Final REPORT

Durability of thermally modified birch (*Betula sp.*) against wood-destroying basidiomycetes

Done:

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1 Test material

Thermally modified birch (*Betula sp.*) sections (in the following: Birch TMT) were provided by Swero GmbH & CO. KG (Wangen i. A., Germany) in autumn 2023. According to the supplier, the material had been treated in a steam-heat process to produce 30 planks with dimensions approx. 95 (width) x 25 (thickness) x 600 (length) mm.

2 Natural durability against basidiomycetes (CEN/TS 15083-1, 2005)

Material: The specimens were 25 × 15 × 50 (long.) mm and had an annual ring orientation of approx. 45°. The specimens were taken one each from the 30 planks. Virulence control specimens for the brown rot fungus were made from Scots pine sapwood (*Pinus sylvestris*) and from European beech (*Fagus sylvatica*) for the white rot fungus.

Leaching: All test specimens were leached according to EN 84 (1997). The specimens were impregnated with distilled water. Subsequently, they were submerged in distilled water, which was changed every second day over a period of 14 days. Finally, the specimens were subsequently dried at 40, 60, 80 and 103°C for 24 h, weighed to the nearest 0.001 g, and conditioned at 20 °C and 65 % RH until constant weight.

Testing: After leaching and conditioning, the specimens were used to perform a durability test according to CEN/TS 15083-1 (2005) using the following test fungi:

Brown rot fungi:

- *Coniophora puteana* = (Schum.:Fr.) P. Karsten BAM Ebw. 15 (*C.p.*)
- *Rhodonia placenta = (Fr.) Niemelä, K.H. Larsson & Schigel (R.p.)*

White rot fungus:

- *Trametes versicolor* = (L.:Fr.) Pilat CTB 863A (*T.v.*)

The specimens were placed in culture vessels (i.e. Kolle flasks) which contained sterilized malt extract agar nutrient medium, which was inoculated with one of the fungal species. All culture vessels were placed in a culture room (22 °C/70 % RH) for a period of 16 weeks. After incubation, the specimens were removed from the culture vessels, cleaned and weighed to the nearest 0.001 g directly after harvesting and after drying at

103 °C for 24 h. The mass loss (ML) of each individual specimen due to fungal decay was calculated based on its oven-dry mass before and after incubation, while the moisture content (MC) of the specimens was calculated based on the mass after harvesting and after oven-drying (see equations 1 and 2).

$$ML = \frac{m_{i,0} - m_{f,0}}{m_{i,0}} \cdot 100 \quad (1)$$

ML *mass loss [%]*

$m_{i,0}$ *oven-dry mass before incubation [g]*

$m_{f,0}$ *oven-dry mass after incubation [g]*

$$MC = \frac{m_f - m_{f,0}}{m_{f,0}} \cdot 100 \quad (2)$$

MC *wood moisture content [%]*

m_f *wet mass after incubation [g]*

$m_{f,0}$ *oven-dry mass after incubation [g]*

The durability of the tested wood was classified according to CEN/TS 15083-1 (2005) as summarized in Table 1.

Table 1: Durability classification according to CEN/TS 15083-1 (2005).

Durability class	**Description**	**Median mass loss [%]**
1	Very durable	≤ 5
2	Durable	> 5 to ≤ 10
3	Moderately durable	10 to ≥ 15
4	Slightly durable	15 to ≥ 30
5	Not durable	> 30

Results: Mass loss and MC after incubation are summarized in Table 2 to Table 4, Figure 1, and Figure 2. Required minimum ML of 20% was achieved by the virulence controls, however the average ML for *R. placenta* was just below 20%.

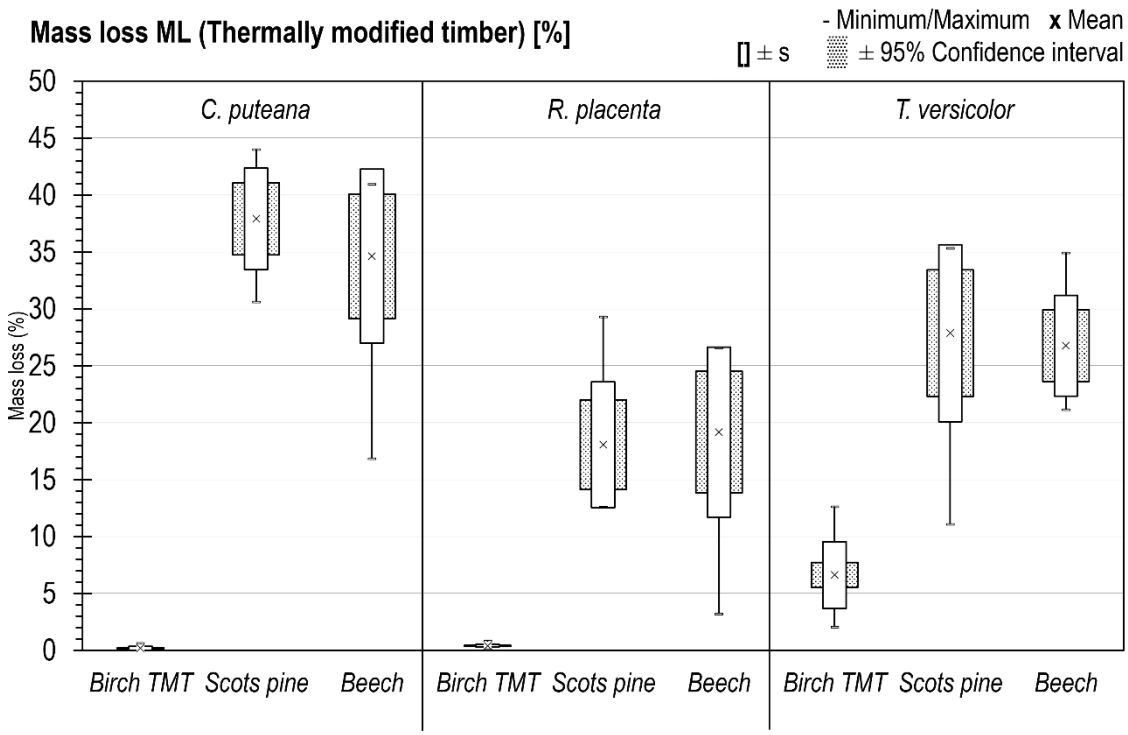

Figure 1: Mass loss of thermally modified birch (Birch TMT) and virulence species after 16 weeks of incubation.

Table 2: Mass loss (ML) and wood moisture content (MC) of thermally modified birch (Birch TMT) and virulence control specimens after incubation with the brown rot fungus *Coniophora puteana.*

Material	Number of replicates	Median ML [%]	Mean ML [%]	SD ML [%]	Mean final MC [%]	DC
Birch TMT	30	0.158	0.174	0.17	48.31	1
Scots pine sapwood	10	38.72	37.91	4.21	73.14	5
Beech	10	38.16	34.62	7.25	67.63	5

Table 3: Mass loss (ML) and wood moisture content (MC) of thermally modified birch (Birch TMT) and virulence control specimens after incubation with the brown rot fungus *Rhodonia placenta.*

Material	Number of replicates	Median ML [%]	Mean ML [%]	SD ML [%]	Mean final MC [%]	DC
Birch TMT	30	0.395	0.406	0.12	22.12	1
Scots pine sapwood	10	16.92	18.06	5.22	71.01	4
Beech	10	22.76	19.18	7.08	63.67	4

Table 4: Mass loss (ML) and wood moisture content (MC) of thermally modified birch (Birch TMT) and virulence control specimens after incubation with the white rot fungus *Trametes versicolor.*

Material	Number of replicates	Median ML [%]	Mean ML [%]	SD ML [%]	Mean final MC [%]	DC
Birch TMT	30	6.586	6.620	2.88	52.15	2
Scots pine sapwood	10	30.97	27.87	7.37	69.39	5
Beech	10	25.25	26.77	4.20	52.36	4

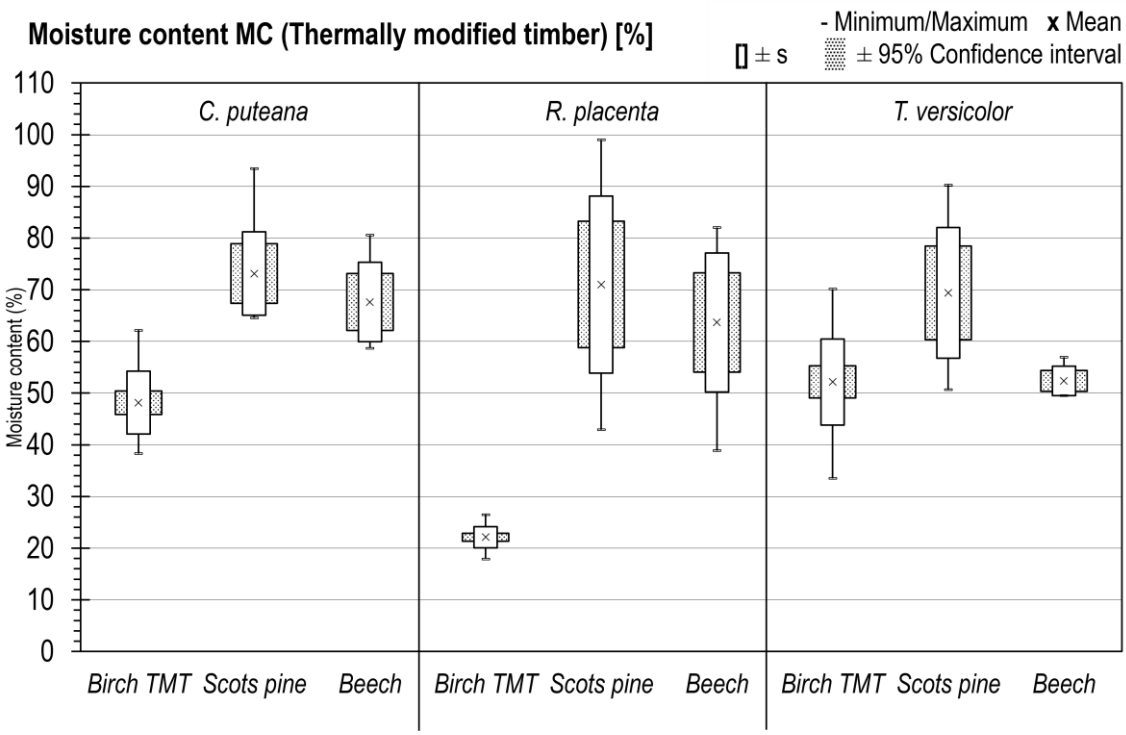

Figure 2: Wood moisture content (MC) of thermally modified birch (Birch TMT) and virulence species after 16 weeks of incubation.

3 Summary

Thermally modified birch (Birch TMT) was assigned to DC1 for the brown rot species *C. puteana* and *R. placenta* and DC2 for the white rot species *T. versicolor*.

Literature

CEN/TS 15083-1 (2005) Durability of wood and wood-based products - Determination of the natural durability of solid wood against wood-destroying fungi, test methods - Part 1: Basidiomycetes. European Committee for Standardization (CEN), Brussels, Belgium.

EN 84 (1997) Wood preservatives - Accelerated ageing of treated wood prior to biological testing - Leaching procedure. European Committee for Standardization (CEN), Brussels, Belgium.

Appendix

Appendix A: Individual data for durability tests

Table A1: Individual data for mass loss (ML), moisture content (MC) and durability class (DC) in durability tests against *Coniophora puteana* – Birch TMT.

ID	Oven-dry mass before incubation [g]	Wet mass after incubation [g]	Oven-dry mass after incubation [g]	ML [%]	MC [%]	DC
Bi1	10,380	15,706	10,360	0,193	51,602	1
Bi2	9,837	15,180	9,824	0,132	54,520	1
Bi3	10,265	15,199	10,255	0,097	48,211	1
Bi4	10,087	14,169	10,052	0,347	40,957	1
Bi5	11,267	16,370	11,258	0,080	45,408	1
Bi6	9,037	13,660	9,034	0,033	51,207	1
Bi7	9,026	13,704	9,017	0,100	51,980	1
Bi8	12,017	17,429	12,002	0,125	45,217	1
Bi9	10,289	14,922	10,253	0,350	45,538	1
Bi10	10,571	14,530	10,505	0,624	38,315	1
Bi11	10,191	15,852	10,192	-0,010	55,534	1
Bi12	9,312	13,797	9,298	0,150	48,387	1
Bi13	9,495	13,263	9,480	0,158	39,905	1
Bi14	10,260	16,665	10,276	-0,156	62,174	1
Bi15	10,849	15,417	10,835	0,129	42,289	1
Bi16	9,931	14,946	9,888	0,433	51,153	1
Bi17	10,694	16,551	10,679	0,140	54,986	1
Bi18	9,673	13,355	9,639	0,351	38,552	1
Bi19	10,108	14,081	10,087	0,208	39,596	1
Bi20	9,010	14,019	9,009	0,011	55,611	1
Bi21	10,971	15,603	10,949	0,201	42,506	1
Bi22	10,356	15,949	10,365	-0,087	53,874	1
Bi23	9,374	13,375	9,358	0,171	42,926	1
Bi24	10,215	15,225	10,195	0,196	49,338	1
Bi25	9,998	14,883	9,987	0,110	49,024	1
Bi26	8,804	12,963	8,784	0,227	47,575	1
Bi27	9,589	14,158	9,558	0,323	48,127	1
Bi28	11,450	17,093	11,426	0,210	49,597	1
Bi29	8,736	13,670	8,719	0,195	56,784	1
Bi30	11,056	15,747	10,990	0,597	43,285	1

Table A2: Individual data for mass loss (ML), moisture content (MC) and durability class (DC) in durability tests against *Rhodonia placenta* – Birch TMT.

ID	Oven-dry mass before incubation [g]	Wet mass after incubation [g]	Oven-dry mass after incubation [g]	ML [%]	MC [%]	DC
Bi1	10,430	12,651	10,383	0,45	21,84	1
Bi2	9,789	11,964	9,749	0,41	22,72	1
Bi3	10,341	12,66	10,283	0,56	23,12	1
Bi4	10,063	12,126	10,024	0,39	20,97	1
Bi5	11,085	13,379	11,046	0,35	21,12	1
Bi6	8,927	10,76	8,896	0,35	20,95	1
Bi7	9,059	10,827	9,027	0,35	19,94	1
Bi8	11,937	14,563	11,887	0,42	22,51	1
Bi9	10,152	12,288	10,107	0,44	21,58	1
Bi10	10,057	12,115	10,021	0,36	20,90	1
Bi11	9,865	12,19	9,824	0,42	24,08	1
Bi12	9,195	11,068	9,168	0,29	20,72	1
Bi13	9,596	11,505	9,563	0,34	20,31	1
Bi14	10,205	12,671	10,177	0,27	24,51	1
Bi15	10,357	12,419	10,321	0,35	20,33	1
Bi16	9,955	12,279	9,871	0,84	24,39	1
Bi17	10,780	13,106	10,725	0,51	22,20	1
Bi18	9,932	11,917	9,897	0,35	20,41	1
Bi19	10,146	11,924	10,11	0,35	17,94	1
Bi20	9,072	11,079	9,036	0,40	22,61	1
Bi21	11,185	13,572	11,132	0,47	21,92	1
Bi22	10,445	12,809	10,404	0,39	23,12	1
Bi23	9,372	11,133	9,329	0,46	19,34	1
Bi24	10,035	12,636	9,993	0,42	26,45	1
Bi25	10,254	12,872	10,244	0,10	25,65	1
Bi26	8,821	11,119	8,789	0,36	26,51	1
Bi27	9,634	11,593	9,59	0,46	20,89	1
Bi28	11,229	13,649	11,179	0,45	22,09	1
Bi29	8,708	10,769	8,674	0,39	24,15	1
Bi30	12,049	14,419	11,992	0,47	20,24	1

Table A3: Individual data for mass loss (ML), moisture content (MC) and durability class (DC) in durability tests against *Trametes versicolor* – Birch TMT.

ID	Oven-dry mass before incubation [g]	Wet mass after incubation [g]	Oven-dry mass after incubation [g]	ML [%]	MC [%]	DC
Bi1	10,422	14,785	9,621	7,69	53,67	2
Bi2	9,777	13,447	9,437	3,48	42,49	1
Bi3	9,879	13,73	9,177	7,11	49,61	2
Bi4	10,067	14,481	9,23	8,31	56,89	2
Bi5	11,434	15,978	10,684	6,56	49,55	2
Bi6	8,919	13,184	8,195	8,12	60,88	2
Bi7	9,087	12,61	8,674	4,54	45,38	1
Bi8	11,55	16,356	10,831	6,23	51,01	2
Bi9	10,089	13,13	9,833	2,54	33,53	1
Bi10	10,014	15,212	8,94	10,72	70,16	3
Bi11	9,778	13,599	9,491	2,94	43,28	1
Bi12	9,346	13,586	8,929	4,46	52,16	1
Bi13	9,474	13,146	8,984	5,17	46,33	2
Bi14	10,177	14,407	9,415	7,49	53,02	2
Bi15	9,711	13,664	9,486	2,32	44,04	1
Bi16	9,914	13,965	8,662	12,63	61,22	3
Bi17	10,789	15,263	9,515	11,81	60,41	3
Bi18	11,281	15,307	10,535	6,61	45,30	2
Bi19	11,085	15,29	10,672	3,73	43,27	1
Bi20	8,902	12,919	8,161	8,32	58,30	2
Bi21	11,126	15,914	10,218	8,16	55,74	2
Bi22	10,785	14,751	10,562	2,07	39,66	1
Bi23	9,611	13,807	9,01	6,25	53,24	2
Bi24	9,785	13,846	9,029	7,73	53,35	2
Bi25	10,119	14,451	9,424	6,87	53,34	2
Bi26	8,816	13,258	8,259	6,32	60,53	2
Bi27	9,622	13,716	8,456	12,12	62,20	3
Bi28	9,939	14,083	9,582	3,59	46,97	1
Bi29	9,134	13,703	8,207	10,15	66,97	3
Bi30	11,553	16,754	11,025	4,57	51,96	1

Table A4: Individual data for mass loss (ML), moisture content (MC) and durability class (DC) in durability tests against *Coniophora puteana* – Scots pine sapwood.

ID	Oven-dry mass before incubation [g]	Wet mass after incubation [g]	Oven-dry mass after incubation [g]	ML [%]	MC [%]	DC
SP 1	8,496	8,974	5,292	37,712	69,577	5
SP 2	8,135	8,533	4,976	38,832	71,483	5
SP 3	8,554	9,768	5,935	30,617	64,583	5
SP 4	8,44	8,718	5,182	38,602	68,236	5
SP 5	8,716	10,084	6,002	31,138	68,011	5
SP 6	8,054	8,103	4,72	41,396	71,674	5
SP 7	8,206	9,137	5,337	34,962	71,201	5
SP 8	8,159	8,483	4,755	41,721	78,402	5
SP 9	9,002	9,753	5,041	44,001	93,474	5
SP 10	8,412	8,81	5,041	40,074	74,767	5

Table A5: Individual data for mass loss (ML), moisture content (MC) and durability class (DC) in durability tests against *Rhodonia placenta* – Scots pine sapwood.

ID	Oven-dry mass before incubation [g]	Wet mass after incubation [g]	Oven-dry mass after incubation [g]	ML [%]	MC [%]	DC
SP 11	8,6	10,742	7,516	12,605	42,922	3
SP 12	8,613	11,426	7,163	16,835	59,514	4
SP 13	7,92	10,281	6,864	13,333	49,781	3
SP 14	7,449	12,198	6,129	17,720	99,021	4
SP 15	7,298	11,2	6,184	15,264	81,113	4
SP 16	8,068	12,992	6,873	14,812	89,030	3
SP 17	8,314	10,553	6,105	26,570	72,858	4
SP 18	7,577	10,493	6,275	17,184	67,219	3
SP 19	7,79	11,43	6,465	17,009	76,798	3
SP 20	8,415	10,221	5,949	29,305	71,810	4

Table A6: Individual data for mass loss (ML), moisture content (MC) and durability class (DC) in durability tests against *Trametes versicolor* – Scots pine sapwood.

ID	Oven-dry mass before incubation [g]	Wet mass after incubation [g]	Oven-dry mass after incubation [g]	ML [%]	MC [%]	DC
SP 21	7,588	11,864	6,746	11,096	75,867	3
SP 22	8,29	11,863	6,666	19,590	77,963	4
SP 23	7,953	9,178	5,56	30,089	65,072	5
SP 24	8,322	10,144	5,671	31,855	78,875	5
SP 25	7,765	8,128	5,022	35,325	61,848	5
SP 26	9,015	10,085	5,973	33,744	68,843	5
SP 27	8,245	8,986	5,962	27,690	50,721	4
SP 28	7,865	7,918	5,255	33,185	50,676	5
SP 29	8,169	10,371	5,45	33,284	90,294	5
SP 30	8,189	10,974	6,316	22,872	73,749	4

Table A7: Individual data for mass loss (ML), moisture content (MC) and durability class (DC) in durability tests against *Coniophora puteana* – Beech.

ID	Oven-dry mass before incubation [g]	Wet mass after incubation [g]	Oven-dry mass after incubation [g]	ML [%]	MC [%]	DC
B 1	12,51	12,088	7,616	39,121	58,718	5
B 2	12,436	12,346	7,616	38,758	62,106	5
B 3	12,405	12,53	7,514	39,428	66,755	5
B 4	12,446	14,382	8,827	29,078	62,932	4
B 5	12,317	11,687	7,273	40,952	60,690	5
B 6	11,849	12,22	7,212	39,134	69,440	5
B 7	11,763	16,653	9,78	16,858	70,276	4
B 8	11,26	12,688	7,03	37,567	80,484	5
B 9	13,179	14,944	8,275	37,211	80,592	5
B 10	12,302	14,539	8,847	28,085	64,338	4

Table A8: Individual data for mass loss (ML), moisture content (MC) and durability class (DC) in durability tests against *Rhodonia placenta* – Beech.

ID	Oven-dry mass before incubation [g]	Wet mass after incubation [g]	Oven-dry mass after incubation [g]	ML [%]	MC [%]	DC
B 11	12,646	15,569	10,823	14,416	43,851	3
B 12	12,877	17,723	9,735	24,400	82,054	4
B 13	12,67	15,028	9,508	24,957	58,056	4
B 14	12,181	16,377	11,79	3,210	38,906	1
B 15	12,713	15,857	9,332	26,595	69,921	4
B 16	12,593	18,925	10,958	12,983	72,705	3
B 17	12,661	16,597	9,84	22,281	68,669	4
B 18	12,68	15,716	9,734	23,233	61,455	4
B 19	11,952	17,05	10,129	15,253	68,329	4
B 20	12,556	16,382	9,482	24,482	72,769	4

Table A9: Individual data for mass loss (ML), moisture content (MC) and durability class (DC) in durability tests against *Trametes versicolor* – Beech.

ID	Oven-dry mass before incubation [g]	Wet mass after incubation [g]	Oven-dry mass after incubation [g]	ML [%]	MC [%]	DC
B 21	12,317	14,024	9,378	23,861	49,541	4
B 22	12,626	14,719	9,382	25,693	56,886	4
B 23	11,873	14,008	9,362	21,149	49,626	4
B 24	12,627	13,222	8,678	31,274	52,362	5
B 25	12,101	13,859	9,1	24,800	52,297	4
B 26	13,162	14,064	9,151	30,474	53,688	5
B 27	12,185	14,131	9,444	22,495	49,629	4
B 28	12,181	14,119	9,251	24,054	52,621	4
B 29	12,579	12,847	8,185	34,931	56,958	5
B 30	12,28	13,088	8,728	28,925	49,954	4