



STUDY ON THE COMPRESSIVE BEHAVIOUR OF FUNCTIONAL KNITTED FABRICS USING ELASTOMERIC MATERIALS

Juliana Cruz¹, Raul Figueiro¹, Filipe Soutinho¹, Carla Ferreira², Paulo Andrade²

¹University of Minho, Department of Textile Engineering, Campus de Azurém, Guimarães, Portugal

²Sonicarla, S.A. Mogege, Famalicão, Portugal
rfang@det.uminho.pt

ABSTRACT

This paper describes the research work being done at University of Minho to study the behaviour of weft-knitted fabrics produced with different elastomeric materials to be applied in medical and well-being products. The compressive characteristic of knitted fabrics play a very important role in several medical situations, such as surgery recovery, pain reduction or leg varicose. An experimental plan has been designed to study the influence of different factors in the compressive behaviour of weft-knitted functional fabrics, including the type of knitted pattern, the linear density of the elastomeric yarn, the linear density of the ground yarn, fiber cross-section and the type of finishing processes after knitted fabric producing. Different knitted fabrics, produced using a seamless machine, have been tested for cyclic tensile behaviour. The elastic deformation and the permanent deformation of each one has been measured and analysed.

Key Words: compressive behavior, elastomeric materials, medical, well-being, knitted fabrics

1. INTRODUCTION

Textile materials play an important and crucial role in designing appropriate structures for the healthcare and medical industries. It has been established that compression therapy by making use of padding and compression bandages is an efficient treatment for healing venous leg ulcers, despite surgical strategies, electromagnetic therapy and intermittent pneumatic compression [1]. During the past few years there have been increasing concerns concerning to the performance of bandages for the treatment of venous leg ulcers. This is because the compression therapy is a complex system and requires two or multi-layer bandages, and the properties of each layer differ from other layers [1].

Compression garments originated in therapeutic medicine. However, a dramatic increase has occurred in the use of compression garments in sport. The garments have anecdotal and research supported evidence of enhancing performance. Improvements were noted in the forces applied by garments, and specifically the contributions of garments to decreased muscle fatigue [2]

The physical properties of weft-knitted fabrics for compressive functional behavior are influenced by different factors – the materials: type of yarn, yarn linear density, type of Elastane, and the production process: machine, and specific parameters of production [3, 4 and 5]. Weft-knitted elastic properties are directly related to the type of yarn used and its mechanical properties. [6]

This paper describes the research work being done at University of Minho to study the behaviour of weft-knitted fabrics produced with different elastomeric materials to be applied in medical and well-being products. Different knitted fabrics, produced using a seamless machine, have been tested for cyclic tensile behaviour. The elastic deformation and the permanent deformation of each one has been measured and analysed.

2. EXPERIMENTAL PLAN

2.1 Materials

Single jersey knitted fabrics tested are produced with 95% Polyamide and 5% of Elastane using seamless technology. Four types of polyamides have been used, two with circular cross-section and other two with trilobal cross-section, with different yarn linear densities. Four types of elastanes have been used including 13, 17, 22 and 78 dtex. Table 1 presents the properties of the different samples produced and tested.

Table 1. Group of samples produced and tested

	Polyamide (PA)		Elastane (EA)	Dimensional Properties			Areal Mass
	Yarn Linear Density (tex)	Cross Sections	Yarn linear density (dtex)	Wales/cm	Courses/cm	Cover factor (K)	g/m ²
A1	7,8	Circular	13	18	30	9	221
A2			17	17	30	9	264
A3			22	18	30	9	269
A4			78	19	36	9	336
B1	15,6		13	16	28	9	285
B2			17	16	29	9	313
B3			22	15	30	9	317
B4			78	16	31	8	386
C1	7,8	Trilobal	13	19	37	9	246
C2			17	18	35	9	281
C3			22	19	35	9	387
C4			78	20	40	8	363
D1	15,6		13	16	30	13	321
D2			17	16	28	12	360
D3			22	16	29	12	364
D4			78	17	31	12	427

2.2 Test Methods

The tensile behaviour of the weft-knitted fabrics with elastomeric materials has been evaluated under single and cyclic testing using a HOUSFIELD H10KS universal tensile tester.

Tests were conducted in the coursewise direction, according to NP EN ISO 1394-2, using Grab method. The cyclic test was conducted by performing 10 cycles up to a force of 10N.

3. RESULTS AND DISCUSSION

3.1 Influence of the elastane linear density in the mechanical behavior

Figures 1 to 4 present the relationship between load and the elastane linear density. Different relationship may be observed for fabrics with polyamide with circular cross-section and polyamide with trilobal cross-section. For weft-knitted fabrics with polyamide with circular cross-section a linear relationship may be observed while for weft-knitted fabrics with polyamide with trilobal cross-section a non-linear relationship is observed.

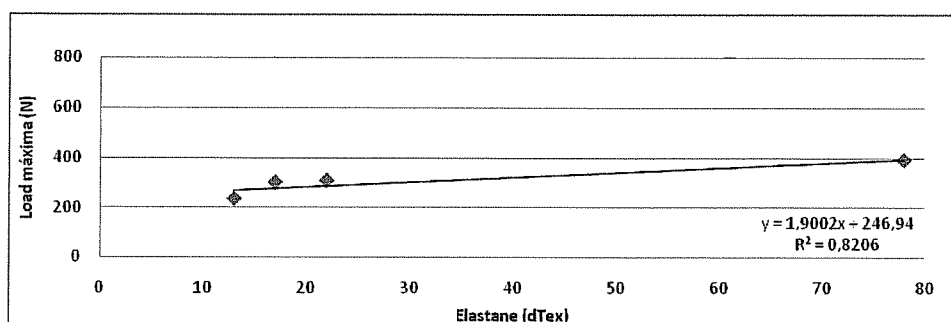


Figure 1. Relationship between load and linear density for fabrics with Elastane PA_78/1_circular

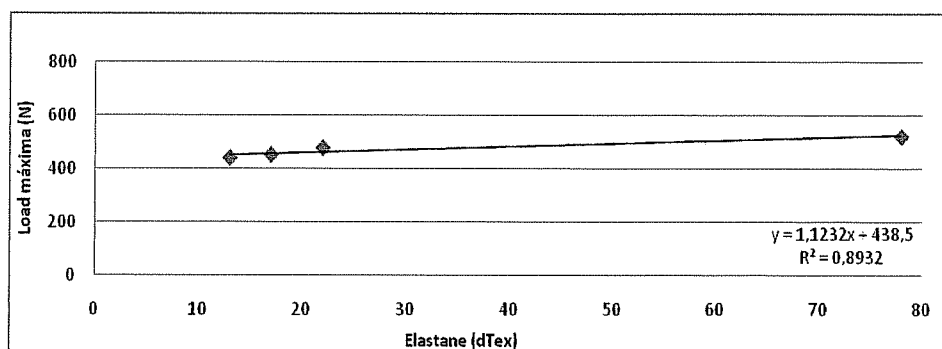


Figure 2. Relationship between load and linear density with Elastane PA_78/2_circular

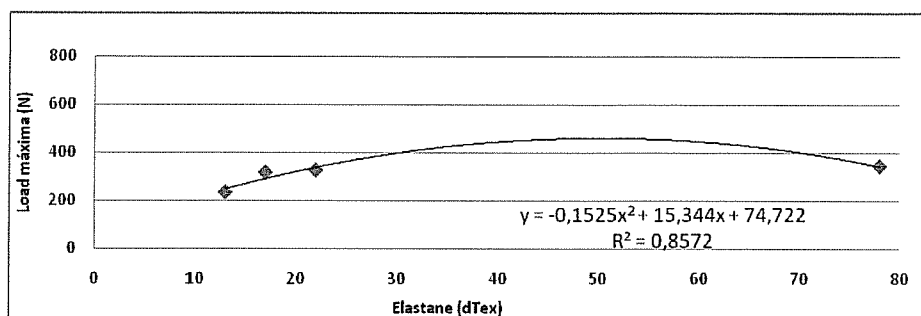


Figure 3. Relationship between load and linear density of Elastane PA_78/1_trilobal

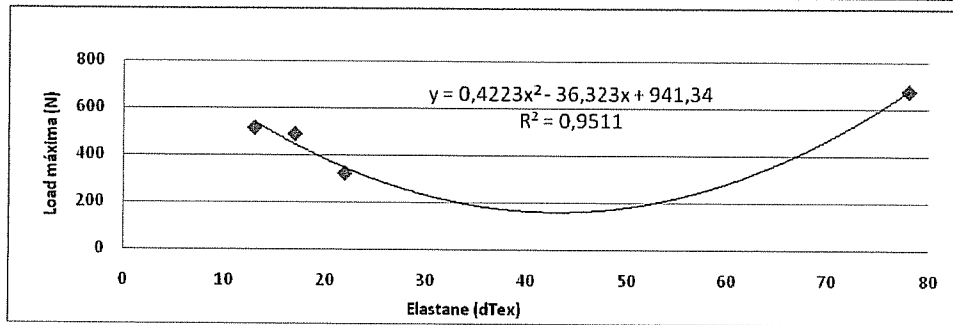


Figure 4. Relationship between load and linear density of Elastane PA_156/1_trilobal

3.2 Cyclic behaviour for fabrics with circular cross section polyamides

Figure 5 presents the results for the first and the 10th cycles, in the cyclic test of circular cross section polyamides.

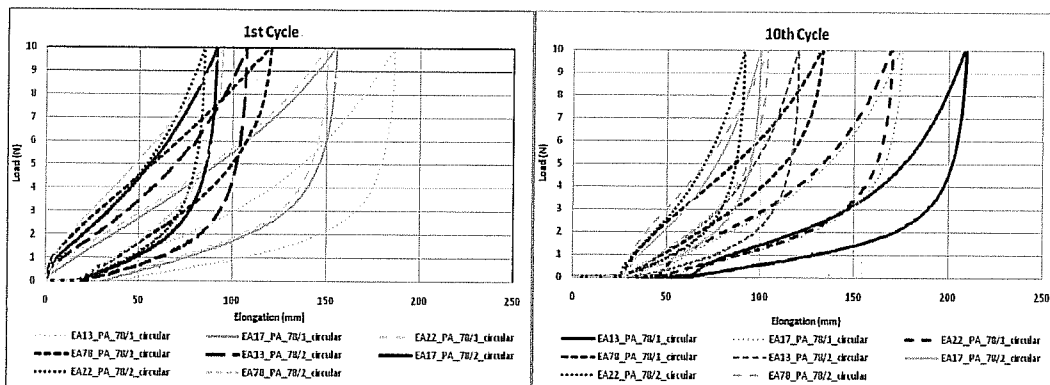


Figure 5. First and 10th cycles for circular cross section polyamides

Results show that sample B3 presents the best results, or either, lower energy dissipation, in the first and in the 10th cycle. Sample A1, presents the higher energy dissipation.

4. CONCLUSIONS

An important influence of the yarn linear density of the polyamide and elastane in the fabric's mechanical behaviour has been observed. Fabrics with polyamide with higher linear density and trilobal cross section, presents the better mechanical behavior, but the lowest elasticity. For the same yarn linear density the cross section does not influence the mechanical properties and the elasticity.

5. REFERENCES

1. M.J. Callam et al., "Effect of Time and Posture on Pressure Profiles Obtained by Three Different Types of Compression", *Phlebology*, vol.6, pp.79-84, 1991.
2. Trevor Higginsa, Geraldine A. Naughtona and Darren Burgessa, "Effects of wearing compression garments on physiological and performance measures in a simulated game-specific circuit for netball; *Journal of Science and Medicine in Sport* (2009) 12, 223—226.
3. J. Haigh, *Wool Science Review*, 64, 81 (1964).
4. T. S. Nutting and G. A. V. Leaf, *J. Text. Inst.*, 55, T45 (1964).
5. B. Hepworth, *Melliand*, 74, 515 (1993).
6. Shin Woong Park*, Stewart Colliel, C. N. Herath², Bok Choon Kang, and Takako Fujimoto; Spirality Related Mechanical Properties of Single Knit Fabrics of LincLITE® and Conventional Yarns; *Fibers and Polymers* 2008, Vol.9, No.4, 467-475.

PROCEEDINGS
of AUTEX2010
10th World Textile
Conference
21-23 June 2010
Vilnius, Lithuania



Organized by:
Kaunas University of Technology
Faculty of Design and Technologies
Department of Textile Technology
www.autex2010.com



ISBN 978-609-95098-2-2

CHARACTERIZATION OF NATURAL FIBERS USED BY NATIVE COMMUNITIES IN LATIN AMERICA

Raul Manuel Esteves de Sousa Fangueiro¹, Emilse Victoria Moreno², Gastón Castro Klingler³, José Vega Reátegui⁴, Júlia Baruque Ramos⁵

¹Departamento de Engenharia Têxtil da Universidade do Minho, Guimarães – Minho, Portugal – rfang@det.uminho.pt; ²Departamento Textil del Instituto Nacional de Tecnología Industrial, Buenos Aires, Argentina – emoreno@inti.gob.ar; ³Escuela de Design y Arquitectura de Pontificia Universidad Católica – Santiago, Chile – gastoncastrok@yahoo.com; ⁴Urku Estudios Amazónicos – Tarapoto, Peru – amiselva@yahoo.es; ⁵Escola de Artes, Ciências e Humanidades da Universidade de São Paulo, São Paulo, Brasil – jbaruque@usp.br

ABSTRACT

This paper shows the work of an international research team (Latin America and Europe) on the study of natural fibers used by native communities in Latin America, under the framework of CYTED. Fibers from Peru, Argentina and Chile have been selected and characterized in terms of tensile properties, thermal behavior, wax and moisture contents and moisture regain. Moreover, SEM has been used to analyze the fibers microstructure. A comparison properties analysis has been performed using conventional fibers like sisal, hem and jute. The results obtained are presented and discussed. The application potential of these fibers is also analyzed.

Key Words: Latin America fibers, textile, vegetal fibers, native communities, properties.

1. INTRODUCTION

For some developing countries, natural fibers are of major economic importance [1]. Ecological concerns have resulted in a renewed interest in natural materials, and therefore issues such as recyclability and environmental safety are becoming increasingly important for the introduction of new materials and products [2]. One of the largest areas of recent growth in natural fiber plastic composites is the automotive industry, particularly in Europe, where natural fibers are advantageously used as a result of their low density and increasing environmental pressures. Increased technical innovations, identification of new applications, continuing political and environmental pressures, and government investment in new methods for fiber harvesting and processing are leading to projections of continued growth in the use of natural fibers in composites, with expectation of reaching 100,000 tonnes per annum by 2010 [3]. Besides new technologies, another possibility is to rescue traditional employment of natural fibers in textile industry. For example, in Philippine three natural fibers maguey, water hyacinth, and saluyot are now being commercialized through blending with polyesters which can spur a revival of the country's textile industry that's been shut down by import liberalization several years back [4].

The aim of the present paper is to characterize fibers from Latin America employed traditionally by native communities, under the framework of CYTED (www.cytod.org). In order to perform the research work fibers from Chile (quiscal, chagual, totora, mahute and junquillo), Argentina (chaguar and coir for purposes of properties comparison) and Peru (huimba, brown cotton, topa, atadijo and chambira) have been selected and their physical properties studied.

2. MATERIAL AND METHODS

2.1. Latin American Natural Fibers

Chile: Quiscal (*Greigia sphacelata* - leaf fiber), chagual (*Puya chilensis* Molina - leaf fiber), totora (*Typha latifolia* - leaf fiber), mahute (*Broussonetia papyrifera* - Eastern Island handcraft treated cork bark which was employed like cloth), junquillo (*Luzula chilensis* - leaf fiber). **Argentina:** Chaguar (*Bromelia urbaniana* - leaf fiber), coconut fiber or coir (*Cocos nucifera* - fruit fiber). It is worth of mention that coconut is an Asiatic native species. In the present study, the respective physical-chemical characteristics of this fiber will be used as comparison parameters in relation to the characteristics of the other fibers. **Peru:** Huimba (*Ceiba samauma* - fruit fiber), brown cotton (*Gossypium barbadense* - fruit fiber), topa (*Ochroma pyramidale* - cortex fiber), atadijo (*Trema micrantha* - cortex fiber), chambira (*Astrocaryum tucuma* - leaf fiber). All species are non-wood products from "Cordillera Escalera" located in San Martín region in Peru and all of them are employed by native communities called "lamistas".

2.2. Analytical Methods

The tests were carried out in University of Minho (Textile Engineering Laboratories, Guimarães, Portugal). Standard test conditions of 65% relative humidity and temperature of 21°C were used for the entire test described below. Fiber fineness (linear density) was calculated according NF G 07-101 method in terms of TEX, defined as the weight in grams per 1000 m of the fiber, by weighing a known length of the fiber. Tensile properties of the fibers were determined according NP EN ISO 2062 method using a universal tensile testing machine (Hounsfield, UK). Micronaire and maturity of brown cotton were determined employing IIC Shirley Fireness and Maturity Tester. Its characterization was performed according ASTM D 5867 method employing Uster Spinlab HVI 900. Nova NanoSEM 200 Scanning Electron Microscope (FEI, USA) was used to investigate the morphological characteristics of individual fibers and fiber bundles. For observation in the SEM, the fibers were laid down on a stub using a conductive carbon tape and were sputter-coated with gold palladium prior to observations. Contents of fats, waxes and impurities were determined according NP 2247 (Point 7.1) method. The experimental conditions were: fiber drying during 4 hs at 105°C; fats, waxes and impurities extraction for 1 h in Soxhlet employing petroleum ether; washing during 1 h in water bath at 65°C and 1h in water at room temperature; fiber drying during 4 hs at 105°C. The fats content was estimated by the equation (%): $((P2 - P3)/P2)*100$. Determinations of humidity content and moisture regain were performed according NP 2249 (Point 3.7.1) method. The fibers were climatized during 24 hs at 21°C and 65% relative humidity, dried during for 4 hs at 105°C and again climatized during 24 hs at 21°C and 65% relative humidity. The humidity content (%) was determined by $((P1 - P2)/P1)*100$. The moisture regain (%): $((P3 - P2)/P2)*100$. Thermal behavior of fibers was analyzed using Digital Scanning Calorimetry (DSC) to determine the mass loss by heat.

3. RESULTS AND DISCUSSION

Tensile tests measure the behavior of fibers when a force of deformation is applied along the fiber axis in terms of strength, tenacity and elongation [5]. The results of strength, tenacity and elongation, expressed as average and standard deviation, are presented in Figure 1. Coir

fiber has a high elongation percentage in comparison to other fibers analyzed. The tenacities of all fibers studied are similar to jute (0.27 - 0.52 N/Tex) and sisal (0.36 - 0.45 N/Tex), but slightly inferior to hemp (0.52 - 0.61 N/Tex) [6]. On the other hand, the elongation of studied fibers (exception coir) is similar to jute (1.7 -2.0 %), sisal (2 - 3%) and hemp (1.8 %) [6].

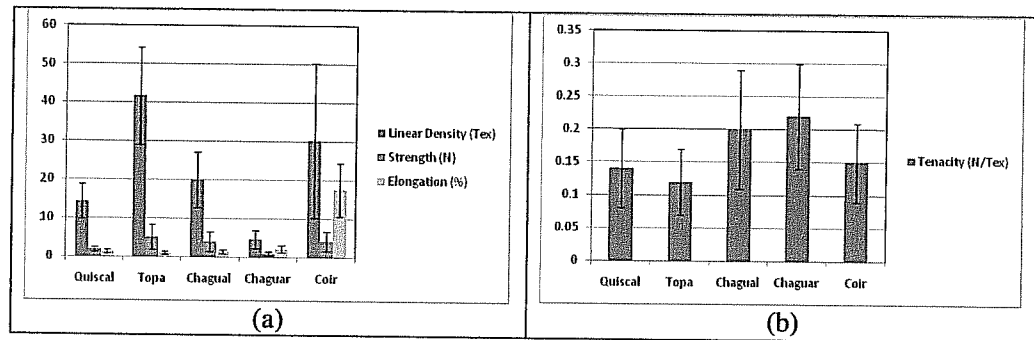


Figure 1 - Tensile properties of quiscal, topa, chagual, chaguar and coir. The results are expressed as average and standard deviation

The classification system employing High Volume Instrument (HVI) systems includes color grade, fiber length, micronaire, strength, length uniformity index, color Rd, color +b, and trash percent area. Classifier determinations are leaf grade, extraneous matter and preparation [7]. The obtained HVI results for brown cotton are expressed in Table 1. The micronaire and linear density values obtained for brown cotton were respectively 3.82 and linear density of 0.387 Tex. This value is similar to the usually employed to white commercial cotton, which is marketed within the limits of 3.9 and 4.5 micronaire, being the ideal between 3.8 and 4.2 [7].

Table 1 – HVI results for brown cotton

	Len 1 (mm)	Len 2 (mm)	Unif	Strength	% Elong	Amount	Work peak	Work total	% Crimp	Modulus
Average	15.36	19.10	80.40	15.83	6.60	1052.00	0.40	1.05	3.15	8.09
Std Dev	0.24	0.25	1.10	1.51	0.60	116.00	0.08	0.13	0.54	1.31
VC %	1.59	1.29	1.30	9.52	8.60	11.00	15.61	12.46	17.05	16.12

The micrographs presented in Figure 2 shown that quiscal has individual fibers with cylindrical and hollow shape, while mahute a quite porous microstructure. For the other fibers, the most of them are joined by the vegetal cortex, diffculting their separation.

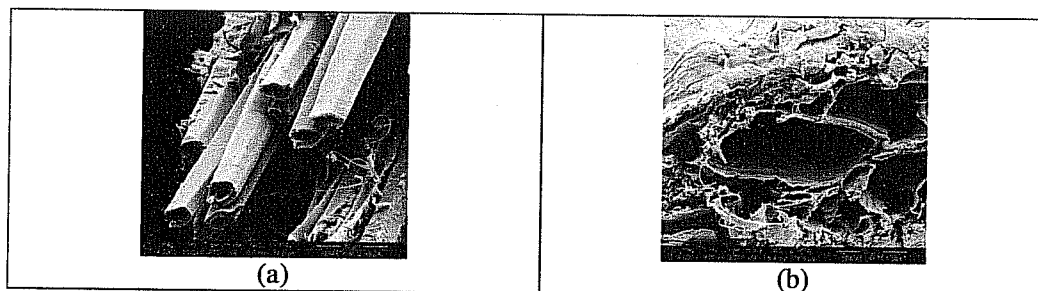


Figure 2 – Electronic microscopy of quiscal (a) and totora (b)

According to Figure 3a, mahute and chaguar fibers presented the highest values of fats, waxes and impurities. The determined values of regain are in the range from 5 % (atadijo) to 10% (quiscal). These regain values are compatible to cellulosic fiber values. Figure 3b shows DSC thermal behavior of the fibers tested. It can be seen that chaguar and quiscal present the highest thermal stability while totora and mahute present the highest mass lost due to heat effect.

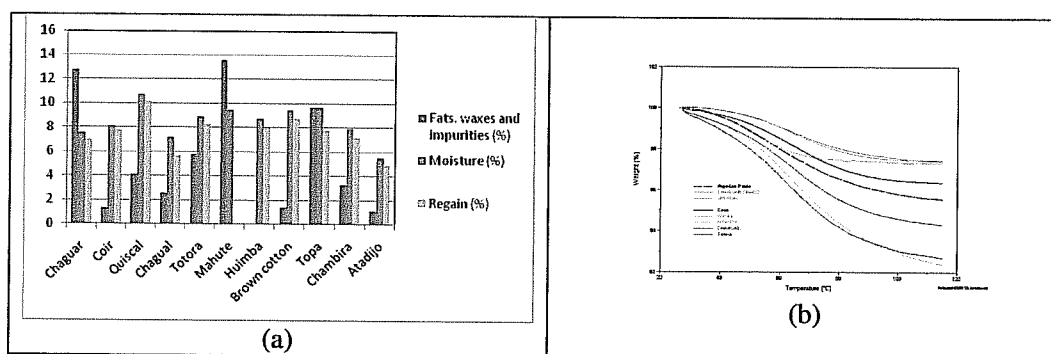


Figure 3 – Comparison of contents of fats, waxes and impurities (a) and thermal behavior (DSC) (b) of chaguar, coir, quiscal, chagual, totora, mahute, huimba, brown cotton, topa, chambira and atadijo.

4. CONCLUSION

The properties of natural fibers used by native communities from Latin America have been studied. These fibers are normally used for handcraft works and represent an important economical source for these communities. The results obtained within this research work shows that, considering the similarity of the physical properties with jute, sisal, hemp (fibers normally employed in composites fabrication), the studied fibers (unless brown cotton), besides traditional applications (clothes, decoration, bags, storage, reinforcement, load bearing, etc) present also application potential for natural fiber reinforced composites.

5. REFERENCES

1. Moir, B.; Plastina, A. Cotton: Review of the World Situation, International Cotton Advisory Committee, Volume 61 - Number 6, July-August 2008.
2. Li, Y.; Sreekala, M.S.; Jacob, M. *Chapter 8 - Textile Composites Based on Natural Fibers*. Natural fibre reinforced polymer composites: macro to nanoscale. Edited by Sabu Thomas & Laly A. Pothan. Old City Publishing, Philadelphia, 2009.
3. Clemons, C.M.; Caulfield, D.F. *Chapter 11 - Natural Fibers*. Functional Fillers for Plastics. Edited by Marino Xanthos, WILEY-VCH Verlag GmbH & Co. KGaA, 2005.
4. Local natural fibers eyed to revive textile industry Publication: Manila Bulletin Date: Thursday, October 8 2009. Available from: <http://www.allbusiness.com/trade-development/international-trade-export/13174093-1.html>, (05,04,2010).
5. Reddya, N.; Yang, Y. Properties and potential applications of natural cellulose fibers from cornhusks. *Green Chemistry*, 2005, 7, 190–195.
6. Kaswell, E. R. *Wellington Sears Handbook of Industrial Textiles*. Massachusetts Institute of Technology (MIT). Wellington Sears Company, New York, 1963. 757 p.
7. Fibras 100%. Qualidade final: Algodão. *Revista Bayer CropScience*, 2005, Jun: 3-4.