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RAPPORT

Investigation into the suitability of Jordan straw for processing to board.

By

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SUMMARY

In this report are discussed the results of an investigation of the suitability of Jordan straw for processing to a product that can be compared with board that is imported in Jordan at the moment.

This product was partly bleached sulphite strawboard.

A comparison has been made too with the same type of board processed from Dutch straw.
To get a better insight in the digestion, the Jordan straw was also analysed.

The partly bleached sulphite board from Jordan straw had at least as good as or better strength properties than the imported single lined (ground wood) board.

However the strength properties of board made from Jordanian straw were less good as those from the Dutch equivalent, and more sodiumcarbonate was necessary for the digestion.
Also the yield of Jordanian board (37%) was lower than that of Dutch board (50%).

An important reason for these differences will be due to the fact that the received Jordan straw samples contained much more dust and fines than the Dutch cutted straw used for the experiments.
Another factor will be, the difference in composition of the Jordanian and Dutch straw. In comparison with the Dutch straw, the Jordan straw is lower in lignin-, lower in α-cellulose- and higher in pentosan content. A lower α-cellulose content pointing to a lower yield and a higher pentosan content to a higher soda consumption.

Which of both factors is the more important one could not be decided upon in this investigation.

INTRODUCTION

In view of the plans for erecting a board mill in Jordan, it was advised, apart from converting waste paper to board, also to use straw for board making. On our part it was considered very desirable to examine if the Jordan straw would be suitable for making a product which could compare with strawboard made from Dutch straw and with board as it is used in Jordan at the moment. Therefore the Jordan Paper Industries Ltd. charged us with research in this field. The following is an account of the method used to examine the straw and gives the results of the investigations.

I. PLAN OF EXPERIMENTS

The experiments were planned as follows: sulphite digestions were made under such conditions that the end pH of the cooking liquor was abt. 8.5, experiments having proved that with sulphite digestions a usable cook may be expected at this end pH.

To reach pH 8.5 three cookings were made with each type of straw: two for orientation and one to reach the desired pH. Part of the slurry from the last cooking was beaten to a beating degree of 45-50° S.R. The beaten pulp was processed, partly bleached, partly unbleached, to strawboard of 300 g/m^2. For comparison Dutch barley- and wheat straw was treated in a similar way.

II. PERFORMANCE OF EXPERIMENTS

A. The raw material

For a good understanding it is desirable, before discussing the actual processing of the Jordan straw, to make some remarks on the quality of the samples of cut straw as we received them. We received two samples, each abt. 50 kg, packed in bags, marked respectively "Barley" and "Corn". The sample "Corn" was recognized as wheat straw.

Compared with what is normally understood by "cut straw", these samples had to be qualified as poor. The straw sent to us had not been cut, but had come in this state during the threshing.

The straw had a great number of small bits (was greatly split up and splintered) and was even partly pulverized, which must have resulted in greater damage to the fibre material than is usually the case with cut straw.

In a comparative examination as the one under consideration these facts should be taken into account.

B. Chemical investigations

Apart from the technological investigations, chemical analyses were carried out with the straw, of which the results are summarized in TABLE I. The aim of these tests was to gain a better insight into the Jordan straw.

C. Digestions

The cooking cycle of all the digestions was the same:

After filling the 100 l rotary digester the contents were heated to 120 °C in 10 minutes. Pressure then rose to abt. 4 kg/cm^2, after which the digester was vented to 1.2 kg/cm^2. Next the contents were heated again to 125 °C and this temperature maintained for 20 mins, the vessel then being vented again.

Then temperature was raised to 170 °C in 15 mins, followed by venting from abt. 9 to 5 kg/cm^2, and after heating to 170 °C, cooking was continued at this temperature (8-9 kg/cm^2) for another 25 minutes. All the cooking trials were started with a dry matter to liquor ratio of 1:3, the sulphite dose being likewise equal for all the cookings, namely 14% Na_2SO_3 on air-dry straw.

Only the amount of soda was varied in order to reach the disered end pH. TABLE II gives a survey of cooking conditions.

D. Finishing of the cooks

The usual procedure was that after digestion the cooks were collected in a bin and weighed; from this weight the dry matter to liquid ratio at the end of the cooking could be computed. The black liquor was sampled for measuring the pH.

Then to the cook was given cold water to prevent a possible post-digestion.

The cooks of about 8.5 end pH were pre-beaten by means of the 12" Sprout Waldron refiner to abt. 30 °S.R.

Final beating was effected in the laboratory Valley beater to a beating degree of 45-50 °S.R. After beating the pulp was sorted over a membrane sorter and part of this sorted pulp was bleached in the laboratory.
The conditions at which bleaching was carried out together with further data with regard to the bleaching, and data on the yields of the various stages of the processing, are summarized in TABLE III.

Of the bleached and unbleached pulp hand-sheets were made by means of the sheet former, and these boards, after conditioning, tested for strength. The results so obtained are included in TABLE IV.

III. DISCUSSION OF RESULTS

A. Chemical investigations (See TABLE I)

Although from the chemical composition of the straw is is not possible to draw conclusions straight away as regards to the strength of the board made from it, some marked differences with the Dutch straw might necessitate modifications in the processing.

In this connection differences worth noticing are in the content of lignin, pentosan and α -cellulose. The lignin content of the two kinds of the Jordan straw is clearly lower, the pentossan content being accordingly higher.

The content of α-cellulose of the Jordan straw is lower, which raised a presumption that the fibre yield of the Jordan straw would be lower than that of the Dutch straw.

This proved to be the case, though this must not be attributed merely to the lower α-cellulose content. This will be further gone into in Chapter III.C.

B. Digestions (See TABLE II)

From the enumeration of data in this table it may be inferred how a cook of about 8.5 end pH was obtained.

In the first of every three cooking this pH was either too low or too high, in the second cook the pH was either too high or too low and in the third cooking the desired pH value was obtained. With Jordan barley the second cooking was good already, but in order to test if the cooking recipe could be duplicated, a third cooking was carried out.

It struck us that with the Jordan straw soda consumption was noticeably higher than with the Dutch straw.

Contrary to the Dutch straw, the Jordan straw had not been freed from dust (de-dusted), so that a considerable amount of the soda added might be absorbed by the dust.

It is also possible that the high pentosan content of the Jordan straw partly explains the higher soda consumption.

Remark:

Cooking in which Jordan straw is freed from dust and fine material could show if the soda consumption would indeed be lower.

C. Bleaching and yields (See TABLE III)

The unbleached pulps obtained, both with the Jordan- and the Dutch straw were all partly bleached in one step and in the same way with diluted bleaching liquor (NaClO solution).

The consumption of chlorine was the same for all the samples, but the yield of bleaching for the Jordan kinds was lower. This will have been influenced by the presence of fine material.

The brightness in °G.E. of the samples was of the same order of magnitude. (60-70 °G.E.)

The yields in all cases are given after a treatment or a series of treatments. The yield after washing of the digested material, show no clear differences yet.

The yields after sorting of the beaten pulp indicate a greater loss for the Jordan straw.

After bleaching the difference, was still more pronounced, while after moulding of the hand-sheets, the yield for the Jordan samples was distinctly lower. This may have been influenced by the chemical composition, but the main cause of these low effeiciences is probably that much fine material was present in the Jordan straw.

Remark:

A cooking as suggested in III.B, in which the dedusted straw would be digested, would no doubt give higher yields compared with the not dedusted material.

D. Strength properties

Both from the bleached and the unbleached pulp, board was moulded after beating in the laboratory Valley beater, having a weight of 300 g/cm^2. In case the m^2-weight differed from 300 g/m^2, the figures found for the strength were converted to this m^2-weight, thus allowing of direct comparison.

As regards the mechanical properties, breaking strength and bursting strength, the Dutch samples give more favourable results. After bleaching the differences were less pronounced, especially in bursting strength.

In this connection it should be remarked that the breaking strength of the unbleached Dutch barley straw (73.8 kg) is probably extremely high. Other experiments give values of the same order of that found for wheat straw.

The fact that compared with the Dutch straw the Jordan straw comes out unfavourable will also be due to the bad condition of the Jordan straw. (Much dust and fine material)

By giving the straw a more careful pre-treatment (less fines), the strength of the board made from it can in all probability be increased.

However comparing the properties of the partly bleached board obtained from the Jordan straw with Dutch lime-strawboard on a non-comparative basis (as such) its strength may be said to be quite satisfactory. Which -because of the (much) lower yield- is not surprising.

E. Comparison of import Jordan board with hand-moulded partly bleached board made from Jordan straw (See TABLE V)

Of a sample white lined board as imported in Jordan (handed to us by Ir. Heesterman) some properties were determined and compared with those of the samples of hand-moulded board obtained from the Jordan straw (for results see TABLE V). The table clearly shows that the quality of the Jordan strawboard at least equals that of the import board, which for a great part consists of ground wood.

In comparing the two it should be kept in mind that a property like the breaking strength of the machine-board has been measured in two directions (machine- and cross-direction), whereas with the hand-moulded board there is obviously no question of fibre orientation in one direction, so that only one value is determined.

Even in the direction of greatest strength (machine direction) the breaking strength of the import board is lower than that of the two kinds of hand-moulded Jordan partly bleached strawboard.

Very marked is the difference in bursting strength, which for the strawboard is twice as high as for the import board.

The procedure of determining the bursting strength is applied to the surface of the board, the influence of machine- or cross-direction being of comparatively little importance.

Flexing strength of the partly bleached hand-sheets is lower than that of the import board, but this need not imply that with the Jordan strawboard which is made on a paper-machine the flexing strength cannot be improved. For experience teaches that of hand-moulded sheets the flexing strength is usually lower than of machine-board of equal weight.

CONCLUSIONS

1. The quality of the samples cut Jordan straw we have received must be qualified as poor in comparison with Dutch cut straw due to the comparatively large amounts of dust and fines.
   The ratio of ear to stalk is less favourable for processing Jordan straw than for Dutch straw, which means that of Jordan straw the percentage of usable fibre material is smaller.
2. Jordan straw has a chemical composition which in some respects noticcable differs from the composition of Dutch straw.
   This will be of influence on the consumption of chemicals necessary for digesting this straw.
3. More soda is required for digesting Jordan straw than Dutch straw.
4. The yield of semi-bleached Jordan straw pulp is abt. 37%; this is considerably lower than that of a similar Dutch pulp (abt. 50%).
   This is due to the poor quality of the cut Jordan straw, perhaps also to its chemical composition.
5. Jordan partly bleached straw-board is less strong than similar Dutch board. This will also be caused by the cut straw being of poor quality.
6. In spite of the Jordan cut straw being of comparatively poor quality, this can be worked up into a semi-bleached board of strength properties at least equalling those of the white lined (ground wood) board imported in Jordan.
7. It is justified to suppose that from a better starting material (dedusted straw), the quality of the strawboard can be improved.

TABLE I - CHEMICAL ANALYSIS

	BARLEY STRAW			WHEAT STRAW		
	JORDANIAN	DUTCH		JORDANIAN	DUTCH	
		Summer	Winter		Summer	Winter
Silicic acid	5.9	4.8	3.6	5.5	6.9	6.4
Ether extraction	1.7	1.2	1.1	1.7	1.4	1.5
Water extraction	7.3	10.3	11.0	8.9	12.4	12.6
Insoluble ash	8.4	3.8	2.6	6.2	7.7	7.8
Insoluble protein	2.1	1.1	1.4	2.7	1.1	2.0
Lignin	12.3	15.7	17.0	12.8	16.0	15.1
Pentosan	30.7	26.1	25.9	31.7	24.6	24.6
α -Cellulose	31.0	37.7	37.4	29.9	33.4	33.2
Acetic acid	2.2	2.5	2.4	2.5	2.0	2.0
Uronic acid	1.0	1.4	1.6	0.9	0.9	1.1

The numbers give percentages on oven dry matter

TABLE II - DATA OF THE DIGESTION

		Filling of the 100 l rotary digester			Amount of chemicals on dry straw			Pulp		Beating
		Air dry	Dry matter		Na_2SO_3	Na_2CO_3	dry m./ liquor ratio	dry m./ liquor ratio	pH	clearence of the disks
		kg	%	kg	%	%	-	-	-	mm
Dutch wheat straw	1	10.0	85.0	8.5	14.0	4.5	3.0	5.0	9.6	0.50
" "	2	10.0	85.0	8.5	14.0	0.5	3.0	4.6	7.0	0.50
" "	3	10.0	85.0	8.5	14.0	2.5	3.0	4.8	8.5	0.50
Jordanian wheat straw	1	10.0	87.0	8.7	14.0	4.5	3.0	4.8	8.1	0.50
" "	2	10.0	86.9	8.7	14.0	6.5	3.0	4.4	9.2	0.50
" "	3	10.0	87.0	8.7	14.0	5.5	3.0	5.5	8.6	0.50
Dutch barley straw	1	10.0	85.1	8.5	14.0	2.5	3.0	4.8	9.4	0.50
" "	2	10.0	85.1	8.5	14.0	0.5	3.0	5.0	8.2	0.50
" "	3	10.0	85.0	8.5	14.0	1.0	3.0	6.3	8.4	0.40
Jordanian barley straw	1	10.0	90.0	9.0	14.0	2.5	3.0	4.9	7.1	0.50
" "	2	10.0	90.0	9.0	14.0	4.5	3.0	4.7	8.5	0.50
" "	3	10.0	89.8	9.0	14.0	4.5	3.0	5.8	8.4	0.75

DIGESTING SCHEME : Heating in 10 min. to 120 °C; blowing off from 4 to 1.2 kg/cm^2
Cooking for 20 min. at 120 °C; " " to 1.2 kg/cm^2
Heating in 15 min. to 170 °C; " " " 9 to 5 kg/cm^2
Cooking for 25 min. at 170 °C; (pressure 8 - 9 kg/cm^2)

TABLE III - DATA ABOUT BLEACHING AND YIELD

		WHEAT		BARLEY	
		DUTCH	JORDANIAN	DUTCH	JORDANIAN
BLEACHING					
Consistency	- %	6.0	6.0	6.0	6.0
Temperature	- °C	30	28	31	31
Time	- min	30	30	30	30
Added bleaching liquor	- % Cl_2 1)	4.0	4.0	4.0	4.0
Consumed bleaching liquor	- % Cl_2 1)	3.2	3.1	3.2	3.2
Yield of bleaching	- % 1)	98.1	94.5	96.0	92.8
Brightness before bleaching	- °G.E.	59	61	57	52
Brightness after bleaching	- °G.E.	67	70	64	60
YIELDS					
After digestion	- % 2)	62.2	63.5	60.0	57.4
After sorting	- % 2)	57.9	55.4	56.0	48.9
After bleaching	- % 2)	56.8	52.3	53.8	45.3
After handsheet formation	- % 2)	52.3	37.7	47.8	36.7

1) these percentages are related to the material to be bleached

2) these percentages are related to oven-dry straw

TABLE IV - STRENGTH PROPERTIES OF BOARD (HANDSHEETS)

	WHEAT		BARLEY	
	DUTCH	JORDANIAN	DUTCH	JORDANIAN
UNBLEACHED				
Basis weight - g/m^2	306	296	296	317
Beating degree - °S.R.	35	48	46	54
Dewatering time - sec. 1)	4.9	7.4	6.1	11.2
Thickness - mm 1)	0.54	0.56	0.49	0.58
Tensile strength - kg 1) 2)	54.3	43.5	73.8	39.4
Stretch - % 2)	2.8	1.6	1.1	1.7
Bursting strength - kg/cm^2 1)	7.7	4.8	10.2	4.8
Flexing strength - kg 1) 2)	0.8	0.4	0.4	0.4
BLEACHED				
Basis weight - g/m^2	300	296	294	294
Beating degree - °S.R.	35	48	46	54
Dewatering time - sec. 1)	4.4	7.2	8.0	11.6
Thickness - mm 1)	0.40	0.57	0.48	0.53
Tensile strength - kg 1) 2)	74.0	57.1	74.8	60.5
Stretch - % 2)	4.1	2.8	1.4	2.1
Bursting strength - kg/cm^2 1)	11.6	9.0	13.6	9.1
Flexing strength - kg 1) 2)	0.6	0.5	0.5	0.3

1) the values of these properties are converted to a basis weight of 300 g/m^2

2) values at a width of 50 mm of the strip to be tested

TABLE V - STRENGTH PROPERTIES OF CARDBOARD IMPORTED IN JORDAN COMPARED WITH HANDSHEETS MADE FROM PARTLY BLEACHED SULPHITE PULP FROM JORDANIAN STRAW

			Imported Machine (lined) Cardboard	Wheat - Handsheets - Partly Bleached	Barley - Handsheets - Partly Bleached
Basis weight	- g/m^2		324	296	294
Bulk (=thickness/100 g/m^2)	- mm/100 g/m^2		0.15	0.19	0.18
Tensile strength					
- machine board					
machine direction	- kg	1) 2)	54.9		
cross direction	- kg	1) 2)	24.8		
- handsheets	- kg	1) 2)		57.1	60.5
Stretch					
- machine board					
machine direction	- %	1) 2)	2.0		
cross direction	- %	1) 2)	3.0		
- handsheets	- %	1) 2)		2.8	2.1
Flexing strength					
- machine board					
machine direction	- kg	1) 2)	1.5		
cross direction	- kg	1) 2)	0.5		
- handsheets	- kg	1) 2)		0.3	0.5
Bursting strength	- kg/cm^2	1)	4.5	9.0	9.1
Brightness	- ° G.E.		62 x)	61	52

1) the values of these properties are converted to a basis weight of 300 g/m^2

2) values at a width of 50 mm of the strip to be tested

x) unlined side