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Algodão colorido e agroecológico pode ser a solução sustentável para a futura indústria têxtil

Colored and agroecological cotton may be a sustainable solution for future textile industry

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RESUMO Os temas agronegócio do algodão colorido e moda praticamente não possuem literatura científica publicada sobre o assunto, principalmente quando o assunto é tratado com o escopo de sustentabilidade. O algodão colorido e agroecológico, apesar da limitação em cores, pode reverter em uma produção industrial com menos impacto ambiental e utilizando menos água. O objetivo deste estudo foi apresentar a fibra colorida e o algodão orgânico, produzidos por pequenos agricultores na região Nordeste do Brasil, como produto alternativo para promover a sustentabilidade no agronegócio do algodão e na indústria têxtil, e identificar a carência de estudos científicos sobre o tema. Foram feitos levantamentos em bases disponíveis de literatura nacional e publicações internacionais sobre o tema e apresentados os resultados de pesquisas de produtos tóxicos utilizados para a produção do algodão branco e na indústria têxtil. Sugere-se que haja incentivo do governo aos agricultores que se dedicam a esta produção e que proporcione a infraestrutura para que o produto atinja o mercado global, por meio de cooperação com países mais pobres, promovendo mudanças mundiais no impacto ambiental na indústria da moda.

Palavras-chave Agronegócios. Desenvolvimento Sustentável. Pesquisa em Agronegócios e Sustentabilidade. Sustentabilidadenaindústria da Moda.

ABSTRACT *The agribusiness topics ofcolored cottonand fashion do not have any practical scientific literature published on the subject,only when the theme is treated primarily as the aim of sustainability. Colored and agroecological cotton, despite the limitation in color,could become an industrial production with less environmental, impact using less water. The aim of this study was to present the colored fiber and organic cotton, produced by small farmers in the Northeast region of Brazil, as an alternative product to promote sustainability in cotton agribusiness and the textile industry, and to identify the lack of scientific studies related to the theme. Surveys were carried out on available national literature and international database publications on the topic, and the results of research on toxic products used for the production of white cotton and textile industry were presented. Governmental incentives through funding agencies to farmers engaged in this production are suggested, in order to improve production and distribution. It is also necessary to provide the infrastructure necessary for this product to reach the global market, including in cooperation with poorer countries in order to promote changes in environmental impact worldwide in the fashion industry.*

Keywords *Agribusiness. Agribusiness Research and Sustainability. Sustainable Development. Sustainability in the Fashion Industry.*

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1. INTRODUCTION

Textile industry requires a large amount of water, and it leads to significant negative environmental impact. One of the mitigations on this process is the use of naturally colored cotton. There are few international and national publications highlighting the Brazilian governmental research agency Embrapa Algodão in the production of colorful and agroecological cotton. Thus, there is a substantial gap for the development and expansion of this production worldwide (ABRAPA, 2013; ATMANI *et al*., 2009; EMBRAPA ALGODÃO, 2012).

Supposing that most production are searching sustainable ways of reaching the market, cotton farmers should develop ways of transforming their activities into sustainable crops. The colorful and agroecological cotton might create this opportunity; however, there is still strong resistance from large cotton producers. The Reach (Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals), the European law the about import of textiles, since 2007, updates and improves the former legislative framework on chemicals and requires producers of other countries to suit (CNI/ABIT, 2012; EUROPA, 2011; INMETRO, 2011).

Nowadays this segment is developed in family farming. Therefore, the most important question to which this study seeks an answer is related to the national and international public awareness on the cotton sustainable production.

This paper aims to identify the lack of perceived importance of sustainability in this topic within academia, represented by the small number of international publications. It also addresses the use of chemicals in the processing of white cotton. Many of these chemicals are environmental pollutants, and their use can be avoided via production of organically produced colored cotton (FORGIARINI, 2006). Such development could be reached in the near future as the use of genetically modified plants, and agroecological techniques are growing in Brazilian agribusiness. The pilot production of colored cotton in the Northeastern of Brazil is a result of some years of study. The final product is a product that saves water during processing, reduces waste within the process, and it is economically feasible over a period of ten years.

The article consists of the literature review on the topic, methodological procedures for the preparation of the work, evidence of the results and discussion, conclusions and references.

2. THEORETICAL FRAMEWORK

2.1. Cotton production and business

Cotton fibers are grown on 34 million hectares globally (7% of the world's arable land). This industry produces 70 million tons of cotton annually being 25 million tons used by the textile industry to produce fabrics, clothing, hospital supplies, and uniforms, amongst other goods (MAPA, 2012; MARIANO, 2011). Cotton yarn is one of the oldest materials used in the textile industry. It accounts for a significant portion of the US$400 billion annual revenue of the yarn industry (MARIANO, 2011). In Brazil, approximately 30 thousand companies produce nearly 10 billion pieces annually. Brazil is the fifth world largest producer of cotton and the fourth largest producer of confections. The production from these products reached US$ 60 billion (in 2011) corresponding to 3.5% of the national GDP, and 5.5% of the manufacturing industry GDP in the country (ABIT, 2012).

Nowadays the use of mixed fibers and chemicals have assumed global importance in the textile manufacturing. Despite the difficulty in reaching market shares, Brazil still has the highest productivity rate among the major producers of cotton. Cotton production has increased significantly, while the total area of cultivated land has only increased from 31 million ha (in 1965) to 33 million ha (in 2010), representing a 6.5% increase in 45 years. In the same period productivity increased from 365 kg/ha to 732 kg/ha, representing an increase of over 200% in the amount of cotton produced per unit of area (MAPA, 2012).

Cotton production jobs require little specialization or training, being a feasible solution to jobs in poor countries. African countries, for instance, sold almost half of cotton production to the United States of America (USA) in 2009, totaling US$ 4.9 billion compared to just US$ 2.1 billion in African sales. African shares have nearly doubled since the 1980s, with an additional production coming from numerous small business owners. Approximately 200 thousand small-scale farmers in Zambia received financial incentives for manufacturing cotton seeds. In the USA 25 thousand producers received government subsidies to help maintain the production. These incentives were offered because the primary goal of the textile sector was the diversification and segmentation of the production, leading to cotton farming and production in particular regions, weaving yarns in others, and manufacturing in other countries (IEMI, 2012; NATHAN ASSOCIATES INC., 2007).

2.2. Textile chain and pollution

Some kinds of industries integrate the fashion chain. It starts with the growth of natural fibers such as cotton, moving to the treatment of artificial fibers (by the chemical and petrochemical industries), and ending with processing and the distribution to consumers. These productions supply the fiber for weaving, knitwear, and nonwoven fabrics (that have no crossing fibers) (MENDES, 2010). These materials are used in the production throughout the garment industry, including clothing, bedding, table linens, bath towels, and specialty fabrics for manufacturing, Civil Engineering, and other types of use. An extensive distribution chain is used to deliver the products to the market. This production chain is big and requires many links and resources, most of the resources are natural; however, during the processing development there is a negative impact in the environment. Some examples are the excessive use of water, and the pollution of waste effluents that are produced during each step of this process (production of synthetic and natural fibers, spinning, weaving and knitting, pre-treatment of tissues, dyeing and printing, finishing, manufacturing, and retail) (ABIT, 2012).

The chemical processes in the textile produce efluents contaminated by chemicals, dyes, and other pollutants. Waste is accrued in all states (solid, liquid and gaseous) via the operations of bleaching, dyeing and finishing, which emit various hazardous chemicals when disposed of improperly. Cotton yarn processing includes various processes that transform raw textile materials into white, dyed, printed, and various finished materials. These processes, as well as desizing, generate wastewater pollutants. However, the textile chain is multilayered, and it still includes wet finishing processes, which prepare the fabric to be dyed, printed, or finished. These methods require substances such as water, resins, dyes, and surfactants (FORGIARINI, 2006).

There were no recent studies for comparative analysis of changes to these waste elements during this period. The present study determined the primary chemicals, auxiliaries, and dyes found in textile effluent, such as ink dyes, azo dyes, disperse dyes, pigments, sodium hydroxide, urea, sodium hydrosulphite, reactive dyes, direct dyes, sulphur, sodium chloride, hydrogen peroxide, sodium silicate, sodium carbonate, acetic acid, ethanol, sodium acetate, sodium nitrite, turpentine paste, inks for printing, binding agents, tapioca starch, sodium bicarbonate, sulphate sodium, muriatic acid, magnesium sulphate, softeners, detergents, sequestrants, humectant, dye fixative, optical dispersion agents, antifoaming agents, protective colloids, white glycerine anti-immigrant, emulsifiers, sizing lubricant, thickener, antioxidant, emulsifier, catalysts, and reducer. And is also pointed the dyes that were most commonly used and most commonly found in the effluents of the companies studied (MARTINS, 1997). The author states that the direct and reactive dyes were most often used, and sulphur dyes were the most common in contaminated effluents from textile production.

The concept of sustainability is to meet the developmental needs of the present without compromising the survival of future generations (GRI, 2010; MARIANO, 2011; WCED, 1987). Consistently planning and executing sustainability practices has been a challenge for businesses, governments and the public society.

In Brazil, Embrapa Algodão has been studying for almost 20 years this topic, in order to develop environmentally friendly strategies for production, processing, and marketing the colored cotton. In addition, this agency produces colored cotton that is friendly to the environment, as it is an organic and pesticide-free product. Since 2007, organic cotton have been produced in 24 countries, and production has grown worldwide by approximately 50% annually (BRASIL, 2011). Organic cotton is also proper for people allergic to artificially colored fabrics. These aspects in this particular cotton have led to an increase in the demand in the international market, particularly in Europe and Japan where the market for natural products has grown tremendously (EMBRAPA ALGODÃO, 2012). According to Beltrão and Carvalho (2004), the Brazilian strategies for production, processing, and marketing of cotton agroecological products led to a product free of pesticides. In 2000, the Northeast area of the country began increasing production, which has put Brazil on the current list of the most important organic cotton producing countries.

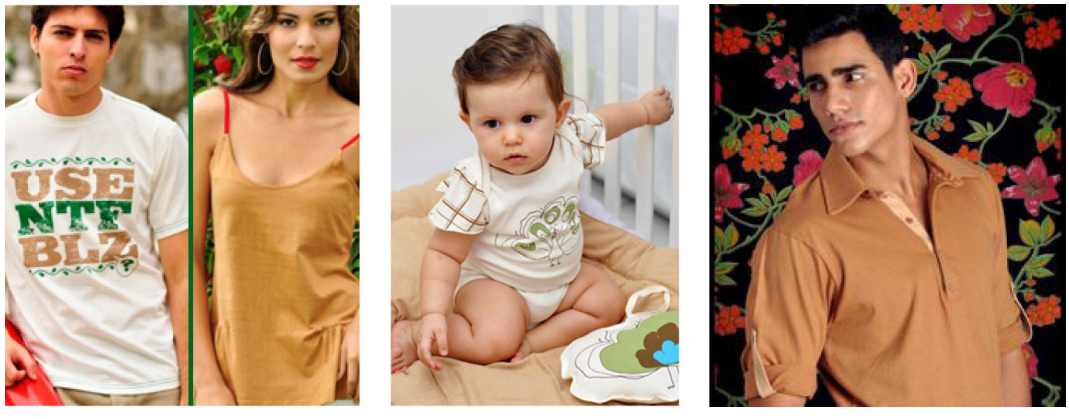
Figure 1 – Fiber cotton of various colors (A), and white cotton (B).

A B

Source: Embrapa Algodão (2012).

Figure 1 shows the genetic BRS 200 Brown, launched in 2000. The second genetic developed was BRS Verde, in 2003. The genetics BRS and BRS Ruby and Sapphire, were both developed in 2005, and the BRS Topaz was developed in 2010 (EMBRAPA ALGODÃO, 2012).

Figure 2 – Images with manufactured clothes using colored cotton.



Source: Natural Fashion (2012).

In Campina Grande, Paraíba, Brazil, the Coopnatural (Textile Cooperative) purchase any colored cotton produced by small producers in the region. The material undergo by processes spinning and weaving. The families and neighborhood associations produce handmade clothes (Figure 2) for the brand Natural Fashion (2012), made with the organic and colored cotton (REBOUÇAS; SALGADO, 2011). The authors suggest that the companies involved want more than a well-articulated speech on sustainability and wish ways to transform the global environmental scenario with new ideas. Refosco *et al.* (2011) indicates that the production of colored cotton fibers have as result in a product with quality and good yield. According to the authors the production of colored fiber can increase the net income of family farmers, because the price of lint cotton (BRS-200 Brown) is 30% higher than a plume of white cotton. In addition, the income increases occur in small and medium apparel industrial businesses that sell colored cotton products, generating a virtuous cycle of income and environmental improvements. Furthermore, a significant amount of water is saved in the fabric dyeing processes.

The production of nearly half kg of yarn or fabric uses an average of 30 L more water than the production of colored fabric, representing 30% of the final cost of manufacturing. Environmental pollution will also be reduced because no chemical dyes used in the manufacturing process (REFOSCO *et al.*, 2011). In 2011, Brazil established technical standards for organic textile cotton products, creating business opportunities for companies to meet the increasing customer demand for sustainable products (BRASIL, 2011). To continually improve the product, sustainable cotton farming processes (organic or agroecological), must maintain quality, consistency, and yield (CARTAXO *et al.*, 2008). However, it is difficult to increase sales due to the lack of data on production, financial viability, and acreage. In addition, scarce and incomplete information about organic and agroecological cotton production makes investing in this area difficult (RAMOS, 2013).

3. METHODOLOGICAL PROCEDURES

3.1. Object of study

The international scientific databases (ScienceDirect, Scielo, Wiley, Francis & Taylor) were searched to find studies on the topic of sustainability in agribusiness cotton, and also the use of colored and agroecological cotton. Practically no results were found about these themes. Thus, the colored and agroecological cotton is an innovation not yet studied deeper internationally.

3.2. Data Collection

The search pointed few studies on sustainability in the chemical industry that involved the textile sector. Articles in scientific journals, magazines and newspapers did contain some secondary data analysis and descriptions of the sustainability chain in textile and fashion. None international publication was found on this specific subject; just few were published by the Brazilian governmental research organization Embrapa Algodão. The numbers of publications is presented here. These studies cover topics such as social responsibility and sustainability. The data presented in the studies included descriptive statistics used to present a projection of production, water savings in relation to the production of white cotton, and the reduction of the effluent from the textile chain when producing organic cotton.

3.3. Data Analysis

The topics surveyed, the keywords used, and the scientific articles found are shown in Tables 1 and 2. The found articles were tabulated and submitted to a descriptive analysis presented in the topic Results, which also show the amount of water and chemicals used in the textile industry. It was described a review of the water use in the last ten years, as well as the possible contamination from these agents that were discarded into the environment during this period.

4. RESULTS AND DISCUSSION

4.1. Publications on the topic

The survey in the ScienceDirect database limited to publications from 2010-2013, indicated few studies that studied colored cotton (Table 1). These results may show the lack of emphasis that sustainable technologies and the production of natural fibers have received from researchers and investors.

Table 1 – Search for keywords in scientific database ScienceDirect.

Keywords used: colored cotton	Number of papers
Sustainability	8
Cotton fibers	6
Dyeing of cotton	8
Cotton fabric	1
Other colorants	2
Varied subjects	49
Total	**74**
Keywords used: agribusiness colored cotton	
Cotton	1
Biodiesel	1
Varied subjects	19
Total	**21**
Keywords used: Brazilian family farming	
None on cotton	275
Total of three subjects surveyed	370

Source: Authors (2014).

Embrapa Algodão has published 14 journals on various agricultural subjects, including 6 journals dedicated to cotton production (Newsletters Research and Development, Technical Circulars, Technical Announcements, Announcements, Documents Series, and Leaflets) and Brochures and Technical books. Embrapa Algodão is an important producer of scientific articles about the theme cotton, providing resource for scholars interested in agroecology as shown in Table 2.

Table 2 – Papers published in journals edited by Embrapa Algodão.

	Search by period	Items submitted annually
2011	103.086	10.547
2012	192.418	3.166
2013	63.487	1.444
Total	359.091	15.157

Source: Authors (2014).

Martins (1997) found that the textile sector represents 25% of the production industrial state of Santa Catarina, Brazil that also produces high amounts of untreated toxic effluents. The author' studied ten companies processing yarn for the textile industry, and presented the waste components in the production process (Table 3). In Table 4, the author presents the chemicals and dyes most commonly used in the textile industry based on a projected production of approximately 1000 tons/month of knitwear. Galindo *et al.* (2001) stated that approximately 15% of the dyes used by the textile industry are lost in the dyeing process and released in the enviromental effluent. This finding agrees with those of Herrmann *et al.* (2001), particularly regarding the detrimental impact of textile effluent on the environment and aquatic life.

Table 3 – Dejects generated in the fiber production process.

Stage	Components of the dejects
Iron	Starch and synthetic gums based on polyacrylates
Pre-ironing	Humectants, salts, caustic soda, and peroxide
Bleaching	Humectants, salts, caustic soda, sequestrants, peroxide and / or chlorine and neutralizers
Dyeing	Colorants, sequestrants, salts, caustic soda and / or kelp
Stamping	Dyes, caustic soda and gums
Washing	Detergents
Softening	Softeners and sliding

Source: Adapted from Martins (1997).

Table 4 – Basic consumption of chemical products and the effluent which pollute the environment, compared to naturally colored cotton.

Chemical product used in usual textile industry	Basic consumption (t/month)	1 – 15% of the effluents' products (average of 10% t/month)
Salt	120.0	12.0
Peroxide	16.0	1.6
Kelp	30.0	3.0
Acetic acid	3.0	0.3
Other acids	6.0	0.6
Reactive dyes	6.4	0.64
Sulfur dyes	13.8	1.38
Total	312.2	21.22

Source: Adapted from Galindo *et al.* (2001) and Martins (1997).

Table 5 shows the consumption of water that is necessary to produce approximately one ton of mesh (BELTRÃO *et al*., 2009), which uses 70% more water than colored cotton production.

Table 5 – Basic water consumption for producing 1 ton of processed 1 ton of white cotton.

Water consumption for processing (1 ton/month)	Unit (L/month)
White cotton	$30 . 10^3$
Colored or ecologic cotton	$9 . 10^3$

Source: Adapted from Beltrão and Carvalho (2004), Galindo *et al*. (2001) and Martins (1997).

Government investment in sustainable agriculture has reached a total of $5 billion in credit lines between the harvest of 2008-2009 and 2011-2012. However, these investments were destinated to large-scale agricultural producers through a variety of funding programs (Constitutional Funds, National Bank for Economic and Social Development – BNDES – and National Program for Strengthening Family Agriculture – Pronaf) (MAPA, 2012). Small-scale and family farmers, who might benefit from greater income distribution, also need to be encouraged to use sustainable and agroecological methods in culture cotton.

Innovations in the textile industry, which include special fabrics that are chemically modified to protect, repel, heat, cool, and retard fire, are being used in engineering, civil construction, and other industries (BELTRÃO, 2011). Another possibility is the use of raw materials and processes that are sustainable, such as the reuse of fibers. One example is fabrics made with polyethylene terephthalate (PET) from disposable plastic bottles, which are made from 50% of polyester and 50% of PET. The dyeing in the colored cotton and ecological is made with inks that have small environmental impacts and from water that is free of heavy metals and polyvinyl chloride (PVC), which contaminates the environment and affects the health of workers who use it (TEONLINE, 2012).

Although these examples are innovative, they do not address the concern related to the sustainability of natural resources and reduction of chemical pollutants arising from manufacturing. Eco-textile products are free of toxic processes. The annual global sales of organic cotton products grew by over 40% between 2001 and 2009. Increased trade of "green" clothing products led large companies to adopt sustainable development strategies. Marks & Spencer stopped using PVC in their packaging in 2007, and Timberland began producing shoes from recycled organic and renewable materials (WU *et al*., 2012).

The GRI (2010) defines sustainable enterprises as companies that claim responsibility for the product that they have produced while the respect to human rights, labor practices, society, and the environment. Thus, it can be inferred that companies are influenced by public opinion and are often held accountable by society for promoting sustainable development. Baskaran *et al*. (2012) used six criteria as indicators of sustainability: discrimination, human rights abuses, child labor, long working hours, unfair competition, and pollution. An analysis of textile chain suppliers revealed that environmental pollution is the main criterion on which companies focus. The study showed the social importance and evaluating suppliers based on the adoption of sustainability criteria in the textile chain (garment manufacturers), and noted that pollution and unfair competition were important criteria for choosing partners in the business chain.

Agroecological cotton is produced in sustainable systems with managed and protected natural resources, and without the use of pesticides, genetically modified organisms, chemical fertilizers, or other inputs that are harmful to human, animal and environment health (BELTRÃO *et al*., 2009).

4.2. Agroecological and colorful cotton

The naturally colored yarn derives from a genetic mutation that causes the cotton plant to release the use. This mutation leads to saving water and eliminates the need for additional dyeing with chemicals. The process was developed by the Brazilian government research agency Embrapa Algodão. Embrapa's network used the technology transfer of the product and facilitates family agriculture practices in order to expand the crop (EMBRAPA ALGODÃO, 2012). Table 6 presents the chronological steps towards to development to colored cotton in Brazil. These cultivars are planted in the Northeastern of Brazil, in the state of Paraiba, through family farms. Since 2000, Brazil has produced a variety of colored cotton strands in the Northeastern, mainly in the state of Paraiba, through family farms. Naturally colored yarn represents a significant reduction in environmental pollution (Tables 4 and 5). The process was developed by the Brazilian government research agency Embrapa Algodão. Embrapa personnel are specialized in technology transfer with low environmental impact and facilitate family agriculture practices (EMBRAPA ALGODÃO, 2012).

Table 6 – Timeline of the development of colored fibers from 2001 to 2010.

Year	Event
2000	Development of the cotton variety BRS 200 Marron (brown)
2001	Fiber color begins commercial scale in Paraíba state by small farmers
2001	Fiber color reaches 30 to 40% higher price per pound relative to white fiber in 2002
2002	Development of the variety BRS Verde (green)
2002	Cultivation of organic fiber begins (without chemicals or fertilizers)
2002	Fiber color reaches 200% higher price per pound relative to white fiber
2005	Development of the variety BRS Rubi (red)
2010	Development of the variety BRS Topázio (blue)

Source: adapted from Beltrão e Carvalho (2004), Embrapa Algodão (2012).

Table 7 – Total of production, water consumption and chemical effluents in ten year ago with cotton production.

Year	Production 1000 tons	H_2O Consumption 1000 tons	Chemical Effluents 1000 tons
2000/2001	1.511	$543.960 . 10^6$	$566.081 . 10^6$
2001/2002	1.245	$448.200 . 10^6$	$466.426 . 10^6$
2002/2003	1.365	$491.400 . 10^6$	$511.383 . 10^6$
2003/2004	2.099	$755.640 . 10^6$	$786.369 . 10^6$
2004/2005	2.129	$766.440 . 10^6$	$797.608 . 10^6$
2005/2006	1.038	$373.680 . 10^6$	$388.876 . 10^6$
2006/2007	1.524	$548.640 . 10^6$	$570.951 . 10^6$
2007/2008	1.602	$576.720 . 10^6$	$600.173 . 10^6$
2008/2009	1.411	$507.960 . 10^6$	$528.617 . 10^6$
2009/2010	1.194	$429.840 . 10^6$	$447.320 . 10^6$
2010/2011	2.052	$738.720 . 10^6$	$768.761 . 10^6$
Total	17.170	$6.181.200 . 10^6$	$6.432.568 . 10^6$

Source: IEMI (2012); Mapa (2012).

In the last ten years there has been a market demand for industries in general, and textile industry in particular, to comply with sustainable production processes. Table 7 represents the production of cotton and the water consumption and chemical effluents in last ten year. According to the Organic Exchange, in 2007-2008, a total of 145.872 tons of organic cotton fiber were produced on 160 ha of cultivated land in 22 countries. This scenario represents an increase of 152% compared to 2006-2007 (ORGANIC EXCHANGE, 2008).

Sustainability and sustainable development have achieved some degree of success in regard to improving environmental indices. However, this initiative does not necessarily reflect in pollution prevention processes. Technology and innovation have had a greater impact on sales and increases in mass production than on sustainable processes (REBOUÇAS; SALGADO, 2011).

Countries producers (China, India and Hong Kong) were characterized as major exporters of textiles and clothing (in 2000 and 2006), with an average growth of 18%/year and an increase of almost US$100 billion in total exports (GARCIA *et al*., 2009). However, Abreu *et al*. (2012) suggest that these trends impact the sustainability because China, in particular, did not support recent environmental legislature or yet trade partnerships with other countries. The study addresses social responsibility in Brazil and China, and showed that neither country incorporates the practice of corporate social responsibility, including sustainability in strategic planning. One result is that the country in which the company operates makes a difference when it comes to adopting these practices. With advantages over the Chinese production model, Brazil has taken the first steps to adopt sustainable practices with the development of the colored cotton.

5. CONCLUSIONS

The present study identified a lack in the scientific articles related to the production of colored cotton for minimizing the environmental impact within the textile industry.

Colored cotton fiber and agroecological fiber can be grown with a minimal water consumption and no chemicals necessary during production. This organic cotton constitutes a solid framework for an agribusiness opportunity in textile production. It may be noted that there is a worldwide increasing demand for the product.

Brazil has established technical standards for organic textile cotton products, developing business opportunities for companies to meet the increasing customer demand for sustainable products.

With the help of Brazilian governmental agencies, it is possible to incentive the production of natural fiber textiles, whose main product will be colored cotton. The fashion garments chain business is vast, complex, and financially significant in the global markets. As the market gets acquainted with the pollution impact of this particular industry, it is expected a shift in future consumer sustainability values.

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