Wearbility Analysis of Knited Fabrics Produced with Colored Organic Cotton, Bamboo Rayon, Corn, Recycled Pet/Cotton and Recycled Pet/Polyester

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Abstract

This work presents a comparative study of the characteristics of knit fabrics, produced from: colored organic cotton, bamboo rayon, corn, recycled PET/cotton and recycled PET/polyester, used in the garments manufacturing. It was produced knit fabric samples with statical weight equal. On the samples were carried out weight trials (ASTM D 3776 – 96), pilling (ASTM D 4970 – 05), rupture pressure (ASTM D 3786 –01), elasticity and elongation (JIS L 1018 – 02), moisture absorption (JIS 1907 – 02) and dimensional alteration (NBR 10320 – 88).The experimental results show that, for all the analyzed characteristics, the raw materials selected to the achievement of this work are adequate to the clothing manufacturing.

Keywords: 1.Knitting 2.Sustainable fibers 3.Clothing 4.Experimental design

1. Introduction

The environment of competitiveness of the textile industries and Brazilian clothing manufacturers have been gradually increasing, a singular and local effect of what had already been happening in every branch all over the world, as a result of the globalization process. This increase introduces, gently, new foreign organizational kinds, more diversified and better adapted to the new economic order conditions.

The pursuit of a sustainable way of life becomes more and more important for the present world and even more for the future generations. For Sachs (2004), 'the sustainability on the human civilizations' time will depend on their capacity of submitting to the precepts of ecological caution and of making a good use of the nature'. In this context, it is a challenge to everyone the attempt of becoming responsible for this concept from the premise that the world is only one and finite; it would then be a common task to all to seek to solutions for the environmental degradation which has been occurring over time.

To the fashion field, it is a challenge to conceive new clothing products according to the sustainable principle, once it is faced as ephemeral, as it has short life cycles and its consumerism appeal becomes a hindrance to such principle. To the textile branch it is also a challenge, for its production chain is a pollutant process which generates many wastes.

The contingent of people and institutions concerned with the environmental problems and the sustainable development have been increasing all over the world, and much has been said about pollution, deforestation, desertification, excessive exploitation of waters and natural resources, inadequate use of agrochemicals and its consequences (GARFORTH, 1993 apud LIMA, 1995). To cater to this demand of consumers, textile branch companies are gradually starting to demand for raw materials produced within less aggressive systems to the environment as a way of distinction and, consequently, fashion can benefit from this attitude.

Among those raw materials, there are the ecological or sustainable fibers:

'[…] among the natural fibers, the organic cotton, cultivated without the use of fertilizers and pesticides, is becoming popular. Those who are deeply concerned with the pollution and problems of health damage associated to the synthetic dyes are propagating the use of the naturally colored cotton' (CHAVAN, 2004).

A viable alternative is the production of fibers from the Polyethylene terephthalate (PET), its use in the textile industry for the manufacturing of fabrics dedicated to several objectives increases at an average rate of approximately 24% a year since 1998.

The bamboo rayon is a chemical fiber (regenerated), obtained from the cellulose of this plant. The rayon fibers are manufactured by means of a very complex process involving more than 120 independent variables. The bamboo fiber is considered a sustainable fiber for it is produced from a renewable raw material, of fast growth and cultivated without the use of pesticides or chemical products. It is a cellulosic fiber, therefore it can be 100% degraded on soil by micro-organisms and solar light, without causing risks or damage to the environment (ALVES et al., 2006).

The corn fiber (Polylactic acid – PLA), known as IngeoTM, is produced from the synthesis of PLA. The polymer is obtained from the extraction of the corn sugar, which is used in the production of the lactic acid. Besides being manufactured from renewable and biodegradable raw material, if compared to other polymers of the petrochemical industry, the fiber emits less carbon dioxide to the atmosphere, and the consumption of fuel for its production is 30% to 40% smaller (VALE et al., 2004).

Currently, the textile manufacturing branch competitiveness is determined by the capacity of comprehending and responding to its clients' needs. In this sense, it can be asserted that the textile industry must be prepared to respond to the fashion phenomenon, which imposes a huge versatility of products and processes and, at the same time, to pay attention to the increasing ecological concern, of welfare, safety and functionality (FILGUEIRAS et al., 2008).

Given this new reality of greater concern with the environment, it is necessary the adjustment of the clothing products to the sustainable measures, to benefit the environment as well as the society.

The objective of this work is to carry out a comparative study of the characteristics of knit fabrics produced from the main sustainable fibers, used in clothing manufacturing.

2. Literature Review

It is not exactly known when the first textile fibers showed. Millions of years ago, the primitive men used to use a great range of plants and growing vegetables to fabrication of traps used to capture animals, besides mats and baskets. The first fibers were made of crude materials, such as: grass, rush and cane, used in the manufacturing of nettings, fishnets, carpets, ropes, etc. Later, techniques were developed to work on more sophisticated natural materials, such as linen, animal hair, cotton and silk (SANCHES, 2011).

Man tried to create an artificial fiber with similar characteristics to those of the natural fibers, since he developed a more specific knowledge on the polymer structure. Only in the second half of the 19th century it was possible to dissolve the cellulose, and it was from the extrusion of these solutions through a metallic winnow that the artificial fiber development was initiated (DEMIR, 1997).

The chemical fibers have become more and more necessary with the spread of their applications, essentially by virtue of the increase in the world population and for reducing the vulnerability of the textile industry to the occasional difficulties of the agricultural production.

Not long ago, we have gained awareness that if the resources are not used in a correct way, the future generations will face serious problems. From that on, another form of human development started to be speculated.

This development should conform with the current industrialization model, but without the complete utilization of the planet's resources so that they do not become exhausted.

In the end of the 20th century, the concept of sustainable development arose. In this kind of development, the social and industrial progress is sought, thinking about the best uses of the biosphere's materials. The concept of the old capitalism development style was replaced by a development in which there is a deep consideration for our planet's resources. Today, technical and scientific basis are sought to a sustainable development in the social, ecological, economic, spatial, political and cultural ambits.

2.1. The Concept of Sustainability

This concept refers to the way of configuring civilization and human activities so that its members and the nations' economy are able to satisfy its needs and express their current abilities and, at the same time, preserve biodiversity and the natural ecosystems, with plans of doing the best in order to make these resources last enough and indefinitely.

In the year of 1987, the United Nations Conference on Environment and Development (UNCED) defined the sustainable development as: 'development which satisfies the present needs without committing the capacity of the future generations to satisfy their own'. This report is part of a series of initiatives which highlight the risks of the excessive use of natural resources. Based on socioeconomic and ecological problems of the present society, the report interconnects economy, technology, society and politics, taking into consideration the new ethical stance regarding the sustainable development (CMMAD, 1991).

That way, it can be concluded that sustainable development is not only connected to a technological concept but, most of all, to an ethical concept. For being connected to the idea of life maintenance, this concept's definition becomes even more ethical than technological, this being why the necessity of a future vision when thinking about a way to side sustainability.

Sustainable measures can be taken in order to reduce social and ecological impacts in all kinds of industries existing now, including the textile industry.

2.2. The Textile Chain

According to the Ministry of Development, Industry and Trade, a commodity chain can be defined as: 'the set of organizations (especially companies), whose processes, activities, products and services are articulated among themselves, as links on the same chain, according to a logical progressive sequence along all the production cycle of a given product or service. It involves all the stages in the production cycle, since the supplying of basic inputs to the product or service deliver to the consumer, customer or end-user, as well as the respective organizations that belong to and constitute the so called chain production segments' (Brazil, 2000).

The textile and clothing manufacturing chain embraces the interaction among capital goods and input suppliers (natural and chemicals), manufactured producers (yarns, fabrics, knit fabrics) and finished goods (textile manufactured). To make easy the visualization of all production processes related to the chain and orientate the public policies and the private investments, the following links are considered: natural fibers, manufactured fibers, spinning, weaving, knitting, manufacturing (articles of clothing and other manufactured) and capital goods (IEMI, 2009).

2.3. The Textile Fibers

According to the American Society for Testing and Materials (ASTM D123-03, 2006), a textile fiber is a generic term used to all the materials that form a basic textile element, and it is characterized by having a length ten times greater than its diameter.

For any and all textile product, the basic materials are the fibers, so that these kinds of structures are the first to contribute to the properties the final products will present.

The textile fibers can have many origins, and this is the commonly used criteria for its classification. This way, fibers can be: of a natural origin, if produced by nature, in a form which makes them apt to textile processing; or of a chemical origin, if produced by industrial processes. The non-natural fibers can be obtained from natural polymers transformed by the action of chemical reagents (artificial fibers) or from polymers obtained through chemical synthesis (synthetic fibers) (ARAÚJO; CASTRO, 1987 apud SANCHES, 2006).

2.3.1. Colored Organic Cotton

The agricultural production is part of the cotton textiles production, in which the biggest environmental problems are concentrated. As it is used a large amount of agrochemicals in the fiber cultivation, on the finishing stage this problem is also highlighted because of the toxic substances applied to bleach and dye the textile products.

Although cotton is a natural fiber, behind it is hidden a long chain of non-natural processes chemically intense, implying huge losses to the world's air, as well as to the soil and water. To harvest this delicate plant, pesticides are heavily pulverized from eight to ten times more each season, and those are so poisonous that gradually make the fields infertile, besides causing serious damages to the humans, the plants and the aquatic life. And this is only the beginning. Once cotton has developed, been harvested and manufactured, the textile process necessary to reach the desirable aesthetic properties requires the use of several materials dangerous to the environment. At least eight thousand chemical substances are used to transform the raw material in final product, among which many are toxic and classified by the World Health Organization as moderately dangerous to extremely dangerous (CHAVAN, 2004), meaningfully affecting the inhabitants' health in the areas where it is cultivated.

The cotton that grows in natural colors along the cultivation is known as naturally colored cotton, and its color is obtained without the help of synthetic or natural dyes. The naturally colored cotton is known over five thousand years ago, but because of the availability of cheap synthetic dyes in several colors and also because of the necessity of greater outputs in spinning and weaving, its cultivation ended up lost. The new movement on environment protection has been driving the cultivation of the naturally colored cotton in many shades, such as green, brown, tannin, yellow, pink, etc. (CHAVAN, 2004).

The main advantage of the colored fiber use is the elimination of dyes in the finishing stage of the fabric, which reduces the environmental impact of the dying process, being appropriate for the production of ecological and organic fabrics (SOUZA, 2000).

It is worth emphasizing that the colored cotton is not necessarily cultivated in organic methods, however it can represent an option of raw material production for ecological fabrics if ecologically correct methods are used in its production chain. It is important to observe that the colors obtained through genetic engineering, just like the transgenic products, are not accepted for the ecological production of fabrics nor to the organic standards for textiles (SOUZA, 2000).

2.3.2. Rayon

The rayon fiber is an artificial lustrous fiber, obtained from a cellulose regeneration process, which can be taken from several sources, such as: wood pulp (like eucalyptus and pinus), cotton linter, wheat, corn or rice husk, bamboo pulp, among others.

The production process of the rayon fibers can be divided in two stages: the first one consists in the dissolution of cellulose through the utilization of a series of chemical processes and transformations, to convert it in a soluble derivate, having the viscose liquid as the resulting product. This stage is called viscose preparation stage.

The second stage, known as strictly speaking spinning, consists in the transformation of the viscose liquid in fibers or continuous filaments, through the liquid extrusion in a regular and continuous way, in a bath containing salts and dilute sulfuric acid, regenerating the soluble derivate in cellulose again.

This second stage of rayon fabrication is divided in two other subgroups, according to the kind of material to be produced: staple fibers or continuous filaments. For the production of staple fibers, the following stages of formation are carried out: fibers curling and cutting, and for the production of continuous filaments, the continuous or centrifuge spinning are performed.

The developments of technology and rayon fibers manufacturing process have been evolving along consecutive decades; currently good quality yarns and fibers are produced. However, the rayon fibers production is forbidden in several countries, because the production process is considerably toxic and pollutant, for it uses carbon sulfide and sodium hydroxide; as a result, these fibers consumption is stagnant for quite a long time and it does not represent more than a small portion of the worldwide textile fibers production (SANCHES, 2011).

2.3.3. Bamboo Fibers

Bamboo, all over Asia, is considered a mystic plant, symbol of strength, flexibility, tenacity, resistance, luck and commitment. Its use by the man dates from over two hundred years before Christ. In Asia, the bamboo is a component part of religious ceremonies and it is considered, by many specialists, one of the most admirable plants in nature, being able to be used as raw material in civil construction, medicinal applications, as a food preservative, in paper and textile substrate fabrication, to reduce soil erosion, in drains fabrication, as a watershed, among others (OSTAPIV, 2007).

According to Das (2007), the bamboo is a highly renewable and sustainable resource in nature, there is no need to replant it for over a hundred years, it presents a fast growth, and the wide net of communication among its roots makes new sprouts to germinate continuously every year. The pinus is replanted after each cut, which is done from 15 to 20 years. The eucalyptus resprouts after the cut, which is done by age seven, but must be replanted after four cycles, which is to say, in the 28th year. The harvest can be done every two year, against seven from the eucalyptus and fifteen or more from the pinus, and the bamboo productivity (in t/ha/year) is analogous to the eucalyptus one and almost twice the pinus productivity. According to Lackman (2007), another great advantage of the bamboo planting is not needing pesticides or fertilizers.

Many studies show that the bamboo cultivation without the pesticide utilization and the rare occurrences of pests' attacks or infections by pathogenic in its plantations happens because of the presence of a natural substance of bacteriostatic character found in this raw material and named bamboo kun (OSTAPIV, 2007)

2.3.4. Bamboo Rayon

The obtainment of the bamboo fibers happens through a series of chemical processes, aiming to the regeneration of cellulose obtained from the bamboo pulp. The process used to the regeneration of cellulose and obtainment of the bamboo rayon fibers is the same viscose process used in the fabrication of regenerated cellulose fibers.
As a result of this chemical process, the final product presents properties quite similar to the conventional viscose, although many manufacturers treat the products manufactured from the bamboo fiber as a different product. However, every bamboo fiber obtained through the production process of the viscose fibers is considered and classified simply as a viscose fiber, including in its identification in the tags of products manufactured from these fibers, just like in the case of viscose fibers obtained from the cellulose regeneration of eucalyptus, wheat, corn or rice husk, all of them classified and identified as viscose fibers.

Regardless the general classification as viscose fiber, yet many producers and suppliers use, usually, some kind of decorative tag or any other kind of extra identification, affirming that the consumer is buying a product manufactured from the bamboo rayon fibers or, plainly, bamboo fibers (SANCHES, 2011).

2.3.5. Corn (PLA – Polylactic Acid)

The PLA fiber is resultant of research carried out by the chemist Carothers, from Du Pont, in 1932. Carothers produced the polymer with low molecular weight through vacuum heating. However, the difficulty to control the reaction to develop a polymer with a greater molecular weight led him to drop the research, turning his studies only to polyester and polyamide.

Recently, it has become possible to optimize those polymerization processes to obtain the PLA yarns, through the fermentation process, with an affordable cost for the production in commercial scale. The PLA fiber must be considered a synthetic fiber for it is obtained through the extraction of sugar from corn (dextrose) for the production of lactic acid (monomer); its official release took place in January 2003 (FALCETTA, 2003).
Valle et al. (2004) explain that: "the preparation of the lactic acid is carried out through the alcoholic fermentation of corn meal, from where the lactic acid can be obtained in three types of isomers: L-lactic, D-lactic and Meso-lactic.

The fiber development process does not pollute the environment, since chemical products with a basis of oil are not used, and this fiber is considered biodegradable, for it has a high rate of degradability on the environment.

2.3.6. Polyester

The term polyester is used for polymeric materials which have esters in the macromolecular chain (DEOPURA et al., 2008).

Although many kinds of polyester have been developed, only with some of them is it possible to produce a good fiber, and they are crystalline with a melting point between 220oC and 280oC. The most important polyester, commercially speaking, is PET – Poly (polyethylene terephthalate).

Polyester is polymerized from a reaction between an alcohol and an acid. The most common reaction is the polymerization between the terephthalic acid and ethylene glycol in a vacuum through a condensation mechanism at a high temperature of 270oC. The polyester fibers are still generally extruded with circular section, yet the fibers can be produced with other special sections.

2.3.7. The PET Fiber

The researches that led to the polyester production at a large scale began only after the II World War, in the 1950s, in laboratories from the USA and Europe. They were based, almost completely, on the textile applications. In the early 1970s, the PET started to be used by the packaging industries. The PET arrived in Brazil in 1988 and followed a similar trajectory to the rest of the world, being firstly used in the textile industry.

Only after 1993 it began to have a heavy expression on the packaging market, notably for the soft drinks. Currently, the PET is present in the most diverse products. In economic terms, it offers the consumer a substantially cheaper, safer and more modern product.

The PET fiber is obtained through the packaging recycling of synthetic materials formed from polymers produced from the reaction of terephthalic acid and ethylene glycol, and has the original colors white, green and beige. It can be blended with cotton, linen and viscose to improve the fabric's lightness, softness and comfort (Valle et al., 2004).

"Recycling is an alternative to reduce the environmental impact of the discarded plastic raw material" (WIEBECK; HARADA, 2005 apud GUELBERT, 2007). The authors highlight the possibility of reprocessing the polymer for the extraction of alchemical resins used in the production of paints. They still approach the unrestrained expansion, in the world market, of PET packagings produced with recycled material, emphasizing that the notable and increasing application lies in this fiber's use in fabrics, polyester knit fabrics and denim manufacturing.

The 4th census carried out by ABIPET (2008) evidences the distribution, in Brazil, of markets for recycled PET, and the biggest utilization of this material lies in the textile products' application. The PET recycling happens the following way: the bottle packs enter the platform where they will be unmade. After this procedure, the bottles are placed on the feeding conveyor belt of the rotating sieve, where the first stage of bottle washing is done. The bigger contaminants are withdrawn (rocks, unattached tops, etc.). The bottles go, then, to the selection conveyor belt, where the presence of other materials is monitored, such as, for instance, PVC, PP, PE, among others, including the metals accused by the ferrous metals detector. The bottles go to the feeding conveyor belt from the first mill where they undergo their first milling which is done wet (with addition of water). The milled material is removed through a double envelope thread, where part of the dirty water is separated from the process. It goes then through the decontamination tanks, in which besides the separation of labels and tops, it can the addition of chemical products for the process finishing. After the tanks, the material is introduced in another mill until it obtains the adequate linear density. The material is pneumatically transported to the washer where, with water addition, it is made the rinsing, then going straight to the dryer. The material is removed from the dryer by a pneumatic transport and taken to the silo, undergoes a non-ferrous metals detector, from which is withdrawn and put in big-bags (bags of approximately 1m3), being ready to be sent to the transformation industry. The little PET flakes obtained after this process and that will, at a later time, be reutilized on the transformation chain are called flakes (VEZZA, 2006).

The procedure of the PET fiber obtainment undergoes all this initial process, the pieces of ground PET, or flakes, are melted until a smooth pulp, which is transformed in a yard that can be dyed of several colors (FARJADO et al. apud VALLE, 2004).

The polymer recycling is a viable alternative to minimize the environmental impact cause by the disposition of these materials in landfills. This topic is becoming more and more important because, besides environmental and economic interests, increasingly strict legislations start to appear, meaning to minimize and/or discipline the solid residues discard (SPINACE, 2005).

3. Materials and Methods

3.1. Materials

The following raw materials were used:

Colored organic cotton spun yarns, nominal dtex: 24,8x1tex; bamboo viscose spun yarns, nominal dtex: 19.1x1tex; corn spun yarns, nominal dtex: 19.6x1tex; recycled PET/cotton (50%/50%) spun yarns, nominal dtex: 19.7x1tex and recycled PET/polyester (20%/80%) filament yarns, nominal dtex: 167 f68dtex.

3.2. Methods

Factorial planning 2^2 were assembled, completely random, to each raw material, and for each machine regulation a replication was made. The execution order of the regulations, as well as their replications', were determined by lottery.

The experimental results' significance was verified through the analysis of variance (ANOVA), with a trust interval of 95% (p=0.05), and the determination of the optimal regulation of the machine, through the analysis of the response surface.

The fabrics were manufactured in a circular machine, single knit, of the L. Degoisey brand, with a 95,25 mm diameter (3 ¾ inches), 236 stitches, with a gauge of 20 stitches per inch and positive feeding system. The knit fabrics were finished, in only bath, in a laboratory beck, to ensure the same conditions of finishing.
On the finished fabrics were carried out weight trials (ASTM D 3776 – 96), pilling (ASTM D 4970 – 05), rupture pressure (ASTM D 3786 – 01), elasticity and elongation (JIS L 1018 – 02), moisture absorption (JIS 1907 – 02) and dimensional alteration (NBR 10320 – 88).

4. Results and Discussions

The experimental values obtained from the trials carried out on the samples are shown on table 1 and on table 2.
Table 1: Average values and standard deviations (Stan. Dev.) calculated on the physical trials of weight, rupture pressure, elasticity on the transversal orientation (Transv. Elast.), elasticity on the longitudinal orientation (Long. Elast.) and pilling.

Table 1

Materials	Calculation	Weight (g/m2)	Rupture Pressure (kPa)	Transv. Elast. (%)	Long. Elast. (%)	Pilling Note
Colored organic cotton	Average	158.44	534.00	66.06	49.66	1/2
	Stan. Dev.	3.29	54.59	3.68	3.74	*
Bamboo rayon	Average	160.96	402.00	62.34	54.53	2/3
	Stan. Dev.	2.06	21.68	7.96	1.38	*
Corn	Average	150.38	346.00	70.29	63.39	2/3
	Stan. Dev.	2.66	25.10	5.52	2.85	*
Recycled PET/Cotton	Average	148.54	582.00	76.21	76.95	2/3
	Stan. Dev.	3.81	44.38	3.78	3.35	*
Recycled PET/ Polyester	Average	170.60	878.00	89.31	90.76	5
	Stan. Dev.	2.60	22.80	4.08	2.35	*

Table 2

Materials	Calculation	Water absorption Transv. (cm)	Water absorption Long. (cm)	Dimen. stability Transv. (%)	Dimen. stability Long. (%)
Colored organic cotton	Average	1.92	1.88	-7.24	-7.95
	Stan. Dev.	0.30	0.19	0.56	1.36
Bamboo rayon	Average	10.84	11.14	-4.79	-6.30
	Stan. Dev.	0.42	0.25	0.61	0.00
Corn	Average	9.76	9.94	-6.47	-5.24
	Stan. Dev.	0.23	0.11	1.66	0.49
Recycled PET/Cotton	Average	1.38	1.42	-1.30	-0.65
	Stan. Dev.	0.22	0.26	0.32	0.56
Recycled PET/ Polyester	Average	12.90	14.50	-0.37	-1.31
	Stan. Dev.	0.47	0.35	0.32	1.13

Table 2: Average values and standard deviations (Stan. Dev.) calculated on the physical trials of water absorption on the transversal orientation of the knit fabric, water absorption on the longitudinal orientation of the knit fabric, dimensional stability on the transversal orientation and dimensional stability on the longitudinal orientation.

The analysis of variance was made to verify if the measures of the experimental values are statistically the equal. For the analysis of results a multiple comparison of averages was carried out, with a trust interval of 95% ($p=0.05$), and the following hypothesis test was used:

H0: $\mu 1 = \mu 2 = \mu 3 = \mu 4 = \mu 5$
H1: $\mu 1 \neq \mu 2$, for any pair i,j

The values obtained were analyzed using the Statistics software. The weight of the finished fabrics ranged from 148.54 g/m2 to 170.60 g/m2, difference which is explained by the dtex variation of the yarns used in the knit fabrics production, which influence directly on the final product's weight.

The textile fabrics properties help us understand the textile articles behavior and their applications. The final product must cater to the consumer's needs and have functionality. According to Kadolph e Langford (2006), the clothing articles must offer: appealing aspect (hand, fit, appearance), protection (heat, water, cold), easy maintenance, comfort and durability.

Comfort, which is the ability of the fiber to retain the body or environment moisture, was evaluated in an objective way, through the determination trial of absorption by capillarity. The articles manufactured with blended yarns of recycled PET/polyester are more comfortable.

Durability is understood as the guarantee of the use conditions of a product for a period of time. To test this property on the knit fabrics, the following physical trials were carried out: rupture pressure resistance, elongation and elasticity. The blended fabric of recycled PET/polyester is the most resistant, and also has higher elasticity on the transversal orientation, as well as on the longitudinal.

Easy maintenance is understood as the guarantee of conservation of the textile article during its use and after washing. The following trials were carried out to verify this property: dimensional stability and inclination to pilling formation. The blended fabric of recycled PET/polyester presents less inclination to pilling formation and the colored organic cotton, more inclination. The blended fabric of recycled PET/polyester has the best dimensional stability on the transversal orientation, and the second best on the longitudinal orientation.

5. Conclusions

All around the world, the contingent of people concerned about the environmental problems and the sustainable development have been increasing. To cater to this demand of consumers, the textile branch companies are, gradually, as a way of differentiation, starting to use raw materials produced from systems less aggressive to the environment.

The fashion clothing exerts influence over the people and, by proposing products developed in a sustainable ambit, a critical thought regarding the consumption of ecologically correct products can be stimulated.

The functional requirements usually intended for the textile articles are: comfort during the use, relative protection to weather conditions (rain, wind, snow, low temperatures, etc.), aesthetics, easy maintenance and durability.
This work consisted of verifying among the sustainable fibers – colored organic cotton, bamboo rayon, corn fiber, recycled PET/cotton and recycled PET/polyester – which are the ones that most grant functionality to the textile articles.

The experimental results show that, for all the analyzed characteristics, the raw materials selected to the achievement of this work are adequate to the clothing manufacturing. However, the fabrics manufactured with recycled PET/polyester blended yarn, compared to the ones manufactured with colored organic cotton, bamboo rayon, corn and recycled PET/cotton blended yarn, have a greater potential to cater to the consumer's needs.

References

ABIPET – Associação Brasileira da Indústria do PET., 4° censo de 2008. Disponível em http://www.abipet.com.br. Acesso em: nov. 2010.

ALVES, V. J. da S. et al., Desenvolvimento sustentável na indústria têxtil: estudos de propriedades e características de malhas produzidas com fibras biodegradáveis. XXII Congresso Nacional de Técnicos Têxteis – VIII Fenatêxtil. Recife – PE, julho 2006.

American Society for Testing and Materials, ASTM D 123-03. Standard terminology relating to textiles. West Conshohocken, 2006. 10p.

American Society for Testing and Materials, ASTM D 3776-96; Standard test method for mass per unit area (weight) of fabric. West Conshohocken, 2006. 5p

American Society for Testing and Materials, ASTM D 3786-01; Standard test method for hydraulic bursting strength of textile fabrics – Diaphragm bursting strength tester method. West Conshohocken, 2006. 4p.

American Society for Testing and Materials, ASTM D 4970-05; Standard test method for pilling resistance and other related surface changes of textile fabrics: Martindale Tester. West Conshohocken, 2006. 4p.

BRASIL. Ministério do Desenvolvimento, Indústria e Comércio., Metodologia de gestão para adensamento de cadeias produtivas. MDIC: SEBRAE, Brasília, 2000.

BROEGA, A.C.; SILVA, M.E.C., O conforto como ferramenta do design têxtil. 3º Encuentro Latinoamericano de Deseño, Buenos Aires (Argentina), julio 2008.

CHAVAN, R.B. Fibras ecológicas e têxteis ambientalmente corretos. II Simpósio Internacional de Engenharia Têxtil e XXI Congresso Nacional dos Técnicos Têxteis, Natal – R.N., 07 a 11 de Setembro 2004.

GUELBERT, T. et al., A embalagem pet e a reciclagem: uma visão econômica sustentável para o planeta. Enegep 2007.

CMMAD - Comissão Mundial Sobre Meio Ambiente e Desenvolvimento. Nosso futuro comum. Rio de Janeiro: Fundação Getulio Vargas, 1991. 430 p.

DAS, S., Properties of bamboo fiber. 2007. Disponível em: www.fibre2fashion.com. Acesso em: nov. 2009.

DEMIR, A., Synthetic filament yarn texturing technology. Ed. Prentice-Hall, New Jersey, 1997.

DEOPURA, B. L. et al., Polyesters and polyamides. The Textile Institute, CRC, Woodhead Publishing Limited, Flórida, 2008.

FALCETTA, E.J., Nova geração de fios sintéticos. Revista Textília, n. 48, p. 14-22. 2003.

FILGUEIRAS, A. et al., A importância das fibras e fios no design de têxteis destinados à prática desportiva. Revista da Associação Estudos em Design. PUC-Rio, Rio de Janeiro, 2008.

FORMIGONI , A.; RODRIGUES, E. F., A Busca pela Sustentabilidade do PET, através da Sustentabilidade da Cadeia de Suprimentos. 2nd International workshop advances in cleaner production, São Paulo, maio, 2009.

FOURNÉ, F., Synthetic Fibers: Machines and Equipment, Mannufacture, Properties. Hanser Publishers. Munich. 1998.

HERCULANO, F. C., et al., Índice de desenvolvimento sustentavel no setor agrícola: um estudo de caso da tecnologia do algodão colorido orgânico em Bom Sucesso – PB. Rev. Engenharia Ambiental: pesquisa e tecnologia. V.5, n.2, p. 14-23, mai/ago, 2008.

IEMI – Instituto de Estudos e Marketing Industrial., Brasil Têxtil 2009 – Relatório setorial da indústria têxtil brasileira. IEMI, São Paulo, 2009.

Japan Industrial Standards, JIS L 1018-02; Testing methods for knitted fabrics. Tokyo, 2006. 55p.

Japan Industrial Standards, JIS L 1907-02; Testing methods for water absorbency of textiles. Tokyo, 2006. 5p.

KADOLPH, S.J.; LANGFORD, A.L., Textiles. Ed. Prentice Hall. New Jersey, 2006.

LACKMAN, M., Bamboo: facts behind the fiber. 2007. Disponível em: http://organicclothing.blogs.com/my_weblog/2007/09/bamboo-facts-be.html. Acesso em: dez.2008.

LIMA, P. J. B. F. Algodão orgânico: bases técnicas da produção, certificação, industrialização e mercado. Reunião Nacional do Algodão. Londrina, Ago.1995.

OSTAPIV, F., Análise e melhoria do processo produtivo de tábuas de bambu (Phyllostachys pubescens) com foco em pisos. Programa de Pós-graduação em Engenharia Mecânica e de Materiais, Universidade Tecnológica Federal do Paraná, Curitiba, 2007. Dissertação de Mestrado.

SACHS, I., Desenvolvimento includente, sustentável sustentado. Ed Garamond, Rio de Janeiro, 2004.

SANCHES, R.A., Estudo comparativo das características das malhas produzidas com fibras sustentáveis para fabricação de vestuário. São Paulo, Escola de Artes, Ciências e Humanidades, Universidade de São Paulo, 2011. Tese de Livre-Docência.

SANCHES, R.A., Procedimento para o desenvolvimento de tecidos de malha a partir de planejamento de experimentos. Campinas, Faculdade de Engenharia Mecânica, Universidade Estadual de Campinas, 2006. Tese de Doutorado.

SPINACÉ, M. A. S.; PAOLI, M. A., A tecnologia da reciclagem de polímeros. Quim. Nova, v. 28, n. 1, p. 65-72, 2005.

SOUZA, M. C. M. Produção de algodão orgânico colorido: possibilidades e limitações. Informações Econômicas, SP, v.30, n.6, jun. 2000.

VALLE, M.C.G et al., Uma nova geração de fibras: um estudo sobre a busca pelo conforto e redução dos impactos ambientais. Rev. Univ. Rural, Sér. Ciências Humanas. Seropédica, RJ, EDUR, v. 26, n. 1-2, jan.- dez., 2004.

VEZZÁ C.S.B; COTAIT, P.L.A. Produção de fibras para produção de tecidos a partir da reciclagem de PET. 2006. Disponível em: www.poli.usp.br/d/pme2599/2006/Artigos/Art_TCC_054_2006.pdf. Acesso em: nov. 2008.