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7th INTERNATIONAL SYMPOSIUM ON NATURAL POLYMERS AND COMPOSITES

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FOREWORD

It is a great pleasure for us to welcome all the participants of the **XII International Macromolecular Colloquium and the 7th International Symposium of Natural Polymers and Composites.** We are very pleased with your contributions which are very important to the success of the Meeting. During this time, researchers will have the opportunity to initiate and enhance fruitful interactions among different institutions around the world working in the field of Polymer Science and Technology. We hope this Meeting will also offer a good opportunity to improve the research on the field of natural polymer-based materials and composites developed in Brazil.

Without your participation and specially the contribution of those presenting the 30 lectures, 34 oral sessions and 411 posters it would not be possible to organize this Meeting. We would like to acknowledge also the support from BRASKEM, CAPES, CNPq, FAPERGS, FAPESP, Petrobras and PROPESQ-UFRGS and the participation of the exhibitors dpUnion, Instrutécnica, Polimate and Reoterm.

We wish all the participants lots of interesting discussions and important stimulus for their further work and a pleasant stay in Gramado.

Organizing Committee

EVALUATION OF MECHANICAL PROPERTIES IN CORNHUSKS.

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Corn husks from nineteen types of corn elite hybrids were evaluated mechanically by tensile test. It was measured the Elastic Modulus, Tensile Strength and Elongation at Break in both longitudinal and transverse orientation of fibers. A methodology was defined to process the data in order to avoid under or overestimation of the measured properties. Elastic Modulus and Tensile Strength measured in longitudinal orientation showed higher results than in transverse orientation. Anisotropy of mechanical properties of corn husks was evaluated.

Introduction

Corn today is the third most produced grain in the world, behind only to rice and wheat. According to Food and Agricultural Organization of the United Nations, in 2007 Brazil was the third biggest producer of this grain, totalizing a production of 51,589,721 tons, behind China (151,970,000 tons) and USA (332,092,180 tons).

After harvest, great part of the agricultural waste, as though stems and husks are left in the ground in order to decompose and fertilize the soil. However the potential uses of these materials are huge, especially in energetic[1], textile[2] and composites materials areas[3]. One of the interest uses of cornhusk, mainly to families in poor regions of Brazil, is in handicraft. This activity provides income to this families and increment to gross domestic product of the country[4].

The objectives of this work are to use tensile test to evaluate the mechanical properties of cornhusks from different kinds of corn and to define a methodology to process the dates obtained in the mechanical tests.

Experimental

Materials:
Nineteen types of corn elite hybrids husks were evaluated, from Embrapa Maize and Sorghum germoplasm bank.

Methods:

Sample preparation

Two types of specimen were tested, specimen that were longitudinal and transversal to the corn husk fibers direction. These were taken from the inner third of the corn husk to prevent irregular specimen and stress concentration. Figure 1 shows a typical corn husk and the specimen cut-out area.

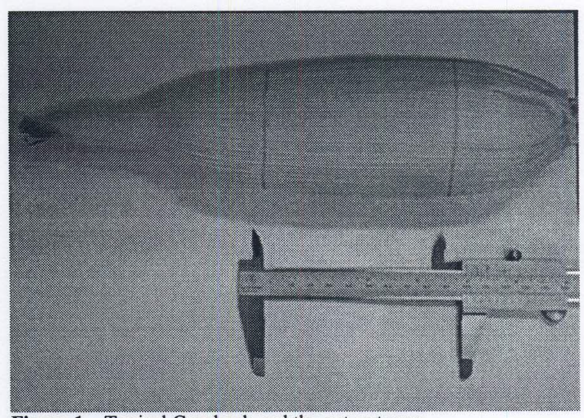

Figure 1 – Typical Cornhusk and the cut-out area

The samples were prepared manually according to the geometry 9cm x 1cm, as figure 2. Peaces of s sandpaper of 2cm x 2cm were fastened in the ends of the samples in order to avoid the slip of it in the claws of the mechanical test machine, following them the sample with the effective geometry of 5cm x 1cm. To fix these sandpapers, it was used cyanoacrylate based glue (Superbonder®). fix these sandpapers, it was used cyanoacrylate based glue (Superbonder®).

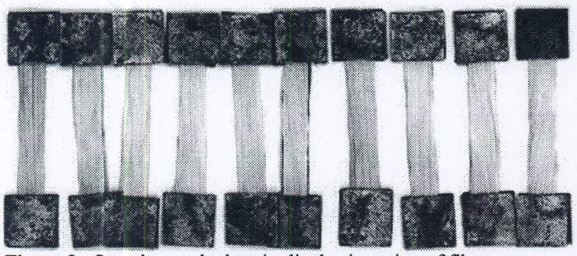

Figure 2 - Samples on the longitudinal orientation of fibers.

Tensile Tests

The tensile tests were conducted to ten samples to each corn elite hybrid husk in an EMIC universal testing machine model DL3000 with manual grips and a 50 kgf load cell. The tensile test speed was 5mm/mim. The data obtained to samples after test and data processing were: Elastic Modulus (E), Elongation at Break (ε) and Tensile Strength at Break (σ) to cornhusks tested in longitudinal and transverse fibers orientation.

Data Treatment

In transverse and longitudinal orientation, the elongation at break needed to correction, because in this orientation, the cornhusks shows its fibers bent on each other (called in this work accordion phenomenon, because cornhusks cut in this orientation show off its fibers in a conformation similar to the bellows of an accordion). So, in the beginning of the test, the elongation in the sample isn't because the elongation suffered by the fibers, but because the deployment of fibers on each other. This fact causes an error associated to elastic modulus and elongation at break and therefore, an adjustment is needed. Figure 3 shows a typical behavior of the accordion phenomenon:

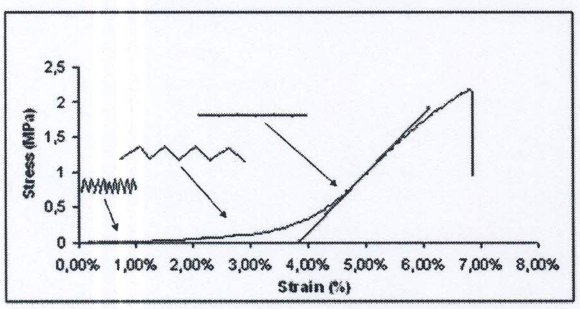

Figure 3 – Accordion phenomenon scheme during tensile test. The cornhusk shows its fibers bent on each other. The point that the red line touches the axis represents the end of accordion phenomenon.

Results and Discussion

After obtained data from the equipment, these data had to be processed mathematically in order to avoid that the accordion phenomenon influence on the elastic modulus and elongation at break results. The considerations for the data processing were as follows:

- To samples that didn't show off the phenomenon, the elastic modulus was obtained to elongations up to 1%, using the zone inside this interval with the biggest slope of the curve Stress x Strain.

- To determine the elastic modulus and elongation at break on the specimens that showed off the accordion phenomenon, the data processing was utilized to determine the elongation on the specimen due to this. This mathematical processing consisted of first identifying the region of the curve in which the phenomenon happened by the relatively low strain level when compared with the entire curve. After identification, drew a line tangent to the graph region with higher slope. The point in which this line crossed with the x axis represents the elongation value that will be discounted to elongation to break calculus and the slope of the tangent line is the elastic modulus found to the specimen.

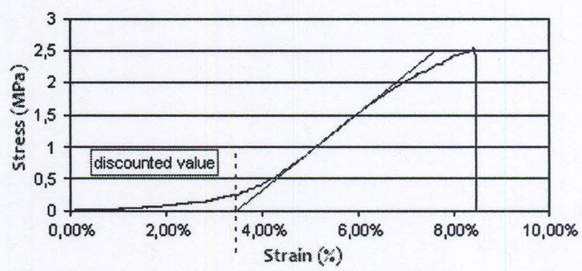

Figure 5 – Mathematical processing to determine the value of discount due to the accordion phenomenon occurred in the samples with the transverse orientation of fibers.

All the results found to the tested cornhusks are in the follows tables. It was obtained, up to the consideration to data processing, the elastic modulus, elongation at break and tensile strength at break. With all these results, it was made a statistic analyze in order to obtain average, standard deviation, standard error of the mean, minimum and maximum values for each type of cornhusks tested. Then the graphics were plotted with the compared results of the measured properties in the longitudinal and transverse orientation. The line x = y that is present on the graphics represents the region in which the measured property is equal in both orientation.

Table 1 – Descriptive statistical treatment of elastic modulus to the tested samples.

	Elastic Modulus (MPa)											
	Average		SD		SEM		Max		Min		N	
	L	T	L	T	L	T	L	T	L	T	L	T
S1	464	70	82	39	27	12	618	119	382	29	9	10
S2	652	97	168	25	53	9	949	138	454	72	10	8
S3	642	91	142	36	47	11	756	149	381	42	9	10
S4	722	48	194	15	61	5	1072	77	461	29	10	8
S.5	508	96	203	25	64	8	725	124	482	51	10	10
S6	519	87	218	19	69	6	883	123	292	60	10	10
S7	494	37	66	22	22	7	593	83	389	16	9	10
S8	714	69	82	11	26	4	858	85	618	47	10	9
S9	674	133	109	40	35	13	860	181	519	68	10	9
S10	928	47	119	18	38	6	1125	81	680	28	10	10
S11	517	64	83	28	26	11	656	111	395	31	10	7
S12	513	57	106	28	34	9	645	106	358	28	10	10
S13	541	92	116	33	37	11	757	135	421	26	10	10
S14	524	51	157	29	50	9	791	101	256	14	10	10
S15	391	59	87	55	28	17	504	183	270	20	10	10
S16	511	49	118	24	37	8	735	86	365	18	10	8
S17	468	24	120	21	40	8	622	71	261	11	9	7
S18	503	40	100	21	32	7	623	78	295	11	10	9
S19	642	34	37	13	12	4	687	50	578	4	10	10

Table 2 - Descriptive statistical treatment of tensile strength at break to the tested samples.

	Tensile Strength at Break (MPa)											
	Average		SD		SEM		Max		Min		N	
	L	T	L	T	L	T	L	T	L	T	L	T
S1	11,17	2,73	2,52	0,71	0,89	0,22	13,61	3,83	6,55	1,56	8	10
S2	17,46	1,71	5,38	0,78	1,70	0,28	25,90	2,62	10,84	0,57	10	8
S3	19,18	2,51	5,06	1,49	1,79	0,47	23,98	4,33	10,79	0,39	8	10
S4	13,67	1,12	4,09	0,33	1,29	0,12	20,53	1,59	8,44	0,57	10	8
S.5	10,26	2,02	2,14	0,57	0,68	0,17	13,86	2,71	7,24	0,63	10	10
S6	7,82	2,56	5,83	1,02	1,84	0,32	20,23	4,00	5,93	1,02	10	10
S7	11,51	0,96	1,80	0,40	0,60	0,13	15,22	1,95	9,29	0,66	9	10
S8	14,64	2,85	3,59	0,59	1,13	0,20	22,27	3,60	9,92	1,97	10	9
S9	13,18	2,73	3,13	1,33	0,99	0,44	17,05	4,53	9,04	1,00	10	9
S10	20,31	1,47	3,21	0,52	1,02	0,16	24,22	2,09	13,96	0,53	10	10
S11	10,27	1,48	2,07	0,73	0,66	0,28	13,52	2,65	7,22	0,85	10	7
S12	10,19	2,05	2,96	0,92	0,94	0,29	15,72	4,14	6,89	1,04	10	10
S13	13,09	1,73	3,20	1,00	1,01	0,32	18,06	3,05	7,66	0,11	10	10
S14	11,60	1,74	3,55	0,51	1,12	0,16	18,27	2,64	6,70	0,92	10	10
S15	9,82	0,97	3,16	0,55	1,00	0,17	13,67	2,13	5,34	0,44	10	10
S16	9,65	0,96	3,75	0,74	1,19	0,26	17,84	2,09	4,54	0,36	10	8
S17	10,27	0,98	2,88	0,52	0,96	0,20	16,84	1,78	7,04	0,25	9	7
S18	11,80	0,86	2,26	0,44	0,71	0,15	14,55	1,60	7,05	0,41	10	9
S19	12,55	0,99	2,70	0,43	0,85	0,14	16,45	1,54	9,19	0,06	10	10

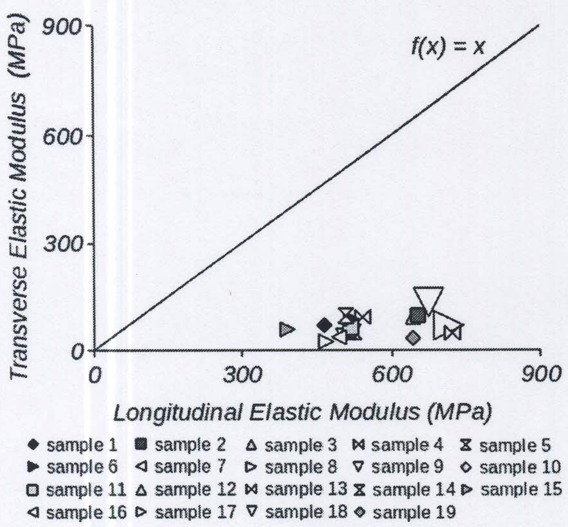

Figure 5 – Graphic comparing the elastic modulus measured in transverse and longitudinal orientation.

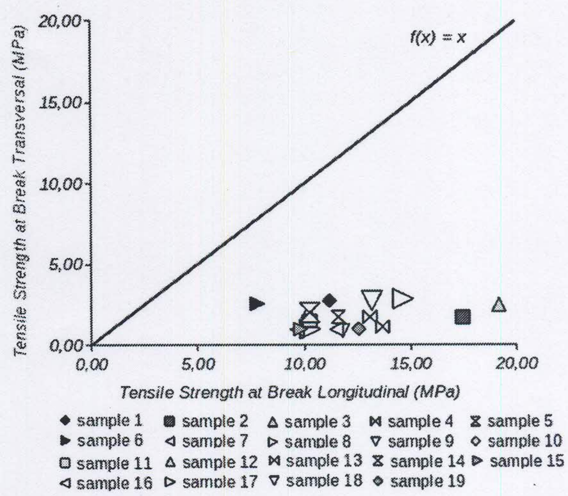

Figure 6 – Graphic comparing Tensile Strenhgth at Break measured in transverse and longitudinal orientation.

Table 3 – Descriptive statistical treatment of elongation at break to the tested samples.

	Elongation at break (%)											
	Average		SD		SEM		Max		Min		N	
	L	T	L	T	L	T	L	T	L	T	L	T
S1	3,80	5,70	0,98	2,71	0,35	0,86	4,81	8,45	2,22	2,04	8	10
S 2	4,45	1,81	1,25	0,87	0,40	0,31	7,37	3,46	3,01	0,56	10	8
S 3	5,15	3,99	0,66	2,15	0,23	0,68	6,04	7,24	4,02	0,56	8	10
S 4	3,27	2,81	0,91	1,41	0,29	0,50	4,53	4,52	1,73	1,16	10	8
	3,82	2,04	3,61	0,58	1,14	0,18	13,86	3,27	1,65	1,16	10	10
S 6	3,26	3,16	1,95	1,07	0,62	0,34	6,05	4,59	2,75	1,36	10	10
S 7	5,33	3,85	1,53	1,06	0,51	0,34	7,38	5,13	3,37	1,95	9	10
S 8	3,85	4,74	0,96	1,07	0,30	0,36	5,10	6,32	2,59	3,10	10	9
S 9	3,47	1,87	1,02	0,50	0,32	0,17	5,35	2,61	2,30	1,16	10	9
S 10	5,63	3,30	1,27	1,45	0,40	0,46	7,73	5,37	3,99	1,33	10	10
S 11	3,39	2,50	0,70	1,19	0,22	0,45	4,83	4,99	2,05	1,46	10	7
S 12	3,54	3,96	0,84	1,06	0,27	0,33	5,53	5,32	2,78	2,56	10	10
S 13	3,93	1,78	1,10	0,82	0,35	0,26	6,17	3,28	2,30	0,41	10	10
S 14	3,46	4,78	0,58	2,33	0,18	0,74	4,30	8,27	2,70	1,98	10	10
S 15	4,21	3,86	1,14	2,52	0,36	0,80	5,35	8,79	2,22	0,30	10	10
S 16	3,25	2,10	0,99	0,97	0,31	0,34	5,64	3,26	1,61	0,47	10	8
S 17	4,14	6,90	1,36	3,95	0,45	1,49	6,77	10,77	2,41	1,22	9	7
S 18	5,19	3,53	1,27	1,01	0,40	0,34	8,05	4,96	3,62	2,20	10	9
S 19	3,53	3,06	1,08	1,17	0,34	0,37	5,63	5,51	2,00	1,47	10	10

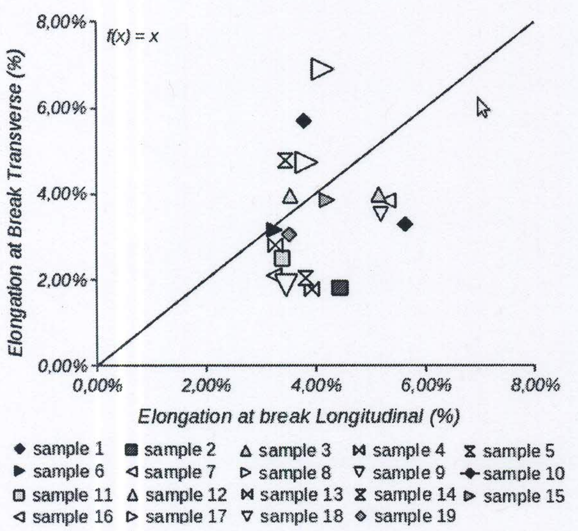

Figure 7 – Graphic comparing Elongation at Break measured in transverse and longitudinal orientation.

It can be observed that both Elastic Modulus and Tensile Strength present biggest values in longitudinal direction, but the Elongation at Break in both direction are similar. It's interesting that the values on the graphic are near the y = x line, showing similar properties in both direction.

Regarding the math correction to data processing, if this procedure had not been made, the values of Elastic Modulus in transverse orientation would be underestimated, and the Elongation at Break would be overestimated. It would happen because the accordion phenomenon.

Conclusions

In the present work, it was analyzed cornhusks from nineteen types of corn elite hybrids husks, in order to evaluate the mechanical properties.

A methodology was developed to better evaluation of the obtained data, whereas the accordion phenomenon underestimates the Elastic Modulus and overestimates the Elongation at Break. This phenomenon doesn't influence the Tensile Strength.

It was verified mechanical anisotropy in both Elastic Modulus and Tensile Strength. By the sum of Medias in both directions, it's realized that Elastic Modulus in longitudinal direction is almost nine times bigger than in transverse direction, and Tensile Strength is more than seven times bigger in longitudinal direction.

Acknowledgements

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