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Data Article

Experimental dataset supporting the physical and mechanical characterization of industrial base tissue papers

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ABSTRACT

Tissue paper is defined by its physical and mechanical properties, namely: high softness, low grammage, high bulk and high liquid absorption capacity. It is expected that the production of tissue paper will continue to grow, which increases the importance of better understanding the processes involved in its production as well as its optimization [1]. The experimental data presented in this article, are the physical-mechanical characterization of a group of 13 industrial base tissue papers, which were collected at the end of the tissue paper machine on Portuguese factories. These samples vary in grammage, composition and creping [2], enabling a later evaluation of the crepe type [3] and its relationship with the final properties of the tissue paper.

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Specifications Table

Subject	Materials Science (General)
Specific subject area	Industrial Base Tissue Paper
Type of data	Tables
How data were acquired	MorFi® analyzer (morphological analysis), ISO standards methods, AccuPyc® II 1340 helium pycnometer (porosity analysis), TSA - Tissue Softness Analyzer (softness analysis)
Data format	Raw and Analyzed data
Parameters for data collection	13 industrial base tissue papers with different grammages were obtained *in situ* on Portuguese factories
Description of data collection	Techpap MorFi® analysis was performed to determine the industrial base paper morphology. Papers grammage, thickness and bulk were measured using paper tissue standards ISO 12625-6 and ISO 12625-3 respectively. The porosity was determined using a Micromeritics AccuPyc® II 1340 helium pycnometer. The absorption capacity was measured according to ISO 12625-8 applying the immersion method. Tensile tests were done in machine and cross directions (MD and CD) according with ISO 12625-4. Handfeel, real softness, smoothness/roughness, and stiffness were measured using the Emtec TSA - Tissue Softness Analyzer. All these determinations were done at 23°C and 50% humidity (ISO 187).
Data source location	FibEnTech - Fiber Materials and Environmental Technologies Research Unit, Universidade da Beira Interior (UBI), Covilhã, Portugal RAIZ - Forest and Paper Research Institute, Eixo, Aveiro, Portugal
Data accessibility	With the article

Value of the Data

- The data are relevant in tissue paper materials research to obtain premium tissue paper materials.
- These data allow to evaluate the relationship between the final properties of the paper and the raw material.
- These data allow to evaluate the relationship between the raw material and the type of crepe obtained with a specific creping angle and blade.
- These data could make an important impact in the industrial production of tissue paper.

1. Data Description

In this article are presented the mean values and the standard deviations for all the measured data for the characterization of 13 industrial base tissue papers (identified from A to M) of different Portuguese factories. In Table 1 is showed the data of grammage, thickness and bulk for all the industrial base tissue papers. The morphological data for all the industrial base tissue papers, which is available in Tables 2 and 3, correspond to the number of fibers, length, width, coarseness, kink, curl, broken ends, and fines. Table 4 presents the results of the measured data in the porosity tests for all the industrial base tissue papers and the calculated apparent porosity [4]. The obtained data for water absorption time and water absorption capacity are shown in Table 5. In Tables 6 and 7 are listed the mechanical properties measured (tensile tests) in the machine direction (MD) and cross direction (CD) for all the industrial base tissue papers. The properties are the force, strength, tensile index, elongation at break, and Young modulus. Finally, the handfeel tests results (*HF*) and the corresponding TSA parameters, in particular, real softness/ fiber stiffness (*TS*7), paper surface roughness (*TS*750), frequency (*fTS*750), paper stiffness (*D*), plasticity (*P*), hysteresis (*H*), and elasticity (*E*) for all the industrial base tissue papers on top (Yankee side), bottom (Hood side), and globally are found in Tables 8,9,10,11 and 12. All

Table 1
Mean values and standard deviations of the grammage, thickness and bulk tests data for all the industrial base tissue papers.

	Grammage (g/m^2)		Thickness (μm)		Bulk (cm^3/g)	
Base paper	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$
A	19.1	0.1	121.0	2.1	6.33	0.10
B	18.8	0.2	137.8	4.4	7.32	0.26
C	16.2	0.2	122.9	1.5	7.58	0.10
D	17.2	0.1	113.0	1.2	6.55	0.07
E	15.8	0.1	113.3	0.9	7.16	0.06
F	16.3	0.2	126.2	1.9	7.74	0.10
G	15.7	0.3	116.2	2.7	7.41	0.25
H	15.8	0.2	116.3	2.7	7.37	0.24
I	15.7	0.3	110.0	2.4	7.03	0.22
J	16.0	0.3	112.5	0.7	7.09	0.14
K	16.0	0.4	110.7	1.9	6.89	0.26
L	17.5	0.2	126.7	1.3	7.25	0.09
M	17.3	0.2	131.4	2.3	7.62	0.11

Table 2
Mean values and standard deviations of the morphology test data for all the industrial base tissue papers.

	Fibers (million/g)		Length weighted in length (mm)		Width (μm)		Coarseness (mg/100 m)	
Base paper	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$
A	18.0	1.1	0.850	0.007	19.5	0.1	8.04	0.00
B	14.7	0.2	0.930	0.004	20.8	0.2	9.47	0.00
C	16.7	0.2	0.860	0.006	20.1	0.1	8.80	0.00
D	14.7	0.2	0.930	0.004	20.8	0.2	9.47	0.00
E	16.8	0.4	0.862	0.010	20.0	0.1	8.73	0.26
F	17.4	0.2	0.859	0.002	20.3	0.3	8.48	0.12
G	18.1	0.5	0.814	0.006	19.4	0.1	8.32	0.25
H	18.3	0.5	0.812	0.005	19.4	0.1	8.22	0.21
I	21.2	0.3	0.733	0.005	19.6	0.1	7.87	0.09
J	20.4	0.3	0.742	0.002	19.6	0.1	8.11	0.11
K	20.8	0.1	0.732	0.001	19.8	0.1	8.04	0.06
L	22.4	0.1	0.740	0.001	19.3	0.0	7.14	0.03
M	17.3	0.2	0.784	0.003	20.7	0.1	9.25	0.06

Table 3
Mean values and standard deviations of the morphology test data for all the industrial base tissue papers.

	Kink fibers (%)		Curl (%)		Broken ends (%)		Fines (% area)	
Base paper	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$
A	40.1	0.2	9.2	0.0	23.2	0.3	14.1	0.1
B	43.7	0.2	10.0	0.0	26.8	0.3	14.3	0.3
C	47.9	0.6	10.2	0.0	24.8	0.2	16.1	0.7
D	43.7	0.2	10.0	0.0	26.8	0.3	14.3	0.3
E	130.8	0.3	10.1	0.0	25.3	0.1	14.7	0.1
F	130.7	0.2	10.4	0.0	26.3	0.9	16.1	0.9
G	48.7	0.6	10.3	0.1	23.4	0.4	15.3	0.4
H	48.0	0.6	10.2	0.0	22.7	0.4	14.5	0.5
I	50.7	0.5	11.3	0.1	23.6	0.5	15.8	0.2
J	50.7	0.2	11.2	0.1	24.0	0.5	16.0	0.3
K	50.2	0.3	11.2	0.1	25.0	0.4	15.9	0.2
L	45.6	0.2	9.8	0.1	22.6	0.1	13.9	0.1
M	48.4	0.2	10.3	0.0	26.3	0.4	14.4	0.1

Table 4
Mean values and standard deviations of the porosity tests data for all the industrial base tissue papers and the results of the apparent porosity.

Base paper	Porosity (%)		Apparent Porosity (%)
	$\bar{x}$	$\pm\sigma$	
A	91.6	0.0	89.7
B	90.9	0.0	91.1
C	92.2	0.0	91.5
D	90.8	0.0	90.6
E	93.9	0.0	90.9
F	89.1	0.0	91.7
G	95.7	0.0	91.2
H	95.7	0.0	91.1
I	90.1	0.0	90.7
J	90.9	0.0	90.8
K	90.3	0.0	90.6
L	90.8	0.0	91.1
M	91.3	0.0	92.3

Table 5
Mean values and standard deviations of the water absorption time and water absorption capacity tests data for all the industrial base tissue papers.

Base paper	Water Absorption Time (s)		Water Absorption Capacity (g/g)	
	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$
A	4.688	0.420	6.862	0.310
B	4.644	0.370	7.573	0.310
C	3.969	0.030	8.173	0.090
D	4.272	0.450	7.990	0.160
E	4.895	0.510	7.636	0.170
F	4.158	0.640	8.180	0.390
G	4.852	0.060	9.007	0.190
H	4.856	0.070	8.642	0.270
I	4.606	0.060	7.850	0.130
J	4.262	0.410	7.908	0.170
K	4.727	0.510	7.883	0.210
L	4.641	0.400	7.436	0.090
M	4.852	0.510	8.614	0.250

Table 6
Mean values and standard deviations of the tensile tests data (MD and CD) for all the industrial base tissue papers.

	Force (N)				Strength (N/m)				Tensile Index (Nm/g)			
	MD		CD		MD		CD		MD		CD	
Base paper	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$
A	14.19	1.00	8.80	0.30	0.284	0.020	0.176	0.006	14.86	1.04	9.21	0.32
B	10.52	1.06	6.48	0.23	0.210	0.021	0.130	0.005	11.19	1.12	6.89	0.24
C	8.71	0.45	4.40	0.23	0.175	0.009	0.088	0.005	10.62	0.55	5.37	0.28
D	9.82	0.33	4.78	0.18	0.196	0.007	0.095	0.004	11.69	0.40	5.68	0.21
E	8.60	0.60	4.37	0.29	0.172	0.012	0.087	0.006	10.68	0.74	5.43	0.36
F	8.95	0.64	4.22	0.20	0.179	0.013	0.084	0.004	10.98	0.80	5.17	0.24
G	7.96	0.72	3.94	0.13	0.159	0.014	0.079	0.003	10.14	0.92	5.02	0.16
H	7.97	0.64	4.12	0.14	0.159	0.013	0.082	0.003	10.09	0.81	5.21	0.18
I	7.75	0.46	4.08	0.09	0.156	0.010	0.082	0.002	9.87	0.59	5.20	0.11
J	7.51	0.41	3.54	0.24	0.150	0.008	0.071	0.005	9.39	0.51	4.42	0.30
K	8.19	0.31	3.80	0.26	0.164	0.006	0.076	0.005	10.24	0.39	4.75	0.32
L	8.88	0.42	3.87	0.19	0.178	0.008	0.077	0.004	10.04	0.47	4.37	0.22
M	8.38	0.34	3.68	0.15	0.168	0.007	0.074	0.003	10.03	0.41	4.40	0.17

Table 7
Mean values and standard deviations of the tensile test data (MD and CD) for all the industrial base tissue papers.

	Elongation at Break (%)				Young Modulus (MPa)			
	MD		CD		MD		CD	
Base paper	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$
A	28.97	1.49	2.90	0.13	13.21	1.67	74.29	6.30
B	24.16	1.53	3.02	0.15	8.36	0.97	42.22	2.42
C	25.04	1.00	3.44	0.38	8.70	0.36	28.68	1.42
D	22.53	1.78	4.00	0.47	15.04	2.36	31.53	2.19
E	24.56	1.28	3.23	0.32	9.43	0.80	33.59	1.13
F	26.27	1.29	3.89	0.44	7.80	0.28	24.58	1.37
G	23.48	1.89	4.36	0.30	10.54	1.92	22.11	1.38
H	23.22	2.13	4.15	0.27	10.17	0.79	23.79	1.62
I	24.80	1.59	3.30	0.21	8.51	0.73	35.56	0.92
J	25.76	1.16	3.50	0.52	7.81	0.44	27.73	1.10
K	24.64	1.10	3.32	0.39	9.51	0.69	30.49	3.61
L	27.04	1.04	2.88	0.43	6.84	0.25	29.02	2.32
M	22.96	0.975	3.25	0.25	10.13	0.45	22.34	1.16

Table 8
Mean values and standard deviations of the handfeel (*HF*) tests data for all the industrial base tissue papers.

	HF					
	Top		Bottom		Global	
Base paper	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$
A	59.1	3.4	49.5	2.3	54.3	5.7
B	54.2	3.6	52.7	3.2	53.5	3.3
C	71.3	1.5	67.7	1.9	69.5	2.5
D	67.4	2.8	61.1	1.7	64.3	4.0
E	74.7	1.7	67.6	2.6	71.2	4.3
F	73.2	1.8	64.3	2.3	68.7	5.1
G	73.1	0.9	71.0	0.6	72.1	1.3
H	71.5	1.9	68.6	1.7	70.0	2.3
I	71.4	1.6	71.0	4.0	71.2	2.9
J	72.3	4.3	64.9	2.9	68.6	5.2
K	63.0	4.7	63.0	2.6	63.0	3.6
L	72.3	2.7	69.4	1.7	70.9	2.6
M	74.2	1.9	65.2	1.6	69.7	5.0

Table 9
Mean values and standard deviations of the TSA parameters tests data for all the industrial base tissue papers.

	TS7 Parameter					
	Top		Bottom		Global	
Base paper	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$
A	25.6	1.8	30.7	1.2	28.2	3.0
B	27.9	1.9	28.7	1.7	28.3	1.8
C	19.6	0.8	21.4	1.0	20.5	1.3
D	21.7	1.4	24.9	0.9	23.3	2.1
E	18.0	0.9	21.7	1.3	19.9	2.2
F	18.5	0.9	23.2	1.2	20.8	2.6
G	18.8	0.4	20.0	0.3	19.4	0.7
H	19.7	1.0	21.2	0.8	20.4	1.1
I	19.8	0.8	20.1	2.0	20.0	1.5
J	19.4	2.2	23.2	1.5	21.3	2.7
K	24.2	2.4	24.2	1.4	24.2	1.8
L	18.9	1.4	20.5	0.9	19.7	1.4
M	17.8	1.0	22.5	0.8	20.1	2.6

Table 10
Mean values and standard deviations of the TSA parameters tests data for all the industrial base tissue papers.

	*TS*750 Parameter						*fTS*750 Parameter (Hz)					
	Top		Bottom		Global		Top		Bottom		Global	
Base paper	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$
A	18.3	1.1	32.7	1.8	25.5	7.7	399.8	55.4	397.8	30.8	398.8	42.3
B	23.9	1.4	31.1	2.0	27.5	4.1	540.0	50.8	446.4	46.8	493.2	67.5
C	15.1	0.5	17.4	1.1	16.2	1.4	800.2	40.9	785.0	45.2	792.6	41.5
D	16.4	0.6	18.3	0.2	17.3	1.1	861.8	46.5	828.0	122.8	844.9	89.3
E	11.8	0.2	16.9	1.2	14.3	2.8	947.6	29.2	829.0	61.4	888.3	77.2
F	13.0	0.6	18.4	1.0	15.7	2.9	841.8	17.2	658.4	36.6	750.1	100.3
G	15.1	0.7	15.3	0.9	15.2	0.8	806.6	52.9	821.8	78.5	814.2	63.6
H	15.4	0.7	16.5	0.6	15.9	0.8	805.8	35.3	827.2	46.8	816.5	40.6
I	15.9	1.0	13.1	1.4	14.5	1.9	910.4	31.9	969.2	41.7	939.8	46.8
J	13.0	1.2	17.2	0.4	15.1	2.4	950.2	38.1	878.6	63.5	914.4	62.1
K	17.0	1.1	18.5	0.8	17.8	1.2	759.0	76.5	869.8	49.9	814.4	84.4
L	14.7	0.7	20.5	0.6	17.6	3.1	773.8	49.1	594.0	84.5	683.9	115.0
M	15.8	0.9	19.1	0.6	17.4	1.9	749.0	60.2	736.0	116.0	742.5	87.4

Table 11
Mean values and standard deviations of the TSA parameters tests data for all the industrial base tissue papers.

	D Parameter (mm/N)						*P* Parameter (μm)					
	Top		Bottom		Global		Top		Bottom		Global	
Base paper	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$
A	2.0	0.0	2.1	0.0	2.0	0.0	-30.2	9.5	-50.1	5.1	-40.2	12.7
B	2.0	0.1	2.1	0.0	2.1	0.1	-17.8	5.3	-34.6	9.9	-26.2	11.6
C	2.4	0.0	2.5	0.0	2.4	0.0	-28.2	10.9	-47.3	12.4	-37.8	14.9
D	2.2	0.0	2.2	0.0	2.2	0.0	-20.9	6.4	-24.8	12.6	-22.9	9.7
E	2.4	0.0	2.4	0.0	2.4	0.0	-30.1	4.8	-54.2	19.1	-42.2	18.2
F	2.5	0.0	2.5	0.0	2.5	0.0	-48.4	6.3	-52.8	8.4	-50.6	7.4
G	2.4	0.1	2.5	0.0	2.5	0.1	-22.9	12.5	-38.7	3.8	-30.8	12.1
H	2.5	0.0	2.4	0.1	2.5	0.1	-38.8	12.7	-20.2	7.0	-29.5	13.8
I	2.4	0.0	2.5	0.1	2.5	0.1	-30.6	6.3	-48.9	11.8	-39.8	13.1
J	2.6	0.1	2.5	0.0	2.6	0.1	-53.5	13.8	-62.5	11.4	-58.0	12.8
K	2.5	0.1	2.4	0.0	2.4	0.0	-52.6	16.0	-49.8	6.9	-51.2	11.7
L	2.6	0.1	2.6	0.0	2.6	0.0	-105.2	14.8	-119.0	17.6	-112.1	17.0
M	2.5	0.0	2.5	0.0	2.5	0.0	-85.0	20.4	-91.3	11.5	-88.2	16.0

Table 12
Mean values and standard deviations of the TSA parameters tests data for all the industrial base tissue papers.

	H Parameter (J)						*E* Parameter (mm/N)					
	Top		Bottom		Global		Top		Bottom		Global	
Base paper	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$	$\bar{x}$	$\pm\sigma$
A	28.2	11.7	29.6	6.6	28.9	9.0	2.0	0.0	2.0	0.0	2.0	0.0
B	26.7	6.0	23.5	14.1	25.1	10.4	2.0	0.1	2.1	0.0	2.1	0.1
C	26.8	7.9	29.7	9.5	28.3	8.4	2.4	0.0	2.5	0.0	2.4	0.0
D	22.2	6.6	22.8	10.1	22.5	8.0	2.2	0.0	2.2	0.0	2.2	0.0
E	27.7	6.8	28.3	9.2	28.0	7.6	2.4	0.0	2.4	0.0	2.4	0.0
F	30.7	7.2	27.3	6.6	29.0	6.8	2.5	0.0	2.5	0.0	2.5	0.0
G	19.6	13.4	26.3	10.0	22.9	11.7	2.4	0.1	2.6	0.0	2.5	0.1
H	23.5	11.2	13.8	6.2	18.7	10.0	2.5	0.0	2.4	0.1	2.5	0.1
I	20.6	5.7	28.6	6.1	24.6	6.9	2.4	0.0	2.5	0.1	2.5	0.1
J	33.7	7.5	31.3	7.9	32.5	7.4	2.6	0.0	2.5	0.0	2.6	0.0
K	29.7	5.7	30.2	7.4	30.0	6.2	2.4	0.1	2.4	0.0	2.4	0.0
L	36.0	3.6	35.4	4.0	35.7	3.6	2.5	0.0	2.5	0.0	2.5	0.0
M	34.8	7.6	37.8	6.5	36.3	6.9	2.4	0.0	2.4	0.0	2.4	0.0

the raw data presented in this manuscript is available in the Excel file attached as an appendix supplementary material.

2. Experimental Design, Materials and Methods

An extensive characterization of the 13 different samples of the industrial base tissue papers was carried out, using different methods. We started by determining the grammage, thickness and bulk. The grammage, expressed in g/m^2 was determined in accordance with ISO 12625-6:2005 [5] and using a Mettler Toledo PB303 Delta Range analytical balance. The thickness was also determined using a FRANK-TPI® Micrometer according to ISO 12625-3:2014 [6]. Finally, the bulk, could be determined using the same standard as before, since it is the inverse of density. The morphology of all base papers was evaluated using the MORFI® Fiber and Shive Analyser from Techpap SAS, that provides us the quantity of fibers in the structure, fiber length and width, coarseness, kink fibers, curl, broken ends and fines percentage in area [7]. The Apparent porosity (theoretical) was determined, for all the industrial base tissue papers samples, using Eq. 1,

$$P\ (\%) = 100\ \times \left(1 - \frac{\rho_{sample}}{\rho_{cellulose}}\right) \tag{1}$$

where $\rho_{cellulose}$ is the density of the cellulose (which is assumed to be 1.6 g/cm^3) and ρ_{sample} is the density of the sample (g/cm^3), which is the inverse of the bulk (cm^3/g) [4]. The porosity was determined using a Micromeritics AccuPyc II 1340 helium pycnometer for all the samples too. The water absorption time and the water absorption capacity was measured according to ISO 12625-8:2010 [8]using a FRANK-TPI® tissue absorption tester to apply the immersion method. The industrial base tissue paper samples were cut, doing an adaptation to the above standard, with the dimensions, width 76±1 mm and length 100±1 mm, in the machine direction, since the toilet base paper does not have a defined service length. Tensile tests were done in machine and cross directions (MD and CD) for all the samples, according with ISO 12625-4:2005 [9], on a Thwing-Albert® VantageNX Universal Testing Machine. For the measurements of *HF, TS*7, *TS*750, *fTS*750, *D, P, H*, and *E*, the Tissue Softness Analyzer (TSA) from EMTEC was used [10]. The handfeel (*HF*) is one of the parameters calculated by the TSA combining several measurements of the samples to obtain a global quantification of softness of the papers. In this case the QA I algorithm was used for the calculation of the *HF*. All the toilet base paper samples were prepared accordingly with the machine specifications.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

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Supplementary Materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.dib.2020.106434.

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