower, it depends of the kind of board, the material and the thickness. The density can oscillate around 100 Kg/m³. A honey comb board with a total thickness of 50mm manufactured from paper honey combs with a diameter of 21mm in the core and thin particleboard decks can have a density about 11 kg/m³. The same board with a thickness of 22mm already has a density of 230 kg/m³ approximately. The heaviest wood based panels such as highly compressed plywood from phenol resin impregnated veneers have a density of about 1300 kg/m³ (Michanickl s.a.)

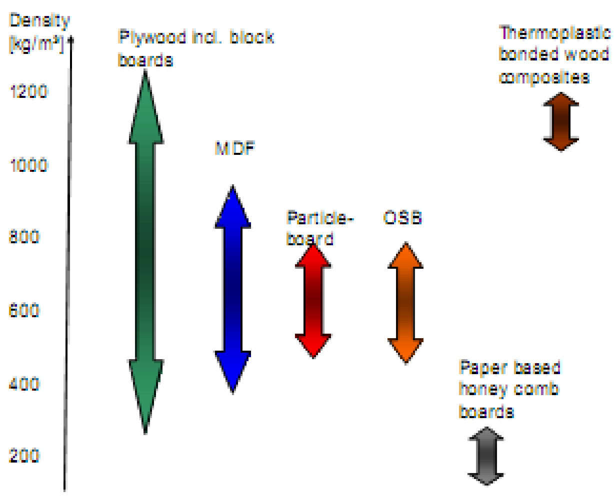

Figure 3: Density ranges of different panel types (Michanickl, s.a.)

The wood industry is not focused only on light materials. They also develop elaborated wood products by increasing the density ranges of the MDF to 800 until 950 kg/mm³. These were used in this project. Another example is the Particleboard which becomes a higher density with 100 kg/mm³ and is playing an important role in all markets, because the quality of the production process is more competitive (Michanickl s.a.).

In the building sector, the wood materials if we compare them with the typical materials are lighter than traditional materials as Concrete beam, Steel I-beam or Aluminum. Furthermore, compared with other building materials, they are environmentally beneficial. The wood material also allows the user to cut the beams easily into proper dimensions and to cut holes in the web where they are needed. For example the I-joist, which is one of the wood light framed floors or Kerto in all its variations used for all roof systems, load bearing web etc. (Marchas and Fahl 2007)

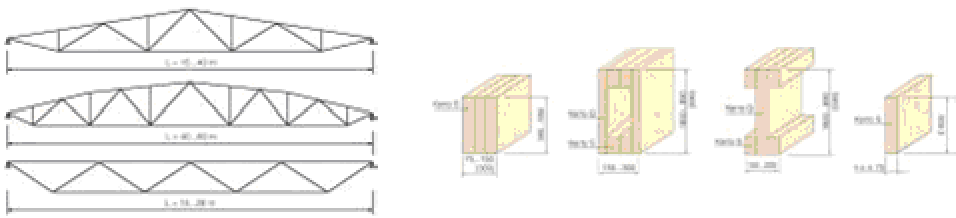

Figure 4: Uses of Kerto (Fahl 2007)

Figure 5: Samples of I-joist (Marcha 2007)

Figure 6: Samples of Kerto (Fahl 2007)

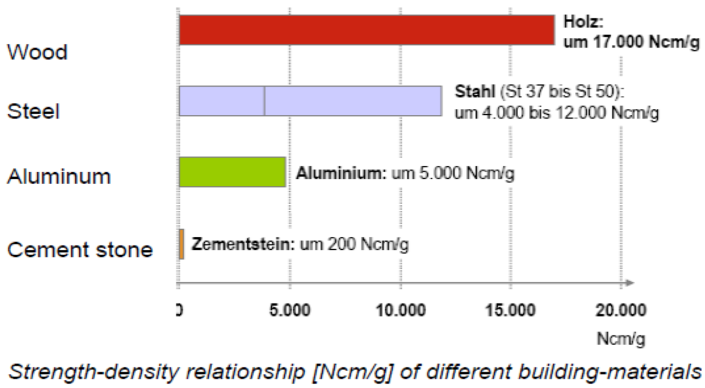

Figure 7: Comparison with other buildings-materials (Brokovic 2006)

This work wants to describe the process of obtaining a new light material which name is MCB (Material Cob Board). First comes an overview on some lightweight panels as honeycomb, hemp-board, flax-board, compact light board, chip boards with geometric cavities, light MDF which are used for performance wood doors. Thus, the author will compare these materials with MCB material. This new material in origin is for interior house doors, but we cannot neglect the option to find other uses as interior walls, furniture, etc. for this new material.

1.1. Honeycomb sandwich panel

The honeycomb sandwich panels offer outstanding stiffness and strength for low weight. These properties are increasing with the thickness of the honeycomb. They are made with two surface layer separated by a layer, which looks like a honeycomb made by paper or other materials like aluminum, PVC, etc. The materials depend on the needs.

Figure 8: Doors made with honeycomb sandwich panel (Honicel Nederland B.V.)

Table 1: Comparative strength properties of the honeycomb panels and particleboard panels used in the construction of the honeycomb panels (Barboutis and Vassilou)

Strength property	Pbd thickness 7.8 mm	Pbd thickness 2x7.8 mm	Pbd thickness 16.1 mm	Honeycomb thickness 51.7 mm
Relative thickness	0.5	1*	1.03	3.31**
Density (g/cm^3)	0.766	0.766	0.658	0.321
Relative density	1	1	0.859	0.419
Relative MOR	1.07	1	1.02	0.06
Relative MOE	1.02	1	1.02	0.19
Relative Impact bending strength	0.45	1	0.86	1.80

* It is considered as the basis (value 1)

** Calculated values in relation to the basis value

The uses are aircraft flooring and interiors, ship and train interiors, tooling industry, construction industry, etc. Honeycomb works on the I-beam principle.

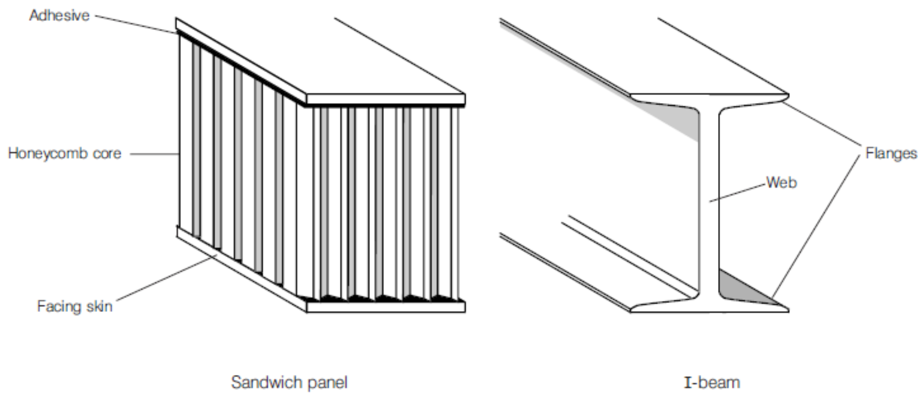

Figure 9: Shows the construction of a sandwich panel compared to I-beam (Hexcel Composites 2000)

The honeycomb can be compared with the I-beam; the facing skin from the sandwich panel is doing the same function than the flanges from the I-beam, and the honeycomb core can be compared with the web of the I-beam. The core of the honeycomb can resist the stress from the shear loads and increases the stiffness of the structure. The structure of the sandwich panel honeycomb allows high torsion and bending rigidity (Hexcel Composites 2000, www.hexcel.com).

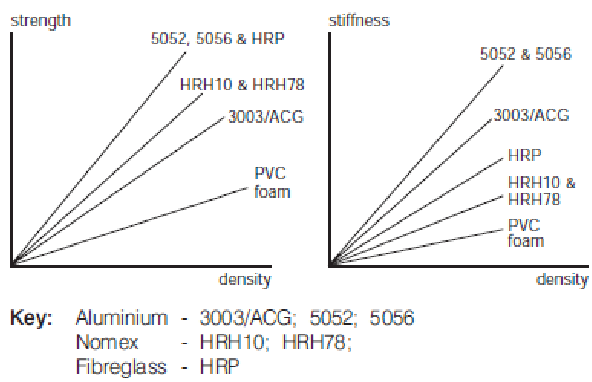

Figure 10: Comparison of different core materials between strength, stiffness and density (Hexcel Composites 2000)

The table 2 shows the values of bending of honeycomb sandwich panel with paper core and particleboard surface layer, comparing with different particle-boards.

Table 2: Mechanical properties of honeycomb sandwich panel and particleboard (Barboutis and Vassalou)

Material panel (Nominal thickness)	Bending strength: Modulus of rupture (MOR) (N/mm^2)	Bending strength: Modulus of elasticity (MOE) (N/mm^2)	Impact bending strength (IBS) (kJ/mm^2)
Honeycomb 8+36+8 mm	0.92(0.07)*	505(63)	4.79(0.39)
Particleboard 16 mm	14.62(0.63)	2730(227)	2.30(0.08)
Particleboard 8 mm	15.27(0.47)	2741(362)	1.20(0.04)
Particleboard 2 x 8 mm	14.31(0.56)	2680 (325)	2.66(0.06)

* Mean values of 15 samples and standard deviation in parenthesis

Table 3: Mechanicals properties of different honeycomb materials (Hexcel Composites 2000)

PRODUCT CONSTRUCTION		COMPRESSION		PLATE SHEAR			
Density	Cell Size*	Stabilized		L Direction		W Direction	
kg/m^3 (lb/ft^3)	mm (in)	Strength MPa	Modulus MPa	Strength MPa	Modulus MPa	Strength MPa	Modulus MPa
3003 Aluminium							
29 (1.8)	19 (3/4)	0.9	165	0.65	110	0.4	55
37 (2.3)	9 (3/8)	1.4	240	0.8	190	0.45	90
42 (2.6)	13 (1/2)	1.5	275	0.9	220	0.5	100
54 (3.4)	6 (1/4)	2.5	540	1.4	260	0.85	130
59 (3.7)	9 (3/8)	2.6	630	1.45	280	0.9	140
83 (5.2)	6 (1/4)	4.6	1000	2.4	440	1.5	220
5052 Aluminium							
37 (2.3)	6 (1/4)	1.35	310	0.96	220	0.58	112
50 (3.1)	5 (3/16)	2.3	517	1.45	310	0.9	152
54 (3.4)	6 (1/4)	2.6	620	1.6	345	1.1	166
72 (4.5)	3 (1/8)	4.2	1034	2.3	483	1.5	214
83 (5.2)	6 (1/4)	5.2	1310	2.8	565	1.8	245
127 (7.9)	6 (1/4)	10.0	2345	4.8	896	2.9	364
130 (8.1)	3 (1/8)	11.0	2414	5.0	930	3.0	372
5056 Aluminium							
37 (2.3)	6 (1/4)	1.8	400	1.2	220	0.7	103
50 (3.1)	3 (1/8)	2.4	669	1.7	310	1.1	138
50 (3.1)	5 (3/16)	2.8	669	1.8	310	1	138
72 (4.5)	3 (1/8)	4.7	1275	3.0	483	1.7	193
HRH10 Nomex (Aramid)							
29 (1.8)	3 (1/8)	0.9	60	0.5	25	0.35	17.0
32 (2.0)	5 (3/16)	1.2	75	0.7	29	0.4	19.0
32 (2.0)	13 (1/2)	1.0	75	0.75	30	0.35	19.0
48 (3.0)	3 (1/8)	2.4	138	1.25	40	0.73	25.0
48 (3.0)	5 (3/16)	2.4	140	1.2	40	0.7	25.0
64 (4.0)	3 (1/8)	3.9	190	2.0	63	1.0	35.0
64 (4.0)	6 (1/4)	5.0	190	1.55	55	0.86	33.0
80 (5.0)	3 (1/8)	5.3	250	2.25	72	1.2	40.0
96 (6.0)	3 (1/8)	7.7	400	2.6	85	1.5	50.0
123 (7.9)	3 (1/8)	11.5	500	3.0	100	1.9	60.0
144 (9.0)	3 (1/8)	15.0	600	3.5	115	1.9	69.0
29 (1.8)	5 OX (3/16)	1.0	50	0.4	14	0.4	21.0
48 (3.0)	5 OX (3/16)	2.9	120	0.8	20	0.85	35.0
HRH78	Typical mechanical properties are similar to HRH10, however, the aramid sheet manufacturing tolerances are wider therefore minimum values may be reduced.						

1.2. Compact light board

The goal of this kind of panels is the perfect commitment between lightness and stability. The density is between 275 kg/m³ with 60 mm of thickness and 430 kg/m³ with 30 mm of thickness. It is made by a warm extrusion press (Figure 12). The tubes unite the Softwood UF/E1 shavings. The compact light board has a core of different thickness, the tube diameter is minimum 22 mm, and both external surface layers are 4 mm thick MDF.

Figure 11: Sample of door made with compact light board (www.sauerland-spanplatte.de)

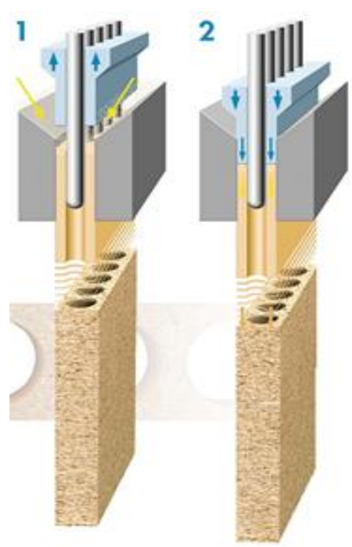

Figure 12: Warm extrusion press (www.sauerland-spanplatte.de)

The plates have a high compressive strength. In the middle layer of the extruded material, it is possible to adjust the tube structure to customer needs. Resopal offers a post-forming process in the HPL-coated kitchen countertop with the sandwich core, and MDF Röhrenspanplatte board with a thickness of 38 mm to 50 mm (BM-Marktübersich 2005, www.sauerland-spanplatte.de)

Figure 13: Sample of compact light board (BM-Marktübersich 2005)

Table 4: Technical data per model of panel from Sauerland Spanplett (www.sauerland-spanplatte.de)

Thickness: 32mm	RT/RK1	RD	VL	VV	HVA	Units
Bending tensile strength - Vertical - Parallel	 3,8 1,1	 4,0 1,2	 5,5 1,5	 6,5 1,8	 12,2 1,8	 N/mm² N/mm²
E-mod - Vertical - Parallel	 900 120	 900 120	 800 110	 1100 140	 1800 170	 N/mm² N/mm²
Transverse tensile strength	>0,5	>0,6	>0,6	>0,7	>0,8	N/mm²
Surface pressure Max. permitted without significant compression	10	12	16	18	22	bar
Weight -per m² -per m³ -based on VSP	 8,2/8,8 257/274 520	 9,6 300 525	 15,7 490 490	 19,2 600 600	 20,8 650 650	 Kg/m² Kg/m³ Kg/m³ VSP

1.3. Light MDF

The normal light MDF is for applications in dry conditions as interior decoration and furniture production, but for special needs it is possible to make it with more moisture resistance against biological hazards und fire resistance. An advantage is that it has a low formaldehyde emission (E1 class). This MDF is made of 100% softwood and without coarse fibers in the surface (www.Spanogroup.be).

Figure 14: Sample of light MDF board (www.Spanogroup.be)

Table 5: Technical specifications of light MDF (www.spanogroup.be)

General characteristics + standard	Unit	Average values														
Thickness EN 324-1	mm	8	9-9,6	10	11,5-12	13	14	15	16	18	19	22	25	28	30	38
Density EN 323	Kg/m³	650	650	640	600	600	600	600	600	600	600	600	600	600	600	600
Moisture content EN 322	%	6-10	6-10	6-10	6-10	6-10	6-10	6-10	6-10	6-10	6-10	6-10	6-10	6-10	6-10	6-10
Technical characteristics + standard		5/95 Percentile values														
Swelling/24h EN 317	%	20	16	16	16	14	14	14	14	14	14	12	12	12	12	11
Internal bond EN 319	N/mm²	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,4
Bending strength EN 310	N/mm²	20	20	20	20	18	18	18	18	18	18	15	15	15	15	14
Modulus of elasticity EN 310	N/mm²	1700	1700	1700	1700	1600	1600	1600	1600	1600	1600	1500	1500	1500	1500	1400

1.4. Flax-board

Flax-board is a particle-board composite of flax fibers and urea resin glue (Urea Formaldehyde). This material is 100% recyclable and is used for thermal and acoustic insulation. The density of this board is very low (from 320 Kg/m³ until 560 Kg/m³), depending of the thickness which have a range from 16 mm to 50 mm per board (www.linex-pg.nl)

Figure 15: Sample of flax-board www.bm-online.de , BM-Marktübersicht: Moderne Leichtbauwerkstoffe (2005)

Table 6: Mechanical properties of flax-board (www.linopan.be)

		UNIT	
Density tolerance	EN 323	Kg/m3	± 8 %
Thickness tolerance	EN 324.1		
between panels		mm	± 0,3
within panel		mm	0,2
Bending strength	EN 310	N/mm2	4,5
Modulus of elasticity	EN 310	N/mm2	750
Tensile strength	EN 319	N/mm2	0,1
Surface strength	EN 311	N/mm2	0,35
Screw holding	EN 320		
		N	NA
		N	NA
Thickness swelling 24 hours	EN 317	%	< 18
Moisture content	EN 322	%	5 up to 10

1.5. Cannabis-board

Cannabis-board is a fiber-board, made of cannabis fibers. The production of this material is very recent, because all over the world the production of cannabis was forbidden due to the level of THC. THC is a substance which popularized the use of the Cannabis Sativa as drug. In the mid-90s the Scientifics classified the species which have lower quantity of THC, but are interesting for an industrial use (www.kosche.de).

Figure 16: Sample of Cannabis-board (www.kosche.de)

The most common uses for the cannabis-board are: furniture, indoors, ship-construction, and kitchen-furniture. The density of cannabis-board are lower than many wood-products, thus the isolation property is higher than many wood-products.

Table 7: Technical data from Cannabis-board (www.resopal.de)

			Thickness	
	Unit	Standard test	18 / 19 mm	25 / 40 mm
Format			5200 mm x 2020 mm 2600 mm x 2022 mm	
Length Tolerance	mm/m	EN 324-1	±3	
Width	mm/m	EN 324-1	-1 to +5	
Wedging	mm/m	EN 324-2	≤ 2	
Thickness Tolerance	mm	EN 324-1	+ 0,3	
Density	Kg/m^3	EN 323	320	300
Density Tolerance	Kg/m^3	EN 323	±20	±20
Moisture content	%	EN 322	6 - 9	
Bending Strength	N/mm^2	EN 310	5	

Bending – E mod	N/mm²	EN 310	700	
Bond strength	N/mm²	EN 319	0,2	
Swelling 24 h Water storage	%	EN 317		≤9
Formaldehyde Emission class		EN 120		E1
Screw Strength	N	EN 320	185	
Soundness	N/mm²	EN 311	0,5	

After describing the background of the wood composite light materials, the next paragraph shows a short description of all materials which were used as surface layer for make the samples is following:

1.6. Medium Density Fiber-board (MDF).

Medium Density Fiber-board (MDF) is a wood composite material made by wood fibers. It is normally made as board, though it is used for furniture and building materials. The MDF is replacing other materials like particleboard in uses such as furniture manufacture, flooring, etc. Its advantages include high strengths (Modulus of Rupture of 80MPa and Modulus of Elasticity 3000Mpa), ease machining, and it has an environmental advantage, which is that it can be made of a wide variety of fibrous products. A problem is that, MDF compared to natural wood, has a higher density than plywood or chip board, because the resins are heavy. Also it is very sensible to moisture content, thus, to avoid this problems, specials types of MDF should be used (Callum 1999).

Figure 20: Sample of MDF (www.finsa.es)

Then we can see two tables of technical specifications:

Table 8: Mechanical properties of MDF (www.finsa.es)

TEST METHOD	PROPERTIES	UNITS	THICKNESSES mm							
			1,8/2,5	>2,5/4	>4/6					
EN 323	DENSITY (*)	kg/m3	850	825	800					
EN 319	INTERNAL BOND	N/mm2	0,90	0,90	0,85					
EN 310	BENDING STRENGTH	N/mm2	38	38	38					
EN 310	MODULUS OF ELASTICITY	N/mm2	---	---	2700					
EN 317	THICKNESS SWELLING 24 H	%	45	35	28					
EN 318	DIMENSIONAL MOVEMENT LENGTH/WIDTH	%	0,4	0,4	,4					
EN 318	DIMENSIONAL MOVEMENT TICKNESS	%	10	10	10					
EN 311	SURFACE SOUNDNESS	N/mm2	>1,2	>1,2	>1,2					
EN 382-1	SURFACE ABSORPTION (TWO FACES)	mm	> 150	> 150	> 150					
EN 322	MOISTURE CONTENT	%	7+/-3	7+/-3	7+/-3					
ISO 3340	GRIT CONTENT	% Weight	≤0,05	≤0,05	≤0,05					

Table 9: Physical properties of MDF (www.finsa.es)

TOLERANCE ON NOMINAL DIMENSIONS										
TEST METHOD	PROPERTIES	UNITS	THICKNESSES mm							
			1,8/2,5	>2,5/4	>4/6					
EN 324-1	THICKNESS	mm	Lijado: +/-0,15 Sin lijar: +/-0,20	Lijado: +/-0,15 Sin lijar: +/-0,20	Lijado: +/-0,15 Sin lijar: +/-0,20					
EN-324-1	LENGTH/WIDTH	mm	+/- 2 mm/m .	+/- 2 mm/m .	+/- 2 mm/m .					
EN 324-2	SQUARENESS	mm/m	+/-1,5 mm/m .	+/-1,5 mm/m .	+/-1,5 mm/m .					
EN-324-2	EDGE STRAIGHTNESS	mm/m	+/-1,5 mm/m .	+/-1,5 mm/m .	+/-1,5 mm/m .					

1.7. Particle board (FPY).

Particle-board FPY (Chipboard in some countries) is an engineered wood product, made with wood particles, such as wood chips, sawmills shavings and resins, which are pressed and extruded. The raw material can come from different species as Pine, Softwoods, Spruce and Douglas. It is used in countertops, door core, floor underlayment, kitchen cabinets, manufactured home decking, office and residential furniture, shelving, stair treads and store fixtures. Today the manufacture processes are improving the physical properties increasing fire retardant and moisture resistance (Composite Panel Association www.pbmdf.com).

Figure 21: Sample of FPY (www.finsa.com)

The next table shows the physical properties of FPY:

Table 10: Physical properties of FPY (www.thelaminexgroup.com.au)

Physical Properties
(Typical physical properties when tested to AS/NZS 1859.1: 2001.Int)

Property	Unit	Board Thickness 9mm	12mm	16mm	18mm	25mm
Board Density	Kg/m^3	670	670	640	635	620
Internal Bond	KPa	550	550	460	460	440
Modulus of Rupture	MPa	18	18	18	16	16
Modulus of Elasticity	MPa	2600	2600	2500	2500	2200
*Screw Holding - Face	N	N/A	N/A	700	700	700
*Screw Holding - Edge	N	N/A	N/A	800	800	800
Surface Soundness	MPa	0.9	0.9	1.1	1.1	1.1
Moisture Content	%	5-8	5-8	5-8	5-8	5-8
Thickness Swell 24hr	%	18	15	15	15	15

*Values reflect new testing methods for screw holding properties in AS/NZS 4266.13: 2001 (Int).

1.8. High-Density Fiber-board (HDF)

The high-density fiber-board or HDF (Hardboard in some countries), was developed accidentally in 1924 by William H. Manson. It is a composite panel made by fibers and resins, such as phenol formaldehyde with a concentration in order of 1-2% of dry board weight, consolidated under hot-press operation in which high temperature (190°-235°C) and high pressure (500 -1500psi) are employed to bring the lignin to a thermoplastic condition and thus densify the fiber material (Haygreen and Bowyer 1996). The species used are different kinds of Softwood, Pines, Spruce, Douglas and Northern Hardwoods. Some common uses are prefinished panels, siding, perforated board, exterior trim, office and residential furniture and door skins (www.pbmdf.com).

Figure 22: Sample of HDF.

The next table shows the physical properties of HDF:

Table 11: Technical specifications of HDF (www.flakeboard.com)

Property	Thickness'	FIBREX®, FIBREX® VESTA, and FIBREX® PG Average Values	FIBREX® LF Average Values	FIBREX®, FIBREX® VESTA, FIBREX® PG and FIBREX® LF Specifications	FIBREX® Plus and FIBREX® FR Average Values	FIBREX® Plus and FIBREX® FR Specifications
Density (kg/m³)	<3mm	910	920	>870	990	>960
	3mm to 3.9mm	900	910	>860	980	>960
	>3.9mm	900	900	>850	970	>960
IB (N/mm²)	<3mm	1.65	2.00	>1.03	2.00	>1.59
	3mm to 3.9mm	1.48	1.86	>1.03	1.86	>1.59
	>3.9mm	1.28	1.72	>0.90	1.83	>1.59
MOR (N/mm²)	<3mm	45.5	49.0	>37.9	58.6	>46.9
	3mm to 3.9mm	44.8	48.3	>37.2	53.1	>46.9
	>3.9mm	42.7	46.9	>34.5	51.0	>46.9
Moisture Content (% d.b.)	<3mm	5.0	5.1	4 to 9	5.1	4 to 9
	3mm to 3.9mm	5.3	5.1	4 to 9	5.1	4 to 9
	>3.9mm	5.6	5.8	4 to 9	5.8	4 to 9
Linear Expansion (%)	All	0.25	0.25	≤ 0.30	0.25	≤ 0.30
Thickness Raw (mm)	All	+/−0.2	+/−0.2	+/−0.2	+/−0.2	+/−0.2
Thickness Sanded (mm)	All	+/−0.1	+/−0.1	+/−0.1	+/−0.1	+/−0.1
Length Tolerance (mm)	All	+/−3.2	+/−3.2	+/−3.2	+/−3.2	+/−3.2
Width Tolerance (mm)	All	+/−2.0	+/−2.0	+/−2.0	+/−2.0	+/−2.0
Squareness Tolerance (mm)	All	+/−4.0	+/−4.0	+/−4.0	+/−4.0	+/−4.0
Formaldehyde Emissions (ppm)	All	0.15	0.09	FIBREX® 0.21, FIBREX® VESTA 0.21, FIBREX® PG 0.21, FIBREX® LF 0.13	0.15	0.21

1.9. Maize (Zea mays. Ssp.)

Figure 23: Maize (Zea mays. ssp.)

Maize *(Zea mays. ssp.)* is a plant domesticated by indigenous in Mesoamerica in prehistoric times. They cultivated numerous varieties along the time. In the 16th century the plant was introduced by Spanish trade first to Europe and after to the rest of the world. The Maize, since always has been a base food in many places and one of the first foods where the genetic code had been changed by people.

The maize is subject to numerous pathogens. The most commune solution is the use of species with a modified genetic code and phyto-sanitary treatments. Two examples are:

- *Ostrinia nubilalis* and *Ostrinia furnicalis*, which are two borers that infect big part of the maize from Europe and Asia with the microsporidia *Nosema pyrasta* and *Noesema furmacalis*
- Maize streak virus (MSV) which has been considered generally as viruses limited to phloem tissues.

The uses that are given to maize can be, biomass (after extracting the grains from the cobs) for heating, food, bio-fuel production, chemical substances and medicines, as ornamental product, in art (Maiti and Wesche-Ebeling, 1998), but this work focus on a new use: The core of MCB boards. For make the core of the board cobs from two provenances were taken and also compared. These are Food-maize **(Futtermais)** and Growing-maize **(Saatmais)**.

2. MATERIALS AND METHODS

The materials which were used on the manufacturing of the MCB board are three kinds of surface layer (MDF, HDF and FPY), and two kinds of core layers (Food-maize "*Futtermais"* and Growing-maize *"Saatmais"*). The maize for the core layer of Growing-maize proceeds from Niederösterreich. After a soft dry process at 40°C, the cobs got moisture content of 13%. The maize for make the core layer of Food-maize proceeds from two different producers from Steiermark. After some days in the laboratory with a natural draying process, the moisture content from Food-maize became 10%.

The production of samples for the MCB material is not complex and for this process was necessary design two machines. The first machine cut the cobs in cylinders with the same size and the second machine put the cobs in the right position on the surface layer. The cobs were attached between two layers of MDF, HDF and FPY with glue PVAC and the process was finished with a pressure machine. The thickness of the surface layers are 4.2mm MDF, 3.8mm HDF and 4mm FPY. After obtaining the MCB material, the samples have to bear some mechanical tests. The features of the mechanical test are in the standards (ÖNORM EN and DIN), and the explication for performance all mechanical test.

The production of the MCB board (regardless of the core layer and the outer layers) been used one glue layer of 200g/m² approximately on both sides of the core layer, for join the core layer with both surface layers. The glue layer was performed using a glue roller on both sides of the core layer. The light material was pressed during 20 minutes at 60°C with a pressure of 0,6MPa.

Table 12: Relation of standard already used on the mechanicals test

Standard	Date	Type of Mechanical Test	Number of samples	Surface Layers
EN 320	1993	Screws extendable resistance test	18 samples from Futtermais and 18 samples from Saatmais	MDF
EN 480	1995	Bending test	12 samples from Futtermais and 12 samples from Saatmais	HDF, MDF, FPY
DIN 52185	1976	Compression cobs	20 samples from Futtermais and 20 samples from Saatmais	HDF, MDF, FPY
EN 319	1993	Tensile test	19 samples from Futtermais and 20 samples from Saatmais	HDF
EN 789	1996	Parallel compression	14 samples from Futtermais and 14 samples from Saatmais	HDF, MDF, FPY
EN 789	1996	Compression	12 samples from Futtermais and	MDF

EN 323	1993	Density MCB	24 samples from Saatmais 14 samples from Futtermais and 14 samples from Saatmais	HDF, MDF, FPY

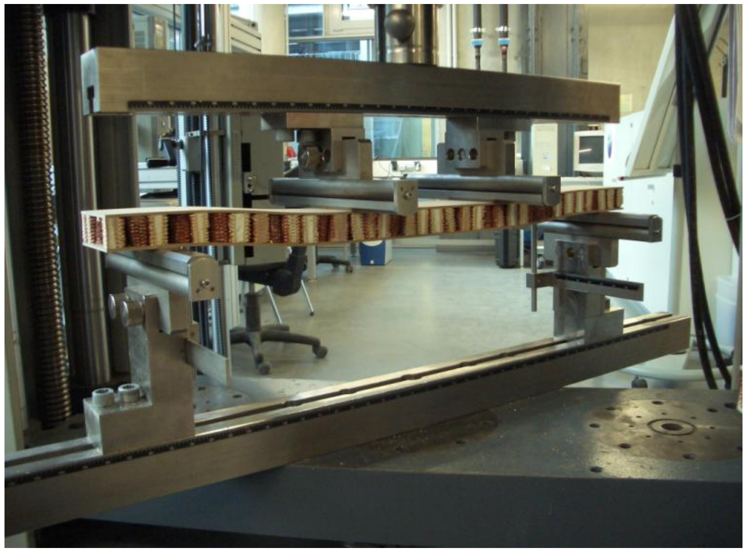

Figure 24: Samples of MCB during the bending test (4 Ptk).

2.1. Cross section of the Wood Ring and density of cobs from Food-maize (Futtermais) and Growing-maize (Saatmais)

For measure the cross section of the Wood Ring, the program Imag-J for analyze the pictures from Futtermais and Saatmais measuring the external diameter (D), wood ring diameter (d1) and core diameter (d2), measuring each diameter on two directions with 90°. The cross section of the wood ring is the difference between the area calculated with (d1) and the area calculated with (d2). First all cobs were scanned on the side with the bigger diameter. One time the cobs are on the scanner, a rule was put with the cobs for calculate the change of unit form pixels to mm.

Ruler (pixels)	**781.023**
Ruler (mm)	**100**

Then the pictures were processed for calculate the cross section of the Wood Ring. The figures 25 and 26 show the cobs with the Wood Ring.

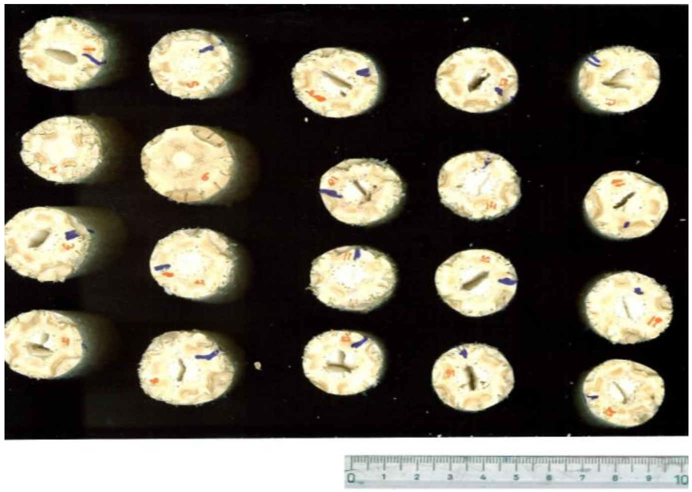

Figure 25: Cobs from Saatmais with ruler

Figure 26: Cobs from Futtermais with ruler

The density was calculated using 20 samples of food-maize and 20 samples of growing-maize. The dimensions of cobs are 30 mm of diameter and 50 mm of length. For calculate the density of cobs, was necessary measure two times the diameters for both sides of cobs and as well in the middle of cobs changing 90° the position of the caliber.

2.2. Tensile strength for samples with two kinds of core layers and a surface layer of MDF

The samples of this mechanical test are composed of two surface layers of Medium Density Fiber-board and with two kinds of core layer. The first kind of core layer is made of cobs from food-maize (Futtermais) and the second kind of surface layer is made of cobs from growing-maize (Saatmais). The thickness of the cobs sections was of 33mm and the thickness of the MDF surface layer was of 6mm. The number of samples is 19 for “Futtermais” and 20 for “Saatmais”. The dimension of the samples is 50mm of length and 50mm of wide. The transverse tensile strength (Rm) was the measured variable. The unit of this variable is N/mm². The purpose of this mechanical test is to determinate resistance to the deformation under load, comparing two different surface layers. The setups for perform this mechanical test are in the standard ÖNORM EN 319. To perform the compression test in parallel was used a universal Zwick Roell 100th.

The preload of the test was 50N and the speed test was defined with 0.5mm/min.

2.3. Perpendicular compression strength for samples with two kinds of core layers and a surface layer of MDF

The samples of this mechanical test are composed of two surface layers of Medium Density Fiber-board (MDF), and with two kinds of core layers. The first kind of core layer is made with “Futtermais“and the second kind of core layer is made with “Saatmais”. The measure of the samples is 75mm of wide and 75mm of length. The number of the samples for this mechanical test is of 12 samples with core layer of “Futtermais” and 24 samples with core layer of “Saatmais”. The variable which was measured is the compression strength (Rm). The unit from this variable is N/mm². The purpose of this mechanical test is obtaining the resistance to de deformation under load with the “Rm” from the samples. The samples have to be compared between them, for to find some difference between the core layer of “Futtermais” and the core layer of “Saatmais”. This mechanical test was performed according with the ÖNORM EN 789 March 1996. To perform the compression test in parallel was used a universal Zwick Roell 100th.

The preload of the test was of 50N, the test speed of 3.5mm/min, the offset yield strength defined of 1% and the determination of the modulus of elasticity was with 20-30% of the maximum force.

2.4. Screws extendable resistance for samples with two kinds of core layers and a surface layer of MDF

This mechanical test was performed two times. The first time the screw was locked in the surface layer (out of plane), and the second time the screw was locked in the core layer (in plane). The samples are with a surface layer of MDF with a thickness of 6mm and the core layer of “Futtermais” or “Saatmais”. The number of samples is 18 each kind of core layer in the mechanical test “in plane”, and 18 samples each kind of core layer in the mechanical test “out of plane”. The size of the samples is 75mm long, 75mm wide. The variable which was measured in the mechanical test “in plane”, and in the mechanical test “out of plane” is the screws extendable resistance (Rm). The unit from this variable is N. The purpose of the mechanical test “in plane” is to compare the tensile strength from the core layer with a screw. The purpose of the mechanical test “out of plane” is to compare the tensile strength from the surface layer with a screw. The standard for performance those mechanical test is ÖNORM EN 320 October 1993. To perform the compression test in parallel was used a universal Zwick Roell 100th. The test speed was 10mm/min.

2.5. Perpendicular compression strength for samples of growing-maize cobs (Saatmais) and food-maize cobs (Futtermais)

The samples for the perpendicular compression strength are cobs from food-maize (Futtermais) and cobs from growing-maize (Saatmais). The number of samples for this mechanical test is 20 for “Futtermais” and 20 for “Saatmais”. The size of the samples is 30mm of diameter and 50mm of length. The variables measured are the compression strength (Rm). The unit from this variable is N/mm^2. The purpose of this mechanical test is to compare two kinds of cobs, measuring the “Rm”. The goal of this mechanical test is obtaining the resistance to de deformation under load with the “Rm” from the samples. The standard used to perform this mechanical test is DIN 52 183

September 1975. To perform the compression test in parallel was used a universal Zwick Roell 100th. The test speed was 2mm/min and the preload of 20N.

To determinate the perpendicular compression strength of wood ring was comparing the same samples as is explained in the above paragraph. The unit from this variable is N/mm². The results and the graphic are showed in the paragraph 3.5. The formulas to calculate the perpendicular compression strength are showed below.

$$F= (\pi/4)*D^2$$

$$\text{Compression strength of wood ring}= F/ ((\pi/4)*d^2_1-d^2_2)$$

F→ Force of compression strength for the external diameter (N)
D→ External diameter of cobs (mm)
d_1→ Diameter of wood ring from cobs (mm)
d_2→ Diameter of core from the cobs (mm)

2.6. Bending test for samples with three kinds of surface layers, and two kinds of core layers

The samples for the bending test are with three kinds of surface layers. Those surface layers are made of High Density Fiber-board (HDF), Particle-board (FPY), and Medium Density Fiber-board (MDF). The core layers of “Futtermais” (Food-maize) and “Saatmais” (Growing-maize). The variables measured are the bending elasticity modulus (E mod), the bending strength (R m) and the shear modulus (G mod). The units for all variables are N/mm². These measurements were performed with a universal Zwick Roell 100th. According with the ÖNORM EN 408 (version of 2005).The number of samples for this mechanical test is of 12 for each kind of samples with a surface layer of “MDF”, “FPY” and “HDF” and with both kinds of core layers (Futtermais and Saatmais). The sizes of the samples are 860mm x 100mm x thickness. The thickness is compound with 33mm long from the cobs, and the thickness of the surface layers (4.2mm MDF, 3.8mm HDF and 4mm FPY). The maize sections were glued vertically between the surface layers by a glue layer with 200g/mm² of PVAc adhesive. The plates were in a hot press at 60°C with an applied pressure of 0.6MPa during 20 minutes. The thickness of the plates depending on the surface layer: 41.3mm with MDF, 40.3mm with HDF and 41.1mm with FPY.

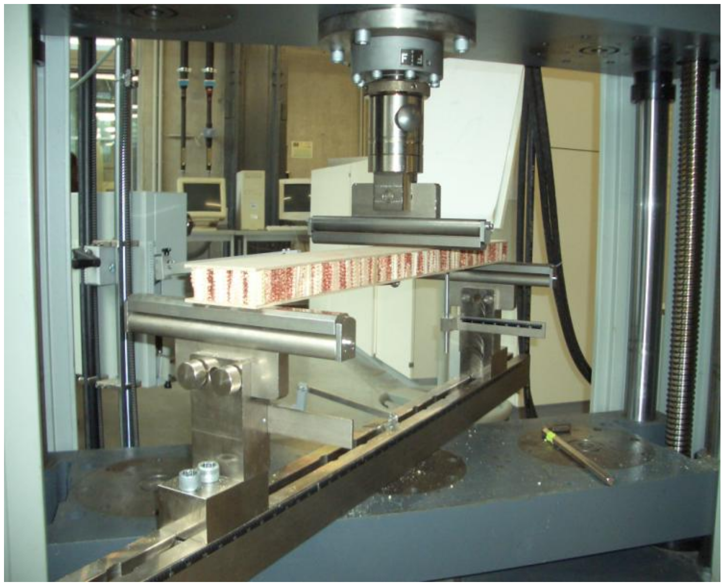

Figure 27: Determination for the modulus of elasticity by three-point bending with variable span. Size of sample (860 x100mm x thickness) mm. Surface layer of this sample made with MDF and with core layer of food-maize

The determination of the shear modulus was, according to ÖNORM EN 408 paragraph 12. The apparent modulus of elasticity (Em,app) was calculated with a span of 219mm, 265mm, 355mm and 820mm and with the secant. The next table shows the features of the mechanical test.

Table 13: Determination for shear modulus with different speeds test, and with different spans. The initial force is for all spans of 20N.

Spans	219mm	265mm	355mm	820mm
Initial force	20N	20N	20N	20N
Temporal E-modulus	40-160N	20-130N	30-120N	30-120N
Test speed	0,58 mm/min	0,88mm/min	1,54mm/min	3,24mm/min

The shear modulus was calculated according to ÖNORM EN 408, paragraph 12.4.

The elasticity modulus was calculated with four different points of force and the linear regression is between 50 and 300N.Others test parameters: preload 20N, longitude of the reference beam: 250mm, subjection spans length min: 246mm, 738mm span and a test of 7.3mm/min.

As shows the next figures, to determinate the bending strength was the final test with four-point bending at a test speed of 3mm/min until the sample is collapsed.

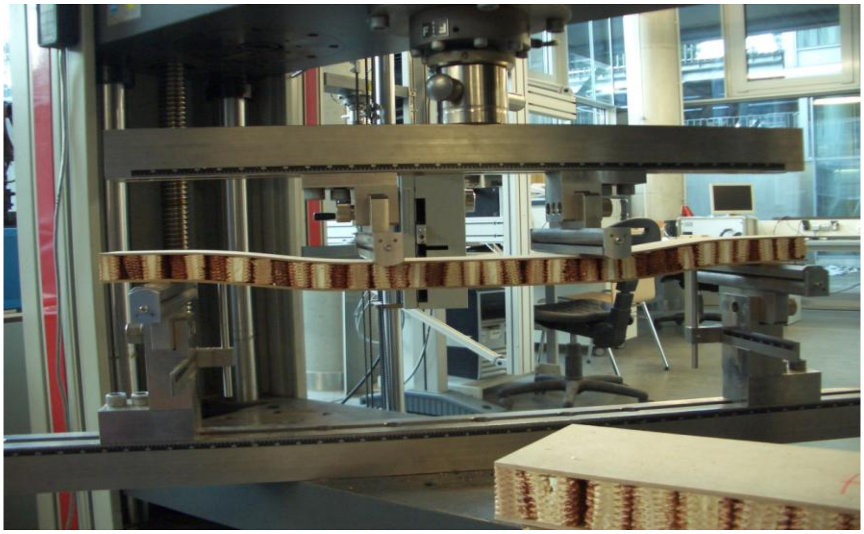

Figure 28: Determination of the bending strength by four points bending until the sampled is collapsed.

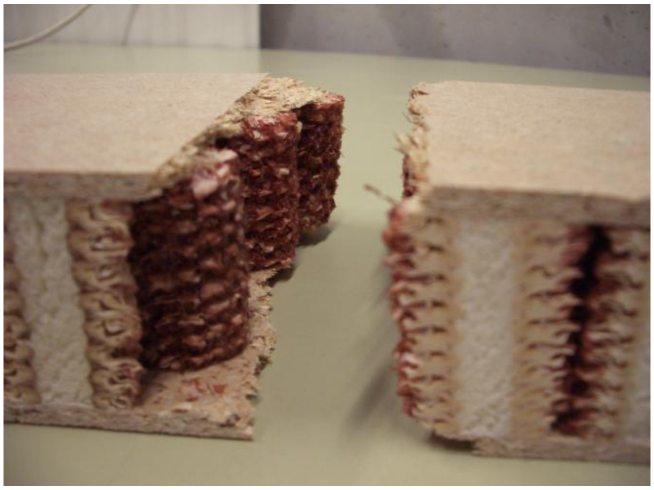

Figure 29: Sample collapsed after the test four points bending with surface layer of FPY and core layer of food-maize.

The bending strength was obtained doing the bending test with 4 points “trav”. The modulus of elasticity was obtained doing the bending test with 4 points “makro”.

2.7. Compression strength in parallel, for samples with three kinds of surface layers and two kinds of core layers

The samples for the compression test in parallel are with three kinds of surface layers. Those surface layers are HDF, FPY, and MDF. The core layers of the samples are again “Futtermais” and “Saatmais”. The variables measured, are the modulus of elasticity (E mod) and the compression strength (Rm). The unit for all variables is N/mm². The number of samples for this mechanical test is 14 each kind of surface layer and core layer. The size of the samples is 100mm of length, 40mm of height and 50mm of wide. The purpose of this mechanical test is to compare the samples with three kinds of surface layer and two kinds of core layer, measuring the “Rm” and the “E mod”. Measuring these variables allows obtaining the resistance to de deformation under load and the slope of the stress-strain curve in the elastic deformation region. The standard for this mechanical test is ÖNORM EN 789 with date of 1996. To perform the compression test in parallel was used a universal Zwick Roell 100th.

The preload of the mechanical test is 200N; the speed test is 0.3mm/min and the modulus of elasticity was determined with 10-40% of maximum force.

2.8. Density and moisture content of MCB samples

The calculations for density and moisture content of MCB samples are in the standard ÖNORM EN 323 edition 1993. The number of samples is 14 samples of each surface layer and each core layer, with sizes of 50mm width, 40mm high and length of 100mm.

3. Results

3.1. Cross section of the Wood Ring and density of cobs from Food-maize (Futtermais) and Growing-maize (Saatmais)

For calculate the cross section of the wood ring, was necessary to measure the area of the core and the wood ring. The value for the cross section of the wood ring was obtained by subtracting the area of the core to the area of the wood ring, obtaining values of density on Futtermais samples between 191 until 285 mm^2 and values on Saatmais samples between 199 until 311 mm^2. These values are from 20 samples of Futtermais and 20 samples of Saatmais with sizes of (30x50) mm.

There is no difference between both kinds of samples as shows the (Table 14) with a value of the T-TEST of 0.6; as well shows the 5% Fractil value with 145 mm^2 for samples of Futtermais and 106 mm^2 for samples of Saatmais. The average values of density from samples of Futtermais are 238±47 mm^2 and from samples of Saatmais is 255±56 mm^2.

Table 14: Cross section of wood ring (mm^2) from samples of Futtermais and Saatmais. Size of each sample: (30x50) mm. Number of samples: 20 of Futtermais and 20 of Saatmais

	Average	SD	5% Fractil	T-TEST
Futtermais	238	47	145	0.6
Saatmais	255	56	106	

Figure 30 shows graphically the cross section values of wood ring of both kinds of samples.

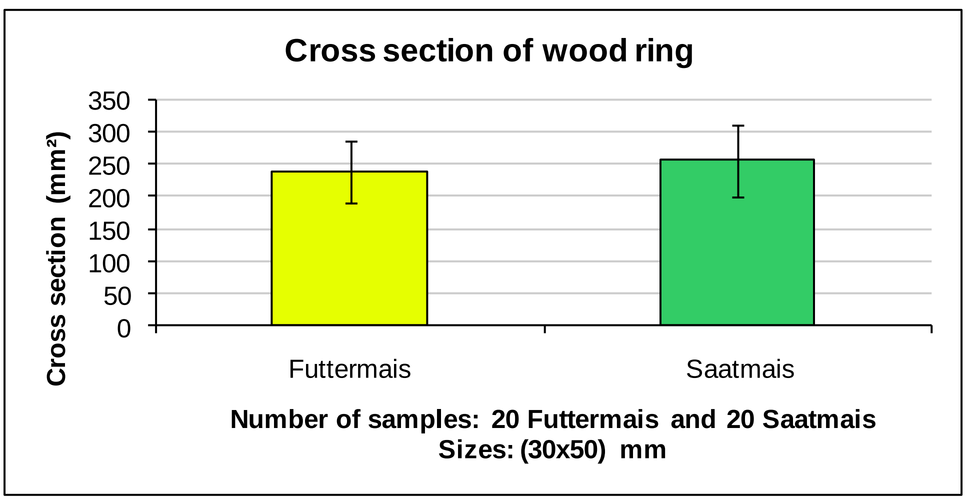

Figure 30: Cross section of wood ring (mm^2) from samples of Futtermais and Saatmais. Size of each sample: (30x50) mm. Number of samples: 20 of Futtermais and 20 of Saatmais

The samples of Futtermais obtains them a density values between 329 until 445 Kg/m^3, and the density values from samples of Saatmais density values between 378 until 454 Kg/m^3. The values are from 20 samples of Futtermais and 20 samples of Saatmais with sizes from both kinds of cobs of (30x50) mm.

Table 15: Density of cobs (Kg/mm^3) from samples of Futtermais and Saatmais. Size of each sample: (30x50) mm. Number of samples: 20 of Futtermais and 20 of Saatmais

	Average	SD	5% Fractil	T-TEST
Futtermais	387	58	327	0.07
Saatmais	416	38	343	

The previous table shows the mean values of the density for samples of Futtermais and Saatmais. The average values for the density of cobs are 387±58 Kg/m^3 for samples of Futtermais and 416±38 Kg/m^3 for samples of Saatmais. The 5% Fractil is 327 Kg/m^3 for samples of Futtermais and 343 Kg/m^3 for samples of Saatmais. There is no difference between both kinds of samples as shows the (Table 15) with a value of the T-TEST of 0.07.

Figure 31 shows graphically the density values of both kinds of samples.

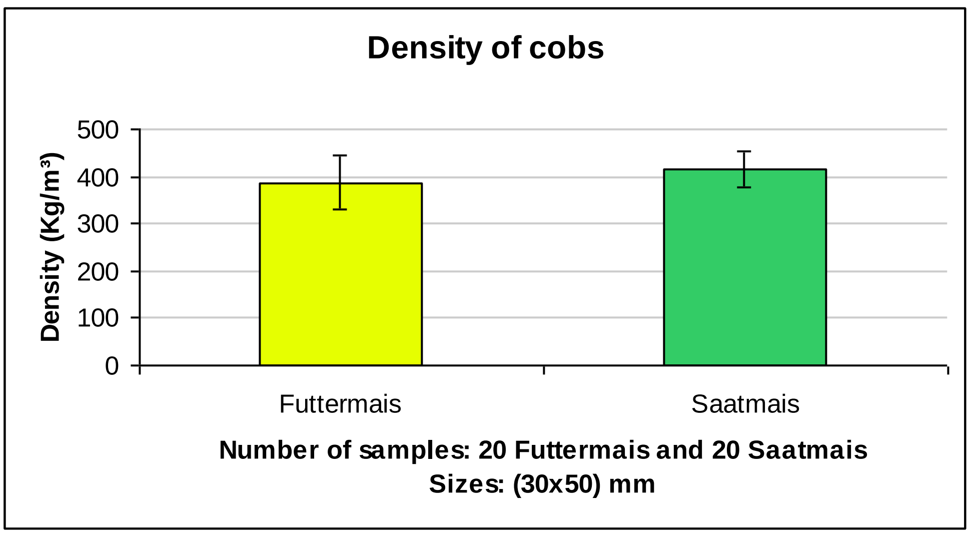

Figure 31: Density of cobs (Kg/m^3) from samples of Futtermais and Saatmais. Size of each sample: (30x50) mm. Number of samples: 20 of Futtermais and 20 of Saatmais

3.2. Tensile strength for samples with two kinds of core layers and a surface layer of MDF

The tensile strength was determinate with samples with a surface layer of MDF of 6 mm of thickness. 19 samples were tested with core layer of Futtermais and 20 samples with core layer of Saatmais. During the test, the crack was mainly in the surface layers material, in the side of the bonded joint.

For samples with a surface layer of 6 mm MDF was founded a tensile strength values of 0.33±0.06 N/mm^2 using a core layer of Futtermais and values of 0.30±0.09 N/mm^2. The 5% Fractil is 0.21 N/mm^2 for samples of Futtermais and 0.1 N/mm^2 for samples of Saatmais. There is no difference between both kinds of samples as shows the (Table 16) with a value for the T-TEST of 0.26.

Table 16: Tensile strength (N/mm^2) from samples of core layer made with Futtermais and surface layer of MDF, and samples made with core layer of Saatmais and surface layer made of MDF. Size of samples is (50x50x40) mm. Number of samples: 19 samples with core layer of Futtermais and surface layer of 6 mm MDF, and 20 samples with core layer of Saatmais a surface layer of 6 mm MDF. Following the standard ÖNORM EN 319

	Average	SD	5% Fractil	T-TEST
Futtermais	0.33	0.06	0.21	0.26
Saatmais	0.30	0.09	0.1	

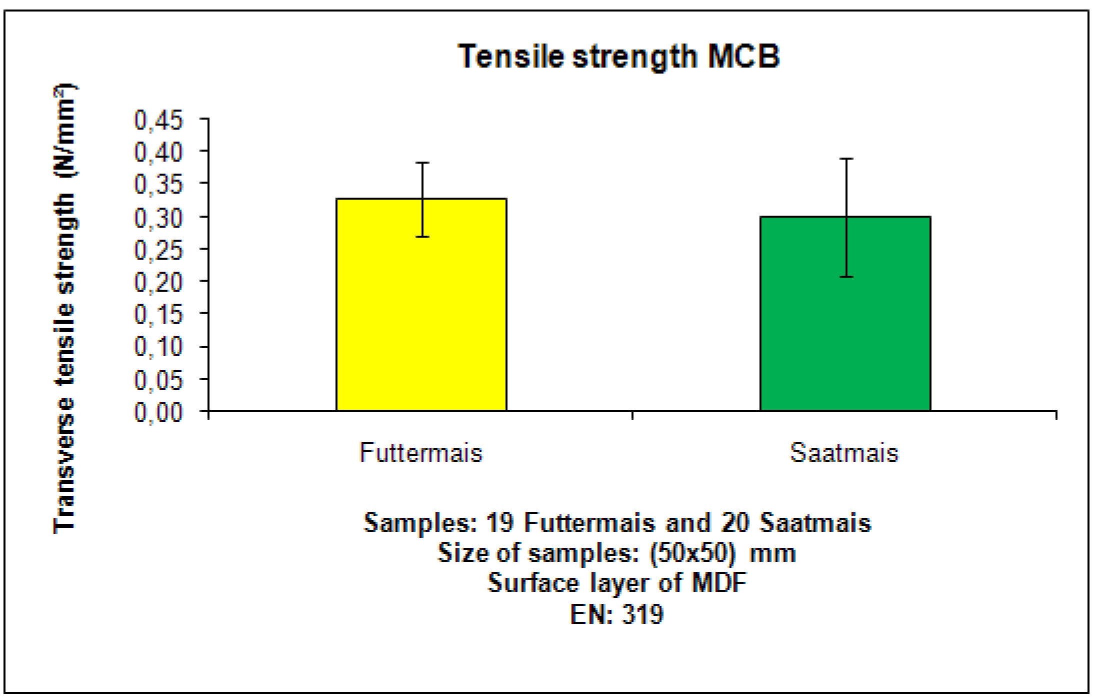

Figure 32: Tensile strength (N/mm^2) from samples of core layer made with Futtermais and surface layer of MDF, and samples made with core layer of Saatmais and surface layer made of MDF. Size of samples is (50x50x40) mm. Number of samples: 19 samples with core layer of Futtermais and surface layer of 6 mm MDF, and 20 samples with core layer of Saatmais a surface layer of 6 mm MDF. Following the standard ÖNORM EN 319

3.3. Perpendicular compression strength for samples with two kinds of core layers and a surface layer of MDF

The perpendicular compression strength was determinate with 12 samples made with core layer of Futtermais and 24 samples made with core layer of Saatmais. The surface layer was made with MDF of 6 mm thickness.

The (Table 17) shows the main values of perpendicular compression strength for MCB samples. The average values of compression strength were of 2.60±1.07 for samples of core layer made with Futtermais and 3.20±0.35 for samples of core layer made with Saatmais. There is no difference between both kinds of samples as shows the (Table 17) with a value for the T-TEST of 0.08. The 5% Fractil is 1.87 N/mm^2 for samples with core layer of Futtermais and 2.54 N/mm^2 for samples with core layer of Saatmais.

Table 17: Perpendicular compression strength (N/mm^2) from samples of core layer made with Futtermais and surface layer of 6 mm MDF, and samples made with core layer of Saatmais and surface layer made of MDF. Size of samples is (75x75x40) mm. Number of samples: 12 samples with core layer of Futtermais and surface layer of MDF, and 24 samples with core layer of Saatmais a surface layer of MDF. Following the standard ÖNORM EN 789 March 1996

	Average	SD	5% Fractil	T-TEST
Futtermais	2.60	1.07	1.87	0.08
Saatmais	3.20	0.35	2.54	

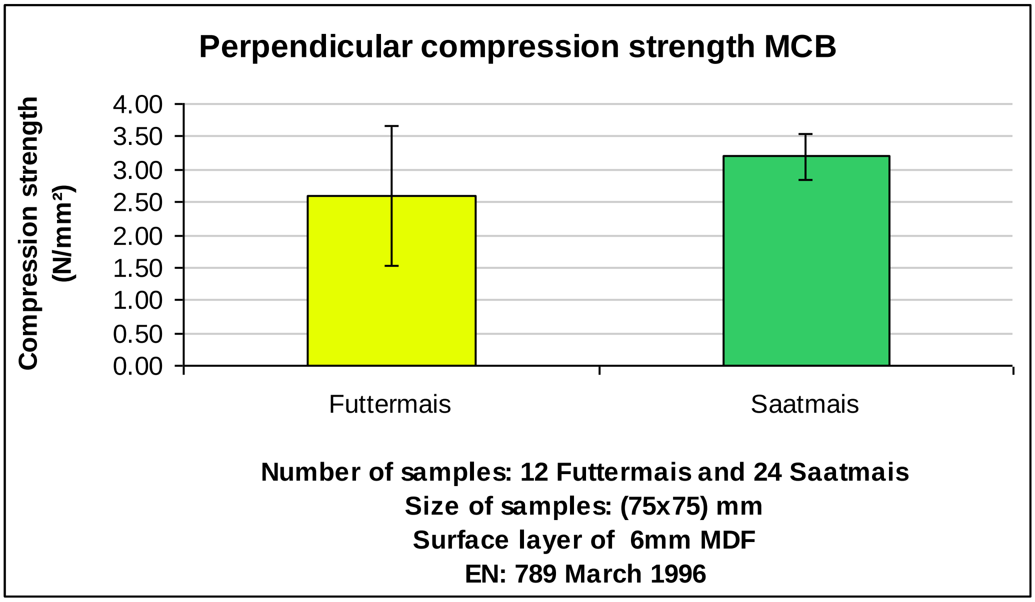

Figure 33: Perpendicular compression strength (N/mm^2) from samples of core layer made with Futtermais and surface layer of 6mm MDF, and samples made with core layer of Saatmais and surface layer made of MDF. Size of samples is (75x75x40) mm. Number of samples: 12 samples with core layer of Futtermais and surface layer of MDF, and 24 samples with core layer of Saatmais a surface layer of MDF. Following the standard ÖNORM EN 789 March 1996

3.4. Screws extendable resistance for samples with two kinds of core layers and a surface layer of MDF

The screws extendable resistance was determinate testing 18 samples per kind of core layer, by “In plane” (the screw was locked in the core layer) and by “Out of plane” (the screw was locked in the surface layer). The material used for performance the surface layer was MDF with 6 mm of thickness.

The (Table 18) shows the main values of screws extendable for MCB samples. The average values of screws extendable were of 103±122 N for samples of “In plane_Fu”, 120±130 N for samples of “In plane_Sa”, 646±134 N for samples of “Out of plane_Fu” and 611±178 N for samples of “Out of plane_Sa”. There is no difference between both kinds of core layer by In plane and by Out of plane, as shows the (Table 18) with a value for the T-TEST of 0.7 by In plane and 0.5 by Out of plane. The 5%

Fractil by “In plane” is 0 for both kinds of core layer. The 5% Fractil by Out of plane is 456 N for samples with a core layer of Futtermais and 288 N for samples with a core layer of Saatmais.

The standard deviation by in plane for both kinds of core layer is higher than the average values because, during the mechanical test, the 7 samples with a core layer of Futtermais got a value of 0, and 6 samples with a core layer of Saatmais got a value of 0. This is the reason why the values of 5% Fractil for samples of “In plane_Fu” and “In plane_Sa” got values of 0.

Table 18: Screws extendable resistance (N). Surface layer used for preformatted MDF material with a thickness of 6 mm. Two kinds of core layer: Futtermais and Saatmais. 18 samples with core layer of Futtermais for the “In plane test” (the screw was locked in the core layer), 18 samples with core layer of Saatmais for the “In plane test” (the screw was locked in the core layer) 18 samples with core layer of Futtermais for the “Out of plane test” (the screw was locked in the surface layer), 18 samples with core layer of Saatmais for the “Out of plane test” (the screw was locked in the surface layer). Sizes of samples (75x75x40) mm. Following the standard ÖNORM EN 320 October 1993

	Average	SD	5% Fractil	T-TEST
In plane_Fu	103	122	0	0.7
In plane_Sa	120	130	0	
Out of plane_Fu	646	134	456	0.5
Out of plane_Sa	611	178	288	

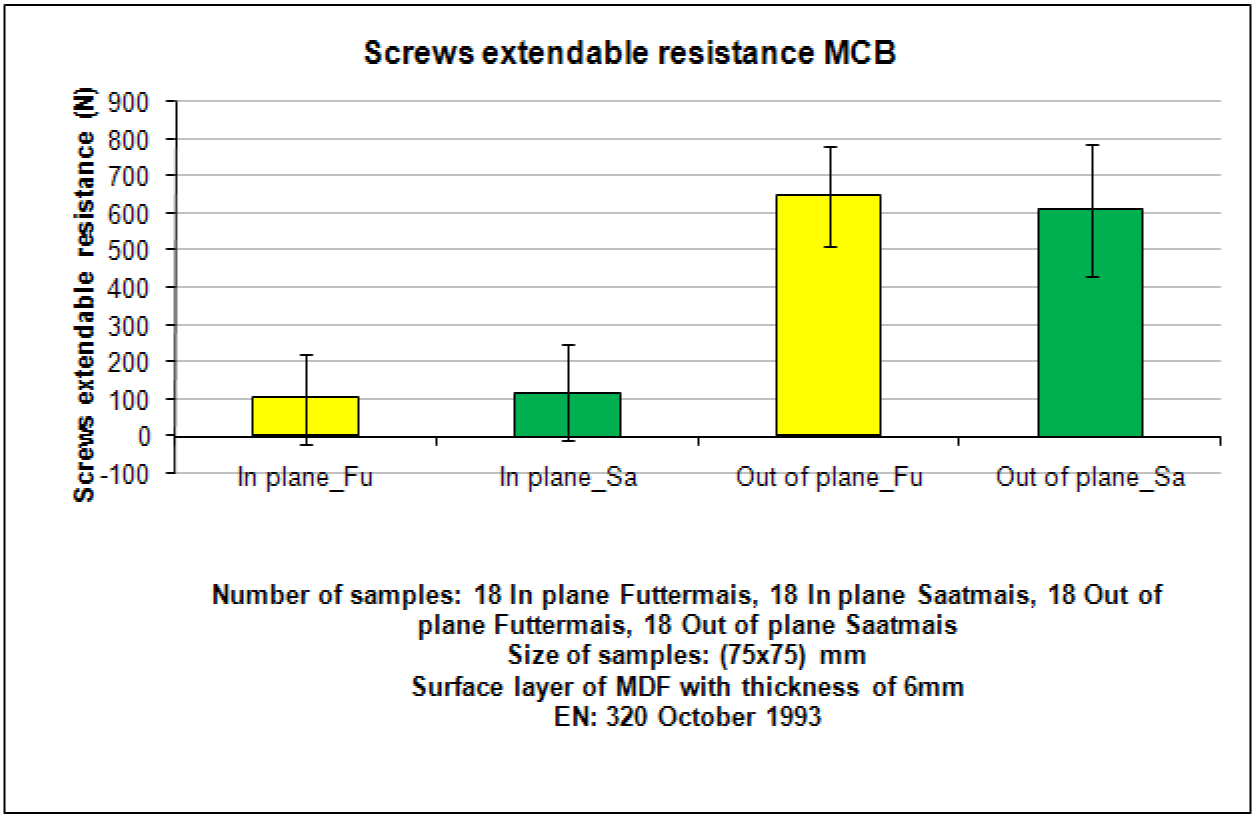

Figure 34: Screws extendable resistance (N). Surface layer used for preformatted MDF material with a thickness of 6 mm. Two kinds of core layer: Futtermais and Saatmais. 18 samples with core layer of Futtermais for the “In plane test” (the screw was locked in the core layer), 18 samples with core layer of Saatmais for the “In plane test” (the screw was locked in the core layer) 18 samples with core layer of Futtermais for the “Out of plane test” (the screw was locked in the surface layer), 18 samples with core layer of Saatmais for the “Out of plane test” (the screw was locked in the surface layer). Sizes of samples (75x75x40) mm. Following the standard ÖNORM EN 320 October 1993

3.5. Perpendicular compression strength for samples of growing-maize cobs (Saatmais) and food-maize cobs (Futtermais)

To determinate the compression strength of cobs was necessary measure 20 cobs of Futtermais and 20 cobs of Saatmais with a size of (30x50) mm.

The (Table 19) shows the mean values of compression strength for cobs. The results obtained were 5.0±1.4 N/mm^2 for cobs of Futtermais and 6.0±1.3 N/mm^2 for cobs of Saatmais. The values of 5% Fractil are 3.3 N/mm^2 for cobs of Futtermais and

4.0 N/mm^2 for cobs of Saatmais. There is no difference between both kinds of cobs by, as shows the (Table 19) with a value for the T-TEST of 0.06.

Table 19: Perpendicular compression strength for samples of growing-maize (Saatmais) cobs and food-maize cobs (Futtermais). Units: N/mm^2. Number of samples: 20 of Futtermais and 20 of Saatmais. Size of samples: (30x50) mm. Following the standard DIN: 52 185 September 1975.

	Average	SD	5% Fractil	T-TEST
Futtermais	5.0	1.4	3.3	0.06
Saatmais	6.0	1.3	4.0	

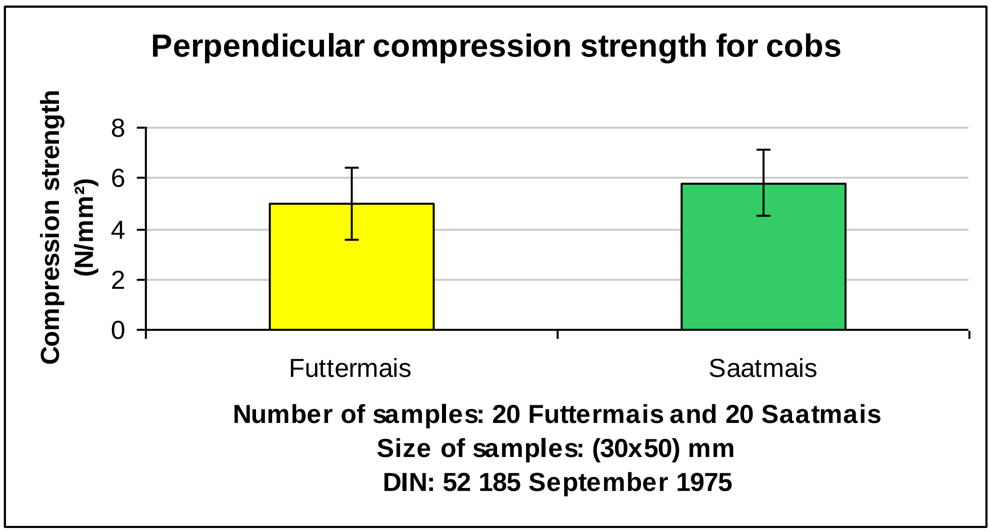

Figure 35: Perpendicular compression strength for samples of growing-maize (Saatmais) cobs and food-maize cobs (Futtermais). Units: (N/mm^2). Number of samples: 20 of Futtermais and 20 of Saatmais. Size of samples: (30x50) mm. Following the standard DIN: 52 185 September 1975.

The (Table 20) shows the mean values of compression strength of wood ring for cobs. The results obtained were 11.5±3.0 N/mm^2 for wood ring cobs Futtermais and 13.0±3.0 N/mm^2 for wood ring of Saatmais. The values of 5% Fractil are 6.0 N/mm^2 for wood ring of Futtermais and 9.0 N/mm^2 for wood ring of Saatmais. There is no difference on the wood ring between both kinds of cobs by, as shows the (Table 20) with a value for the T-TEST of 0.2.

Table 20: Perpendicular compression strength of wood ring, comparing samples of growing-maize (Saatmais) cobs and food-maize cobs (Futtermais). Units: N/mm^2. Number of samples: 20 of Futtermais and 20 of Saatmais. Size of samples: (30x50) mm.

	Average	SD	5% Fractil	T-TEST
Futtermais	11.5	3.0	6.0	0.2
Saatmais	13.0	3.0	9.0	

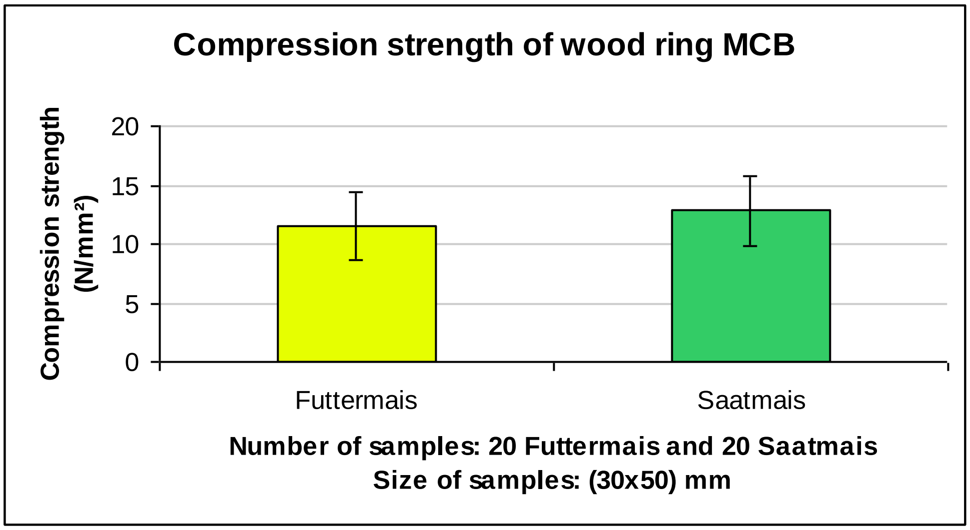

Figure 36: Perpendicular compression strength of wood ring, comparing samples of growing-maize (Saatmais) cobs and food-maize cobs (Futtermais). Units: N/mm^2. Number of samples: 20 of Futtermais and 20 of Saatmais. Size of samples: (30x50) mm.

3.6. Bending test for samples with three kinds of surface layers and two kinds of core layers

To determinate the flexural modulus of elasticity was tested 12 samples of each kind of MCB. The next table (Table 21) shows the results obtained on each kind of MCB sample, where the higher values are from the samples with a core layer made of Saatmais. The highest value of this mechanical test is from the samples with a surface layer of HDF and core layer of Saatmais (HDF_SA), giving a value of

10590.0±1022.0N/mm^2. There is no difference on flexural modulus of elasticity between samples with a surface layer of FPY and core layer of Futtermais (FPY_FU) and samples with a surface layer of FPY with core layer of Saatmais (FPY_SA), as shows the (Table 21) with a value for the T-TEST of 0.7. There are some differences on flexural modulus of elasticity between samples with a surface layer of MDF and core layer of Futtermais (MDF_FU) and samples with a surface layer of MDF with core layer of Saatmais (MDF_SA), as shows the (Table 21) with a value for the T-TEST of 1.3E-04. There are some differences on flexural modulus of elasticity between samples with a surface layer of HDF and core layer of Futtermais (HDF_FU) and samples with a surface layer of HDF with core layer of Saatmais (HDF_SA), as shows the (Table 21) with a value for the T-TEST of 2.6E-03.

The values of 5% Fractil for the samples were: 4839.0N/mm^2 for samples of MDF_FU, 5389.0N/mm^2 for samples of MDF_SA, 7999.0N/mm^2 for samples of HDF_FU, 8967.0N/mm^2 for samples of HDF_SA, 5035.0N/mm^2 for samples of FPY_FU and 4936.0N/mm^2 for samples of FPY_SA.

Table 21: Flexural modulus of elasticity 4Pkt._makro (N/mm^2). Number of samples: 12 with each kind of surface layer and core layer. Samples of a surface layer of MDF and core layer of Futtermais (MDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of HDF and core layer of Futtermais (HDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of FPY and core layer of Futtermais (FPY_FU), Samples of a surface layer of FPY and core layer of Saatmais (FPY_SA). Size of samples: (860x40x100) mm. Following the standard ÖNORM EN: 408 April 205.

	Average	**5% Fractil**	**SD**	**T-TEST**
MDF_FU	5215.0	4839.0	233.0	1.3E-04
MDF_SA	6068.0	5389.0	529.0	
HDF_FU	9374.0	7999.0	700.0	2.6E-03
HDF_SA	10590.0	8967.0	1022.0	
FPY_FU	5865.0	5035.0	569.0	0.7
FPY_SA	5969.0	4936.0	922.0	

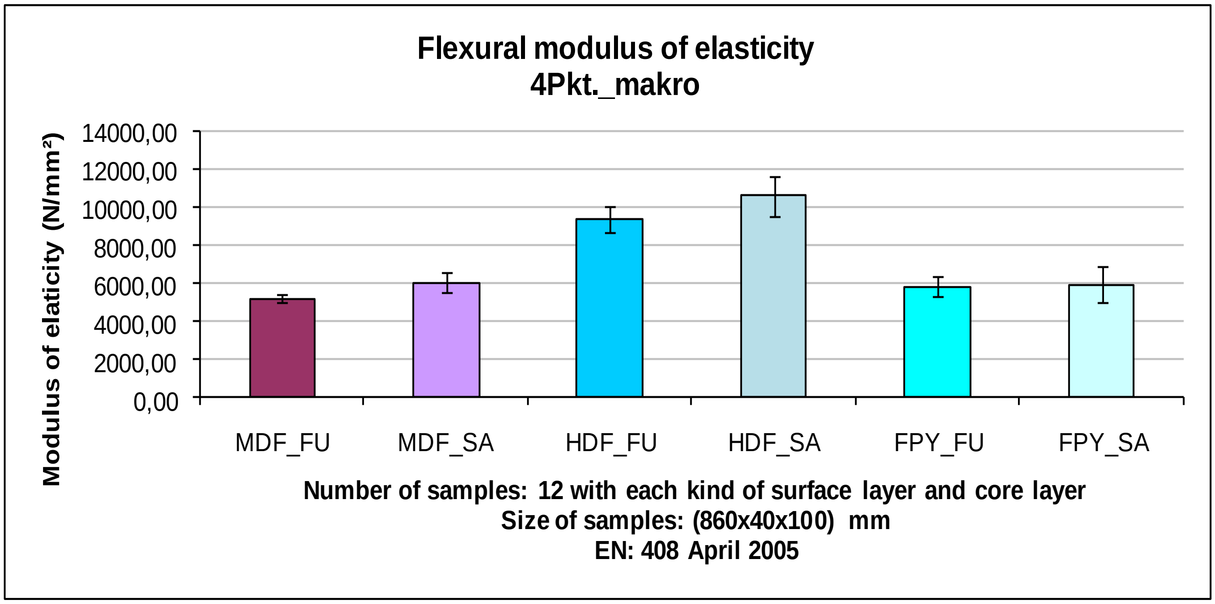

Figure 37: Flexural modulus of elasticity 4Pkt._makro (N/mm^2). Number of samples: 12 with each kind of surface layer and core layer. Samples of a surface layer of MDF and core layer of Futtermais (MDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of HDF and core layer of Futtermais (HDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of FPY and core layer of Futtermais (FPY_FU), Samples of a surface layer of FPY and core layer of Saatmais (FPY_SA). Size of samples: (860x40x100) mm. Following the standard ÖNORM EN: 408 April 205.

To determinate the bending strength was tested 12 samples of each kind of MCB. The next table (Table 22) shows the results obtained on each kind of MCB sample, where the higher values are from the samples with a core layer made of Saatmais. The highest value of this mechanical test is from the samples with a surface layer of HDF and core layer of Saatmais (HDF_SA), giving a value of 6.4±0.5N/mm^2. There is no difference on bending strength between samples with a surface layer of FPY and core layer of Futtermais (FPY_FU) and samples with a surface layer of FPY with core layer of Saatmais (FPY_SA), as shows the (Table 22) with a value for the T-TEST of 0.1. There are some differences on bending strength between samples with a surface layer of MDF and core layer of Futtermais (MDF_FU) and samples with a surface layer of MDF with core layer of Saatmais (MDF_SA), as shows the (Table 22) with a value for the T-TEST of 2.2E-04. There are some differences on bending strength between samples with a surface layer of HDF and core layer of Futtermais (HDF_FU) and samples with a surface layer of HDF with core layer of Saatmais (HDF_SA), as shows the (Table 22) with a value for the T-TEST of 3.0E-11.

The values of 5% Fractil for the samples were: 3.3N/mm^2 for samples of MDF_FU, 4.3N/mm^2 for samples of MDF_SA, 3.3N/mm^2 for samples of HDF_FU, 5.5N/mm^2 for samples of HDF_SA, 4.4N/mm^2 for samples of FPY_FU and 4.4N/mm^2 for samples of FPY_SA.

Table 22: Bending strength 4Pkt._trav (N/mm^2). Number of samples: 12 with each kind of surface layer and core layer. Samples of a surface layer of MDF and core layer of Futtermais (MDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of HDF and core layer of Futtermais (HDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of FPY and core layer of Futtermais (FPY_FU), Samples of a surface layer of FPY and core layer of Saatmais (FPY_SA). Size of samples: (860x40x100) mm. Following the standard ÖNORM EN: 408 April 205.

	Average	SD	5% Fractil	T-TEST
MDF_FU	3.0	0.1	3.3	2.2E-12
MDF_SA	5.0	0.2	4.3	
HDF_FU	4.0	0.4	3.3	3.0E-11
HDF_SA	6.4	0.5	5.5	
FPY_FU	5.0	0.2	4.4	0.1
FPY_SA	5.0	0.3	4.4	

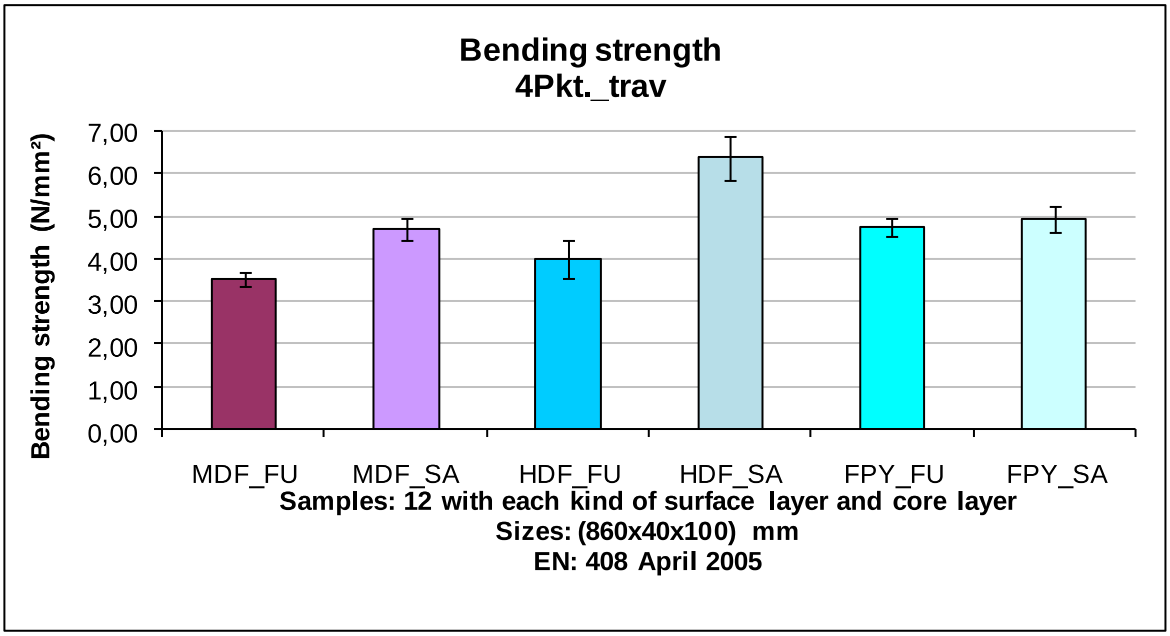

Figure 38: Bending strength 4Pkt._trav (N/mm^2). Number of samples: 12 with each kind of surface layer and core layer. Samples of a surface layer of MDF and core layer of Futtermais (MDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of HDF and core layer of Futtermais (HDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of FPY and core layer of Futtermais (FPY_FU), Samples of a surface layer of FPY and core layer of Saatmais (FPY_SA). Size of samples: (860x40x100) mm. Following the standard ÖNORM EN: 408 April 205.

To determinate the shear modulus was tested 12 samples of each kind of MCB. The next table (Table 23) shows the results obtained on each kind of MCB sample, where the higher values are from the samples with a core layer made of Saatmais. The highest value of this mechanical test is from the samples with a surface layer of HDF and core layer of Saatmais (HDF_SA), giving a value of 33.0±3.7N/mm^2. There are some differences on shear modulus between samples with a surface layer of FPY and core layer of Futtermais (FPY_FU) and samples with a surface layer of FPY with core layer of Saatmais (FPY_SA), as shows the (Table 23) with a value for the T-TEST of 3.1E-07. There are some differences on shear modulus between samples with a surface layer of MDF and core layer of Futtermais (MDF_FU) and samples with a surface layer of MDF with core layer of Saatmais (MDF_SA), as shows the (Table 23) with a value for the T-TEST of 6.4E-10. There are some differences on shear modulus between samples with a surface layer of HDF and core layer of Futtermais (HDF_FU) and samples with a surface layer of HDF with core layer of Saatmais (HDF_SA), as shows the (Table 23) with a value for the T-TEST of 6.0E-10.

The values of 5% Fractil for the samples were: 12.1N/mm^2 for samples of MDF_FU, 19.6N/mm^2 for samples of MDF_SA, 13.0N/mm^2 for samples of HDF_FU, 27.7N/mm^2 for samples of HDF_SA, 13.0N/mm^2 for samples of FPY_FU and 18.5N/mm^2 for samples of FPY_SA.

Table 23: Shear modulus of MCB samples (N/mm^2). Number of samples: 12 with each kind of surface layer and core layer. Samples of a surface layer of MDF and core layer of Futtermais (MDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of HDF and core layer of Futtermais (HDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of FPY and core layer of Futtermais (FPY_FU), Samples of a surface layer of FPY and core layer of Saatmais (FPY_SA). Size of samples: (860x40x100) mm. Following the standard ÖNORM EN: 408 April 205.

	Average	SD	5% Fractil	T-TEST
MDF_FU	13.3	0.7	12.1	6.4E-10
MDF_SA	23.0	2.1	19.6	
HDF_FU	15.0	1.2	13.0	6.0E-10
HDF_SA	33.0	3.7	27.7	
FPY_FU	14.0	1.0	13.0	3.1E-07
FPY_SA	24.0	3.3	18.5	

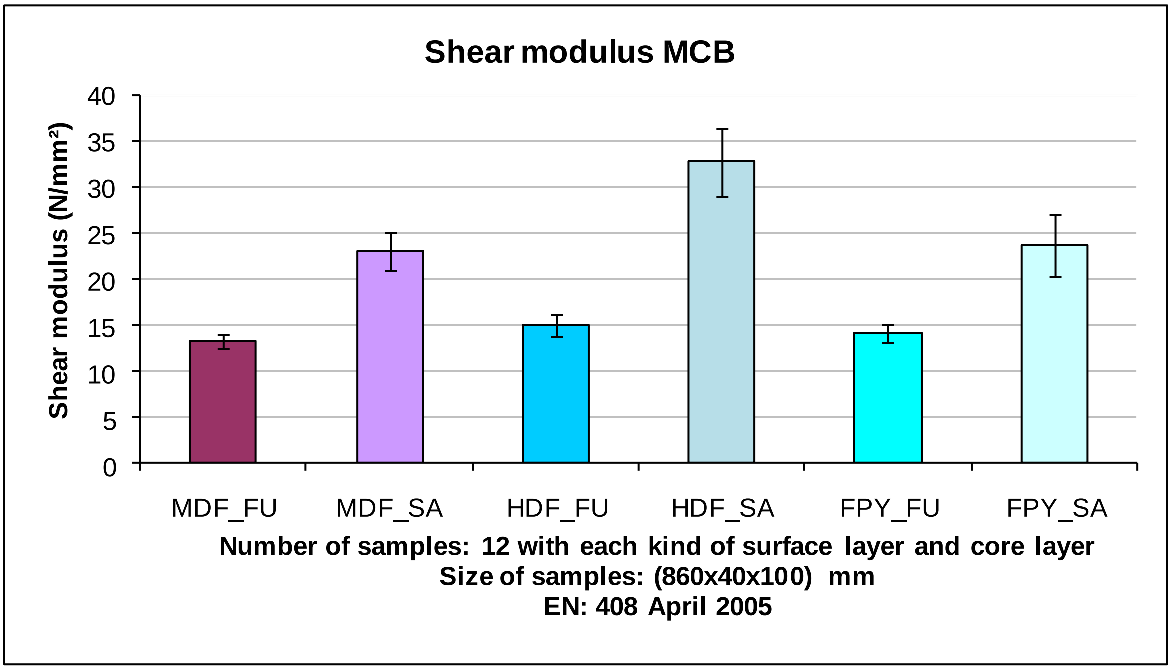

Figure 39: Shear modulus of MCB samples (N/mm^2). Number of samples: 12 with each kind of surface layer and core layer. Samples of a surface layer of MDF and core layer of Futtermais (MDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of HDF and core layer of Futtermais (HDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of FPY and core layer of Futtermais (FPY_FU), Samples of a surface layer of FPY and core layer of Saatmais (FPY_SA). Size of samples: (860x40x100) mm. Following the standard ÖNORM EN: 408 April 205.

3.7. Compression strength in parallel, for samples with three kinds of surface layers and two kinds of core layers

The values of compressions strength and modulus of elasticity in parallel were obtained measuring 14 samples of each different MCB material. All samples with a core layer of Saatmais obtained the higher values for compression strength.

The next table (Table 24) shows the values obtained during the mechanical test. The highest value for compression strength is from the samples with a surface layer of HDF and core layer of Saatmais (HDF_SA); these samples obtained an average value of 5.4±0.3N/mm^2 with a 5% Fractil of 4.7N/mm^2. There is no difference on compression strength in parallel between samples with a surface layer of FPY and core layer of

Futtermais (FPY_FU) and samples with a surface layer of FPY with core layer of Saatmais (FPY_SA), as shows the (Table 24) with a value for the T-TEST of 0.61. There are some differences on compression strength in parallel between samples with a surface layer of HDF and core layer of Futtermais (HDF_FU) and samples with a surface layer of HDF with core layer of Saatmais (HDF_SA), as shows the (Table 24) with a value for the T-TEST of 0. There are some differences on compression strength in parallel between samples with a surface layer of MDF and core layer of Futtermais (MDF_FU) and samples with a surface layer of MDF with core layer of Saatmais (MDF_SA), as shows the (Table 24) with a value for the T-TEST of 0.

Table 24: Compression strength in parallel of MCB samples (N/mm^2). Number of samples: 14 with each kind of surface layer and core layer. Samples of a surface layer of MDF and core layer of Futtermais (MDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of HDF and core layer of Futtermais (HDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of FPY and core layer of Futtermais (FPY_FU), Samples of a surface layer of FPY and core layer of Saatmais (FPY_SA). Size of samples: (50x40x100) mm. Following the standard ÖNORM EN: 789 March 1996.

	Average	**SD**	**5% Fractil**	**T-TEST**
MDF_FU	2.9	0.2	0.1	0
MDF_SA	3.3	0.2	3.0	
HDF_FU	5.0	0.2	4.5	0
HDF_SA	5.4	0.3	4.7	
FPY_FU	3.2	0.1	3.0	0.61
FPY_SA	3.3	0.2	3.0	

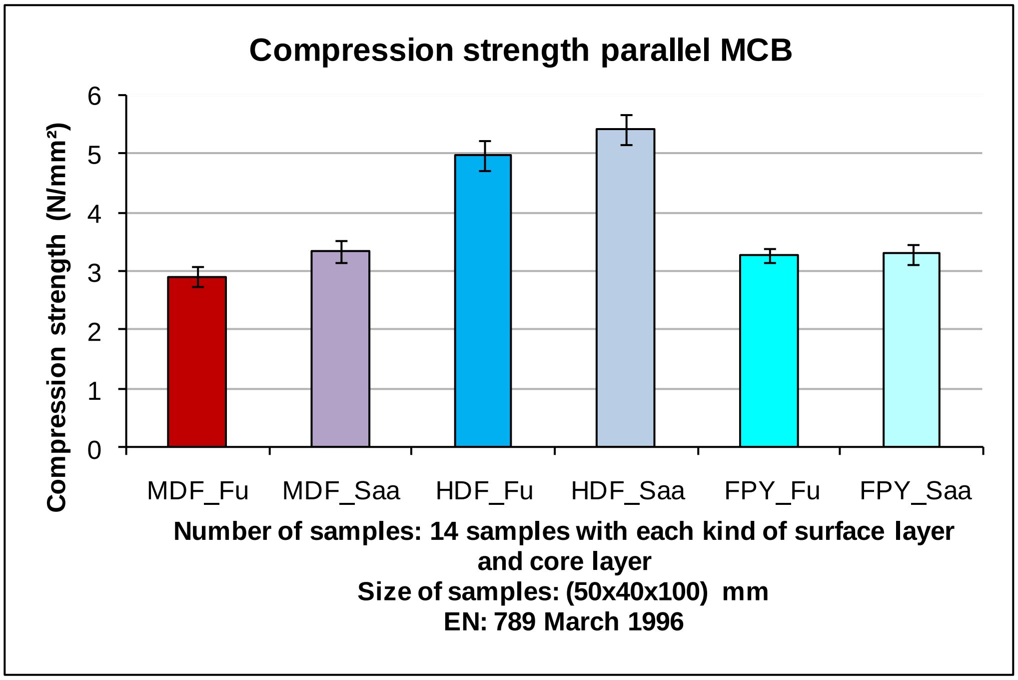

Figure 40: Compression strength in parallel of MCB samples (N/mm^2). Number of samples: 14 with each kind of surface layer and core layer. Samples of a surface layer of MDF and core layer of Futtermais (MDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of HDF and core layer of Futtermais (HDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of FPY and core layer of Futtermais (FPY_FU), Samples of a surface layer of FPY and core layer of Saatmais (FPY_SA). Size of samples: (50x40x100) mm. Following the standard ÖNORM EN: 789 March 1996.

The next table (Table 25) shows the values obtained during the mechanical test. The highest value for modulus of elasticity in parallel is from the samples with a surface layer of HDF and core layer of Saatmais (HDF_SA); these samples obtained an average value of 941.0±76.4N/mm^2 with a 5% Fractil of 847.4N/mm^2. There are some differences on modulus of elasticity in parallel between samples with a surface layer of MDF and core layer of Futtermais (MDF_FU) and samples with a surface layer of MDF with core layer of Saatmais (MDF_SA), as shows the (Table 25) with a value for the T-TEST of 0. There is no difference on modulus of elasticity in parallel between samples with a surface layer of HDF and core layer of Futtermais (HDF_FU) and samples with a surface layer of HDF with core layer of Saatmais (HDF_SA), as shows the (Table 25) with a value for the T-TEST of 0.58. There is no difference on modulus of elasticity in parallel between samples with a surface layer of FPY and core layer of Futtermais

(FPY_FU) and samples with a surface layer of FPY with core layer of Saatmais (FPY_SA), as shows the (Table 25) with a value for the T-TEST of 0.29.

Table 25: Modulus of elasticity parallel of MCB samples (N/mm^2). Number of samples: 14 with each kind of surface layer and core layer. Samples of a surface layer of MDF and core layer of Futtermais (MDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of HDF and core layer of Futtermais (HDF_FU), Samples of a surface layer of HDF and core layer of Saatmais (HDF_SA), Samples of a surface layer of FPY and core layer of Futtermais (FPY_FU), Samples of a surface layer of FPY and core layer of Saatmais (FPY_SA). Size of samples: (50x40x100) mm. Following the standard ÖNORM EN: 789 March 1996.

	Average	SD	5% Fractil	T-TEST
MDF_FU	469.0	50.1	394.0	0
MDF_SA	529.2	23.0	478.0	
HDF_FU	917.0	141.5	810.0	0.58
HDF_SA	941.0	76.4	847.4	
FPY_FU	538.0	23.3	490.0	0.29
FPY_SA	509.4	95.0	212.4	

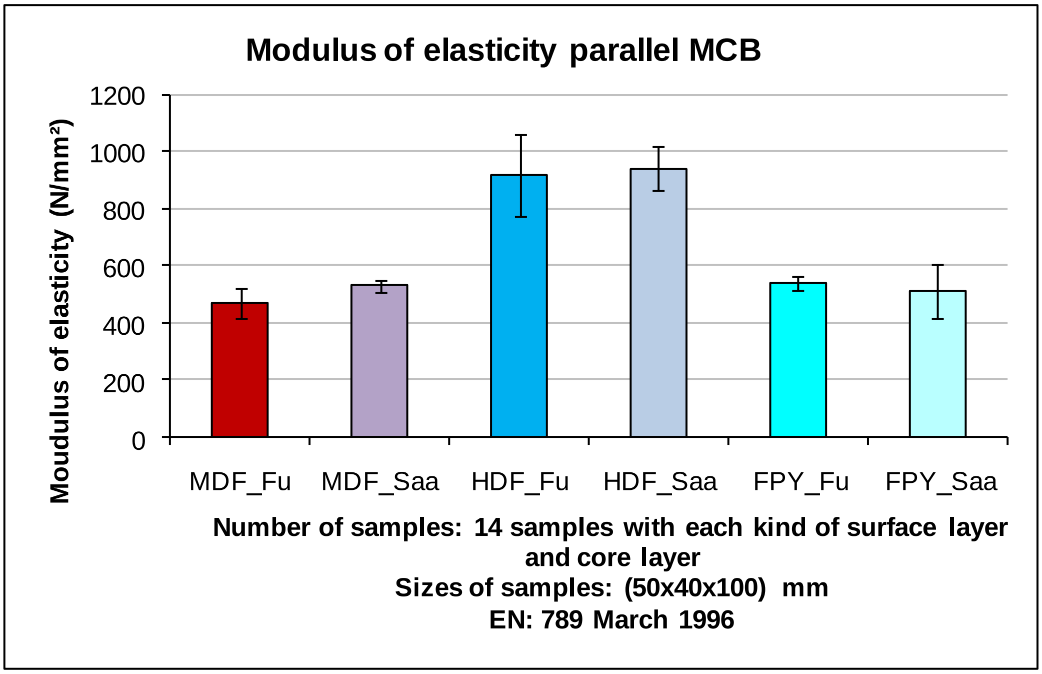

Figure 41: Modulus of elasticity parallel of MCB samples (N/mm^2). Number of samples: 14 with each kind of surface layer and core layer. Samples of a surface layer of MDF

and core layer of Futtermais (MDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of HDF and core layer of Futtermais (HDF_FU), Samples of a surface layer of HDF and core layer of Saatmais (HDF_SA), Samples of a surface layer of FPY and core layer of Futtermais (FPY_FU), Samples of a surface layer of FPY and core layer of Saatmais (FPY_SA). Size of samples: (50x40x100) mm. Following the standard ÖNORM EN: 789 March 1996.

3.8. Density and moisture content of MCB samples

The density and the moisture content from the MCB material were determinate using the same samples as in the mechanical test of compression strength in parallel, or the mechanical test of modulus of elasticity in parallel. The highest value of density and moisture content is from samples of a surface layer of HDF and core layer of Saatmais (HDF_SA). The values for these samples are 468.0±13Kg/m^3 for the density with a 5% Fractil of 448.0Kg/m^3 (as shows the Table 26), and a 10.68±0.12% of moisture content (as shows the Table 27). The lower value of density is from samples with a surface layer of FPY and core layer of Futtermais (FPY_FU), giving an average value for density of 342.0±12.0Kg/m^3 with a 5% Fractil of 319.0Kg/m^3. The lower value of moisture content is from samples with a surface layer of HDF and core layer of Futtermais (HDF_FU), giving a value of 10.20±0.06% (as shows the Table 27 and the Figure 43).

Table 26: Density of MCB samples (N/mm^2). Number of samples: 14 with each kind of surface layer and core layer. Samples of a surface layer of MDF and core layer of Futtermais (MDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of HDF and core layer of Futtermais (HDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of FPY and core layer of Futtermais (FPY_FU), Samples of a surface layer of FPY and core layer of Saatmais (FPY_SA). Size of samples: (50x40x100) mm. Following the standard ÖNORM EN: 323 edition 1993.

	Average density (Kg/m³)	SD	5% Fractil
MDF_FU	351.0	17.0	324.0
MDF_SA	428.0	16.0	403.0
HDF_FU	375.0	15.0	354.0
HDF_SA	468.0	13.0	448.0

FPY_FU	342.0	12.0	319.0
FPY_SA	426.0	16.0	404.0

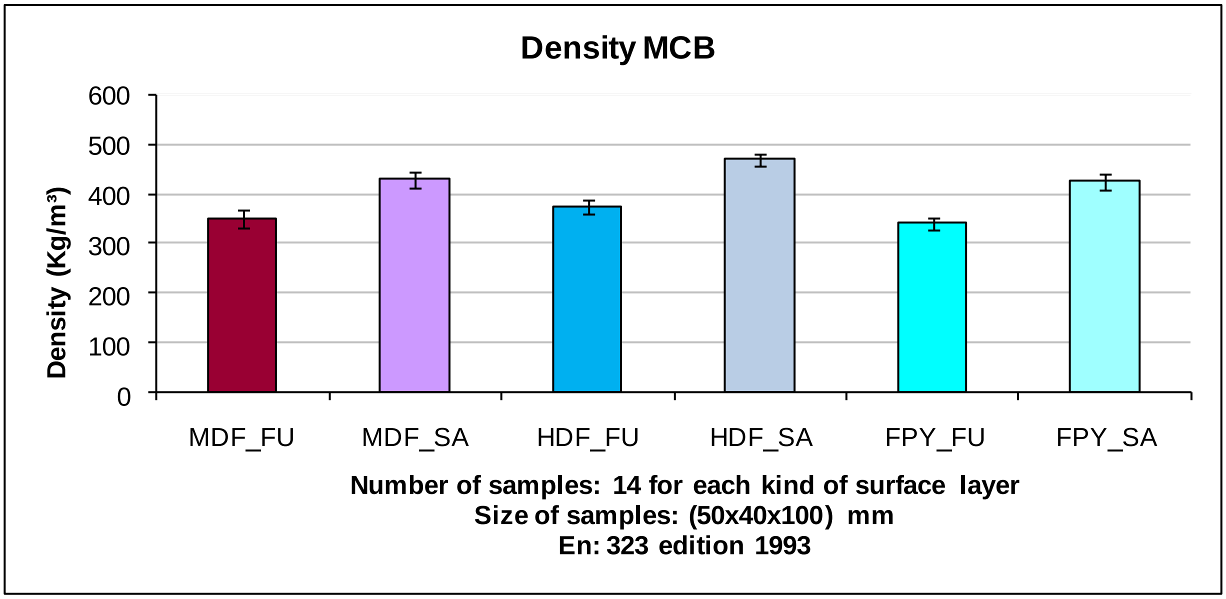

Figure 42: Density of MCB samples (N/mm^2). Number of samples: 14 with each kind of surface layer and core layer. Samples of a surface layer of MDF and core layer of Futtermais (MDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of HDF and core layer of Futtermais (HDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of FPY and core layer of Futtermais (FPY_FU), Samples of a surface layer of FPY and core layer of Saatmais (FPY_SA). Size of samples: (50x40x100) mm. Following the standard ÖNORM EN: 323 edition 1993.

Table 27: Moisture content of MCB samples (%). Number of samples: 14 with each kind of surface layer and core layer. Samples of a surface layer of MDF and core layer of Futtermais (MDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of HDF and core layer of Futtermais (HDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of FPY and core layer of Futtermais (FPY_FU), Samples of a surface layer of FPY and core layer of Saatmais (FPY_SA). Size of samples: (50x40x100) mm.

	Average of moisture content (%)	SD
MDF_FU	10,40	0,06
MDF_SA	11,13	0,18
HDF_FU	10,20	0,06

HDF_SA	10,68	0,12
FPY_FU	11.00	0,08
FPY_SA	11,50	0,11

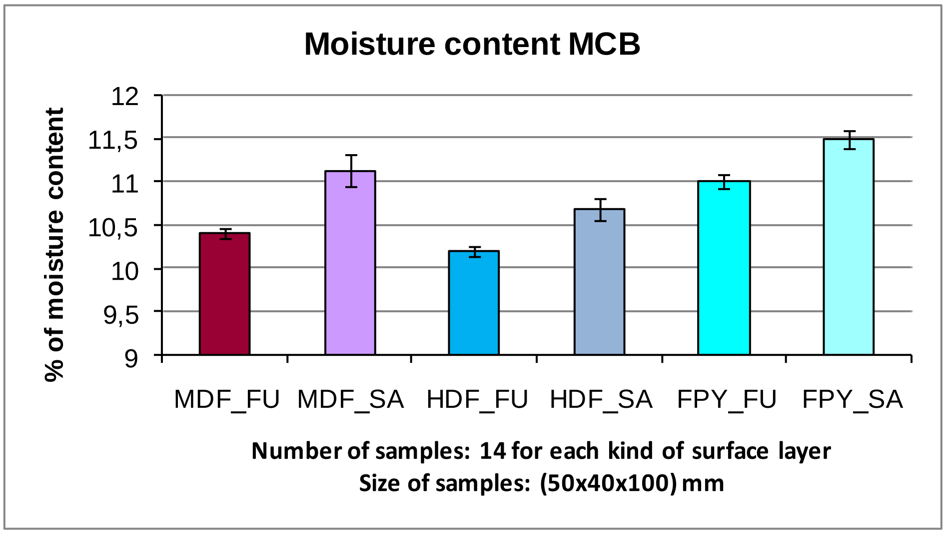

Figure 43: Moisture content of MCB samples (%). Number of samples: 14 with each kind of surface layer and core layer. Samples of a surface layer of MDF and core layer of Futtermais (MDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of HDF and core layer of Futtermais (HDF_FU), Samples of a surface layer of MDF and core layer of Saatmais (MDF_SA), Samples of a surface layer of FPY and core layer of Futtermais (FPY_FU), Samples of a surface layer of FPY and core layer of Saatmais (FPY_SA). Size of samples: (50x40x100) mm.

4. Discussion

The samples of MCB material obtained the same results about the transverse tensile strength, so, the different measures are from the glue layer, because depends of the quantity of glue and the dryer time; as well from the surface layers because the fissure was mainly in the surface layers material, in the side of the bonded joint.

The experiment for determinate the perpendicular compression strength, gave a value 20% higher for samples of MCB with a core layer of Saatmais than the value of perpendicular compression strength for samples of MCB with a core layer of Futtermais. This higher capacity to hold up the perpendicular compression strength for the samples with a core layer of Saatmais is directly proportional to the cross section area of the wood ring in the cobs. This is proved too in the paragraph (3.5) in this work, making a mechanical test for check the perpendicular compression strength of the cobs and the calculations for determinate the force which can be hold up for the wood ring of a cob.

The values obtained from the test (out of plane) are quite similar for samples with a core layer of Saatmais or for samples with a core layer of Futtermais, because all samples from this test had the same surface layer (MCB 6mm thickness), and the values of the screw extendable resistance are only come from the surface layer. The values obtained from the test (in plane) are the same because the screw was many times locked between cobs or giving a cero value because there was no cobs.

With all described before, is possible to imagine the results of this test. All samples with a core layer of Saatmais have a higher value than the samples with a core layer of Futtermais.

The kind of surface layer is important too, because the differences between samples with different surface layers are so higher. The samples with a surface layer of HDF and core layer of Saatmais have a higher value of modulus of elasticity in the bending test.

The samples with a core layer of Saatmais and surface layer of HDF have the higher values of bending strength. These values are influenced for the features of the surface layer and the wood ring.

The kind of core layer is important because all MCB samples with a core layer of Saatmais got higher values of the shear modulus than the MCB samples with a core layer of Futtermais. The MCB samples with a surface layer of HDF and core layer with Saatmais got the highest values than the rest of the samples.

The compression strength in parallel depends of the cross section from the wood ring cobs in the core layer. All MCB samples with a core layer made with Saatmais got higher values of compression strength in parallel, because the cross section of this kind of cobs is bigger than the wood ring from the cobs of Futtermais.

After to describe the features from the MCB samples, is possible know which one is the sample with high values. This sample is the HDF_SA (surface layer of HDF and core layer of Saatmais).

Comparing the MCB material (samples of HDF_SA) with the materials which are using for the productions of wood door; the MCB panel have similar qualities than compact light board how shows the next table. The value of density gave for the MCB material proves that have enough capacity for insulate.

Is necessary to remark the extreme high value of shear modulus, nearly ten times higher than the value of shear modulus from Compact light board as shows the

(Table 28), as well as the lowest value of Screws extendable resistance due to the special distribution of the cobs in the core layer.

Table 28: Comparison between different materials

	Honey comb sandwich	Compact light board	Light MDF	Flax-board	Cannabis-board	MCB
Density (kg/m³)	321	430	600	560	300	**468±13**
Moisture content (%)			10	10	9	**11**
Bending Strength (N/mm²)	0.92	6.5	14	4.5	5	**6.4±0.5**
Bending Emod (N/mm²)	505	1800	1400		700	**10590.0±1022.0**
Bending Gmod (N/mm²)						**33.0±3.7**
Screws extendable resistance in plane (N)						**120**
Screws extendable resistance out of plane (N)					185	**610**

5. Conclusion

The material which gave better results is HDF_SA (surface layer of HDF and core layer made with Saatmais). The cross section of the wood ring is influencing on the results, giving higher values on compression strength in parallel and perpendicular on the MCB samples with core layer of Saatmais. The distribution of the cobs inside of the core layer determinate the Screw extendable resistance in plane, because the distribution of the cobs is irregular, giving values very lows. With the values from the Screw extendable resistance out of plane is completely different because the surface layer is making all force.

The MCB material has similar values than the Cannabis board, and then is possible to compare both new light wood materials attributing the qualities from the

Cannabis board. Are possible assign, the uses for the MCB board comparing it with the Cannabis board. This uses are: furniture, indoors, ship-construction, and kitchen-furniture.

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