Nordic Industrial Fund
center for innovation and commercial development

- Nordic Wood 2

Project P 98141 «Wood in the Food Industry»

Gunilla Beyer, Swedish Institute for Wood Technology Research
Birna Gudbjörnsdottir, Icelandic Fisheries Laboratories

Project part report no. 5

Short report from a pilot study regarding wood treatments and hygienic properties of wood

Herninge, København, Oslo, Reykjavik, Stockholm, Tromsø
25 april 2000

FOREWORD

Wood used to be the most common material for packaging, workbenches, shelves, tools, buildings, interiors etc., in the food industry in the Nordic countries. The use of wood has however decreased, and other materials like plastic, concrete, stainless steel and aluminium have taken its place. The reason for this negative development seems to be declining market demands, partly caused by legislation in Europe and elsewhere.

Despite this, nearly 1,5 million cubic meter of timber per year is used for pallets and packaging in the Nordic countries. These products are hence of great importance for the wood industry as the alternative production of packaging materials may be chips for pulp production. Based on that background, a Nordic research project was initiated to find out more about the behaviour of wood in contact with foodstuff.

The main object of the project has been to collect data regarding wood products and their substitutes when used in the food industry, and to find suitable methods to identify and measure the growth of bacteria on wood and their substitutes.

This report is one in a series of reports where the results from the Nordic Wood 2 project no. P 98141 ”Wood in the Food Industry” are presented.

In this part report, the results of a small test regarding water absorption and bacteria recovery on wood (pine and spruce) are presented.

The project is funded by the Nordic Industrial Fund through their program Nordic Wood 2 which is an R&D program for the Nordic wood industry. The Nordic timber and woodworking industry and national funding authorities in the Nordic countries have raised additional funding.

The fishery research laboratories in Iceland and Norway have carried out most of the research work of the project. These laboratories are the Icelandic Fisheries Laboratory and Fiskeriforskning (Norway). In this particular test, laboratory work has also been carried out at Trätek, Swedish Institute for Wood Technology Research.

The project has a steering group with the following members:

- Heine Aven, chairperson — Aven AS, Norway
- Marianne Moltke, deputy chair person — Norwood AS, Denmark
- Stefan Nilsson — Åsljunga Pallen AB, Sweden
- Bjarni Ingibergsson — Limtré h.f., Iceland

Terje Apneseth has been the Nordic project leader and editor of some of the part reports.

The following industries, organisations and research institutes have contributed with their know-how and services:

Denmark: Norwood A/S, Dansk Træemballage A/S, Dansk Teknologisk Institutt, Træteknik (DTI)

Iceland: SÍF. h.f., Limtré h.f., BYKO h.f., Samskip h.f., Vörubrétti h.f., Icelandic Fisheries Laboratory (IFL)

Norway: Aven AS, Høylandet treindustri AS, Saltfiskforum, Fiskeriforskning, Norsk Treteknisk Institutt (NTI)

Sweden: AB Gyllsjö Träindustri, Åsljunga Pallen AB, Strandbergs Trä och Pallindustri, Trätek, Institutet för träteknisk forskning,

The participants would like to forward their warm thanks to Nordic Industrial Fund and the national funding authorities in Denmark, Iceland, Norway and Sweden that have contributed to the funding of the project.

This part report no.4 is written by: **Gunilla Beyer**, Swedish Institute for Wood Technology Research
Birna Gudbjörnsdottir, Icelandic Fisheries Laboratories.

Oslo 25 april 2000

Norwegian Institute of Wood Technology,

Terje Apneseth

Summary

Wood is not regarded as a suitable material in contact with food. Wood is a hygroscopic material and under certain circumstances exposed to attacks from moulds and blue stain etc. At moisture contents under 20% the growth of fungi is prohibited. Treatments to avoid water absorption and make wood water-repellent are therefore of interest. The aim with this pilot study was to test if water-repellent treatments have an effect on bacterial recovery.

In this study untreated, wax treated and wax impregnated samples were exposed to accelerated ageing with 24 hour water-sprinkling and 24 hour drying per cycle. After each cycle the moisture content was calculated.

For Ultrawood treated pine the weight increase after rain varied between 7.6 and 12.3%. Most of these samples had moisture content below 20% after rain.

For wax treated pine the weight increase varied between 14.8 and 20.3 %. The mean moisture content after the last rain cycle was 28.6%. For spruce the weight increase is around 10% with wax treatment. The moisture content after the rain cycles varied from 17.1 to 22.0%.

Samples were also tested for bacteria using the swabbing method. Wet and dry samples were contaminated with *Pseudomonas* sp isolated from fisheries environment. The results from the bacterial testing show that the recovery from the samples is quite low. Ultrawood treatment gave lower recovery compared with untreated samples. The recovery of bacteria from waxed spruce was the highest of the treated samples. Significantly more bacteria were recovered from the pre wet wood surface than from dry wood.

Table of contents

Background

Wood is not regarded as a suitable material in contact with food. Wood is porous and it is said to be lack of good cleaning/sanitary methods. New laws and directives within EU are creating a problem when using wood in food handling and distribution. But it's not only the packaging chain that is affected. The use of wood in buildings for food handling purposes and in hospitals is also debated. The packaging sector is however the first to be affected. Wooden pallets are now replaced by plastic pallets for hygienic reasons in the food industry and grocery sector. But it's not quite clear what is meant by hygienic, what the hygienic criteria are and what test methods shall be used.

Within Nordic Wood, partners from the woodworking industries, the Nordic Institutes for Wood Technology Research and the Fishery Institutes in Norway and Iceland are working together to investigate the hygienic and sanitary properties of wood, work out test methods and test wood in different products for different purposes. The wooden pallet is one important product that is affected and looked upon first.

Introduction

Pallets are important in the material handling chain. But the handling environments are sometimes severe and cause damages or exposure to harsh climatic conditions, which cause the pallets to look dirty. The users, especially within the grocery industry want a neat pallet and new requirements are coming for hygienic pallets with sanitary properties.

Wood is a hygroscopic material and under certain circumstances exposed to attacks from mould and blue stain etc. At moisture contents under 20% the growth of fungi is prohibited; the most favourable moisture content is 30-80%. Many standards and specifications for pallets therefore prescribe moisture content below 22%. Treatments to avoid water absorption and make wood water-repellent are therefor of interest. The aim with this pilot study was to test if water-repellent treatments have an effect on bacterial growth and recovery.

Materials and methods

One way to get a water-repellent effect is to treat the timber with a wax emulsion, which is a fairly simple and inexpensive method. Previous studies have shown that water absorption is reduced with 40-60% (Nussbaum, 1992 and Beyer, 1997). The growth of blue stain and mould is also reduced. Another method is impregnation with a water-repellent agent.

In this study untreated, wax treated and wax impregnated samples were exposed to accelerated ageing, 10 cycles, in an Atlas Weather-o-Meter Ci 65 with 24 hours water sprinkling and 24 hours drying per cycle. After water sprinkling, 30 l/sample/h, the weight was noted and the water absorption is expressed in %. The drying cycles were under exposure of UV-light for 24 hours according to ASTM standard G26-92(ASTM Standard).

1. Untreated samples of pine (Pinus Sylvestris), 20x100x310mm.

2. Wood samples of spruce (Picea Abies) and pine, 20x100x310 mm, were treated with a wax emulsion, Mobilcer 45, corresponding to 80-90 g/m2 (called wax1) respectively

3. Wood samples of pine, 20x100x310 mm, were impregnated with Ultra Wood (UW) at two different concentrations - 1% and 2% active substance.

The samples were conditioned at 20 °C/65% RH to a moisture content of around 12% before testing. Some of the samples were also sent to Icelandic Fisheries Laboratories for bacterial testing.

Table 1. Ultra wood impregnation

Impregnation		Ultrawood					
	1% impregnation with active substance 2% impregnation with active substance						
Sample no	Board no	Weight before	Weight after	Absorptio n	% **	1%	
1	1	319	467	148	46,4		
2	2	314	576	262	83,4		
3	3	346	433	87	25,1		
4	4	351	581	230	65,5		
5	3	314	398	84	26,8		
6	1	304	588	284	93,4	2%	
7	2	310	502	192	61,9		
8	3	341	579	238	69,8		
9	4	366	549	183	50,0		
10	5	292	511	219	75,0		
							B*
1%B	2	299	578	279	93,3	1%	1
1%B	7	303	410	107	35,3		2
2%B	4	309	547	238	77,0	2%	3
2%B	1	320	656	336	105,0		4

*Bacterial testing

** Differences in absorption caused by different amount of heartwood pieces. Heartwood can not be impregnated.

Table 2. Samples treated with wax emulsion

Wax 1			Wax 2		
Sample	WoM sample	B sample no*	Sample	WoM sample	B sample no
Pine	14 15		**Pine**	19 20 21	
		5 6 7			11 12 13
Spruce	16 17 18		**Spruce**	22 23 24	
		8 9 10			14 15 16
Untreated pine		17 18			

*B: bacterial test

Test organism and surface contamination

The samples B were used for bacterial testing according to the methods evaluated in the report no. 2 and regarded as suitable for wood (Lorentzen, Guðbjörnsdóttir, 2000). The swabbing method was used and at the same time a one rapid method was also performed. Adenosine Triphosphate (ATP) - bioluminescence is known to be a good method for assessing the hygienic status of food contact surfaces. A swab is taken of the surface to be examined and the ATP present is extracted and assayed by the addition of luciferase/luciferin. Portable and food factory safe instruments can measure the amount of the light that is emitted by the reaction. The light released during the reaction indicates the contamination level of the surface; more light then more contamination. Wet and dry samples were contaminated with *Pseudomonas* sp isolated from fisheries environment. The samples were kept in the lab for at least 4 days until they stop loosing weight. The wet samples were prepared by soaking the wooden samples into water for 18-20 hours just before the experiment started. The samples were disinfected prior to the experiments. They were wrapped into aluminium paper and put in autoclavable bags, sealed with autoclavable tape. The sterilisation time was 15 min at 121°C. The microbial suspension was in brain heart infusion (BHI-difco) and the initial level of the microorganisms was 10^{8} CFU/ml. A volume of 0.5 ml of the inoculum was spread evenly on the pith side of the wood samples. The contamination time was 2 hours at 20°C.

The bacteriological tests were later repeated under the same conditions.

Results and discussion

Weather-o-Meter testing (WoM)

The WoM testing is regarded as quite a hard climatic exposure. The results - water uptake and moisture content - from each test cycle are shown in Appendix 1.

For Ultrawood treated pine the weight increase after rain varied between 7.6 and 12.3%. Most of these samples had moisture content below 20% after rain, except sample 3 and 5. From table 1 it's shown that for sample 3 and 5 the uptake of the water repellent was also very low. The weight increase after rain for untreated pine was around 30% and the end moisture content 45.1-47.4%.

For wax treated pine the weight increase varied between 14.8 and 20.3 %. The mean moisture content after the last rain cycle was 28.6% but varied between 20% and 42%. The result was independent of the amount of wax and is probably more dependent on the amount of heartwood and sapwood.

For spruce the weight increase is around 10% with wax treatment. The moisture content after the rain cycles varied from 17.1 to 22.0%.

The water repellent effect remains after testing as shown in pictures 4 and 5, Appendix 2.

Microbiological sampling

The results from the first experiment carried out are shown in table 3 and in figure 1 and 2. The recovery from the samples are quite low but that is what was experienced in the preliminary experiments where the method was evaluated (Lorentzen and Guðbjörnsdóttir, 2000). The main difference is between wet and dry samples. The recovery was higher from wet samples (0.13-5.30%) compared to dry samples (0-0.09%). Ultrawood treatment gave lower recovery compared with untreated samples. The results from 2% wax emulsion on spruce were similar to non-treated pine but when increasing the concentration the recovery became higher. The lower concentration of wax emulsion on wet pine (2%) gave higher recovery compared to higher concentration (4%) but that should be tested further.

Table 3. Results of bacterial sampling and ATP measurement

Serie	B Sample no	Treatment	Condition of wood	Level of contami-nation	Number bacteria	Recovery (%) of bacteria	RLU (relative light units)
1	1	1% UW pine	dry	$6,4x10^7$	1085	0,0	104,5
1	1-2	1% UW pine	wet	$5x\ 10^7$	312.000	0,62	124,5
2	3	2% UW pine	dry	$6,4x10^7$	8550	0,01	127,5
2	3-4	2% UW pine	wet	$5x\ 10^7$	287.500	0,58	92,5
3	5	2% wax pine	dry	$6,4x10^7$	27.950	0,04	274
3	5	2% wax pine	wet	$5x\ 10^7$	1.751.500	3,50	235,5
4	8	2% wax spruce	dry	$6,4x10^7$	18.100	0,03	466,5
4	8-9	2% wax spruce	wet	$9,6x10^7$	124.000	0,13	378
5	11	4% wax pine	dry	$6,4x10^7$	13700	0,02	252
5	11	4% wax pine	wet	$5x\ 10^7$	320.000	0,64	na
6	14	4% wax spruce	dry	$6,4x10^7$	60.000	0,09	422,5
6	14	4% wax spruce	wet	$5x\ 10^7$	2.650.000	5,30	244,5
7	17	non- treated pine	dry	$6,4x10^7$	18.550	0,03	102
7	17-18	non- treated pine	wet	$5x\ 10^7$	850.000	1,70	195

Figure 1. Recovery of bacteria from dry samples

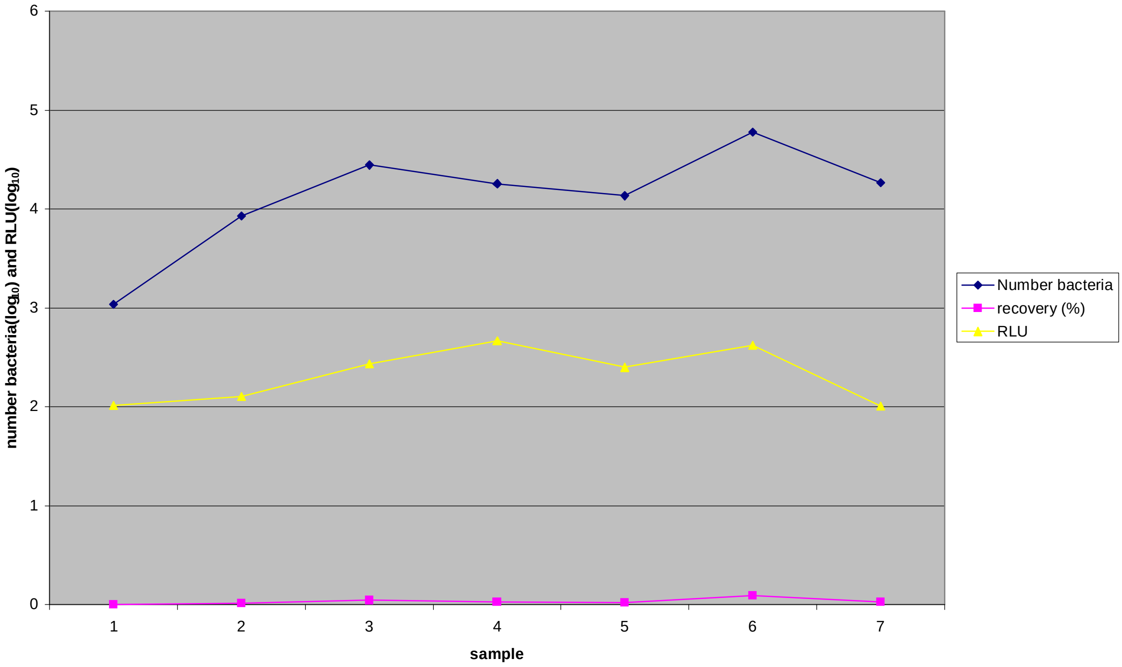
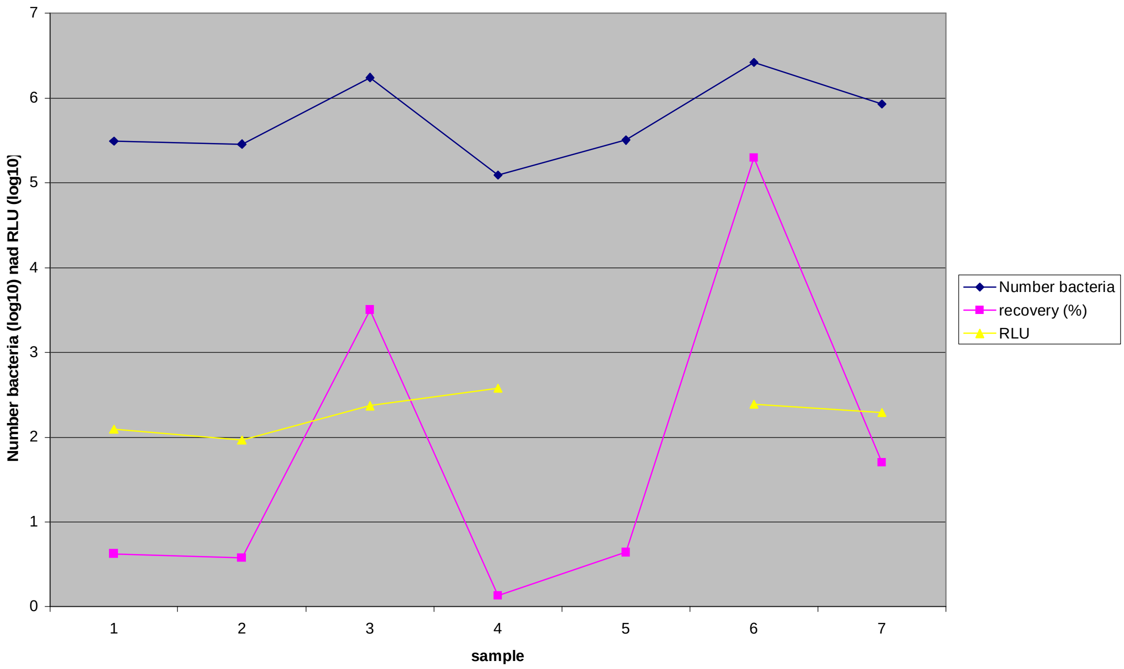


Figure 2. Recovery of bacteria from wet samples



As mentioned, the bacteriological tests were later repeated and the results are shown in Table 4. Overall results are shown in table 5 and 6.

Table 4. Results of bacterial sampling and ATP measurement. Experiment 2. Average number of two measurements

Series	Sample no	Treatment	Condition of wood	Level of contamination	Number bacteria	Recovery (%) of bacteria	RLU (relative light units)
1	1	1% UW pine	dry	3,2 x 10^7	3330	0,01	52
1	1-2	1% UW pine	wet	2,1 x 10^7	16985	0,08	14
2	3	2% UW pine	dry	3,2 x 10^7	4950	0,02	55
2	3-4	2% UW pine	wet	2,1 x 10^7	15900	0,08	39,5
3	5	2% wax pine	dry	3,2 x 10^7	20355	0,06	47
3	5	2% wax pine	wet	2,1 x 10^7	82500	0,4	33,5
4	8	2% wax spruce	dry	3,2 x 10^7	34000	0,1	54
4	8-9	2% wax spruce	wet	2,1 x 10^7	1480500	7,05	197
5	11	4% wax pine	dry	3,2 x 10^7	8300	0,03	61
5	11	4% wax pine	wet	2,1 x 10^7	39750	0,2	213
6	14	4% wax spruce	dry	3,2 x 10^7	32500	0,1	54,5
6	14	4% wax spruce	wet	2,1 x 10^7	77000	0,4	111
7	17	non-treated pine	dry	3,2 x 10^7	31800	0,1	50

Table 5. The figures are of average from both experiments - 4 measurements.

Series	Treatment	Condition of wood	Level of contamination	Recovery (%) of bacteria
1	1% UW pine	dry	approx. 10^7	0,02
1	1% UW pine	wet	approx. 10^7	0,32
2	2% UW pine	dry	approx. 10^7	0,02
2	2% UW pine	wet	approx. 10^7	0,31
3	2% wax pine	dry	approx. 10^7	0,05
3	2% wax pine	wet	approx. 10^7	1,83
4	2% wax spruce	dry	approx. 10^7	0,07
4	2% wax spruce	wet	approx. 10^7	3,59
5	4% wax pine	dry	approx. 10^7	0,03
5	4% wax pine	wet	approx. 10^7	0,15
6	4% wax spruce	dry	approx. 10^7	0,14
6	4% wax spruce	wet	approx. 10^7	2,7
7	non-treated pine	dry	approx. 10^7	0,27
7	non-treated pine	wet	approx. 10^7	1,7

The results from the second experiment supported the results from the first one. The recovery was higher from wet samples (0.15-3.59%) compared to dry samples (0.02-0.14%). Ultrawood treatment gave lower recovery compared with untreated samples. The recovery of bacteria from 2% and 4% wax emulsion on spruce was the highest of the treated samples. The lower concentration of wax emulsion on pine (2%) gave higher recovery compared to higher concentration(4%), which is the same result as in the first experiments.

Previous reports have demonstrated low recovery of bacteria from wood surfaces as stated by Welker et al, 1996 and our study confirmed that. Significantly more bacteria were recovered from the pre wet wood surface than from dry wood as shown in table 3, 4 and 5. The same report shows that wood surface gives higher ATP values compared to plastic and stainless steel but our study showed the opposite if compared to study performed at IFL 1998 (Guðbjörnsdóttir and Einarsson, 1998). This should be investigated more in the field studies.

Table 6 Summary of the results from bacteriological testing

Serie	sample nr.	H-nr.	weight	weight a. wetting.	contamination	no. bacteria	% recovery	ATP / RLU	Aw	treatment
1	1,1	520	76,20	85,30	4,50E+07	34000	0,08	106	0,96	1% UW pine
	1,2	499	68,51		5,76E+07	1100	0,00	149		
	1,3	500	75,19		5,76E+07	1070	0,00	60		
	1,4	255	74,22	83,59	1,89E+07	970	0,01	12		
	2,1	256	78,95	88,26	1,89E+07	33000	0,17	16		1% UW pine
	2,2	240	67,26		2,88E+07	5300	0,02	50		
	2,3	241	72,98		2,88E+07	1360	0,00	54		
	2,4	521	76,00	84,64	4,82E+07	590000	1,23	143		
2	3,1	522	86,20	93,50	4,82E+07	420000	0,87	105		2% UW pine
	3,2	501	76,45		5,76E+07	7300	0,01	89		
	3,3	502	78,51		5,76E+07	9800	0,02	166		
	3,4	257	78,03	86,39	1,89E+07	8300	0,04	21		
	4,1	258	71,45	80,02	1,89E+07	23500	0,12	58		2%UW pine
	4,2	242	69,48		2,88E+07	5200	0,02	74		
	4,3	243	76,12		2,88E+07	4700	0,02	36		
	4,4	523	79,20	87,76	4,82E+07	155000	0,32	80	0,96	
3	5,1	503	90,75		5,76E+07	15900	0,03	366		Pine-2% - 1
	5,2	504	84,91		5,76E+07	40000	0,07	182		
	5,3	524	87,60	106,93	4,82E+07	153000	0,32	294		
	5,4	525	86,20	104,05	4,82E+07	3350000	6,96	177	0,99	
	6,1	259	73,47	98,81	1,89E+07	104000	0,55	36		Pine-2% - 2
	6,2	260	72,96	101,11	1,89E+07	61000	0,32	31		
	6,3									
	6,4									
	7,1									Pine-2% - 3
	7,2									
	7,3	244	74,59		2,88E+07	39000	0,14	71		
	7,4	245	76,62		2,88E+07	1710	0,01	23		
4	8,1	505	69,58		5,76E+07	21200	0,04	615		Spruce 2% -1
	8,2	506	71,90		5,76E+07	15000	0,03	318		
	8,3	534	70,65	79,38	8,60E+07	114000	0,13	570		
	9,1	535	78,85	88,80	8,60E+07	134000	0,16	186		Spruce 2% -2
	9,2	261	78,44	87,90	1,89E+07	141000	0,75	172	0,99	
	9,3	262	80,24	88,63	1,89E+07	2820000	14,92	222		
	10,1									Spruce 2% -3
	10,2	246	86,05		2,88E+07	25000	0,09	40		
	10,3	247	80,62		2,88E+07	43000	0,15	68		
5	11,1	507	87,32		5,76E+07	17200	0,03	257		Pine 4% - 1
	11,2	508	73,11		5,76E+07	10200	0,02	247		
	11,3	526	81,21	104,80	4,82E+07	X		55		
	11,4	527	84,20	105,80	4,82E+07	320000	0,66	X	0,99	
	12,1				0,00E+00					Pine 4% - 2
	12,2				0,00E+00					
	12,3	248	72,39		2,88E+07	8300	0,03	37		
	12,4	249	71,83		2,88E+07	8300	0,03	85		
	13,1									Pine 4% - 3
	13,2									
	13,3	263	71,57	90,27	1,89E+07	4500	0,02	125		
	13,4	267	72,86	90,90	1,89E+07	75000	0,40	301		
6	14,1	509	75,08		5,76E+07	37000	0,06	435		Spruce 4% - 1
	14,2	510	80,52		5,76E+07	83000	0,14	410		
	14,3	528	82,52	93,31	4,82E+07	3300000	6,85	264		
	14,4	529	82,60	100,97	4,82E+07	2000000	4,15	225	0,97	
	15,1	250	81,42		2,88E+07	24000	0,08	52		Spruce 4% - 2
	15,2	251	80,92		2,88E+07	41000	0,14	57		
	15,3									
	16,1	265	88,71	101,85	1,89E+07	37000	0,20	169		Spruce 4% - 3
	16,2	266	78,43	96,55	1,89E+07	117000	0,62	93		
	16,3									
	16,4									
7	17,1	511	82,15		5,76E+07	19500	0,03	87		Untreated
	17,2	512	84,03		5,76E+07	17600	0,03	117		
	17,3	530	86,30	98,50	4,82E+07	850000	1,77	100		
	18,1	531	73,50	87,71	4,82E+07	930000	1,93	290	0,98	Untreated
	18,2	252	68,66		2,88E+07	46000	0,16	49		
	18,3	253	71,51		2,88E+07	17600	0,06	51		

Conclusion

This pilot study shows that the water uptake is reduced for both Ultrawood and wood treated with wax emulsion. The experience with wax impregnation is less than with treatment of wax emulsion. The advantage with wax emulsion is that it can be used on both spruce and pine. The effect on bacterial growth need however to be better investigated. Also non-treated spruce should be used as a reference. Eventually could also sterilisation with UV be used to make sure that sterilisation in the autoclave doesn't effect the wax and wood.

As mentioned earlier other tests have shown that the weight increase for wax treated pine is 50-60% lower than for untreated pine and 40-50% lower for wax-treated spruce compared to untreated. The growth of blue stain and mould was in general significantly lower for the wax treated material. For wax treated pallets made of spruce and stored outside the water repellent effect lasted for a year.

The wax treatment will cause a minor reduction in friction, but this doesn't seem to be a problem. Exposure of wax treated spruce to higher temperatures - 60°C and 70°C - didn't cause any sticky effect to the wax.

Ultrawood is a method of impregnation and can only be used for pine and similar species. The results show a reduction on recovering bacterial growth both for wet and dry samples compared with non-treated pine and the method should therefore be further investigated.

Wax treatments are considered environmentally friendly and both methods are thus of interest for the purpose of wood in contact with food. The recovery of bacteria from wax treated sample was lower compared with untreated samples. The recovery of bacteria from wood treated with wax emulsion on spruce was highest of the treated samples.
The recommendation is to use Ultrawood and wax treated samples in field tests for comparison with non-treated wood and eventually some other treatments.

References

ASTM G 26-92. Standard Practice for Operating Light-Exposure of Non-metallic Materials. ASTM Standard

Beyer, Gunilla, Nordman-Edberg, Katarina: Vaxbehandling av pallvirke. Trätek Rapport L 9705058, 1997

Guðbjörnsdóttir, B. and Einarsso, H (1998). IFL report no 09-98. Evaluation off cleanliness by Adenosine triphosphate bioluminesent assay.

Lorentsen, G., Guðbjörnsdóttir, B. and Weider, I. (2000). Project report no 3. Wood in Food. Measuring methods.

Nussbaum, Ralph: Vaxbehandling som regnskydd för konstruktionsvirke - Fältförsök. Trätek Rapport I9208050, 1992

Welker, C., Faiola, N, Davis., S, Maffatore, I. and Batt, C.A. (1997). Bacterial Retention and Cleanability and Plastic and Wood Cutting Boards with Commercial Food Service Maintenance Practices. Journal of Food Protections. Vol. 60, No.4, pp 407-413