Evaluation of consumer perceptions and acceptance of sustainable fashion products made of bacterial cellulose

Armine Ghalachyan

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Evaluation of consumer perceptions and acceptance of sustainable fashion products made of bacterial cellulose

by

Armine Ghalachyan

A dissertation submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Major: Apparel, Merchandising, and Design

Program of Study Committee:
Elena Karpova, Major Professor
Ann-Marie Fiore
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The student author, whose presentation of the scholarship herein was approved by the program of study committee, is solely responsible for the content of this dissertation. The Graduate College will ensure this dissertation is globally accessible and will not permit alterations after a degree is conferred.

Iowa State University
Ames, Iowa
2018

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DEDICATION

I dedicate this work to the three most important women in my life—my mother, Araksi Ohanyan, and my wonderful daughters, Silvia Aydinyan and Victoria Aydinyan. I am incredibly fortunate to have these ladies in my life.
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ABSTRACT

Due to tremendous contributions of the fashion industry to environmental degradation, novel sustainable materials and practices are becoming increasingly important. The purpose of this research was to investigate consumer perceptions of fashion products made from bacterial cellulose (BC), a novel sustainable material. Research objectives were to: (a) understand how consumers perceive and characterize BC material based on the senses of touch, sight, smell, and hearing; (b) identify areas for material improvement and potential barriers and motivations for consumer acceptance of products made of BC; and (c) evaluate the acceptability of BC, from a consumer perspective, as a novel material for use in fashion products. For the study, BC material was developed through Kombucha fermentation, then used to design a women’s bag. A new comprehensive framework for Fashion Product Evaluation (FPE) was developed, tested and validated.

Embedded mixed methods research design was utilized to conduct the study. Focus group discussion was the primary method, and sensory evaluation of the BC material was the embedded method. A three-part holistic sensory evaluation method was developed to examine consumer perceptions of BC material. Six focus group sessions were held to collect data, with 33 female participants in total. Descriptive statistic was used to analyze the sensory evaluation data. Priori and open coding methods were used to analyze the focus group data.

BC material was found to be acceptable for fashion accessories (e.g., shoes, bags, belts), but not for clothing. Material texture and novelty were found to be favorable characteristics. Thinness, translucency, unpleasant odor, and skin-like and worn appearance were unfavorable characteristics. Name of the material and lack of consumer knowledge were the barriers for BC adoption, whereas uniqueness, vintage-looking appearance, sustainability, and environmentally-
and animal-friendly nature were the motivators. The results present valuable insight for future research directions and further BC improvement. Bio-based materials, such as BC, might help the fashion industry to become less dependent on non-renewable fiber sources and other natural resources and reduce its environmental impact.

An important methodological contribution of this study is the new, holistic sensory evaluation method for fashion products, which is the first in the field to consider all human senses but taste. As new unconventional and often non-textile materials (e.g., BC, smart textiles, sensors, solar cells) are increasingly being incorporated into fashion products, holistic sensory evaluation becomes essential for capturing and evaluating the total range of sensory characteristics of products and fully assessing consumer perceptions, acceptance, and satisfaction.

Important theoretical contribution of this study lies in the development of the new FPE framework. FPE is the first framework to integrate apparel evaluative criteria into a unified comprehensive classification system with four mutually exclusive and clearly defined dimensions. It can be useful to researchers and businesses for understanding consumer perceptions and evaluation of products and purchase decision processes as well as identifying and addressing gaps between consumer needs and product attributes.
CHAPTER 1. INTRODUCTION

Background

Sustainability Issues in the Fashion Industry

From cultivation of raw fibers and manufacturing to consumption and disposal, the life cycle of a fashion product is plagued with negative environmental impacts (Kozar & Hiller Connell, 2015). Compounding these effects is the industry’s continuing growth—by 2030, the global production of apparel and footwear is expected to grow by 63%, amounting to 102 million tons (Watson, Eder-Hansen, & Tarneberg, 2017). One of the major issues facing the fashion industry is the tremendous amount of waste it produces. Only 16% of the 16 million tons of post-consumer textile waste, including clothing, footwear, and other textile items, was recycled in 2014 in the U.S., while 84% was either incinerated or landfilled (Environmental Protection Agency, 2016).

The fashion industry has become one of the most polluting industries in the world (Austgulen, 2016). Issues related to environmental pollution and degradation include depletion of natural resources and ecosystem pollution by hazardous chemicals such as pesticides, dyes, and finishes (Dickson, Loker, & Eckman, 2009; Kozar & Hiller Connell, 2015). Fast fashion, characterized by short (often two-week) production cycles and constant availability of new low-cost low-quality fashion products, exacerbates the issue by promoting a continuous cycle of planned obsolescence, disposal, and replacement of fashion goods (Hawley, 2015; Lewis, 2015). The growing demand for fashion products has created higher demand for raw materials, particularly for manufactured fibers such as non-renewable petroleum-based polyester (Cao, Wool, Bonanno, Dan, Kramer, & Lipschitz, 2014).
The traditional linear take-make-use-dispose business model has perpetuated unsustainable practices in the fashion industry by creating a constant demand for large amounts of cheap materials and other resources (Watson et al., 2017). Little consideration is given to recovery of resources or sustainability in general with this model (Durham, Hewitt, Bell, & Russel, 2015). In contrast, the Cradle to Cradle (C2C) sustainable design framework outlines a fundamentally different production process—a zero-waste, closed-loop production cycle, marked with continuous reuse of technical materials and return of biodegradable materials to biological cycles (McDonough & Braungart, 2002).

**Traditional Materials in the Fashion Industry**

Unsustainable industry practices are also related to traditional materials used in fashion products. Natural fibers such as hemp, cotton, and wool are generally associated with being environmentally-friendly as well as renewable and biodegradable. However, the full environmental cost of materials cannot be determined by fiber content alone (Chen & Burns, 2006). For example, traditional cotton cultivation is laden with heavy environmental impacts due to its requirements for large amounts of water and chemicals (Fletcher, 2008; Karthik & Gopalakrishnan, 2014). Even though organic fibers, often popularized as alternative or sustainable, may be cultivated using environmentally-friendly processes, the amount of resources used for fiber processing and irrigation can still add up to significant environmental costs (Hansen & Schaltegger, 2016).

Animal fibers are also associated with significant environmental impact resulting from extensive land use, high levels of greenhouse gases released, and ethical issues related to animal welfare (Lehmann et al., 2018; Plannthin, 2016). Traditional leather production is an especially harmful process for human health and the environment (Cao, Wool, et al.,
Conventional synthetic fibers such as polyester and nylon use significantly less water compared to natural fibers, but their production is energy-intensive and dependent on non-renewable petrochemical sources, and they are not biodegradable (Lehmann et al., 2018). Synthetic fibers can also release toxic emissions and shed non-biodegradable microfibers into the environment during product use (Fletcher, 2008; Hansen & Schaltegger, 2016). While conventional materials used in the fashion industry offer many beneficial properties, they also present sustainability problems, with heavy environmental costs associated with production, consumption, and disposal of these materials.

**Need for Sustainable Materials**

Using sustainable materials in fashion products has become a priority for many companies (Lehmann et al., 2018). For example, Nike, Adidas, and North Face have all introduced environmentally-friendly production initiatives, including utilization of non-hazardous and recycled materials (Herva, Alvarez, & Toca, 2011). Replacing virgin polyester, the most widely used fiber in textile production, with recycled fibers has become one of the priorities for fashion brands, because it can help to significantly reduce toxins, energy use, and harmful emissions (Lehmann et al., 2018). However, products made from recycled synthetics tend to be of lower quality and still can contribute to the problem of microfiber shedding into the environment.

The *Pulse of the Fashion Industry 2018* report emphasizes that “while all of these efforts represent progress, the ultimate solution remains still to be found” (Lehmann et al., 2018, p. 40). While recycled, organic, and other similar fibers are helping the fashion industry move toward a more sustainable future, a new generation of novel bio-based materials may be the ultimate solution to sustainability problem. Bio-based materials have
gained increasing prominence in recent years because they are renewable, biodegradable, recyclable, and do not depend on petroleum (Zhang, Xu, Huang, & Tao, 2016).

Bio-based materials are non-fossilized and biodegradable organic materials originating from plants, animals, and microorganisms (Kabasci, 2014). While a number of bio-based materials have been explored for applications in the fashion industry, including casein, chitin, spider silk, alginate, nettle, banana leaf, and others (Thangavelu & Subramani, 2016), such materials are still in development stages and have not achieved feasible wide-scale fiber and material production (Rana, Pichandi, Parveen, & Fengueiro, 2014a).

**Bacterial Cellulose**

Bacterial Cellulose (BC) is an emerging bio-based material produced by bacteria often referred to as bacterial nanocellulose, or microbial cellulose (Radhakrishnan, 2014; Shah, Mazhar, Khattak, & Park, 2013). It is a natural, nontoxic, and biodegradable biopolymer with unique properties that make it extremely versatile and usable in a variety of applications (Gama, Gatjenholm, & Klemm, 2013; Miner, Gallego, Rojo, & Mondragon, 2014). Compared to plant-based cellulose, BC has high purity and free of lignin and hemicellulose (Gama at al., 2013), so it requires no processing for removal of such substances. In terms of renewability rates and cellulose yield, BC can offer the outstanding advantage of producing BC sheets with desired geometry and other characteristics (color) that can be cultivated within 1-4 weeks, making it a ‘monthly’ renewable material. A unique BC variety can be produced through fermentation of Kombucha, a lightly acidic beverage made through fermentation of sweetened tea (Zhu, Li, Zhou, Lin, & Zhang, 2014).
**Application of BC for Fashion Products**

Using bio-based renewable materials might help the fashion industry to become less dependent on non-renewable fiber sources, reduce its demand for other natural resources, and diminish the environmental impact associated with production and consumption of fashion products (Cao, Wool et al., 2014; Kozlowski, Searcy, & Bardecki, 2016; U. S. Department of Agriculture, n. d.). As a biodegradable material, BC can help to ‘close the loop’— create zero-waste fashion products — using a circular system of material use (McDonough and Braungart, 2002). While there has been a significant amount of research related to BC applications in a variety of fields, including biomedical engineering, wound dressing, food, cosmetics, electronics, and acoustics (Gama et al., 2013; Miner et al., 2014), there has been only limited research on BC applications in the fashion industry. Only a few studies have examined BC production processes and material testing for fashion product applications (Freeman, Gillon, James, French, & Ward, 2016; Lee, 2011; Lee, Xiang, Ghalachyan, Ramasubramanian, Li, and Farr, 2014; Smail, 2016; Wood, Liu & Salusso, 2015).

Assessing consumer perceptions and acceptance of BC as a novel sustainable material for fashion products is another research area requiring examination. Studies have shown that consumers are progressively aware and concerned about the global sustainability problems (Gam & Banning, 2011; Gleim, Smith, Andrews & Cronin Jr., 2013). However, consumption of sustainable products has not grown according to expectations due to lack of acceptance and popularization of these products (Gleim et al., 2013; Moon, Youn, Chang, & Yeung, 2013). Barriers to acceptance of sustainable apparel by consumers include lack of knowledge about their effects on environment, difficulty in finding sustainable products, high prices, and
perceptions of these products as non-fashionable or unattractive (Gleim et al., 2013; Kozar & Hiller Connell, 2015; Moon et al., 2013). It is essential to assess consumers’ perceptions of novel sustainable products to ensure that their preferences and needs are considered. This could lead to design of new and successful products.

**Research Purpose and Objectives**

The purpose of this study was to investigate consumer perceptions of fashion products made from bacterial cellulose (BC), a novel sustainable material. Specific objectives were to:

a) understand how consumers perceive and characterize the BC material based on the senses of touch, sight, smell, and hearing;

b) identify areas for material improvement and potential barriers and motivations for consumer acceptance of products made of BC; and

c) evaluate the acceptability of bacterial cellulose as a novel material for use in fashion products from a consumer perspective.

**Significance of the Research**

Commercial adoption of novel sustainable materials such as BC can help reduce the fashion industry’s contribution to significant and growing negative environmental effects. It is important to examine BC and its possible applications for apparel and accessories because, at this stage, very little knowledge exists in this area. While some researchers have explored BC production processes in lab and non-industrial settings and experimented with designing products made of the material (Lee, 2011; Lee et al., 2014; Smail, 2016; Wood et al., 2015), these processes have not been thoroughly documented. This study fills the void in this area
by methodically documenting the process of BC production in a lab setting, including specific conditions, inputs, and time frames for material fermentation, dyeing, drying, and enhancement. Detailed account of designing and manufacturing a BC-based fashion product is also presented in this study to provide useful information for advancing use of BC material for fashion products, specifically by fashion businesses looking for alternative sustainable materials. Researchers and designers can utilize this knowledge as building blocks to continue improving and innovating BC production and application processes.

Furthermore, no previous studies have examined perceptions and acceptability of products made of BC from a consumer perspective. Since BC has not yet been adopted commercially for fashion products and is completely different from more conventional materials used for apparel and accessories, it is important to understand how consumers perceive and characterize BC material and how they view products made of it before entering into its commercialization. Conducting sensory evaluation could help achieve a more complete picture of how consumers perceive the properties of BC material, based on all relevant human senses. Factors that could motivate or deter consumers from accepting products made of such a novel material should also be studied. Examining these aspects can help in identification of areas for improving BC material to aid in addressing such issues during material and product development stages prior to launching products into the marketplace. Appropriate marketing strategies based on insights gained from consumer feedback could effectively support potential development of BC products.

This study specifically contributes to the existing research on textiles and apparel product evaluation by developing and testing a holistic sensory evaluation method. Sensory evaluation in the apparel field has traditionally focused on evaluation of appearance (sight)
characteristics or tactile/thermal (touch) properties of materials and products (Balaji, Raghavan, & Jha, 2011; Phillippe, Schacher, Adolphe, & Dacremont, 2003). In this study, sensory evaluation includes a more broadly-based consumer evaluation of BC material taking into account the senses of sight, touch, smell, and hearing, all the sensory modalities except for the sense of taste. No previous studies have been found conducting a holistic sensory evaluation of textiles and apparel. Product developers could effectively use sensory evaluation method to examine and improve prototypes and products. Researchers may use this method to examine consumer perceptions of innovative textile and fashion products. While negative characterizations of products can help in identifying areas for further research and improvement, positive perceptions can provide similar guidance and potentially lead to development of effective marketing strategies.

Given the increased importance of new material sources (Lehmann et al., 2018), such as BC, as well as increased demand for smart textiles and wearable technology (“Smart Textiles,” 2017), holistic sensory evaluation gains increased importance. Plastics, wires, and novel fibers added to clothing or other fashion products may embody particular odors or make sounds while moving or flexing. Because new unconventional and often non-textile materials are increasingly being incorporated into fashion products, holistic sensory evaluation becomes essential for capturing and evaluating the total range of sensory characteristics of such products and fully assessing consumer perceptions, acceptance, and satisfaction.

**Definition of Terms**

*Bacterial cellulose*: a biopolymer produced by bacteria, *Gluconacetobacter xylinus* (*G.xylinus*), with molecular formula and morphology similar to that of plant cellulose,
although not including impurities such as lignin, pectin, and hemicellulose (Lin, Calvar, Catchmark, Liu, Demirci, & Cheng, 2013; Gama et al., 2013).

Attribute: perceived characteristic of a material or a product (ASTM E253-15a, 2015).

Bio-based materials: non-fossilized and biodegradable organic materials originating from plants, animals, and microorganisms (Kabasci, 2014).

Evaluative criteria: attributes or dimensions used by consumers to evaluate products and make purchasing decisions (Forney, Park & Brandon, 2005).

Extrinsic attributes: intangible product characteristics not a physical part of a product; changing these will not affect the product (Eckman, Damhorst, & Kadolph, 1990).

Fashion product: apparel and accessories, including footwear, handbags, hats, eyewear, and other related products reflecting currently prevalent styles and used by a large segment of the population.

Fermentation: a biotechnological process involving a “chemical transformation of complex organic compounds into simpler compounds by the action of enzymes, organic catalysts produced by microorganisms, including yeast, moulds and bacteria” (Ojha & Tiwari, 2016, p. 1).


Intrinsic attributes: inherent parts of a product that if changed would alter the product itself. These attributes relate to product appearance, composition, and structure and are
observable or perceivable through use of the senses (Abraham-Murali & Littrell, 1995; Fiore & Ogle, 2000).

**Kombucha**: a lightly acidic beverage derived through fermentation of sweetened tea.

**Marketing attributes**: product attributes defined or added by retailers or manufacturer to aid in promoting and selling of products.

**Perception**: “The awareness of a stimulus by way of the senses” (ASTM E253-15a, 2015, p. 5).

**Social-communicative attributes**: abstract and subjective characteristics ascribed to products by consumers based on their ideas, perceptions, and judgements. Such attributes can relate to a product’s symbolic and communicative aspects that allow consumers to express or communicate their feelings and identities (Bye & Hakala, 2005; Lamb and Kallal, 1992).

**Sustainable apparel**: “Apparel products that maximize positive and minimize negative environmental, social, and economic effects along their supply and value chain” (Moon et al., 2013, p. 393).

**Sensory evaluation**: a method of studying reactions to stimuli (products and materials) perceived through the senses of sight, smell, taste, touch and hearing (ASTM E253-15a, 2015; Stone, Bleibaum & Thomas, 2012).
CHAPTER 2. LITERATURE REVIEW

In this chapter, the concepts of sustainability and sustainable fashion products are defined, followed by a discussion of sustainable fashion product design. The review goes on to discuss traditional fibers and materials used in fashion products and introduce innovative sustainable materials, such as bacterial cellulose, its cultivation, applications, advantages and challenges it presents for use in fashion products. Sensory evaluation methods and their application in the textiles and apparel field are presented next. The chapter continues with review of literature on consumer evaluation of apparel products and critical review of existing theoretical frameworks. Development of a new framework for Fashion Product Evaluation is described next.

Sustainable Fashion Product

Definition of Sustainability

The term “sustainability” originated from the concept of “sustainable development,” popularized in 1987, after the report of the United Nation’s World Commission on Environment and Development, titled “Our Common Future” (International Institute for Sustainable Development, n. d.). The report defined sustainability as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” and anchored it around social and economic development as well as protection of the environment and natural resources (Bärlund, n.d., para. 2). Many terms such as “ethical,” “environmentally- or eco-friendly,” “green,” and “ecological” have been used in parallel with the term “sustainable” (Gam & Banning, 2011). While sustainability may seem an ambiguous concept and is often regarded as solely an environmental concern, true
“sustainability” addresses social, economic, and environmental dimensions—the three pillars of sustainability (Kozar & Hiller Connell, 2015).

**Sustainability Frameworks**

The global drive for sustainable development has resulted in a multitude of frameworks, standards, indicators and certification processes directed towards measuring sustainability performance, sustainable products, and solving sustainability issues. For example, a widely accepted sustainability framework, Life Cycle Assessment (LCA), allows assessing resources used for and potential environmental impact of a product throughout its life cycle or entire value chain, from raw material stage, through production, use and disposal (Finnveden et al., 2009). Specific to fashion products, Higg Index developed by Sustainable Apparel Coalition (SAC) enables companies to self-assess potential environmental and social impact of apparel and footwear products throughout product life cycle and supports decision-making that reduces these impacts (Cao, Dickson, et al., 2014; Sustainable Apparel Coalition, n. d.).

Another sustainable design framework, Cradle to Cradle (C2C), facilitates sustainable product design, including safe material use, continuous recovery and reuse of materials, clean water, renewable energy and social equity (MBDC, 2012). While most sustainability frameworks focus on efficiency and reduction of harmful effects of product manufacturing, use, and disposal, the main idea of C2C is the complete absence of these effects with “the goal of zero: zero waste, zero emissions, zero ecological footprint” (McDonough & Braungart, 2002, p. 67). Instead of the traditional linear “cradle-to-grave” product design, C2C promotes a closed-loop cycle of materials, products and processes (Gam, Cao, Farr, Heine, 2009). According to the C2C framework, products can be composed either of
biodegradable materials that will become nutrients for biological cycles, or of technical materials that will continue to circulate as valuable industrial inputs.

**Sustainable Fashion Product Design**

Sustainability is one of the major concerns currently facing the fashion industry (Kozlowski et al., 2016). Negative environmental and social impacts are present at all stages in fashion product lifecycle, from production and distribution to consumption and disposal (Kozar & Hiller Connell, 2015). These include human rights violation in production facilities (e.g., use of child labor, unsafe work environment), depletion of natural resources (e.g., use of large amounts of water, energy, and non-renewable resources), pollution of air, soil, and water systems by release of hazardous chemicals (e.g., pesticides, fertilizers, finishes, dyes), generation of tremendous amounts of pre- and post-consumer waste sent to landfills (Dickson et al., 2009; Kozar & Hiller Connell, 2015). In fact, the fashion sector is considered one of the most polluting industries globally (Austgulen, 2016).

Research on sustainable fashion product design and development has included Cradle to Cradle (C2C) apparel design studies and application of various engineering design processes, such as Design for Disassembly (DfD) and Design for Adaptability (DfA), to sustainable apparel design (Cao, Chang et al., 2014; Gam, Cao, Bennet, Helmkamp & Farr, 2011; Gam et al. 2009). Researchers have also focused on upcycling or transformation of post-consumer textile waste into new products that are of similar or higher value, functionality and quality, which help to prolong product serviceability (Lewis, 2015; Vadicherla & Saravanan, 2014). However, practical and economic viability of these methods in the fashion industry is tied with multiple challenging factors such as availability of
recycling infrastructure, disposal behavior by consumers, product construction and composition, physical condition, etc. (Durham et al., 2015).

While prolonging product serviceability can be helpful in reducing the negative impacts of the fashion industry by decreasing demand for new materials and diverting products from landfill, fundamental changes are necessary at product design stage. This is especially true given the fact that even in a developed country like the United States, which has various waste management capabilities, only about 15% of textile waste is recycled, although 100% of textiles are recyclable (Lewis, 2015). Meanwhile, consumption of apparel and footwear has been growing and is expected to continue rising (Schlossberg, 2017).

In the current industrial system, general design intentions are to make an attractive and affordable product that “meets regulations, performs well enough and lasts long enough to meet market expectations” (McDonough & Braungart, 2002, p. 37). With no due consideration about sustainability, the fate of most products designed in this manner is the landfill or incinerator. Sustainable product design strategies have focused on solutions to reduce the fashion industry’s negative impacts through DfD or similar strategies, selection of environmentally-friendly materials, and dematerialization (Kozlowski et al., 2016). While some focus has also been placed on developing innovative bio-based renewable materials for fashion products, the research in this area is lacking. Novel bio-based materials can help the fashion industry become less dependent on non-renewable resources and become more sustainable (Kozlowski et al., 2016). With renewable bio-based materials, it could be possible to create zero-waste products that enrich and enhance the environment at the end of their lifecycle, rather than become a burdensome issue in need of solutions and transformations.
Materials for Fashion Products

Traditional Materials

Traditionally, the materials used in the fashion industry are obtained from natural or manufactured fiber sources (Fletcher, 2008). Natural fibers come either from plant sources such as cotton and flax, or from animal sources such as hair/wool, feathers/down, and silk (Bubonia, 2014). Conventional manufactured fibers can be grouped in two categories—synthetic fibers and regenerated fibers. Synthetic fibers are produced from petroleum-based sources and include polyester, nylon, and acrylic. Regenerated fibers are composed of chemically processed cellulose. Lyocel, acetate, and rayon are examples of regenerated fibers (Price, Cohen, & Johnson, 2005).

Natural fibers. Natural fibers are often perceived to be sustainable (Hawley, 2015). However, while these fibers come from naturally-occurring sources, their cultivation and processing involves a wide range of unsustainable practices such as large amounts of water and energy use, extensive use of harmful chemicals in the form of fertilizers and pesticides (Fletcher, 2008; Karthik & Gopalakrishnan, 2014). For example, wool production is linked to land deterioration due to overgrazing, pollution from pesticides applied to animals for preventing parasite infestation, effluents containing wool grease sludge with solid impurities, and use of chemicals to improve fiber properties (Fletcher, 2008; Karthik & Gopalakrishnan, 2014).

Cotton. Production of cotton is linked to many environmental problems, such as excessive land use and erosion, water depletion due to irrigation, high levels of fertilizer and pesticide use and subsequent contamination of soil, water, wildlife, and human health issues (Hansen & Schaltegger, 2016; Karthik & Gopalakrishnan, 2014). Cultivation of one kilogram
of cotton requires 8,000 liters of water, while production of one kilogram of polyester uses little or no water (Fletcher, 2008). However, twice the energy required for cotton production is required for polyester production. While cotton occupies only about 3% of the global agricultural land, 25% of the global pesticide use is for cotton cultivation (Hansen & Schaltegger, 2016).

**Organic cotton and hemp.** Organic cotton is seen as a more sustainable alternative to conventional cotton (Fletcher, 2008; Hansen & Schaltegger, 2016). It is environmentally-friendly in the sense that it is produced using crop rotation, often rain irrigation (about 60%), and without harmful chemicals (Karthik & Gopalakrishnan, 2014). However, these organically grown fibers are associated with lower crop yield and are cost-intensive due to increased need for manual labor (Hansen & Schaltegger, 2016). Although organic cotton has seen a rise in popularity in recent years, it still constitutes only about 1% of the total global cotton production (Hansen & Schaltegger, 2016). Hemp fiber, due to its higher yield, beneficial effects on soil structure, and low requirements for pesticides and fertilizers, has been considered as a more sustainable fiber alternative (Fletcher, 2008). However, the difficulty of textile production due to fiber characteristics as well as government regulations are constraining its wide acceptance (Hansen & Schaltegger, 2016). Due to its narcotic properties, cultivation of hemp is banned in many countries (Fletcher, 2008).

**Synthetic fibers.** Synthetic fibers might appear to be a better choice in terms of environmental impact as they have the potential to be continuously recycled into new products, resulting in zero waste (Hawley, 2015). However, the recycled materials are often of lower quality than virgin fibers (Karthik & Gopalakrishnan, 2014). Conventional synthetic fibers are not sustainable due to their dependency on petrochemicals as a fiber source and for
energy required for production, toxic emissions to water and air (Fletcher, 2008). These fibers are not biodegradable and, if not repurposed, synthetic products take dozens of years to degrade, polluting the environment. High environmental and social costs are also associated with the vast web of pipelines and other infrastructure required for extracting, transporting, and processing oil (Fletcher, 2008). Another often-overlooked negative aspect related to the use of synthetic materials in consumer goods is the leakage of non-biodegradable particles, due to continuous product abrasion, into the environment, causing harmful effects on nature and humans (Hansen & Schaltegger, 2016).

**Regenerated synthetic fibers.** Regenerated synthetic fibers such as rayon, acetate, and lyocell are made of cellulose from wood pulp, which is chemically processed and extruded as continues filaments (Fletcher, 2008; Thangavelu & Subramani, 2016). Viscose rayon, originally known as artificial silk, accounts for about 90% of all regenerated synthetic fibers produced (Rana, Pichandi, Parveen, & Fangueieo, 2014b). The production of this fiber is laden with heavy environmental impacts as the wood pulp cellulose used comes mostly from mature forests, contributing to depletion of natural resources, and its processing requires large amounts of harsh chemicals, causing water and air pollution (Fletcher, 2008; Karthik & Gopalakrishnan, 2014). Lyocell is considered a more environmentally friendly regenerated fiber as its production involves using wood pulp from trees specifically grown for this purpose and use of significantly less hazardous chemicals for processing, which are then recovered, purified and recycled (Karthik & Gopalakrishnan, 2014).

**Leather.** Leather is another widely-utilized material for fashion products. Leather production is especially harmful to the environment and human health due to hazardous chemical use and waste generation (Cao, Wool, et al., 2014). For example, Chromium VI, a
known carcinogen, is used in 90% of global leather tanning production. It is not fully absorbed by or bound to leather and ends up in large amounts in effluent streams, causing large-scale pollution (Kanagaraj, Senthilvelan, Panda, & Kavitha, 2015). Significant amount of solid waste is generated during leather production, composed of skin’s non-fibrous proteins released during treatment processes, fibrous proteins such as hair and flesh, raw hide trimmings, shavings, leather strips, and lime and chrome sludge (Kanagaraj et al. 2015). In addition, ethical issues related to animal welfare and consumption of animal skins and furs for fashion are also important concerns (Plannthin, 2016).

**Presence of harmful chemicals in conventional materials.** Another negative aspect related to use of conventional materials for fashion products is the presence of harmful chemicals within the materials. From fiber to finished goods, production of these materials involves many chemical processes (Swedish Chemical Agency, 2013). Multiple treatments are used for enhancing material appearance and performance qualities (e.g., dyes, fire retardants, stain repellents) (Dickson et al., 2009). At least 1,900 chemicals are used in textiles production, out of which 165 have been identified to be hazardous, including substances considered to be carcinogenic, mutagenic, allergenic, and have long-term hazardous effects on the environment (Swedish Chemical Agency, 2013).

While there is a range of natural and synthetic fibers available, a limited number of fiber types dominate the industry, causing significant environmental problems such as depletion of natural resources, pollution of water stream, soil, and air due to emissions and tremendous amount of waste (Fletcher, 2008). Hansen and Schaltegger (2016) state that either alternative farming or production systems have to be adopted, or alternative fibers and materials sought to ensure availability of sustainable materials for fashion products.
Innovative Sustainable Materials

As global drive for sustainability in the fashion industry intensifies, the interest and demand for new sustainable materials, processes, and products follows. Sustainable can be considered materials that have no or minimal negative environmental, economic, and social impacts during their entire lifecycle. As building blocks of fashion products, fibers and materials are often a starting point for sustainable product development (Kozlowski et al., 2016).

**Bio-based renewable materials.** Global environmental concerns such as depletion of natural resources and overflowing landfill space have resulted in increased interest in bio-based renewable and biodegradable fiber sources. Bio-based materials refer to materials derived from biomass, which is a “nonfossilized and biodegradable organic material originating from plants, animals, and micro-organisms” (Kabasci, 2014, p. 2). Especially of increased interest have been rapid renewable and annually renewable fibers, where the crop regrows in less than three years and one year, respectively (Fletcher, 2008). Renewable fibers have been extracted from natural sources such as starch, cellulose, animal or plant proteins, fats and oils, or synthesized through microbial fermentation and polymerization (Miner et al., 2014).

Within this context, new types of biodegradable renewable fibers made from plant-based sources have gained significant prominence (Fletcher, 2008). A notable example is the polylactic acid (PLA), a biodegradable fiber obtained from corn, sugar beet, and sugarcane (Rana et al., 2014a). PLA shares many similar characteristics with common thermoplastic fibers and is the first synthetic fiber produced from renewable sources that can be melt-processed (Thangavelu & Subramani, 2016).
**Protein-based renewable fibers.** Other renewable fibers include casein fibers produced from milk protein and intended to compete with wool, chitin fibers derived from cuticular and exoskeleton of invertebrates (e.g., crabs, shrimp, insect), and chitosan found in cell walls of fungi, molds, and yeasts (Rana et al., 2014a; Thangavelu & Subramani, 2016). Chitin can be produced from seafood industry waste (Rana et al., 2014a). Spider silk is another renewable protein fiber that has gained significant interest because of its unique properties such as outstanding mechanical strength, elongation, and resiliency. However, farming and production of spider silk is still in early stages (Thangavelu & Subramani, 2016). Another potential protein fiber that has gained attention is obtained from Hagfish slime, composed of mucins and seawater held together by long protein threads, which is extruded by the animal as a defensive mechanism (Thangavelu & Subramani, 2016).

**Plant-based renewable fibers.** Alginate fibers, extracted from seaweed sources (e.g., brown algae kelp, sargassum) have also been explored as renewable biodegradable fibers (Rana et al., 2014b; Thangavelu & Subramani, 2016). Bamboo fibers, made of cellulose obtained from fast-growing bamboo grass have long been considered sustainable renewable source for fiber production. However, the majority of bamboo fibers today are produced following the production method of viscose rayon, which is heavy on aggressive chemical use, thus is not sustainable (Karthik & Gopalakrishnan, 2014). Other plant-based fibers that have been explored as sources for sustainable fashion products include pineapple leaf, sisal leaf, nettle, ramie, jute, coconut shell and banana stem fibers (Debnath, 2016).

Another group of renewable fibers from agricultural sources—plant or vegetable oils—have been investigated as raw materials for sustainable product development, due to their abundance, low price, and renewable character (Miner et al., 2014). Soybean oil, linseed
oil, rapeseed oil, and palm oil have the potential to substitute petrochemical-based fibers and materials (Cao, Wool et al., 2014). Soybean oil is the most abundant and less expensive vegetable oil globally, and can be a byproduct of soybean flour production (Miner et al., 2014). Cao, Wool et al. (2014) used palm, soybean and linseed oils, combined with chicken feather fibers, to develop leather substitute (eco-leather), thermosetting resin, and hard composites. In combination with 100% organic cotton and C2C certified wool fabrics, these materials were used to develop sustainable shoes and a coat prototype (Cao, Wool et al., 2014).

**Innovations in leather.** Innovation in sustainable leather production has been a focus in academia as well as fashion industry. For example, Modern Meadow (n. d.) has developed a novel technology to “biofabricate” leather without an animal by growing collagen (a protein found in the skin) from animal cells, from which leather material is developed. The leather developed with desired structural and aesthetic properties, is tanned and finished using ecologically-mindful processes. Recently, Nike has also reported developing new sustainable leather substitute called Flyleather that is composed of 50% of recycled natural leather fiber, fused with other synthetic fibers and processed to look like natural leather (Nike News, 2017). It is important to note that many fibers derived from various animal and plant sources are still in development stages (Rana et al., 2014a), thus are not feasible sources for wide-scale fiber and material production for the fashion industry.

Bacterial cellulose (BC) produced by several species of bacteria is another novel fiber source that has been investigated in a number of industries (Radhakrishnan, 2014; Shat et al., 2013). Yet, very little research has been done on BC in the field of fashion. BC, discussed in the next section, is a promising innovative renewable material that can help the fashion
industry reduce its negative environmental and social impacts. High mechanical strength, moldability, biocompatibility, purity, porosity, and other characteristics allow BC to be a remarkably versatile material (Gama et al., 2014; Miner et al., 2014) that can be used for fashion products.

**Bacterial Cellulose as a Novel Sustainable Material**

Bacterial cellulose (BC) is a biopolymer that can be produced by several species of bacteria, the most important of which is *Gluconacetobacter xylinus* (*G. xylinus*) identified in 1886 (Gama et al., 2013). Cellulose produced by bacteria has molecular formula and morphology similar to that of plant cellulose; however, bacterial cellulose is pure and does not require additional processing to remove impurities such as lignin, pectin and hemicellulose that are part of plant-based cellulose (Lin et al., 2013). *G. xylinus* can be found in nature, in places such as rotting fruits or other places that have fixed sources of carbon such as sugars or alcohol—it is able to make use of various sugars and other compounds for synthesizing cellulose (Saxena & Brown, Jr., 2013).

**BC production.** BC can be produced in laboratory conditions through static (stationary) or agitated (shaking) culture cultivation (fermentation) methods. In agitated cultivation, small BC particles or pellets are produced (Saxena & Brown, 2013). In static cultivation method, the cellulose is formed on the surface (air-liquid interface) of the culture medium in a stationary container. In this case, a cellulose membrane or pellicle is produced on the entire culture medium surface conforming to the form of the container (Shah et al., 2013). During the static cultivation process, “the glucose chains produced inside the bacterial body extrude out through tiny pores present on their cell envelope,” which then combine and form microfibrils, which in turn aggregate to form cellulose ribbons (Shah et al., 2013).
These nanofiber ribbons later form a highly porous web network structure (Shah et al., 2013) referred to as pellicle, membrane, sheet, mat, film, etc., in the literature (Jozala et al., 2016; Mikkelsen, Flanagan, Dykes, & Gidley, 2008; Miner et al., 2014). As the cultivation time increases, the membrane becomes thicker, growing downward until, due to oxygen insufficiency, the cells entrapped in the membrane become inactive or die (Shah et al., 2013). BC can be shaped into 3-dimensional structures during cultivation using various molds and porogens (Gama et al., 2013).

Various BC composites have been synthesized by incorporating a variety of materials, ranging from organic polymers to inorganic nanoparticles, where BC served as a support matrix or a reinforcing material (Miner et al., 2014; Shah et al., 2013). The BC composite synthesis is mainly done via in situ addition of reinforcement material to BC culture media or ex situ addition of reinforcement materials into BC fiber structure (Shah et al., 2013). Composites allow modification and enhancement of BC properties to be used in various applications such as in biomedical field (wound dressing, burn treatments, tissue engineering, etc.), electrical devices, conductive material, sensors, foods, packaging and cosmetics, etc. While BC has been valued for its porosity and moisture-holding capacity, recent research has also focused on increasing hydrophobicity of the material for improving its barrier properties (Silva, Andrade & Gama, 2013).

**Directions for BC improvement.** A major direction in BC research has been the improvement of cellulose production and yield (Shah et al., 2013). In this respect, studies have focused on the role of the fermentation conditions (static or agitated), different nitrogen and carbon sources, various strains of bacteria, and other aspects of BC production (Nguyen, Flanagan, Gidley, & Dykes, 2008). For example, mannitol, glucose, glycerol, fructose,
sucrose, and galactose have been used as carbon sources and supported BC growth (Mikkelsen et al., 2009). Another direction is the identification of alternative and more economical raw sources for BC production, which includes low cost agricultural products and industrial or agricultural wastes such as waste of beer fermentation broth, distillery effluents, rice bark, wheat straw, cotton textile waste, etc. (Hong, 2012; Jahan, Kumar, & Saxena, 2017; Shah et al., 2013).

**Kombucha fermentation of BC.** Among various BC forms synthesized by different species of bacteria, a unique BC variety can be easily produced through fermentation of Kombucha (Nguyen, 2008; Zhu et al., 2014), a popular health drink obtained through fermentation of sweetened tea. BC membrane is produced at the surface of the fermenting tea, as fermentation progresses (Zhu et al., 2014). This flat membrane, when removed and dried, results in a leather-like material, which can be used in fashion products. While BC has been studied for multiple applications, from biomedical tissue engineering through wound dressing to foods and cosmetics (Gama et al., 2013; Miner et al., 2014), research on its use in the fashion industry is very limited.

**BC advantages and challenges.** Among many advantages of BC is its high purity, in comparison to plant cellulose, and the fact that no harsh chemicals are required for production (Kucinska-Lipka, Gubanska & Janik, 2015; Lee, 2011). However, BC presents several challenges as a potential material for fashion products. Lee (2011) reported that leather-like BC material could absorb moisture and liquid from the environment and human body, resulting in swelling and softening of the material. With the objective of producing BC mats with reduced absorbency, Lee, Xiang, Ghalachyan, Ramasubramanian, Li, and Farr (2014) coated the mats with polylactic acid (PLA) nanofibers via electrospinning.
evaluation revealed the need for additional coating as one layer did not provide adequate barrier against moisture absorption (Lee et al., 2014).

A research group in Queensland University of Technology used BC to make fashion products such as shoes and jackets (Smail, 2016). They used coconut oil to make it supple and flexible. It was reported that the material was hard to sew, but molding it and gluing worked better (Smail, 2016). In another study, Wood et al. (2015) investigated the influence of fermentation conditions on BC physical and mechanical properties and the potential of producing material that is inherently colored. Natural dyes (e.g., saffron, beet, turmeric) and blue artificial dye were successfully used to grow colored BC (Wood et al., 2015). The tensile strength and elongation of BC was found to be higher than most nonwoven fabrics used for consumer goods, and the tearing strength and stiffness was similar (Wood et al., 2015).

BC is a promising renewable bio-based material with a great potential for applications in fashion products. Using bio-based materials can help the industry become less reliant on non-renewable petroleum, reduce demand for other natural resources, and contribute to reduction of the industry’s environmental and social impacts (U. S. Department of Agriculture, n. d.). In terms of renewability rates and cellulose yield, BC can offer outstanding advantage as the fiber mats with desired shape, size, thickness, and other characteristics (e.g., color) can be cultivated within several weeks, making it ‘monthly’ renewable material (1-4 week cultivation process). BC is a:

…fascinating material. From one hugely efficient, single production method, at least three direct products can be obtained: a health drink, a foodstuff, and potentially a
‘vegetable’ material. In a process that takes about ten days, the material can be harvested by simply lifting it off the liquid. (Launch, n. d., para. 3).

The BC growth medium/liquid can be reused for cultivating new cellulose. Moreover, a sustainable closed-loop production could be set up, where the cellulose would be used as renewable material for making fashion products and the liquid could be used as Kombucha health drink. Produced from Kombucha, using common natural ingredients, BC and products made with it could become biological nutrient at their end-of-life stage (McDonough & Braungart, 2002). When not needed any more, they can be composted or become fertilizers for farmers, re-entering the biological cycle instead of going to ‘grave.’ After customers are finished using a product that is designed to be a biological nutrient, they can “throw it onto the soil or compost heap without feeling bad—even, perhaps, with a kind of relish” (McDonough & Braungart, 2002, p. 109).

Fibers and materials are building blocks of any fashion product. Material selection can play a big role in what effects the product will have on the environment and human life during its entire lifecycle. Conventional materials used in today’s fashion industry greatly contribute to the environmental degradation and social problem. Using innovative sustainable materials such as BC can help the fashion industry become more sustainable.

**Sensory Evaluation of Materials and Products**

Sensory science was developed for food products and has its roots in physiology, psychology and psychophysics (Chambers IV & Wolf, 1996; Moskovtz, Munoz & Gacula, 2008). Sensory evaluation is “used to evoke, measure, analyze and interpret reactions to stimuli perceived through the senses” (ASTM E253-15a, 2015). Stone et al. (2012) provide
an appended definition that specifies: “… reactions to those characteristics of foods and materials as they are perceived by the senses of sight, smell, taste, touch, and hearing” (p. 15). Significant part of the sensory testing techniques has been developed in the food sciences field, however, these methods have also been used for non-food product evaluation (Moskovitz et al., 2008).

For conducting sensory evaluation, it is important to understand how sensory evaluation is processed and integrated in the brain (Stone et al., 2012). Each of the five senses has their own “unique receptors and neural pathways to higher and more complex structures of the brain” and, while “at the periphery, receptors for a specific sense respond to a specific type of stimulation that is unique to that system”, at higher centers in the brain, “considerable integration occurs” (Stone et al., 2012, p. 18). This means that “products are a complex source of stimulation and that stimulation will not be exclusive to a single sense, such as vision or taste” (Stone et al., 2012, p. 18). This principle is considered a fundamental component of sensory evaluation, and failure to account for it can result in partial or inaccurate evaluations. For example, requiring consumers to evaluate only one sensory attribute can result in more variable and less sensitive responses as perceptions and evaluations related to the other senses will be embedded in these responses (Balaji, 2011; Stone et al., 2012).

Traditionally, sensory evaluation has relied on trained experts to ensure objective assessment of product characteristics. Experts not only have extensive training but a high degree of sensory acuity as well (ASTM E253-15a, 2015). Selecting and training experts can take several months, as they have to be selected based on certain sensory perception
thresholds and need to become proficient in test procedures, meaning of sensory descriptors and language (Stone et al., 2012).

Free-Choice Profiling descriptive evaluation method, introduced by Williams and Langron (1984), is an approach that does not require assessor screening and training, and has been used for sensory evaluation with ‘naïve’ consumers (Deliza, MacFie & Hedderley, 2005; Guardia, Aguiar, Claret, Arnau & Guerrero, 2010). The Free-Choice Profiling allows assessors to use their own words to describe sensory characteristics of a product, after which they rate the intensity of those characteristics (Stone et al., 2012, ASTM 253-15a, 2015). A wide range of methods have been developed and used for sensory evaluation, classified in three main categories: descriptive, discrimination, and affective (Stone et al., 2012).

Descriptive analysis is used to describe and quantify sensory attributes of a stimulus by a panel of assessors (ASTM E253-15a). This category includes methods such as Flavor Profile, Quantitative Descriptive Analysis, Qualitative Descriptive Profiling, Free-Choice Profiling, etc. (Stone et al., 2012). Discrimination tests, such as Duo-Trio or Paired-Comparison tests are used for determining differences among two or more stimuli (ASTM E253-15a).

Affective methods of sensory evaluation measure product acceptance, preference or liking (Philippe et al., 2003; Stone et al., 2012).

**Sensory Evaluation of Apparel**

Sensory evaluation of apparel products has been generally focused on the tactile and appearance properties (Balaji et al., 201; Phillippe et al., 2003). Tactile comfort, particularly, has received much attention by researchers. In fact, many scholarly articles use the term ‘sensory’ interchangeably with tactile or touch sensation. Along with psychological and thermal comfort, tactile comfort is one of the defining aspects of overall clothing comfort.
(Stankovic & Bizjak, 2014). “Tactile comfort relates to the mechanical interaction between clothing material and human body” (Stankovic & Bizjak, 2014, p. 203). According to Cardello, Winterhalter, and Schutz (2003), two fundamental dimensions of sensory experiences occur during the contact of human skin with clothing material. The first dimension relates to specific sensations or sensory attribute being experienced such as roughness and softness. The second is the quantitative intensity or magnitude of the specific sensations experienced such as extremely rough or very soft. Both of these dimensions have to be examined and identified for drawing conclusions about tactile sensory perceptions (Cardello et al., 2003).

Multiple instrumental and subjective methods have been used for measuring tactile properties of textiles. AATCC 5-2011 test method, for example, provides guidelines for the subjective evaluation of fabric hand, which is the perception of fabric characteristics experienced through sense of touch when fabric is handled by hands. ASTM D6828-02 is a test method for measuring fabric stiffness by using a Handle-O-Meter instrument (An, Gam & Cao, 2013). Kawabata Evaluation System for Fabrics (KES-F) is an existing objective evaluation tool for fabric tactile properties based on its physical, mechanical, thermal and surface characteristics (Bacci et al., 2012; An et al., 2013).

Phillippe et al. (2003) applied sensory evaluation techniques for textile product evaluation. Specifically, a trained panel for sensory evaluation was developed and used for descriptive sensory evaluation of various fabrics. However, this involved evaluation of fabric tactile properties only. To date, no study was found that conducted a complete sensory evaluation of materials for fashion products. Given the increased importance of new fibers and materials, as well as rapid development of wearable technology and smart textiles and
clothing, conducting a complete sensory evaluation becomes essential for understanding consumer acceptance of novel products and materials. As novel fibers and non-textile components are incorporated into fashion products, only tactile and/or visual evaluation methods may not be able to capture and assess the complete sensory characteristics of products as perceived by consumers.

**Human Perception**

Perception is the process by which the sensations experienced through the sensory receptors (eyes, ears, nose, mouth, fingers) in response to stimuli (e.g., sound, texture) are selected, organized, and interpreted (Solomon & Rabolt, 2004). “The study of perceptions, then, focuses on what we add to or take away from these raw sensations as we choose to notice, and then go about assigning meaning to them” (Solomon & Rabolt, 2004, p. 290). The perceptual process includes *exposure, attention, and interpretation* stages. Abraham-Murali and Littrell (1995) explain that consumers use two perceptual modes to identify product attributes: data driven mode and concept driven mode. In the data driven mode, consumers use their senses to obtain information about concrete product characteristics such as color and feel. In concept driven perceptual mode, “the consumer engages in cognitive abstraction and associations to bring about intangible, abstract attributes, such as whether a garment will be easy to care for or will give confidence to the wearer” (Abraham-Murali & Littrell, 1995, p. 66).

**Consumer Evaluation of Apparel Products**

Evaluation of apparel products involves “taking a critical look at the decisions made in the design process” to guide further design development (Watkins & Dunne, 2015). This
assessment phase might include consumer testing of new products or prototypes. As Fiore and Damhorst (1992) note, the fact that a product meets specifications set forth by product designers does not necessarily mean that it will satisfy consumer needs and preferences. For developing successful products, it is critical to understand how consumers perceive and evaluate new products and what evaluative criteria they use in the process (May-Plumlee & Little, 2006). Evaluative criteria are attributes or dimensions used to evaluate products and make purchasing decisions (Forney et al., 2005; Jeong & Lee, 2014). Eckman et al. (1990) describe evaluative criteria as “manifestations of the consumer’s underlying values and attitudes, stored information and experience, and various psychological, sociological, and economic influences” (p. 13).

Apparel evaluative criteria have been the focus of many studies, where various criteria and classification schemes were used. Table 2.1 presents a summary of attributes and classification schema from most prominent studies. Evaluative criteria have often been classified and studied based on extrinsic and intrinsic cues. Intrinsic cues are tangible product attributes that are inherently part of the product and cannot be altered without physically changing the product (Eckman et al., 1990; Swinker & Hines, 2006). Examples of intrinsic attributes are fiber content and color. Extrinsic cues are not a physical part of the product, and changing them will not affect the product (Eckman et al., 1990; Forney et al., 2005). These include price, brand, country of origin, and store that product is sold in.

Eckman et al. (1990) and Forney et al. (2005) specify that extrinsic attributes are assigned by retailers or manufacturers. However, classifications of extrinsic attributes have also included attributes like ‘approval of others’ or ‘coordination with wardrobe’ (Eckman et al., 1990), which are consumer defined.
Table 2.1

Apparel evaluative criteria identified in extant research

<table>
<thead>
<tr>
<th>Authors/study</th>
<th>Evaluative criteria/product attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eckman et al. (1990)</td>
<td><strong>Aesthetic criteria (5)</strong>: Color/pattern, styling, fabric, uniqueness, appearance</td>
</tr>
<tr>
<td></td>
<td><strong>Usefulness criteria (4)</strong>: Versatility, matching, appropriateness, utility</td>
</tr>
<tr>
<td></td>
<td><strong>Performance and quality criteria (4)</strong>: Fit, comfort, care, workmanship</td>
</tr>
<tr>
<td></td>
<td><strong>Extrinsic criteria (3)</strong>: Price, brand, competition</td>
</tr>
<tr>
<td>Fiore &amp; Damhorst (1992)</td>
<td>(16 total attributes classified in 4 categories)</td>
</tr>
<tr>
<td></td>
<td><strong>Intrinsic cues, including aesthetic attributes</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Layout (6)</strong>: Garment style, silhouette and shape (overall and parts), fashionability, coordination with existing wardrobe, compatibility of style with body, situational appropriateness</td>
</tr>
<tr>
<td></td>
<td><strong>Fabric (7)</strong>: Overall pleasingness of fabric, feel or hand of fabric, weight of fabric, fabric selection for the style, fiber content, care, well-constructed</td>
</tr>
<tr>
<td></td>
<td><strong>Newness (2)</strong>: Novelty, style</td>
</tr>
<tr>
<td></td>
<td>(15 cues classified in three categories)</td>
</tr>
<tr>
<td>Lamb &amp; Kallal (1992)</td>
<td><strong>Functional (5)</strong>: Fit, mobility, comfort, protection, donning/doffing</td>
</tr>
<tr>
<td></td>
<td><strong>Expressive (4)</strong>: Values, roles, status, self-esteem</td>
</tr>
<tr>
<td></td>
<td><strong>Aesthetic (3)</strong>: Art elements, design principles, body/garment relationship</td>
</tr>
<tr>
<td></td>
<td>(12 needs/criteria classified in 3 categories)</td>
</tr>
<tr>
<td></td>
<td><strong>Physical appearance (4)</strong>: Fabric (e.g., content, weight), color/pattern/texture, construction (e.g., even hems), styling (e.g., neckline, sleeve style)</td>
</tr>
<tr>
<td></td>
<td><strong>Physical performance (5)</strong>: Fabric, color (e.g., does not fade), care (e.g., washable, easy care), workmanship (e.g., strong seams, zipper does not break), garment (e.g., hold shape, fits well, easy to put on)</td>
</tr>
<tr>
<td></td>
<td><strong>Expressive (4)</strong>: Looks good on me, provides scope for individual creativity, appropriateness to lifestyle, comments of others</td>
</tr>
<tr>
<td></td>
<td><strong>Extrinsic (6)</strong>: Brand, price, store/catalog, country of origin, care label, service</td>
</tr>
<tr>
<td></td>
<td>(19 total attributes classified in 4 categories)</td>
</tr>
</tbody>
</table>
Table 2.1 continued

<table>
<thead>
<tr>
<th>Authors/study</th>
<th>Evaluative criteria/product attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiore &amp; Ogle (2000)</td>
<td><strong>Aesthetic benefits</strong>&lt;br&gt;<strong>Formal benefits</strong> (2): Beauty, sensual pleasure&lt;br&gt;<strong>Expressive benefits</strong> (2): Aroused emotion, creative expression&lt;br&gt;<strong>Symbolic benefits</strong> (3): Alternative existence, cognitive challenge, identity&lt;br&gt;<strong>Instrumental benefits</strong>&lt;br&gt;<strong>Formal benefits</strong> (5): Efficiency, physical comfort, physical protection and safety, sexual attractiveness, structural quality&lt;br&gt;<strong>Expressive benefits</strong> (3): Reflected emotion, regulated emotion, spiritual ecstasy&lt;br&gt;<strong>Symbolic benefits</strong> (5): Quest for knowledge, self-acceptance, social acceptance and affiliation, spiritual protection, status&lt;br&gt;(20 total benefits classified in two categories with three subcategories each)</td>
</tr>
<tr>
<td>Swinker &amp; Hines (2006)</td>
<td><strong>Informational cues</strong>&lt;br&gt;<strong>Extrinsic cues</strong> (3): Brand name, country of origin, cost&lt;br&gt;<strong>Intrinsic cues</strong> (3): Garment construction, fabric, notions and findings used&lt;br&gt;<strong>Appearance cues</strong> (5): Color, design features, fashionability, fabric feel, style in relations to figure&lt;br&gt;<strong>Performance cues</strong> (5): Garment care, garment holding shape, fabric pilling, wrinkling, durability&lt;br&gt;<strong>Expectations for high-quality garments</strong>&lt;br&gt;<strong>Aesthetic</strong> (2): Fashionable vs. less fashionable, more style details&lt;br&gt;<strong>Economic</strong> (2): Lasts longer than lower quality, quantity vs. quality&lt;br&gt;<strong>Physiological</strong> (2): Better fit, comfort&lt;br&gt;<strong>Social/psychological</strong> (5): Feel good about self, feel more positive, more accepted, more knowledgeable, more successful&lt;br&gt;(16 cues classified in 4 categories and 11 expectations classified in 4 categories)</td>
</tr>
<tr>
<td>Jeong &amp; Lee (2014)</td>
<td><strong>Intrinsic criteria</strong> (6): Color, comfort, design, fabric, fit, workmanship&lt;br&gt;<strong>Social criteria</strong> (4): Advertising, model, country of origin, brand&lt;br&gt;<strong>Economic criteria</strong> (2): Price, discount&lt;br&gt;(12 criteria classified in three categories)</td>
</tr>
</tbody>
</table>

Abraham-Murali & Littrell (1995) stated that in addition to objective product attributes, consumers also evaluate products based on abstract attributes “ascribed to the product by the user” (p. 65). It is apparent that classifying evaluative criteria in intrinsic and
extrinsic categories may not accurately and fully reflect all criteria used by consumers to evaluate products.

Eckman et al. (1990) conducted interviews in retail settings to elicit descriptions of evaluative criteria in the consumers’ words. Based on this study, focused on women’s apparel, 17 criteria were identified and grouped in four general categories: (a) aesthetic criteria, (b) usefulness, (c) performance and quality, and (d) extrinsic criteria (Table 2.1). Aesthetic criteria were found to be the most important to the women in the study. The authors note that open-ended consumer responses at the point of purchase setting revealed mostly surface criteria, possibly leaving out underlying criteria like fashion risk, prestige, symbolic meanings of garments, and others. Abraham-Murali and Littrell (1995) emphasized the importance of studying and defining these factors as they play an important role in product evaluation.

Abraham-Murali and Littrell (1995) attempted to create a comprehensive list of apparel attributes. Based on focus group interviews, 79 attributes used by consumers to evaluate apparel were identified and classified in four themes: (a) physical appearance, (b) physical performance, (c) expressive, and (d) extrinsic (Table 2.1). Compared to Eckman et al. (1990) classification, this study was more successful in identifying a broader range of attributes. While there is a considerable overlap of the categories between the two studies, such as performance or extrinsic attributes, some categories are different. For example, Eckman et al. (1990) classified ‘appropriateness’ and ‘matching’ under usefulness category, while Abraham-Murali and Littrell (1995) classify these as expressive attributes.

Fiore and Ogle (2000) stated that consumers evaluate products “based on optimum value received from the product or product environment,” where value was defined as “the
accumulation of perceived benefits derived by the consumer from acquisition, ownership, use, discussion about, or appreciation of the product or product environment” (p. 34). The authors classified 20 benefits into two categories: aesthetic and instrumental. Each category contains three sub-categories: (a) formal, (b) expressive, and (c) symbolic (Table 2.1). Aesthetic benefits are defined as “rewarding and pleasurable in and of themselves,” whereas instrumental benefits are utilitarian or functional in nature, and are “rewarding” as they help to achieve or gain external goals other than aesthetic experience, e.g., social or economic benefits (Fiore & Ogle, 2000, p. 36).

The formal benefits “refer to perceivable (sensory) features of the form or structure of the product or environment”, for example, color, shape, texture, line, balance, proportion, harmony, etc. (Fiore & Ogle, 2000, p. 37). Pleasant sensory stimulation derived from these features result in aesthetic values for consumers such as beauty and sensual pleasure. Consumers derive instrumental values from formal qualities as well such as physical comfort, quality, protection, sexual attractiveness. Expressive benefits “denote formal qualities used to express or evoke emotion,” which can be satisfying or pleasurable for its own sake (aesthetic value) or used to achieve therapeutic effects (instrumental value). Symbolic benefits help communicate ideas about a person or the surrounding environment. According to the authors, while aesthetic values derived from communication is cognitive pleasure from presentation of ideas, instrumental values (e.g., status, self-acceptance, social affiliation) involve “psychological comfort from symbolic meaning associated with ownership or use of a product and interaction with an environment” (Fiore & Ogle, 2000, p. 37).
Jeong and Lee (2014) investigated knitwear involvement as an antecedent of evaluative criteria (Table 2.1). Evaluative criteria adopted in this study from previous research included: (a) intrinsic criteria (design, color, fabric, comfort, fit, workmanship), (b) social criteria (advertising, model, country of origin, brand), and (c) economic criteria (price, discount). This classification differs from the other classifications mentioned earlier. While intrinsic criteria, similar to other studies, include product physical and performance/quality attributes, extrinsic criteria were divided into social and economic categories. Consumer ascribed criteria such as value, prestige, appropriateness, etc., were not included in the study.

Researchers have studied how consumers evaluate apparel in terms of perceived apparel quality. In some studies, the concept of quality was broadly defined to include a wide range of evaluative criteria that influence consumer perceptions of apparel quality and overall satisfaction. Swinker and Hines (2006) note that “consumers’ perceptions of clothing quality is multidimensional and include a variety of informational cues as well as personal expectations of a quality garment” (p. 219). From previous studies, Swinker and Hines (2006) composed a list of 16 evaluative cues and categorized them into four dimensions: (a) extrinsic cues, (b) intrinsic cues, (c) appearance cues, and (d) performance cues (Table 2.1). Four more categories were developed for consumer expectations for high-quality garments: (a) aesthetic, (b) economic, (c) physiological, and (d) social/psychological. Findings indicated that 75% of the informational cues and 36% of the expectations were used by respondents to evaluate apparel quality. Appearance cues and cost were found to be of greater importance in the consumers’ evaluations of apparel quality, followed by extrinsic and performance cues. Intrinsic cues that include construction, fabric, and notions attributes, were not found to be very influential in how the respondents evaluate apparel quality.
College students were the respondents in this study. With a different population, the results may have been different. Four expectations of high-quality garments (last longer, feel good about self, more style details, and feel more positive) were found to be most important.

In the above study, the authors separately classified and measured informational cues and consumer expectations. As the expectations of quality are used by consumers to evaluate apparel, just like informational cues, they act as abstract evaluative criteria and can be added in a single classification system with informational cues. The authors in this study listed cues such as color, design features, etc., under appearance category, while in other studies these attributes are labeled as aesthetic attributes.

Fiore and Damhorst (1992) examined the importance of intrinsic criteria, including aesthetic attributes, in consumer evaluations of apparel quality. Women’s sportswear pants were used in the study as evaluation stimuli. Based on the analysis, the following categories were identified: (a) layout, (b) fabric, and (c) newness (Table 2.1). The researchers noted that three attributes in fabric category (care, fiber content, and well-constructed) were performance indicators. Fabric care and construction were the strongest estimators of apparel quality. In addition, aesthetic attributes were important in perceived apparel quality. In this study, aesthetic attributes were considered part of intrinsic evaluative criteria, while in other studies aesthetics attributes were listed as a separate category. Layout category seemed to have most of the aesthetic attributes that coincide with aesthetic attributes in other studies. However, a few attributes do not seem to fit with intrinsic attributes as it is defined in other studies.
Consumer Needs as Evaluative Criteria

Criteria used by consumers to evaluate products reflect their values, attitudes, experiences, knowledge, as well as different economic, social, and psychological influences (Eckman et al., 1990; Jeong & Lee, 2014). Consumer needs and desires are also reflected in their product evaluation process. Functional-Expressive-Aesthetic (FEA) consumer needs model developed by Lamb and Kallal (1992) has been widely used for both identifying apparel-related consumer needs and evaluating apparel products or prototypes (Bye & Hakala, 2005; Gam et al., 2009).

According to this model, consumer needs, which serve as apparel design and evaluation criteria, are classified into functional, expressive and aesthetic considerations (Lamb & Kallal, 1992). Functional considerations relate to the utility aspects of apparel products and include fit, mobility, comfort, and protection (Lamb & Kallal, 1992). Communicative and symbolic aspects related to apparel products make up the expressive considerations and include values, roles, self-esteem and status. Aesthetic considerations relate to need for beauty and include color, texture, art elements, etc. The model includes: (a) functional dimension, which is similar to performance/quality dimensions in other classifications (Eckman et al., 1990; Swinker & Hines, 2006); (b) aesthetic dimension that is the same as appearance dimension in other classifications; and (c) expressive dimension that is similar to expressive/symbolic and social/psychological dimensions.

While the FEA model provides a useful framework, it does not fully address the criteria consumers use when evaluating apparel products. For example, price or country of origin are extrinsic product characteristics that are not addressed by the FEA model. Other examples of important criteria not included in the model relate to the structural or physical
aspects of the products such as fabric type, fiber content, product shape, type of closures used, etc. The FEA model does not fully address all possible evaluative criteria related to apparel. Research has shown that consumers evaluate apparel products based on a wider range of criteria, including extrinsic criteria such as price and country of origin, intrinsic criteria such as construction, fabric, fiber content, shape, style and other criteria (Abraham-Murali & Littrell, 1995; Fiore & Damhorst, 1992; Swinker & Hines). 2006).

Need for a Comprehensive Classification System

There is a need for a comprehensive and systematic classification that integrates and logically organizes various apparel evaluative criteria. Such classification can be used as a framework to clarify and simplify the use of evaluative criteria by researchers and businesses. It is important to reconsider and eliminate overlapping categories and evaluative criteria as presented in the existing classifications. Description of categories must be clarified as well. For example, extrinsic and intrinsic categories have been utilized in almost all studies reviewed; however, these terms can create confusion. Whereas some researchers have classified only product structural and physical attributes (e.g., fiber content, construction) under the intrinsic category (Swinker & Hines, 2006), others have also included product performance, quality, and aesthetic attributes (Fiore & Damhorst, 1992; May-Plumlee & Little, 2006).

The use of the term extrinsic as an evaluative category is also in need of reconsideration. Extrinsic category has generally included evaluative criteria such as price, store, brand, country of origin, and other similar manufacturer- or retailer-defined attributes that are not inherent part of products (Eckman et al., 1990). Yet, in a multidimensional classification system, the use of extrinsic category may imply that all other criteria are
intrinsic, which may not be accurate. For example, expressive criteria are not intrinsic part of products. Using terms that accurately describe distinct categories and do not overlap with the other categories can enhance a classification system, making it easier to understand and utilize.

A significant deficiency in the existing apparel evaluative criteria classification systems is the lack of a criterion related to sustainability. Consumers are increasingly aware of environmental and social issues and consider these in their product evaluations and purchasing decisions (Gam & Banning, 2011; Gleim, 2013). Fiore and Ogle (2000) specify that consumer perceptions and perceived value of products may be affected by a company’s practices such as child labor, among other issues. It is critical to include sustainability-related criteria in an evaluative classification. An integrated and expanded classification with distinct categories of evaluative criteria can provide a useful framework for examining and understanding consumers’ perceptions, evaluation process and decision-making related to fashion products such as clothing, footwear, accessories, etc.

Another deficiency in the existing classification systems is the lack of full consideration of human sensory modalities relevant to fashion products (i.e., sight, touch, hearing, smell). While sight (appearance) and touch (tactile properties) modalities are prevalent in fashion product evaluation, smell and hearing modalities are also important, as product can be experienced through these senses as well (Davis, 1996). Clothing and other fashion products can possess certain odors due to fibers, finishes, dyes and other substances used in the production process. A garment in a store, for example, a pair of jeans, could possess a chemical odor that can influence consumer evaluation of the product and purchase decisions. A product may also contain encapsulated essential oils to enhance its properties.
Similarly, a product can produce a sound during movement or interaction with other surfaces because of the type of fabric used and applied finishes. To ensure a more holistic representation of apparel attributes, it is also important to consider criteria related to smell and hearing sensory characteristics.

**Fashion Product Evaluation (FPE) Framework**

Consumers evaluate apparel products using a range of tangible and intangible criteria related to various structural, appearance, and performance characteristics, aesthetics, and symbolic, social and psychological aspects of product (Eckman et al., 1990). Based on the systematic review and analysis of the extant research on apparel evaluative criteria, a new framework for Fashion Product Evaluation (FPE) was developed. FPE framework is a comprehensive classification system that integrates apparel evaluative criteria, or product attributes, into four clearly defined categories.

**Tangible vs. Intangible Criteria**

To begin the classification process, all apparel evaluative criteria identified in extant research were grouped into two broad categories: tangible and intangible. Tangible, or intrinsic, criteria were defined as inherent or physical part of product, changing any of which would change the product itself (Eckman et al., 1990). All tangible criteria were classified into one, intrinsic, dimension. Tangible or intrinsic attributes relate to appearance of product and its compositional or structural aspects, for example, color, texture, style, shape, etc.

Intangible criteria included extrinsic characteristics that are not physical part of product (Abraham-Murali & Littrell, 1995). Changing intangible attributes would not physically alter the product. The majority of apparel evaluative criteria identified in extant
research (Table 2.1) were classified as intangible criteria. The intangible criteria were further grouped into the three distinct dimensions: (a) functional attributes, (b) marketing attributes, and (c) social-communicative attributes (Table 2.2 and Figure 2.1). Each of the dimensions is discussed below.

Table 2.2

*Fashion Product Evaluation (FPE) framework*

<table>
<thead>
<tr>
<th>Intrinsic attributes</th>
<th>Marketing attributes</th>
<th>Functional attributes</th>
<th>Social-communicative attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color/pattern</td>
<td>Brand</td>
<td>Comfort</td>
<td>Fashionability</td>
</tr>
<tr>
<td>Construction</td>
<td>Country of origin</td>
<td>Durability</td>
<td>Pleasing to others</td>
</tr>
<tr>
<td>Design features</td>
<td>Ethics/ social</td>
<td>Fit</td>
<td>Suitability</td>
</tr>
<tr>
<td>Materials</td>
<td>responsibility</td>
<td>Performance</td>
<td>Uniqueness/ novelty</td>
</tr>
<tr>
<td>Shape/silhouette</td>
<td>Price</td>
<td>Protection/safety</td>
<td>Identity/status</td>
</tr>
<tr>
<td>Style</td>
<td>Service</td>
<td>Versatility</td>
<td></td>
</tr>
</tbody>
</table>

During this classification process, each attribute identified in previous studies was carefully evaluated to decide which dimension it belongs to. The attributes within each dimension were compared and re-evaluated again to avoid repetitions. Redundant attributes were eliminated. For example, situational appropriateness (Fiore & Damhorst, 1992), appropriateness (Eckman et al., 1990), and appropriateness to lifestyle (Abraham-Murali & Littrell, 1995) were combined under the suitability attribute. It’s important to note that the framework does not present an exhaustive list of all possible apparel evaluative attributes. Instead, it summarizes and organizes major ones from previous research. Additional attributes can be added to each category.
Figure 2.1. Dimensions and interactions in Fashion Product Evaluation (FPE) framework.

**Intrinsic dimension.** Intrinsic attributes are inherent, tangible part of a product, and changing any of the attributes would alter the product itself. These attributes relate to product appearance, composition, and structure and are observable or perceivable through senses (Abraham-Murali & Littrell, 1995; Fiore & Ogle, 2000). Intrinsic attributes are determined by producers and retailers during product development and manufacturing stages.

Aesthetic and physical appearance criteria (Abraham-Murali & Littrell, 1995; Eckman et al., 1990) and intrinsic and appearance cues (Fiore & Damhorst, 1992; Jeong & Lee, 2014; Swinker & Hines, 2006) identified in extant research were considered for this category (Table 2.1). Attributes included in this category were color/pattern, texture, construction, design features, material, shape/silhouette and style of a product. While the
importance of these attributes can be context-, product- or consumer-specific, these are integral and tangible parts of fashion goods and are considered by consumers in evaluating products.

Color is one of the most important product aspects used by consumers to evaluate apparel and other fashion products (Stone & Farnan, 2017). Pattern of fabric, which is related to the color attribute, refers to arrangement of lines, shapes, spaces and color that creates distinct decorative effects (Davis, 1996). Color and pattern are inherent part of products, and are observable through sense of sight. These attributes give a product a distinct appearance, and changing them would alter the appearance and the product itself (e.g., red bag versus black bag). Material texture is another inherent attribute that can be perceived through touch and vision. Stone and Farnan (2017) define texture as “look and feel of material” (p. 13). Besides texture, various other material attributes could be used by consumers to evaluate fashion products, including fiber content, weight and other properties that help to define the material. Consumers may also use smell and sound attributes to evaluate products (Davis, 1996).

Construction is an important intrinsic attribute as well. It refers to how a product is put together and includes assembly techniques used in making the product such as how different components are joined, and the openings and closures (Davis, 1996). Design features refer to decorative elements used to enhance the appearance of products. Examples of design features include bows or buttons attached to parts of garment that have no functional purpose and are for decoration only. Decorative buckles on boots and other products are also design features. Style, another important intrinsic attribute, refers to a
distinctive appearance of a product achieved through combination of features that makes it different from other products (Stone & Farnan, 2017).

Marketing dimension. Marketing dimension includes product attributes that are defined or added by manufacturers or retailers to aid in promoting and selling products to consumers. Extrinsic and economic evaluative criteria identified in extant research were considered for this dimension (Table 2.1). Marketing attributes determine how much products cost, where they are made, what ethical considerations are followed, what services are included, etc. The following attributes are the most typical and important in the marketing dimension: brand (e.g., designer, retailer, manufacturer name), country of origin (where product was made), price, service (e.g., product warranty) as well as social responsibility/ethics (e.g., sweatshop free, fair trade) (Table 2.2).

Marketing attributes are intangible product characteristics that can be changed by retailers in response to market changes or other factors without physically affecting the product. For example, the product will not be physically affected by changing its price. Marketing attributes are used by retailers to increase product value in the eye of the consumer with the ultimate goal to generate sales. For example, emphasizing a brand’s ethical business practices may be used for this purpose.

Attributes such as brand name, country of origin, and price can be used by consumers to make inferences about overall product quality as well as reduce shopping effort and risk (Rahman, Yan, & Liu, 2009). For example, goods produced in developing countries can be perceived to be of lower quality, than those made in developed countries (Rahman, 2009). Ethics and social responsibility product aspects can also be used by consumers for evaluating fashion products. This attribute was not included in any of the previous classification
systems, however, was considered important to add. Research has shown that consumers have become increasingly aware of environmental and social issues related to production, distribution, consumption and disposal of fashion goods (Gleim et al., 2013; Ma, Gam, & Banning, 2017). Some consumers consider these issues in their purchasing decisions and show interest in environmentally-friendly and/or socially-responsible products (Gleim et al., 2013; Kozar & Hiller Connell, 2013). Sweatshop free, fair trade, sustainably sourced, and other characteristics can be included within the social responsibility attribute.

**Functional dimension.** Functional attributes are enabled by intrinsic attributes and are instrumental outcomes or benefits of using a product (Abraham-Murali & Littrell, 1995). To illustrate, a thicker fabric of a certain weave and fiber content (intrinsic attributes) can allow for a greater sturdiness of the product or provide better defence from cold temperatures. Durability and protection, functional product characteristics, are enabled by these intrinsic material properties. Evaluative criteria related to physical performance, quality, physiological, and other functional product characteristics identified in extant research were included in the functional dimension (Table 2.1).

In contrast to intrinsic attributes, which are tangible outcomes of decisions made by product developers or manufacturers, functional attributes are outcomes of consumer-product interaction. While intrinsic attributes exist without consumer involvement, functional attributes are only enabled or activated in the process of consumers interacting with products, for example, trying them on (enabling fit, comfort) or using them (enabling safety, performance). Functional attributes of the same product might be perceived differently by different consumers. In other words, they vary from consumer to consumer, as they are based on consumer subjective perceptions. For example, consumers could experience fit of a
garment differently—while one consumer may evaluate the fit as good, another could
evaluate it as bad.

In general, intangible criteria, including functional attributes, are more difficult to
assess as the evaluation is often done by consumers, whose perceptions, expectations, and
needs related to products may vary greatly. However, functional attributes are important
characteristics for product success, evidenced by the fact that many of these attributes may be
used by retailers as advertising tools. For example, an outdoor garment’s durability or the fit
of a breastfeeding top may be emphasized in advertisements.

Examples of functional attributes in the framework included: comfort, donning/doffing, durability (e.g., abrasion resistance, dimensional stability), fit (body-garment relationship), performance (antimicrobial, smart, etc.), protection/safety (environmental modifier), and versatility. Durability attribute relates to structural, compositional, and appearance integrity of a product over time. Product performance refers to products’ accurate functionality (Ulrich & Eppinger, 1995). It can be related to added functionalities of products (e.g., antimicrobial properties), intended to enhance the wearer’s experience. With fast development of wearable technology, functional requirements for the apparel products may go beyond the comfort, durability, and other usual aspect related to products. For example, consumers may evaluate products based on how well they assist, monitor, notify, encourage, or enhance various functions of the body and activities of the user.

**Social-communicative dimension.** Social-communicative attributes relate to product’s symbolic and communicative aspects that allow consumers to express or communicate their feeling and identities (Bye & Hakala, 2005; Lamb & Kallal, 1992). These
include intangible attributes such as fashionability, pleasing to others, suitability, and uniqueness/novelty. Social-communicative attributes are higher-level attributes enabled through complex interactions of tangible and intangible product attributes, and consumer-product interactions, all mediated by the culture. Culture represents a set of learned values, norms and symbols accepted by and used by a large group of people (Yurchisin & Johnson, 2010). It acts as a filter or mediator between consumers and their requirements of fashion products (Lamb & Kallal, 1992). Culture permeates all aspects of life in a society, including consumer perceptions of and decisions about marketing and functional product attributes. However, social-communicative dimension includes attributes that are primarily defined by culture/society (not consumer and not manufacturer or retailer).

Abraham-Murali and Littrell (1995) stated that, through mental processing, consumers could combine tangible attributes together into more abstract or ascribed attributes. Consumers can also synthesize a mix of tangible and intangible attributes into more complex attributes to make judgements and inferences about products. For example, consumers may combine tangible attributes such as color and style with intangible attributes such as brand and make an inference about product fashionability. Fashionability of a product is a socially-constructed phenomenon. What is fashionable in one society, or population segment within a society, might not be fashionable in another society or its part. This means that consumers must go through more complex mental processes to make inferences about product fashionability. In addition to synthesizing tangible and intangible attributes, consumers also use culturally-conditioned beliefs and values to evaluate products.

Suitability is another complex social-communicative attribute. It is multi-layered and can refer to appropriateness of products to the person, including appropriateness to body
type, facial features as well as age, personality, values, and lifestyle (Abraham-Murali & Littrell, 1995; Swinker & Hines, 2006). Suitability can also refer to product appropriateness to specific occasions and settings, such as work (Abraham-Murali & Littrell, 1995; Eckman et al., 1990; Fiore & Damhorst, 1992). These ‘appropriateness’ types reflect culturally-defined norms which consumers can use in combination with tangible and intangible product attributes to make judgements whether the product conforms to societal expectation for attire in a special occasion or a body type.

**FPE Framework Propositions**

The proposed FPE framework is based on logical and systematic classification schemata, law-like generalizations (propositions) that define each of the four distinct and mutually exclusive evaluative categories. Each of the four categories addresses a discrete dimension related to product properties and is enabled by different interactions of product-producer-consumer-society/culture. The following propositions have been developed for each dimension for classifying evaluative criteria:

- **Propositions about Intrinsic Attributes**

  P1. Intrinsic attributes are inherent, physical parts of products.

  P2. All tangible product attributes are intrinsic attributes.

  P3. Changing an intrinsic attribute will change the product itself.

  P4. Intrinsic attributes are perceived through human senses (i.e., sight, touch, hearing, smell).

  P5. Intrinsic attributes are related to product appearance, composition, and structure.

  P6. Intrinsic attributes are determined (enabled) by producers during product development and manufacturing.
• *Propositions about Marketing Attributes*

P1. Marketing attributes are added to products by producers and retailers to aid in promotion and sale of products.

P2. Marketing attributes are intangible.

P3. Changing marketing attributes will not change the product itself.

P4. Retailers create added value to attract consumers by controlling and modifying marketing attributes.

• *Propositions about Functional Attributes*

P1. Functional attributes are instrumental outcomes or benefits of using a product.

P2. Functional attributes are activated (actuated) in the process of product use by a consumer.

P3. Functional attributes are enabled by intrinsic attributes (e.g., thick material leads to warmness).

P4. Consumers might perceive and experience functional attributes of the same product differently (e.g., comfort).

• *Propositions about Social-Communicative Attributes*

P1. Social-communicative attributes are higher-level attributes that reflect ascribed meaning or symbol of a product within a culture/society.

P2. Social-communicative attributes are enabled through complex interactions of tangible and intangible product attributes as perceived by consumer and mediated by culture.

P3. Social-communicative attributes are *primarily* defined by culture/society (not by manufacturer/retailer or individual consumer).
The FPE framework can be useful in understanding how consumers characterize and evaluate products to make purchase decisions. It can also be helpful in identifying gaps between consumer needs and desired product characteristics, which can serve as bases for product improvements. This would ultimately lead to providing products that better fit consumer needs and expectation. Besides assessing finished products, the framework can be used in the fashion product development process to assess and identify consumer needs related to specific products, which would then serve as design criteria for making products that better address these needs. Despite the fact that many researchers have studied apparel evaluative criteria and proposed various classifications, FPE is the first framework that integrates evaluative criteria into a unified framework with clearly defined, mutually exclusive dimensions, based on a systematic review of extant literature and developing law-like generalizations.
CHAPTER 3. METHOD

The purpose of this research study was to investigate consumer perceptions of fashion products made of bacterial cellulose (BC), a sustainable novel material. More specifically, the aim was to understand (a) consumers’ perceptions of BC material based on the senses of touch, sight, smell, and hearing; (b) potential barriers to and motivations for consumer acceptance of fashion products made of BC; and (c) overall acceptability of the material from a consumer perspective. The research design and flowchart for the study are presented in Figure 3.1.

![Figure 3.1. Research design and flowchart.](image_url)

First, BC material was developed using the Kombucha fermentation process. The material was used in designing a women’s shoulder bag. Both BC material swatches and the bag itself then used for product evaluation, employing an embedded mixed methods research
design (Creswell, 2009). Qualitative analysis involving focus group discussions was the primary research method, and quantitative analysis involving sensory evaluation of the material was the secondary, embedded method. Data were collected during six focus group sessions in which participants independently completed sensory evaluation of material swatches, then participated in group discussion during which they examined the bag. Sensory evaluation and group discussion data were separately analyzed and, consistent with the nature of a mixed methods study, the results were integrated—compared, contrasted, woven in, and presented as theme-by-theme discussion of research of findings (Fetters, Curry, & Creswell, 2013).

**BC Material Development**

As described in Chapter 2, BC can be produced through fermentation of Kombucha, an acidic tea drink (Zhu et al., 2014). BC material sheets were developed in this study using traditional home-fermentation methods for preparing Kombucha. This process included three main stages: (1) preparation of fermentation medium (tea mixture); (2) fermentation and BC growth; (3) harvesting, treatment and drying of BC sheets.

**Preparation of Fermentation Medium**

The basic fermentation medium consisted of brewed tea with vinegar, sugar and starter culture of bacteria and yeast added. Specifically, the following components were combined to prepare the fermentation medium: distilled water (5L), green or black tea (6 tea bags), white 5% acidity vinegar (about 600 ml), cane sugar (about 500 g) and Kombucha culture (about 100 g), available from specialty stores and various on-line retailers. Large plastic rectangular containers were used for the media. The tea bags were initially brewed in
500 ml of boiled water in a 1L jar for 15 minutes, after which the tea bags were removed and sugar was added to the hot tea and mixed until dissolved. The sweetened tea was then poured into a plastic container, and the remaining water (4.5 L, unboiled) and the vinegar were added to the brew and mixed well to obtain uniform consistency. The Kombucha culture was added to the medium as a last step. The containers were covered with paper towels secured with clips to prevent dust or other foreign particles from entering the media while allowing unobstructed air flow (Figure 3.2).

![Figure 3.2. Media prepared with black and green teas for BC growth](image)

**Fermentation and BC Growth**

The containers containing the BC growth media were kept static and undisturbed at room temperature for approximately four weeks to allow the tea mixture to ferment and produce bacterial cellulose. Within a week of fermentation, a thin transparent BC film could be observed on the surface of the growth medium. BC films grew thicker and became more opaque as the fermentation time progressed, reaching a thickness of $\frac{1}{4} - \frac{1}{2}$ inches by the end of the fourth week (Figure 3.3). As discussed in Chapter 2, during the static cultivation process, BC conforms to the geometry of the container in which it is cultivated, and generally grows on the entire surface of the culture medium. This allowed obtaining rectangular BC sheets, as rectangular containers were used for fermentation.
Harvesting and Treatment of BC Sheets

The BC sheets were removed from the media container (harvested) and subjected to treatment procedures for purification and enhancement of their material properties (Figure 3.4). To get rid of excess sugars, stray cellulose strands, and other impurities such as tea particles, the sheets were washed in hot soapy water, left in the soapy water for 24 hours, then rinsed for about 30 minutes. This process also helped reduce the acidic, vinegary smell the raw material retains after harvesting. Several BC sheets were dyed with red onion skins to obtain reddish material (Figure 3.5). Onion skins were wrapped in cheesecloth and boiled in water for one hour to prepare the dye bath. The BC sheets were boiled in the dye bath for 40 minutes, then rinsed.
After the purification and dying processes, a thin coating of vegetable-based glycerin was applied to BC sheets (both sides) by spreading and rubbing it into the cellulose by hand. Glycerin, a natural humectant that helps to prevent moisture loss, was applied to enhance the flexibility and softness of the final BC material. It should be noted that drying purified BC sheets without such a treatment resulted in curling and bunching of the material, resulting in a final material that was non-uniform, extremely dry, and brittle. Figure 3.6 shows a comparison of a coated BC sample with an uncoated sample.

Glycerin was selected for treating the BC material because of its wide range of beneficial properties. Glycerin (or glycerol) is a clear, colorless and odorless liquid produced from both natural and petrochemical sources and used in a wide range of products ranging
from cosmetics and drugs to foodstuffs (Pagliaro & Rossi, 2012). It is compatible with many other chemical substances, highly stable in storage conditions, non-irritating, and has no known harmful environmental effects (Pagliaro & Rossi, 2012). Glycerin is also produced in abundance as a major byproduct of biodiesel production. Interest in and production of biodiesels has intensified in recent years due to environmental concerns, resulting in an excess supply of glycerin, and extensive efforts have been made to find new applications for it (Silva & Ferreira, 2012). These characteristics make glycerin a suitable candidate for applications related to sustainable products. Glycerin can also be used during the growth process of BC, replacing sugar in the fermentation medium. Research studies have confirmed that glycerin is an effective source for BC growth (Jung et al., 2009; Mikkelsen et al., 2009).

**Drying of BC Sheets**

After the treatment processes, the BC sheets were hung to air dry at room temperature for between 4 and 7 days, depending on material thickness (Figure 3.7). Some sheets were suspended on four sides by wooden rods (rulers in this case) to ensure flat and straight material. Glycerin application was critical during the drying process to ensure high-quality and usable material. For thicker BC sheets, a second Glycerin coating was required after the first 24 hours of drying to prevent wrinkling and curling of the material, especially near its edges. Since about 90% of the BC volume is liquid when it is harvested, the BC sheet thickness diminished significantly to approximately 1/8 of an inch or less due to evaporation during drying. The circular BC starter culture pieces were also harvested and subjected to the same purification and treatment processes. They were laid on a flat surface on top of fiberglass screens to dry at room temperature (Figure 3.7), producing. After drying, BC material in several colors and with leather-like appearance was obtained (Figures 3.8). BC
produced in a green tea medium attained lighter tan color, while a black tea medium produced BC sheets of more yellowish tan color (Figures 3.2 and 3.8).

*Figure 3.7.* Drying BC pieces: a) BC pieces drying on fiberglass screen, b) BC sheets hung to dry, and c) BC sheets hung to dry suspended on four sides.

*Figures 3.8.* BC material obtained through Kombucha fermentation.
Product Design

The Cradle to Cradle (C2C) sustainable design framework (McDonough & Braungart, 2002) was used as a theoretical framework and inspiration for the product design in this study. Consistent with the C2C principles, as a biodegradable material, BC and products made of BC can re-enter the biological cycle as nutrients at their end of life. It was important that any support materials and notions used in constructing the product were also compatible with C2C principles. This was to ensure that the product was recyclable either as a biological nutrient at the end of its life cycle, or that its parts could be disassembled into separate technical materials, such as buckles, for reuse in other products. A women’s shoulder bag was designed for this study with these considerations in mind.

The decision to design a bag versus a clothing item for conducting product evaluation was based on several considerations. First, a bag of one size was sufficient for conducting the evaluation, compared to a clothing item that would require size variations to fit different participants. Second, collection of more consistent data was expected through using a product that did not require fit considerations. Issues with clothing fit and resulting effects on consumer perceptions were eliminated by using a non-clothing product. Finally, the leather-like qualities of the BC material lent themselves to making a fashion accessory more typically fabricated from leather or leather substitutes.

A saddlebag style was selected, inspired by the natural tan, subdued red colors, and natural surface characteristics and ‘imperfections’ of the BC material, evocative of a Western mood. The construction process began with drafting the bag pattern that was then used in cutting the BC sheets, the lining, and the interlining. Canvas fabric (100% cotton) was used as an interlining to provide support and structure to the bag (Figure 3.9). Heavyweight duck
(100% cotton) was used as a lining. The bag was assembled using conventional apparel assembly techniques and a home sewing machine, demonstrating the applicability of these techniques and the sewing machine to BC material. Cotton thread (100%) was used for stitching. For commercial purposes, C2C certified thread and support materials, e.g., lining, should be used. Durable metal hardware was used to attach the shoulder strap to the bag and to provide a length adjuster (Figure 3.9). These components could be removed and reused for other products when the bag was no longer to be used.

**Figure 3.9.** Back of the bag with attached interlining; shoulder straps.

The flap of the bag extended from the upper back to the front, covering the entire front. Two layers of BC material were used to construct the flap, overlapping the reddish and tan colors. Laser-cutting and etching was used to create a floral pattern and a logo on the upper tan piece, using Speedy 400 laser machine (120 Watt, CO2; power – 37%, velocity – 43%, and frequency – 1000 Hz) (Figure 3.10). Adobe Illustrator was used to create both the floral pattern and the logo in preparation for laser cutting and etching. The floral motif symbolized the renewable and biodegradable nature of bacterial cellulose and the sustainability of the bag. When thrown away or composted at the end of its life, the bag
would biodegrade and provide biological nutrients for plants, symbolized by the shoots and flowers in the laser-cut design. Figure 3.11 shows the final product (front and back of the shoulder bag), which was used for evaluating consumer perceptions of BC products.

Figure 3.10. The front flap of the bag with laser-cut floral design.

Figure 3.11. Front (a) and back (b) of the shoulder bag made of BC material.

Product Evaluation

Embedded Mixed Methods Research Design

Mixed methods research design was employed to examine consumer perceptions of fashion products made of BC. More specifically, a concurrent embedded strategy of mixed
methods design was used. In such a design approach, both qualitative and quantitative data are concurrently collected at the same stage of the study. One is the primary method, while the other is secondary, embedded within and supporting the primary method (Creswell, 2009). Such mixed methods research results in “bringing a wider range of evidence to strengthen and expand our understanding of a phenomenon” (Lieber & Weisner, 2010, p. 703), that might not be possible if only a qualitative or a quantitative approach were used (Creswell, 2009).

Triangulation of multiple methods, “corroborating evidence from different sources to shed light on a theme or perspective,” was also used as a measure of trustworthiness or validity of the findings (Creswell, 2013, p. 251). “Rich, thick descriptions”—detailed descriptions of participants, procedures, and themes, including direct participant quotes—were used as an additional measures of trustworthiness (Creswell, 2009, p. 191; Creswell, 2013). Additional steps taken to ensure trustworthiness included taking reflective notes related to data collection process, emerging codes and themes, and general observations throughout the length of the study (Lincoln & Guba, 1985). Checking the transcribed data for accuracy, and confirming that the codes were defined correctly and reflected the data were other measures of trustworthiness utilized (Creswell, 2009).

Qualitative research strategy was selected as the primary method in the study, and focus group discussions were selected as the qualitative data collection method. The embedded quantitative method involved sensory evaluation of BC material, following a modified method of Free-Choice Profiling described in Chapter 2. As a descriptive sensory evaluation method, Free-Choice Profiling helps in understanding the nature of a product,
based on product characteristics or attributes and product qualities or intensities perceived by product assessors (Moskovitz et al., 2008).

Qualitative and quantitative data were concurrently collected during focus group sessions. Participants first completed a sensory evaluation of BC material swatches, then participated in group discussion, using the shoulder bag as the focal point. Combining the group discussion and sensory evaluation data was intended to help achieve deeper understanding related to consumer perception of BC material and BC-based products.

**Research Participants**

Prior to participant recruitment, approval for conducting research with human subjects was obtained from the Institutional Review Board (Appendix A). To recruit participants, a randomized e-mail list of 13,779 female students enrolled in Iowa State University was obtained through the Office of the Registrar. Only female participants were recruited because the product to be evaluated in the study was a women’s shoulder bag. A homogenous sample in terms of gender and age was expected to result in less variability in participant perceptions and attitudes and to therefore generate more relevant and meaningful findings pertinent to a specific consumer market segment. As Creswell (2013) stated, “the more diverse the characteristics of the individuals, the more difficult it will be for the researcher to find common experiences, themes, and the overall essence of the experience for all participants” (p. 150).

The total email list was divided into halves, and students from only one half of the sample were first contacted. It was felt that if additional participants were needed, they could be recruited from the other half of the sample. Each of the first 6,000 female students on the randomized list received an invitation e-mail to participate in the study (Appendix B), and
those expressing interest were asked to sign up for one of the focus group sessions described in the invitation. Up to eight participants could enroll in each session. While 45 students initially expressed interest and signed up to participate in the study, the final sample included 33 participants, because some could not attend due to schedule conflicts and several did not show up for the sessions. Since the six focus group sessions resulted in data saturation, no additional focus group sessions were scheduled and no additional students were contacted. According to Glesne (2011), data saturation is reached when “successive examination of sources yields redundancy and the data you have seem complete and integrated” (p.193).

**Data Collection Procedures**

Participation in the study entailed attending an approximately one-hour focus group session that included sensory evaluation of BC material swatches, followed by a group discussion that focused on the shoulder bag (see protocol in Appendix C). Six sessions were held with 4-7 participants in each. Upon arrival, participants were greeted and asked to briefly introduce themselves, after which the purpose of the study and the session procedures were explained to them. To avoid affecting participants’ perceptions and opinions, information about the source of the BC material, its name, and its sustainable nature was not shared with them. The study was initially presented as only an evaluation of a new material for fashion products, and information about the material’s origin was presented to participants only close to the end of the focus group discussions.

Participants signed consent forms (Appendix D) and completed background information forms to provide demographic information such as age, ethnicity, year in college, and academic major (Appendix E). Two additional questions on the demographic form asked participants about their apparel shopping habits, specifically, for the approximate
number of clothing items and accessories purchased, and the amount of money spent on them over a typical three-month period. Sensory evaluation of BC material was the next step. Participants received detailed instructions for completing the sensory evaluation instrument (Appendix F). Each participant then received a 4” x 4” BC material swatch to examine and was asked to individually complete the three-part sensory evaluation instrument (discussed in detail in the next section).

Finally, participants were presented with the shoulder bag designed for this study (Figure 3.11) and took part in a focus group discussion. The bag was passed around and each participant was given an opportunity to carefully examine the product. Following a semi-structured discussion guide (Appendix G), focus group discussion began only after each participant had been given a chance to examine the bag. They were encouraged to add additional comments and discuss other relevant information they found important to convey, as the free-flowing discussion allowed them to express their feelings, perceptions, and opinions about the product and material using their own words. With the participants’ permission, the group discussion was audio-recorded and later transcribed verbatim for analysis and interpretation.

Each focus group session, including sensory evaluation and group discussion, lasted between one hour and an hour and ten to fifteen minutes. The introductions and completion of the consent and background form took 10 minutes, the sensory evaluation took approximately 20 minutes, and group discussions took approximately 30 minutes. At the end of a session, each participant received a $5.00 coffee shop gift card in appreciation for participation.
Sensory Evaluation

The sensory evaluation was carried out to help understand how consumers perceived and characterized the BC material. The sensory evaluation instrument was developed based on techniques used in the Free-Choice Profiling sensory evaluation method described in Chapter 2 (Appendix F). The three parts of the method are described below.

Part One – free-choice descriptions of BC material. Participants were asked to independently generate attributes describing the sensory characteristics of BC material swatches provided to them. A brief definition of sensory evaluation was included at the beginning of the instrument, followed by instructions for completing the task (Appendix F). Four columns, labeled sight, hearing, smell, and touch, were provided to help participants think of and generate attributes for these senses. Participants were asked to write down attributes describing the BC material swatches in the appropriate columns. Such generation of sensory attributes is essential to sensory evaluation, because through them “we can understand how the panelist perceives the product” and “learn rather quickly why a particular product is acceptable or not acceptable” (Moskovitz et al., 2008, p. 173).

Part Two – rating the intensities and liking of BC material attributes. Participants were asked to evaluate BC material by rating the intensities of 25 attributes on a scale ranging from 0 (not at all) to 5 (extremely). Participants were also asked to indicate how much they liked or disliked each of the 25 attributes on a scale ranging from 1 (dislike) to 3 (like). Empty rows with no attributes were added at the end of the list to let participants rate any attributes they considered necessary to add to the list of the 25 given attributes (Appendix F). The list of the 25 attributes was developed with the help of a panel of experts.
**Development of BC attribute list by experts.** Part Two of the instrument included a list of 25 attributes developed by a panel of experts made up of six textile and apparel faculty members and graduate students majoring in apparel design and product development. These experts, assembled for an hour-long session, were first provided with BC material swatches and asked to individually complete Part One of the sensory evaluation instrument to generate attributes describing the material. Based on the frequency counts of the attributes written down by the experts using the instrument, 93 attributes, with an average of 15.5 attributes per expert, were initially generated. These included: 40 attributes representing the sense of sight and describing how the material looked; 33 attributes representing the sense of touch and describing how the material felt to the touch; 13 attributes describing the material smell; and seven attributes representing the sense of hearing and describing how the material sounded.

After generating these attributes, the experts were asked to share the attributes aloud with the group. First, all six experts shared their complete lists of attributes related to sense of sight, then shared attributes related to the sense of hearing, followed by the same procedure for the senses of smell and touch. The researcher wrote the attributes down on a whiteboard and, after deleting redundant attributes, the final list displayed 41 attributes. Within the 41 attributes, 18 were for the sense of sight, 13 were for the sense of touch, seven were for the sense of smell, and three were for the sense of hearing.

To reduce the number of attributes and make the list more manageable for sensory evaluation, the following steps were taken:

- Attributes using technical vocabulary (non-woven, vellum-like) that could possibly be confusing to participants were excluded.
- Attributes that merely stated the material color (brownish, tan) were excluded; however, attributes characterizing color consistency, e.g., uneven color, were retained;

- The pleasant attribute related to smell was included, whereas the unpleasant attribute was excluded, because including both qualities in the instrument would have been redundant—participants could rate the intensity of the pleasant attribute as not at all pleasant, inferring that a smell, for example, was unpleasant.

- Attributes that were synonymous or described the same idea were combined. For example, unsmooth, rough, and textured attributes were combined as a single rough/textured attribute to describe the textured nature of the material. Not flexible, stiff/rigid, and poor drape attributes were combined into a single stiff/rigid attribute to describe the non-flexible, rigid nature of the material. Other attributes combined in this manner included uneven color and multi-shaded; skin-like and leather-like; translucent and see-through; spotted and mottled/speckled; rough and non-uniform (for the sight category); and wrinkled and having veins/lines.

The reduced list included the following 25 attributes that were used to develop Part Two of the sensory evaluation instrument (Appendix F):

- eight attributes for the sense of sight (uneven color, dull, non-uniform, leather-like, plastic-like, wrinkly, spotted/speckled, translucent/see-through),

- eight attributes for the touch sense (thick, heavy, sticky, soft, rough/textured, stiff/rigid, vinyl-like, dry),
- seven attributes for the sense of smell (vinegary, spicy, sweet, overripe-fruit, ammonia/urine, pleasant), and
- three attributes for the sense of hearing (squeaky, paper-like-sounding, vinyl-like-sounding).

**Part Three – overall liking and acceptability of BC material.** Participants indicated their overall liking of the BC material and assessed how acceptable it was for use in fashion products (Appendix F). The following questions were asked:

- how much they liked or disliked the BC material overall,
- how acceptable they thought the BC material was for clothing;
- how acceptable they thought the BC material was for fashion accessories (e.g., bags, shoes, belts).

At the conclusion, an open-ended question asked participants to provide additional comments and suggestions about the characteristics or use of the material. The three-part instrument was individually completed by each participant. They were allowed to ask questions during the evaluation process.

**Focus Group Discussions**

A semi-structured interview format was utilized for the focus group discussion, following the focus group discussion guide (Appendix G) to solicit participant feedback on the bag they had examined. The guide contained open-ended questions to elicit participant responses addressing the research objectives. More specifically, the guide at its beginning included a few general questions to capture participant first impressions of the BC product and their initial likes and dislikes related to it. This was followed by more focused questions related to tangible and intangible product characteristics such as appearance, function and
durability as well as advantages/disadvantages and social-communicative factors such as product suitability with lifestyle, needs, values, etc., and social feedback. These questions were based on the dimensions of the framework for Fashion Product Evaluation described in Chapter 2. In addition to evaluating the bag, participants were also shown images of clothing and shoes made of BC material (Appendix H) to elicit their opinions about applicability of the material to products of that type as well as acceptability of such products to consumers.

At the end of each focus group discussion, participants received information about the nature of BC material and the bag they had evaluated. They were first told that the material had been obtained through a Kombucha fermentation process and the name of the material was revealed, followed by information related to the sustainable nature of the material and products made of it. Following each introduction, participants were asked for their opinions and whether their opinions had been changed after learning the new information. They were also asked if they were familiar with Kombucha fermentation process, if they knew of any other similar products, how they felt about the name of the material, whether their perceptions of the material and the bag were changed because of the material or its name, and, finally, if consumer perceptions would likely be affected by these factors. The interview concluded with questions asking participants for feedback on how the material and the product could be improved, what other uses they might see for the materials, and any other comments.

Data Analysis

**Description of participants.** Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to analyze demographic characteristics of the research participants, including age, ethnicity, year in college, and
major. Means and standard deviations were calculated to analyze the data on participant apparel shopping habits, including the number of clothing and accessory items purchased and approximate amount of money spent on these items over a typical three-month period.

**Sensory evaluation data analysis.** Descriptive statistics were used to analyze the sensory evaluation data. For Part One of the sensory evaluation, the total numbers of attributes generated by participants were calculated for the four sensory categories combined as well as for each sensory category separately. The mean number of attributes generated per participant for each sensory category was also calculated. Frequencies were calculated for all attributes generated by participants. This helped to identify the high-frequency attributes—the most important attributes used by participants in describing the sensory characteristics of the BC material. For Part Two of the sensory evaluation, means and standard deviations were calculated for the intensity and liking ratings of the 25 attributes to understand how participants perceived the BC material in terms of its sensory characteristics and particular characteristics they had liked or disliked.

For Part Three of the sensory evaluation, means and standard deviations were calculated for ratings of the overall liking of the BC material and the acceptability of the material for clothing and accessories. Pearson correlation analysis was conducted to examine whether the ratings for the overall liking of the BC material, acceptability of the material for clothing, and acceptability of the material for accessories were associated with participant demographic characteristics (age, year in college) and apparel shopping habits (number of clothing and accessory items purchased, and the amount of money spent on clothing and accessories).

**Qualitative data analysis.** Qualitative data were collected through written responses to the open-ended question in Part Three of the sensory evaluation instrument and six focus group discussions. Focus group discussions were transcribed verbatim in preparation for
coding and analysis. The open-ended responses from 33 sensory evaluation instruments were typed and aggregated into one document for coding and analysis. The focus group data were analyzed using a combination of open and priori coding strategies (Creswell, 2009; Glesne, 2011). The open-ended responses were analyzed using open coding due to the simpler and brief nature of the data.

The four dimensions and product attributes outlined in the Fashion Product Evaluation (FPE) framework proposed in Chapter 2 (Table 2.2) served as the a priori coding system for the data analysis. Open coding strategy was also utilized to ensure that data and codes that did not fit within the priori system were identified and coded. The goal of open coding is to remain open to any emergent new directions and themes when analyzing the data (Glesne, 2011).

To prepare for the coding process, a coding form was created with five columns. Four columns, intended for recording priori codes, were labeled as intrinsic, functional, marketing, and social-communicative (Table 2.2). The fifth column was intended for additional codes. The focus group transcripts were read line-by-line and codes were identified and recorded in the coding form under the appropriate categories. The text segments reflecting the codes were marked by sequential numbers, and also recorded next to the code they represented in the coding form.

The recorded codes reflected participants’ characterizations of the BC material and the bag evaluated, and their attitudes, opinions, and ideas related to the use of the bag or similar products. The codes recorded in the coding form were constantly compared to emerging codes as the analyses continued. After the coding process had been completed, the codes were reexamined to further clarify and aggregate them into meaningful categories
(Glesne, 2011; Saldana, 2009). Reexamination of codes and corresponding text segments led to rearranging and reclassifying some codes into different or new categories, resulting in more refined and clear categories that better reflected the data (Saldana, 2009). Many of these categories that described specific material characteristics became final themes. Other categories were combined in meaningful ways into final themes. The final themes were grouped under the four priori dimensions and the open category.
CHAPTER 4. RESULTS

This chapter presents a description of the research participants, the results of sensory evaluation, and analysis of focus group data. Demographic characteristics of the sample are described, including age, ethnicity, year in college, and academic major. In addition, information about the apparel shopping habits of the sample is presented. Specifically, the estimated number of clothing and accessory items purchased and approximate amount of money spent on these items over a typical 3-month period are discussed. The sensory evaluation results are presented in three parts, corresponding to the following three-part procedures carried out for this evaluation:

- Part One – Free-choice description of bacterial cellulose (BC) material
- Part Two – Rating intensities and liking of BC material attributes
- Part Three – Overall liking and acceptability of BC material.

The qualitative analysis results are presented after the analysis of the sensory evaluation data.

Description of Research Participants

Participant Demographic Profile

The research sample included 33 female college students whose demographic characteristics are presented in Table 4.1. Undergraduate students made up 78.8% of the sample, the others being graduate students (21.2%). Sophomores (27.3%) comprised the largest undergraduate student group in the sample, followed by Juniors (24.2%), Seniors, (15.2%) and Freshmen (12.1%).
Table 4.1

Demographic characteristics of research participants (N = 33)

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<th>Demographic Variable</th>
<th>Frequency</th>
<th>Percent (%) of Sample</th>
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<tbody>
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<td></td>
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<td>18</td>
<td>2</td>
<td>6.1</td>
</tr>
<tr>
<td>19</td>
<td>8</td>
<td>24.2</td>
</tr>
<tr>
<td>20</td>
<td>8</td>
<td>24.2</td>
</tr>
<tr>
<td>21</td>
<td>6</td>
<td>18.2</td>
</tr>
<tr>
<td>22</td>
<td>1</td>
<td>3.0</td>
</tr>
<tr>
<td>23</td>
<td>1</td>
<td>3.0</td>
</tr>
<tr>
<td>24</td>
<td>1</td>
<td>3.0</td>
</tr>
<tr>
<td>26</td>
<td>2</td>
<td>6.1</td>
</tr>
<tr>
<td>30</td>
<td>3</td>
<td>9.1</td>
</tr>
<tr>
<td>50</td>
<td>1</td>
<td>3.0</td>
</tr>
<tr>
<td><strong>Ethnicity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>American Indian or Alaska Native</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Asian</td>
<td>3</td>
<td>9.1</td>
</tr>
<tr>
<td>Black or African American</td>
<td>4</td>
<td>12.1</td>
</tr>
<tr>
<td>Hispanic/Latina</td>
<td>2</td>
<td>6.1</td>
</tr>
<tr>
<td>Native Hawaiian or Pacific Islander</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>White</td>
<td>23</td>
<td>69.7</td>
</tr>
<tr>
<td>Other (Buryad)</td>
<td>1</td>
<td>3.0</td>
</tr>
<tr>
<td>Prefer not to answer</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Year in College</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freshman</td>
<td>4</td>
<td>12.1</td>
</tr>
<tr>
<td>Sophomore</td>
<td>9</td>
<td>27.3</td>
</tr>
<tr>
<td>Junior</td>
<td>8</td>
<td>24.2</td>
</tr>
<tr>
<td>Senior</td>
<td>5</td>
<td>15.2</td>
</tr>
<tr>
<td>Graduate</td>
<td>7</td>
<td>21.2</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Participants represented 21 academic majors from a variety of fields, with the number of participants from any given major ranging between one and four. Four participants majored in Apparel, Merchandising, and Design, and three majored in Psychology. There were only one or two participants from each of the other majors that included Animal Ecology, Biology, Material Science and Engineering, Journalism and Mass Communication,
Agronomy, Kinesiology, Computer Science and Engineering, Genetics, Industrial Design and others. The mean participant age was 22 within a range of 18-50, and approximately 67% were of ages 19-21. The majority of the participants were White (69.7%), followed by Black or African American (12.1%), Asian (9.1%), Hispanic/Latina (6.1%), or some other ethnicity (3%).

**Participant Apparel Shopping Habits**

Participants varied in their apparel shopping habits. Over a typical 3-month period, they reported purchasing on average about eight clothing and accessory items \( (M = 8.42, \ SD = 7.32, \ n = 33) \), with a range of 0-35 items. On average, participants spent $145.30 on clothing and accessories \( (M = 145.30, \ SD = 135.86, \ n = 33) \) over a typical three-month period, with a range of $0-$500.

**Sensory Evaluation**

**Part One – Free-choice Descriptions of BC Material**

In Part One of sensory evaluation, participants worked individually to generate a list of attributes describing sensory characteristics of BC swatches provided for their examination and evaluation. Participants listed a variety of attributes under four columns: sight, hearing, smell, and touch. These attributes were mostly one- or two-word descriptors such as “textured” or “organic-looking” or short expressions such as “looks like skin.” A few participants provided more detailed descriptions or explanations such as “sticky when rubbed against the same material, but not against the hand.”

Among the four sensory categories combined, 406 attributes describing the BC material were generated. Senses of sight and touch accounted for the greatest number, with
140 and 139 attributes, respectively. The smell category had 73 attributes and the hearing category had 54. During analysis of these attributes, the same or similar attributes describing the same material characteristic were combined into one group to reduce the data. The attribute that best captured the meaning of each group was selected as the group name. For example, translucent, transparent, and see-through attributes were combined into a see-through group because all described the fact that it was possible to see through the material. As another example, worn, weathered, antique-like, rustic, old-looking, and distressed attributes were grouped into a worn-looking category since they all described the worn and older-looking appearance of the material. The result was 120 distinct attributes (down from the original 406) identified as describing the sensory characteristics of the BC material. Thirty-two of these attributes were related to the sense of sight, 19 to hearing, 32 to smell, and 37 to touch.

High- and low-frequency attributes. Attributes mentioned by at least five out of 33 participants (15%) were deemed high-frequency attributes for the purposes of this research to allow for a broader scope of attributes. Twenty-seven out of the 120 distinct attributes were identified as high-frequency attributes. These are presented in Table 4.2, in order of frequency from highest to lowest. The attributes of the same frequency are listed in alphabetical order. Attributes with frequencies between one and four, low-frequency attributes, are presented in Table 4.3. These attributes were mentioned by fewer than 15% of the participants (by 4 participants or less). Ninety-two of the 120 distinct attributes were of low frequency, with the great majority having frequencies of 1 or 2. Low-frequency attributes were further grouped under common themes based on their general areas of focus.
Table 4.2

*High-frequency attributes* \(^\text{a}\) generated by participants describing characteristics of BC material

<table>
<thead>
<tr>
<th>Sight</th>
<th>N</th>
<th>Hearing</th>
<th>N</th>
<th>Smell</th>
<th>N</th>
<th>Touch</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>See-through (translucent, sheer, transparent)</td>
<td>25</td>
<td>Quiet (noiseless, no sound when bent or rubbed)</td>
<td>9</td>
<td>Unpleasant (bad)</td>
<td>10</td>
<td>Textured (surface lines, ridges, bumpy, wrinkly)</td>
<td>14</td>
</tr>
<tr>
<td>Tan color (beige, light-brown, yellowish)</td>
<td>17</td>
<td>Leather-like sound when rubbed</td>
<td>8</td>
<td>Vinegary</td>
<td>8</td>
<td>Flexible (pliable, bendable, foldable)</td>
<td>11</td>
</tr>
<tr>
<td>Wrinkly (crinkly)</td>
<td>16</td>
<td>Paper-like sound (paper rubbing, book page turning)</td>
<td>8</td>
<td>Old items (cloths, couch, library, antique shop)</td>
<td>6</td>
<td>Stiff (rigid, hard to bend, not flowy)</td>
<td>9</td>
</tr>
<tr>
<td>Skin-like (looks like skin, hide, skin graft)</td>
<td>14</td>
<td>Scratchy noise when rubbed (rough sound when rubbed against itself/with hands)</td>
<td>6</td>
<td></td>
<td></td>
<td>Rough</td>
<td>8</td>
</tr>
<tr>
<td>Textured (cracks, grooves, unique surface details, uneven)</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Leather-like (leathery)</td>
<td>7</td>
</tr>
<tr>
<td>Worn-looking (rustic, distressed, weathered, antique-like, old-looking)</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Soft</td>
<td>7</td>
</tr>
<tr>
<td>Natural (organic)</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Strong (tough)</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Durable</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Paper-like</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rough and smooth/soft at the same time</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Thin</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dry</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dry</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Soft</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Strong (tough)</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Durable</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Paper-like</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rough and smooth/soft at the same time</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Thin</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dry</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Plastic-like</td>
<td>5</td>
</tr>
</tbody>
</table>

Total attributes generated        99 31 24 97
Total distinct attributes         7 4 3 13

*Note.* N = attribute frequency.

\(^{a}\)Attributes with frequencies of five and above.
Table 4.3

Low-frequency attributes* generated by participants describing characteristics of BC material

<table>
<thead>
<tr>
<th>Sight &amp; appearance</th>
<th>Properties of sound</th>
<th>Properties of smell</th>
<th>Properties of touch/hand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rough (not smooth)</td>
<td>3  Crisp</td>
<td>2  Not strong (not too bad)</td>
<td>4  Smooth</td>
</tr>
<tr>
<td>Mottled (has white spots)</td>
<td>2  Good (OK)</td>
<td>2  Musty</td>
<td>4  Has friction (grip)</td>
</tr>
<tr>
<td>Opaque (semi-opaque)</td>
<td>2  Swishy (squishy sound when rubbed/touched)</td>
<td>2  Strong</td>
<td>3  Confusing (strange)</td>
</tr>
<tr>
<td>Thin</td>
<td>2  Dull</td>
<td>1  Sour</td>
<td>2  Fun (feels good to touch)</td>
</tr>
<tr>
<td>Uneven color</td>
<td>2  Natural</td>
<td>1  Strange, odd</td>
<td>2  Lightweight</td>
</tr>
<tr>
<td>Clear</td>
<td>1  Not too squeaky</td>
<td>1  Sweet</td>
<td>2  Not smooth</td>
</tr>
<tr>
<td>Light</td>
<td>1  No creepy sounds</td>
<td>1  Fresh</td>
<td>1  Tacky (slightly sticky)</td>
</tr>
<tr>
<td>Looks dried</td>
<td>1  Not noisy unless rubbed Sticky when rubbed against itself (waxy)</td>
<td>1  Interesting</td>
<td>1  Thick</td>
</tr>
<tr>
<td>Looks sticky</td>
<td>1  Resembling other sounds</td>
<td>1  Rotten-smelling</td>
<td>1  Does not have cheap feel</td>
</tr>
<tr>
<td>Simple</td>
<td>1  Rubbery</td>
<td>3  Tangy</td>
<td>1  Scratchy</td>
</tr>
<tr>
<td>Striking</td>
<td>1  Like Plastic</td>
<td>2  Smell presence/absence</td>
<td>2  Perceived performance</td>
</tr>
<tr>
<td>Waxy</td>
<td>1  Like dry fruit</td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

*Perceived performance

| Fragile (delicate) | 2  | 1  Doesn’t leave hands smelly | 1  Not elastic |
| Holds creases | 2  Not Like plastics | 1  May rub off to other cloths in closet | 1  Flimsy (doesn’t bounce back when folded, little resiliency) | 3  |
| Looks eco-friendly | 2  | 1  No smell | 1  Stretchy (slightly stretchy) | 2  |
Table 4.3 continued

<table>
<thead>
<tr>
<th>Sight</th>
<th>N</th>
<th>Hearing</th>
<th>N</th>
<th>Smell</th>
<th>N</th>
<th>Touch</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bendable</td>
<td>1</td>
<td>Like thick cloth</td>
<td>1</td>
<td>Stays on hand after handling</td>
<td>1</td>
<td>Not durable</td>
<td>1</td>
</tr>
<tr>
<td>Brittle</td>
<td>1</td>
<td></td>
<td></td>
<td>Resembling other smells</td>
<td></td>
<td>Resembling other items</td>
<td></td>
</tr>
<tr>
<td>Does not give sense of reliability</td>
<td>1</td>
<td></td>
<td></td>
<td>Fruity</td>
<td>4</td>
<td>Fruit lather (dehydrated fruit strip)</td>
<td>2</td>
</tr>
<tr>
<td>Durable</td>
<td>1</td>
<td></td>
<td></td>
<td>Ammonia</td>
<td>2</td>
<td>Rubbery</td>
<td>2</td>
</tr>
<tr>
<td>Edges curl/fray</td>
<td>1</td>
<td></td>
<td></td>
<td>Chemical</td>
<td>2</td>
<td>Does not look like leather</td>
<td>1</td>
</tr>
<tr>
<td>Stiff</td>
<td>1</td>
<td></td>
<td></td>
<td>Plastic</td>
<td>2</td>
<td>Leaf-like</td>
<td>1</td>
</tr>
<tr>
<td>Resembling other items</td>
<td></td>
<td></td>
<td></td>
<td>Urine (pee)</td>
<td>1</td>
<td>Dried skin</td>
<td>1</td>
</tr>
<tr>
<td>Leathery (textured leather)</td>
<td>4</td>
<td></td>
<td></td>
<td>Aged cheese</td>
<td>1</td>
<td>Like manmade</td>
<td>1</td>
</tr>
<tr>
<td>Paper-like</td>
<td>2</td>
<td></td>
<td></td>
<td>Aging/old meat</td>
<td>1</td>
<td>Like mixture of paper and plastic</td>
<td>1</td>
</tr>
<tr>
<td>Plastic</td>
<td>2</td>
<td></td>
<td></td>
<td>Clorox</td>
<td>1</td>
<td>Vinyl</td>
<td>1</td>
</tr>
<tr>
<td>Latex-looking</td>
<td>1</td>
<td></td>
<td></td>
<td>Cocoa butter</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stained glass</td>
<td>1</td>
<td></td>
<td></td>
<td>Dandruff</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tea bag</td>
<td>1</td>
<td></td>
<td></td>
<td>Dusty</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Earthy</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Flowery</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Skin/hide</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total attributes generated</td>
<td>41</td>
<td></td>
<td>23</td>
<td></td>
<td>49</td>
<td></td>
<td>42</td>
</tr>
<tr>
<td>Total distinct attributes</td>
<td>25</td>
<td></td>
<td>15</td>
<td></td>
<td>29</td>
<td></td>
<td>24</td>
</tr>
</tbody>
</table>

Note. N = attribute frequency.
'Attributes with frequencies between one and four.
For example, smell attributes focused in three general areas, based on which they were grouped into three themes: (a) properties of the smell; (b) smell presence/absence; and (c) resembling other smells. Table 4.3 shows these attributes ordered according to their frequencies, from highest to the lowest, with those with the same frequency listed in alphabetical order.

**Sight attributes.** On average, participants generated 4.2 attributes related to the sense of sight, with a range of 2-10 attributes per participant. A total of 140 sight attributes were generated. Attributes describing the same idea or property were grouped together. For example, tan, beige, light brown, yellowish attributes were combined into a tan color group. As a result, 32 final attributes related to the sight characteristics of the BC swatches were identified. Seven of the 32 attributes (see-through, tan color, wrinkly, skin-like, textured, worn-looking, and natural) high-frequency, and 25 low-frequency attributes (Tables 4.2 and 4.3).

The see-through attribute was the most referenced sight attribute, with 25 out of 33 participants describing swatches as translucent, transparent, see-through, or sheer. The other two most commonly noted attributes were related to material color and surface texture. Seventeen participants described the color as tan, beige, light brown, or yellowish, while 16 participants noted that the material surface had a wrinkly appearance. Eleven participants described the surface appearance as textured, some specifying that it had unique details, patterns, cracks and grooves. The wrinkly and textured nature is due to the natural surface texture the material acquires as it is harvested and dried. It is apparent that some participants perceived the surface appearance to be a unique feature of the material. To many participants, the material resembled a skin or hide (14) and had a worn or weathered look (10). Participants also thought that the material looked natural or organic (6).
The low-frequency sight attributes generated by participants were focused in three general areas, so they were grouped under three themes: (a) structure and appearance; (b) perceived performance; and (c) resembling other items (Table 4.3). The structure and appearance theme included attributes that described the material’s physical or structural characteristics, e.g., rough (3), thin (2), mottled (2), waxy (1), sticky (1), and other characteristics. The perceived performance theme included attributes describing performance or functional properties of the material as perceived by participants based on sight characteristics. Attributes such as fragile (2), bendable (2), holds creases (2), durable (1) were included under this theme. The resembling other items theme included attributes that associated BC material’s look with other materials such as leather (4), paper (2), plastic (2), stained glass (1), tea bag, etc.

**Hearing attributes.** The average number of attributes generated by participants with respect to the hearing sense was 1.6 per person, with a range of 0-5 attributes. In total, 54 attributes were generated by participants describing the characteristics of BC material related to the hearing sense. Attributes that described the same ideas or characteristics were combined into groups, as previously described. For example, paper-like sound, paper rubbing, book page-turning attributes were grouped into a paper-like sound category. After grouping similar attributes, 19 distinct attributes were identified, with four high- and 15 low-frequency attributes (Tables 4.2 and 4.3).

High-frequency attributes included quiet, leather-like sound, paper-like sound, and scratchy when rubbed attributes (Table 4.2). BC was perceived to be quiet when moved, bent or touched by many participants (9). However, when rubbed against itself, it was characterized as producing certain sounds. Six participants noted that it makes a scratchy or rough sound, and one stated: “The noise when you rub it with your fingers is very quiet, but it makes a louder
scratching noise when folded and rubbed together.” Other participants noted that the material produced a leather-like sound when rubbed (8). The material sound was also likened to a sound produced by paper (8).

The low-frequency attributes for the hearing sense were focused in two general areas, and therefore grouped under two themes: (a) properties of the sound and (b) resembling other sounds. The attributes describing the qualities of the sound produced by the material, grouped under properties of the sound theme, included crisp (2), swishy when rubbed (2), dull (1), not too squeaky (1) and other attributes. Attributes likening the material’s sound to other sounds included rubbery (3), like plastic (2), not like plastic (1), like dry fruit, and like thick cloth (1) attributes.

**Smell attributes.** The average number of attributes generated for the sense of smell was 2.2 per participant, with a range of 1-5. Seventy-three attributes were generated by the participants to describe the BC material based on the sense of smell. After similar attributes describing similar characteristics or ideas were grouped together, the number of distinct attributes describing the smell of the material was 32, three high-frequency and 29 low-frequency. The high-frequency attributes included unpleasant (10), vinegary (8), and old items (6) smells. Ten participants noted that the material smelled unpleasant or bad and eight others thought it smelled vinegary. Six participants likened the smell of the material to old items and places, such as old couch, clothes, library, and antique shop.

The low-frequency smell attributes fell into three areas, and they were grouped into three themes: (a) properties of the smell; (b) smell presence/absence; and (c) resembling other smells. Properties of the smell included attributes characterizing the smell. Four participants characterized it as not too bad or not strong, while a few others described the smell as musty (4)
or strong (3). References were made to the presence or absence of the smell. Two participants noted that the material could be smelled from only up close, while another stated that there was no smell. Participants drew parallels between the smell of the BC swatches and other smells. Four participants described the smell as fruity, and a few others likened it to smells of chemical (2), ammonia (2), urine (2), plastic (2), aging meat or cheese (2), cocoa butter (1), dust (1), flowers (1) and other smells.

**Touch attributes.** The average number of touch sensory attributes generated by the participants was 4.2 per person, with a range of 1-10 attributes. Participants generated 139 attributes describing the BC swatches based on the sense of touch. The same attributes and the attributes describing the same ideas were combined in groups. For example, flexible, pliable, bendable, and foldable attributes fell into the flexible group. As a result, 37 distinct attributes were identified as describing the touch sense of the BC material, 13 high-frequency and 24 low-frequency (Tables 4.2 and 4.3).

High-frequency attributes included: textured, flexible, stiff, rough, leather-like, soft, strong, durable, paper-like, rough and soft and the same time, thin, dry, and plastic-like attributes (Table 4.2). Fourteen participants described the material as textured, wrinkly, and having surface ridges, bumps, or lines. While eight participants described it as rough, the material was described as soft by seven participants. Interestingly, six other participants described the material as being rough and soft/smooth at the same time. Perhaps these participants perceived the material surface as textured and rough, but the overall material as pliable. These contradictory responses could also be because of the natural, slightly uneven distribution of the ridges or texture on the material surface that occur during the material drying process. Because of this, each material swatch exhibited slight variation in texture, with some areas slightly more textured than others.
Material flexibility was another property receiving contradictory responses. The material was described as flexible, pliable, bendable, or foldable by 11 participants, while nine saw it as stiff, rigid, and hard to bend. Perhaps the natural slightly uneven distribution of the texture within the surface of each swatch discussed above affected the participant perceptions. More textured areas of the material could have been evaluated as stiff and smoother parts as flexible. It is also possible that the participants’ associations of the BC material with other materials affected their evaluations, resulting in contradictory responses. For example, some participants described the material as leather-like (7) and others described it as paper-like (6) or plastic-like (5). Participants associating the BC material with leather, for example, could have perceived it as less flexible than leather and, in a similar manner, participants associating the material with plastic could have perceived it as more flexible than plastic. Several participants described the BC material as durable (6), thin (6), and dry (5).

The low-frequency touch attributes generated by participants were focused into three general areas and grouped under three themes: (a) properties of the touch; (b) perceived performance; (c) and resembling other items. Touch properties included attributes such as smooth (4), has friction (3), confusing (2), tacky (2), interesting (1), slippery (1), and a number of other attributes with frequencies of one or two (Table 4.3). The perceived performance theme included attributes related to perceived functional characteristics of the material, including not elastic (3), flimsy (3), stretchy (2), and not durable (1) attributes. The material touch was likened to several other items in addition to leather, paper, and plastic described above. It was variously described as similar to dehydrated fruit, rubber, leaves, dried skin, and vinyl by one or two participants.
Part One summary. In part one of the sensory evaluation, participants received BC material swatches and were asked to evaluate and generate attributes that described the material, based on the senses of sight, hearing, smell, and touch. While 120 distinct attributes were identified describing the material, most were low-frequency attributes with frequencies of one or two. Twenty-seven high-frequency attributes revealed the most important sensory characteristics of BC material. It was described as see-through, and its surface was described as having wrinkly or textured appearance, with unique ridges, details, and patterns. The color of the material was described as tan/beige. Many participants thought the material had an appearance of skin or hide. It was also described to be worn-looking or weathered. Some participants described the material as natural or organic-looking.

The material was described by many participants to be quiet when touched, but to produce a scratchy or rough sound, when rubbed against itself. The sound of the material was likened to the sounds of leather or paper when rubbed. For the smell sensory category, three common characteristics were identified. Nearly one-third of participants noted that the material had an unpleasant or bad smell, while others described it as vinegary. The smell was also likened to the smell of old things, such as old couch, clothes, and antique shop. Four participants described it as not strong or not bad. Other low-frequency attributes described the smell as musty or strong.

The material was described as textured and wrinkly to the touch, with bumps, ridges and lines, similar to descriptions given for the sense of sight. Contradictory descriptions were revealed for several attributes describing the touch properties of BC swatches, with some participants describing the material as rough and others describing it as soft. The material was even described as “rough and soft at the same time” by several participants. Similarly, while the
material was described as flexible by some participants, others described it as rigid and hard to bend. The participants’ associations of the material with plastic, paper, leather, and other materials could have affected their perceptions of the BC swatches. The material was also described as durable, dry, and thin, based on the sense of touch.

Part Two – Rating the Intensities and Liking of BC Material Attributes

In the second part of the sensory evaluation, participants rated the intensity of 25 sensory attributes describing the BC material on a scale of 0 (not at all) to 5 (extremely), then rated how much they liked or disliked each attribute on a scale of 1 (dislike) to 3 (like). As described in Chapter 3, the 25 attributes had been generated in advance by experts in the textiles and apparel field. Descriptive statistics for the intensity and liking ratings of the sensory attributes, including means and standard deviations, are presented in Table 4.4. The attributes with high (3.5 or higher) and low (1.5 or lower) intensity ratings, as well as those with high (2.3 or higher) and low (1.7 or lower) liking ratings are discussed in detail below. High scores are bold-faced and low scores are italicized in the table.

Sight attributes. The sensory category of sight contained attributes that received the highest intensity ratings, including wrinkly, leather-like appearance, and translucent/see-through. The translucent/see-through attribute had a mean intensity rating of 4.39 ($SD = 0.65$) and a mean liking rating of 1.79 ($SD = 0.81$), indicating that participants generally disliked the see-through nature of the material. Leather-like appearance had an intensity rating of 3.58 ($SD =1.21$), and participants liked this attribute ($M = 2.67, SD = 0.59$).
Table 4.4

Intensity and Liking Ratings of Sensory Attributes, $N = 33^a$

<table>
<thead>
<tr>
<th>Sensory Attribute</th>
<th>Intensity Rating</th>
<th>Liking Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td><strong>Sight</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uneven color</td>
<td>1.73</td>
<td>1.35</td>
</tr>
<tr>
<td>Dull appearance</td>
<td>3.00</td>
<td>1.18</td>
</tr>
<tr>
<td>Non-uniform appearance</td>
<td>2.67</td>
<td>1.43</td>
</tr>
<tr>
<td>Leather-like appearance</td>
<td><strong>3.58</strong></td>
<td>1.21</td>
</tr>
<tr>
<td>Plastic-like appearance</td>
<td>2.58</td>
<td>1.44</td>
</tr>
<tr>
<td>Spotted, speckled</td>
<td>1.59</td>
<td>1.52</td>
</tr>
<tr>
<td>Wrinkled</td>
<td><strong>4.48</strong></td>
<td>0.93</td>
</tr>
<tr>
<td>Translucent, see-through</td>
<td><strong>4.39</strong></td>
<td>0.65</td>
</tr>
<tr>
<td><strong>Touch</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thick</td>
<td>1.79</td>
<td>1.34</td>
</tr>
<tr>
<td>Heavy</td>
<td>0.91</td>
<td>1.24</td>
</tr>
<tr>
<td>Sticky</td>
<td>0.82</td>
<td>1.14</td>
</tr>
<tr>
<td>Soft</td>
<td>1.94</td>
<td>1.43</td>
</tr>
<tr>
<td>Rough, textured</td>
<td><strong>3.48</strong></td>
<td>1.16</td>
</tr>
<tr>
<td>Stiff, rigid</td>
<td>1.91</td>
<td>1.40</td>
</tr>
<tr>
<td>Vinyl-like feel</td>
<td>2.81</td>
<td>1.42</td>
</tr>
<tr>
<td>Dry</td>
<td><strong>3.55</strong></td>
<td>1.52</td>
</tr>
<tr>
<td><strong>Smell</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vinegary-smelling</td>
<td>2.94</td>
<td>1.92</td>
</tr>
<tr>
<td>Spicy-smelling</td>
<td>0.48</td>
<td>1.02</td>
</tr>
<tr>
<td>Sweet-smelling</td>
<td>0.91</td>
<td>1.52</td>
</tr>
<tr>
<td>Pleasant-smelling</td>
<td>1.33</td>
<td>1.59</td>
</tr>
<tr>
<td>Overripe fruity-smelling</td>
<td>1.39</td>
<td>1.74</td>
</tr>
<tr>
<td>Ammonia/urine-smelling</td>
<td>1.79</td>
<td>1.75</td>
</tr>
<tr>
<td><strong>Hearing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Squeaky</td>
<td>2.03</td>
<td>1.61</td>
</tr>
<tr>
<td>Paper-like-sounding</td>
<td>2.73</td>
<td>1.60</td>
</tr>
<tr>
<td>Vinyl-like-sounding</td>
<td>3.00</td>
<td>1.44</td>
</tr>
</tbody>
</table>

$^a$ Based on the intensity rating scale ranging from 0 (not at all) to 5 (extremely) and the liking scale ranging from 1 (dislike) to 3 (like).
The mean intensity rating for the wrinkly attribute was 4.48 ($SD = 0.93$), with a mean liking rating of 2.3 ($SD = 0.80$). While most participants thought the surface of material looked wrinkly, this was not considered a negative property. Perhaps many participants associated the wrinkly appearance of the material with the surface characteristics of leather, viewed as a positive attribute. The attributes generated by participants in Part One of the sensory evaluation showed that many described the material as textured and wrinkly with “unique surface details” and that it resembled leather.

**Touch attributes.** The mean intensity ratings for rough/textured ($M = 3.48$, $SD = 1.16$) and dry ($M = 3.55$, $SD = 1.52$) attributes were the highest in the sensory category of touch. The mean liking rating for the rough/textured attribute was 2.42 ($SD = 0.78$), indicating that many participants liked the unique texture of the material. The mean liking rating for the dry attribute was 2.33 ($SD = 0.64$), indicating that participants also liked how the material felt. The heavy ($M = 0.91$, $SD = 1.24$) and sticky ($M = 0.82$, $SD = 1.14$) attributes had the lowest mean intensity ratings in this category, with many participants indicating that the material did not feel at all sticky or heavy. The mean rating for liking the heavy attribute was 2.58 ($SD = 0.55$), indicating that participants tended to like the weight of the material. The mean liking rating for the thick attribute was 2.48 ($SD = 0.66$) and the intensity rating was 1.79 ($SD = 1.34$), indicating that participants thought that the material was not very thick, and that they liked its thickness.

**Smell attributes.** Attributes in the smell sensory category received the lowest intensity ratings (Table 4.4). Participants disagreed that the material had spicy or sweet smell, with mean intensity ratings for spicy-smelling and sweet-smelling attributes of 0.48 ($SD = 1.02$) and 0.91 ($SD = 1.52$), respectively. Similarly, the majority of participant thought the material did not have the smell of overripe fruit ($M = 1.39$, $SD = 1.74$). The mean intensity rating for the pleasant-
smelling attribute was 1.33 ($SD = 1.59$), showing that most participants did not think the material had a pleasant smell. This coincides with the findings from the Part One of the sensory evaluation, where many participants described the smell of the material as bad or unpleasant (Table 4.2).

**Hearing attributes.** All three attributes from the hearing sensory category had more neutral intensity and liking ratings. The mean intensity rating was 2.73 ($SD = 1.60$) for the paper-like-sounding attribute and 3.00 ($SD = 1.44$) for the vinyl-like-sounding attribute, and with respect to both attributes, participants indicated that they neither liked nor disliked these material characteristics. The mean intensity rating was 2.03 ($SD = 1.61$) for the squeaky attribute, indicating that most participants did not agree that the material was squeaky.

**Part Two summary.** In Part Two of the sensory evaluation, participants rated the intensities of 25 material attributes generated in advance by experts in the textiles and apparel field and related to senses of sight, touch, smell and hearing. Participants also rated their liking or dislike for each attribute. The translucent/see-through attribute had one of the highest intensity ratings, while its liking scores showed that most participants disliked this characteristic. Many participants thought the material had a leather-like appearance, and the majority of participants liked this attribute. The wrinkly attribute had the highest intensity rating, with most participants also indicated their liking of this attribute. These results supported the findings in Part One, and the wrinkly and textured surface seemed to be a unique and favorable material attribute.

For many participants, the material seemed rough/textured to the touch. Most participants liked this attribute, confirming that the textured and wrinkly surface of the material was a favorable material characteristic. Based on the ratings, the material was not seen as heavy or
thick, and this was liked by most participants. Most participants indicated that the material had an unpleasant smell, confirming the findings in Part One.

**Part Three – Overall Liking and Acceptability of BC Material**

In the third part of the sensory evaluation, participants were asked to rate how much they overall liked or disliked the material on a five-point scale of 1 (dislike extremely) to 5 (like extremely). They also rated how acceptable the material was for clothing and accessories on a five-point scale of 1 (not at all acceptable) to 5 (very acceptable). Finally, through an open-ended question, participants were encouraged to provide additional comments about the characteristics and use of the material.

The mean rating for the overall liking of the material was 3.39 ($SD = 0.83$), indicating an overall neutral attitude. While more participants liked rather than disliked the material, many participants were neutral. The mean rating for the acceptability of the material for clothing (e.g., vests, jackets) was 2.94 ($SD = 1.30$), indicating that many participants did not find the material to be suitable for clothing. In contrast, the mean score for the acceptability of the material for accessories (e.g., belts, bags, shoes) was 4.48 ($SD = 0.76$), with most participants agreeing that the material was very acceptable for use in fashion accessories.

**Correlation analysis.** Pearson correlation analysis was conducted to examine whether the ratings for the overall liking of the BC material, the acceptability of the material for clothing, and the acceptability of the material for accessories were associated with age, year in college, number of clothing and accessory items purchased, and the amount of money spent on clothing and accessories (Table 4.5). No significant relationships were found among these variables. Age, year in college, number of clothing and accessories purchased, and amount of money spent on
clothing and accessories were not associated with the participants’ liking of the BC materials and their ratings of the material’s acceptability for use in clothing or accessories.

Table 4.5

*Correlation Analysis (N = 33)*

<table>
<thead>
<tr>
<th></th>
<th>Overall Liking of the Material</th>
<th>Material Acceptability - Clothing</th>
<th>Material Acceptability - Accessories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Pearson Correlation</td>
<td>.009</td>
<td>-.054</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.960</td>
<td>.765</td>
</tr>
<tr>
<td>Year in college</td>
<td>Pearson Correlation</td>
<td>-.303</td>
<td>-.034</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.086</td>
<td>.853</td>
</tr>
<tr>
<td>Clothing purchased</td>
<td>Pearson Correlation</td>
<td>.206</td>
<td>.168</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.251</td>
<td>.350</td>
</tr>
<tr>
<td>Money spent</td>
<td>Pearson Correlation</td>
<td>.033</td>
<td>-.064</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.855</td>
<td>.721</td>
</tr>
</tbody>
</table>

**Open-ended responses.** In an open-ended question, participants were asked to provide additional comments about the characteristics and use of the BC material, and all 33 participants provided comments, some very short and others in more detail. Comments related to material characteristics, its perceived performance, possible uses of the material, and suggested improvements were offered by participants. The descriptions of the material were mostly similar to the descriptions generated in Part One and the findings in Part Two.

**BC material characteristics.** The material was described as “too thin” and see-through or transparent, which, according to a participant, “might be seen as a negative, if it allowed the
contents of the purse to be seen.” The participant-generated attributes from Part One and the intensity ratings in Part Two also showed that the material was considered see-through by the majority of participants. Participants also noted that the material had a “distressed look” and a “raw look/feel.” Some participants likened the material to skin, faux leather, or “old leather and books.” Many participants noted that the material is a “great” and “natural” leather alternative. Participants liked the material’s naturalness, uniqueness, authenticity, sustainability, and earth-friendliness. They specifically noted that its unique look, even though “not perfect” and “distressed” was an advantage and had potential for fabricating interesting, avant-garde products.

The smell of the material, characterized as “off-putting,” concerned many participants—it was suggested that “people might dislike the smell it leaves on your hands.” However, other participants thought the material “smells amazing” and that the smell was their “favorite thing about the material.” Others felt that the smell would fade away.

**Perceived performance.** Strength, flexibility, and ability to “take a lot of wear and tear” were characteristics offered by participants to describe the perceived performance or functional aspects of the material. These attributes were also mentioned in Part One. Concerns about the durability of the material when wet were raised by several participants. A participant inquired: “Will it get soggy and weak?” While the perceived durability of the material was described both positively and negatively, in Part One, its performance under different environmental conditions was not mentioned. The material coming into contact with the skin and “rubbing and causing pain” was another concern for several participants. Caring for and cleaning the material was also an issue raised by some participants, and some expressed concerns that animals or babies might chew on or eat the material.
**Suggested improvements.** According to a few comments, the material could be improved by making it more opaque and thicker, and use of multiple layers was recommended to achieve this. This coincides with findings in Parts One and Two of the sensory evaluation that showed that many participants did not like the transparent feature of the material. Another suggestion was to offer a greater variety of colors. Specifically, dyeing the material “unnatural,” “rich,” or “just more” colors were recommended. Another participant mentioned that a line tended to stay on the material after it was creased, and that fixing that characteristic would result in a higher-quality fabric. This was also mentioned in Part One by a few participants. While the material was generally seen as “too stiff” for clothing items, “more structure and thickness” was recommended for use in fashion accessories such as bags.

**Uses of the BC material.** Participants suggested that the BC material could be used for fashion accessories (e.g., bags, belts, shoes/sandals, jewelry, and hair accessories), certain clothing categories (e.g., last-layer clothing items such as vests, motorcycle apparel, costume-making, accents/trims on clothing), and other consumer products (e.g., book covers, shopping bags, avant-garde fabrics). A participant noted that it could be used for “clothing and accessories that are usually made of leather.” In general, participants felt that the material was not very suitable for clothing items, especially those worn against or close to the skin. The ratings of acceptability of BC for clothing and accessories also showed that participants thought BC was acceptable for accessories but not for clothing.

**Part Three summary.** In Part Three of the sensory evaluation, participants rated how much they liked or disliked the BC material overall, as well as how acceptable the material was for clothing and accessories. Participants also provided additional comments about the characteristics and use of the material. While more participants liked than disliked the material,
most participants were neutral. Participants believed that the material was not acceptable for clothing, but indicated that it would be very acceptable for accessories such as bags, belts, and shoes.

In open-ended responses, the material was described as see-through, skin- or leather-like, and distressed or raw-looking. While distressed or not perfect, the material was described as unique. Some participants indicated that the liked the smell, while others thought the smell was off-putting. Some participants had concerns about the material’s durability when wet, and concerns were also raised about the material rubbing and causing pain when in contact with the skin. How to care for the material was also a concern. To improve the material, it was suggested it be made more opaque and thicker. It was recommended that for accessories such as a bag, the material would need more structure and thickness. Offering a greater variety of colors and preventing the material from retaining creaselines after being folded were other suggestions,

Participants also suggested that the BC could be used for fashion accessories and other consumer products such as book covers and shopping bags. Only certain clothing categories such as vests or motorcycle apparel were recommended for the material, and the material was not generally considered to be suitable for clothing.

**Focus Group Discussion Analysis**

After they had individually completed sensory evaluation of BC material swatches, participants were provided with a shoulder bag made of BC material to examine. Group discussions, lasting approximately 30 minutes, followed. Six focus group sessions were held, with a total of 33 female participants. Prompted by semi-structured discussion questions, participants voiced their opinions about various characteristics of the bag (e.g., appearance, quality), the advantages/disadvantages they saw related to using the bag, the likelihood of them
using the bag or different products made of the same material, the likelihood of consumers purchasing products of the same material, and other aspects of the bag in relation to their lifestyles, needs, and values.

Participants were also shown pictures of other products made of BC and asked to provide feedback. The nature of the BC material was only revealed to participants at the end of discussions. First, they received information about the Kombucha fermentation process and the name of the material (bacterial cellulose), followed by information about the sustainable nature of the material and the bag. After each introduction, participants were asked for their opinions, and whether their opinions had been changed by knowing more about the material.

The transcribed data from the focus groups were analyzed using the priori and open coding methods discussed in Chapter 3. Codes were categorized in intrinsic, functional, marketing, and social-communicative priori categories, based on the four dimensions of the Fashion Product Evaluation framework described in Chapter 2. The findings were then grouped under these same four categories, or themes, followed by other findings.

**Intrinsic Attributes**

Intrinsic attributes include product characteristics that are physical or inherent parts of the product that if changed would change the product itself. Based on the analysis of the focus group data, several intrinsic attributes were identified for the bag made of BC, and these attributes, including material properties and design features, are discussed below.

**Material.** In general, the material of the bag was described as “paper-like” and “leather-like,” similar to findings from the earlier stages in the study. Some participants also thought the material looked like “cheap leather,” “fake leather,” and “human skin.” It was also described as “natural,” “earthy,” “organic,” and “interesting.” A significant number of participants indicated
that the material had a “worn-looking” appearance, noting that the material and the bag look “old,” “worn,” or “weathered.” The material was described in a manner similar to that during sensory evaluation. While some disliked its appearance, others liked the “worn out” look, describing it as “vintage” or “with character” and seeing this as an advantage. Other attributes related to the material can be described as follows:

**Texture.** The texture of the bag was an attribute frequently mentioned by participants. Similar to findings from the sensory evaluation, participants stated that the texture of the material had a “distinct pattern,” “crinkles,” “wrinkles,” and “crack.” Some participants suggested “taking off” the texture to make it smooth and soft, while others stated that they liked or “loved the wrinkled texture.” While some participants disliked the texture of the material, it seems that others saw this as a unique characteristic, giving the product an authentic and one-of-a-kind look.

**Thickness, weight and translucency.** The majority of participants described the bag material as “thin,” associating this with lower durability. A few participants liked the thinness and the associated low weight and pliability of the material, which allowed having a “lightweight” bag. Many others wondered whether the material could be made thicker to provide more “structure” and “durability” to the product as well as making the material less translucent/see-through. “I prefer a heavier feeling,” stated one participant, and another noted: “I want more structure in my bags.” One participant proposed that “if it was thicker, it would look a little more, like, quality and sturdy.” Participants generally viewed the thinness of the material as a negative attribute because of the flimsiness of the material, its see-through nature, and its perceived lower durability and quality.

According to one participant, “the material on its own is way too thin, but, when it’s layered, it looks good.” “Layering” the material was suggested as a method for increasing its
thickness, as well as improving its other material properties. Translucency made the material “seem plastic or paper-like” and resemble “wax paper.” Making the material less translucent was suggested for improving the overall quality. The material was also described as see-through or translucent in the first part of the sensory evaluation and, in the second part, increasing the thickness and making it less transparent to improve the material was recommended.

**Smell.** Smell of the bag was found to be a major concern. Participant comments focused on three areas: descriptions of the smell, liking of the smell, and concerns about the interaction of the smell of the bag with other items or smells, such as perfumes and clothing. Similar to findings of the sensory evaluation, the smell of the bag was described as “unpleasant”, “very strong” and “off-putting” by most participants, while a few described it as “not as strong” or “not as obvious if not too close.” Many participants described the smell as “vinegary” or “sour.” Others thought the material smelled “fruity,” “musty,” and like “ammonia” or “urine.” The participants who were not bothered by the smell noted that it was reminiscent of “old books” and an “antique shop” and, as one of the participants expressed it: “It gave me nostalgia.” Another participant described the smell as a “statement smell.”

While a few participants stated that they did not “mind it” or “it didn’t bother them,” the majority indicated that they did not like the smell and suggested that the smell has to be improved or eliminated if the product is to be acceptable for consumers. Concerns were raised that the smell “stays on your hands” and may rub off to other products or interfere with perfume smells (e.g., “I’d worry that my things would start smelling like that.”). Participants wondered if “the smell would go away once you used it,” a characteristic of leather and other similar materials and products.
Design features and style. The bag was described as “cute”, “adorable,” and “not as different from a normal bag.” For some participants, the floral design on the bag looked “really good,” while others said that it was “too young” or “childish.” As one of the participants stated, “I like my purses to look a little bit older, mature.” Another participant noted: “I like basic pieces. Without the flowers, I would like it a little more, as it would go with different outfits.” However, other opinions were also offered: “I really like the design on the front. I think it adds a lot to it [the bag] and makes it look… natural.” Some participants liked the style of the bag, while others preferred different styles, such as bigger bags for carrying more things or more “simplistic styles.”

Color. The appearance of the bag was heavily discussed, particularly with respect to color. While some participants liked the lighter, “natural” tone of the material, the majority preferred the contrasting reddish color and suggested that darker shades would be more preferable. For example, a participant stated that “the darker color looks a lot nicer… that’s something really pretty,” while another said: “If you dyed it, like, those blacks, it would be more well-taken, cause it’s [the material] kind of skin-like.” The darker colors were associated with a more “leathery” look, versatility, and professionalism. In Part Three of the sensory evaluation, when participants had access only to the natural tan material color, offering a variety of colors (e.g., rich colors, “unnatural” colors) was also recommended, as a way for improving the material.

Functional Attributes

Functional attributes include product characteristics related to utility, serviceability, and performance. A number of functional attributes based on analysis of the focus group data were
identified, including durability, water and stain resistance, colorfastness, abrasion resistance and creasing. These are described in more detail below.

**Durability.** Durability of both the material and the bag was another major concern raised by participants. A few of them thought the bag looked durable, noting that it “feels usable and durable,” “strong,” and “looks like it will last a while.” “I think it’s durable. I wouldn’t be worried about it,” stated another participant.

However, the majority noted that the bag did not seem durable because the material seemed “too thin,” “cracked,” “delicate” and “fragile.” One of the participants stated: “if you had that thickness… it would look a little more sturdy and durable.” The “cracked” and “dry” appearance of the strap and the bottom of the bag were associated with a worn look and less durability. (It should be noted that the material in those parts of the bag were drier, compared to other parts, and showed some cracks.)

“Layering” the material or reinforcing it with other fabric was suggested as another way, in addition to increasing the thickness, to increase the bag’s durability. “This part looks sturdy, cause it’s layered, so it looks a lot stronger,” commented one of the participants, comparing single- and double-layered parts of the bag. Another participant noted, “I like the parts that are layered more. They are more durable and thicker.” Referring to the lined parts of the bag, one participant stated that the material “looks more durable when layered and paired with other fabrics.”

Performance both of the material and the bag was also discussed with respect to suitability under different weather conditions; for example, a participant was concerned: “…right now it looks durable, but it’s normal conditions. Let’s say, if I would leave it under the sun for the whole day, would it be more dry and more wrinkly? Or maybe when you got into rain, the
heavy rain… I hope my bag wouldn’t fall apart.” Concerns about material performance at low temperature were also raised.

**Water and stain resistance and colorfastness.** The water and stain resistance and colorfastness of the material were also discussed in evaluating the bag. While the bag was perceived to be “waterproof” or “water resistant” by some participants, others asked if it would “disintegrate when wet” or allow items inside the bag to get wet under rainy conditions. Some participants were also concerned about whether the material would stain, wondering if they were “going to have stains on the bag, if they spilled something on it,” and if it would be possible to “wipe off” spills. A few participants were concerned that the color of the material “may run” if it got rained on and that the color would change in the sun.

**Abrasion resistance and creasing.** Participants also discussed whether the material would not abrade, “scuff” or “snag” easily. The general impression was that it didn’t look “like it would rip” or “snag on something,” and that “nothing gonna scratch it” or “you can’t even shove your finger through it, or your nail.” “I appreciate that it doesn’t look like it’s gonna break or bend” noted one participant. A few participants noted that the material retains crease lines when folded and pressed. One of them stated, “I feel like if you stored it, and one of the petals was [folded], it might stay that way,” while another noted that she didn’t like the “bends in the strap.” A third participant shared, “It’s a downside that I can put a crease in it,” followed by agreement by other participants who stated that “Yes, you can see it” and “it does crease, but it doesn’t crackle on it.”

**Marketing Attributes**

The marketing dimension includes product attributes that are retail- or manufacturer-added and aid in marketing the product to consumers. Several marketing attributes related to the
bag were identified through analysis of focus group discussions. These included price, target market, material name, and product information, and are discussed below.

**Price and target market.** There was a consensus among participants regarding the price and target market or appropriate consumer age group. Participants noted that they would pay about $20-35 for the bag. One of them stated that she would pay up to $50, as the bag “looked like a handmade item and those were more expensive.” It was suggested that the “target would definitely be the younger generation” and the bag “would be well received by the younger age group.” Participants stated that “moms would not buy it” and neither would older people, who “are more set in their ways” or conservative and traditional in their choices.

**Product information.** When it was explained that the BC production process was accomplished through tea/Kombucha fermentation, participants expressed surprise and excitement. “I think it’s awesome and I love it,” stated one participant, while others stated: “I would totally buy it” and “That’s really cool!” Another participant noted, “As a genetics major, I love it!” Some participants wanted to know more about the material, asking “Is it biodegradable?” or “What is the cost per yard?” Only one participant had previous experience with BC material, as she had completed a related experiment in high school. A few other participants were familiar with the Kombucha drink.

After receiving information about the sustainable nature of the material, participants expressed increased interest in the bag and stated that they would be open to buying and using products made of BC. One participant said, “I like it more [now that I know what it is]. It’s more appealing.” Another stated, “It gives you a good reason to buy it.” “When I first saw it, I thought it would make a good leather alternative. Now that I know it’s sustainable, I’d definitely push people to buy it,” stated another participant.
It was suggested that consumers must be informed about the BC material to make sure they understand, appreciate and are open to purchasing products made of it. Consumers would buy products made of BC “if they were informed about it” and if there was “a cause or campaign behind it.” “Knowing what it’s made of increases product value, for sure” stated a participant. According to another’s comment, “If it was in a store, there would definitely need to be a sign that tells you what it’s made of. Otherwise, people wouldn’t know.”

The fact that the material was made from tea and was “cruelty-free” and “eco-friendly” were considered “big marketing points” that “would peak a lot of people’s interest.” There would be a “huge market for it now,” stated a participant. Another participant noted, “If I knew what it was made of, I would be drawn in. I’d like to support animals and the environment.” It was suggested that “the vegan and organic,” “sustainable” and “environmentally-conscious” consumers would be particularly interested in BC products. BC was viewed as a possible leather alternative by several participants and adding “little fun facts” about its tea-based source would make people more interested in it.

**Material name.** While BC received positive feedback as a sustainable leather alternative, its name, specifically the bacterial designation, was not considered appealing. The suggestion was not to use the name in marketing BC product, because ‘bacteria’ could “throw a lot of people off.” Instead, it was recommended to use a name connected to Kombucha, such as “Kombucha leather,” because “the people would go for it.” “Bio-leather” was another name recommendation. While one participant couldn’t think of an appropriate name for the material, she recommended not to have “faux leather” in the name, as “people will think it’s cheap.”
Social-Communicative Attributes

Social and communicative attributes include characteristics related to a product’s symbolic, communicative, and social aspects that are used by consumers to express their feelings and identities through clothing choice. Several social-communicative attributes related to the BC bag were identified through the focus group data analysis. These include uniqueness/novelty, fashionability, and lifestyle and values.

**Uniqueness/novelty.** The bag was described as “unique” or “different” by several participants. They noted that the bag is “different. Not that much in the stores right now, and one of my best friends would fall in love with this. I feel like there are certain people that would love it.” For some, uniqueness was related to the material texture and the surface characteristics of the bag. “The wrinkles make it look kind of unique,” stated a participant, adding: “I feel like if you made that same bag, each one would end up looking a little bit different, and, I think, that’s really cool.” Another participant noted about the bag: “It’s got a lot of character. Even if rain left some marks that would just add to it.” The unique texture of the material was also referenced in the sensory evaluation.

The tea-based source of the material was viewed as an “innovative” product attribute. For example, all participants in one focus group nodded in agreement, as one of them stated: “It’s impressive, actually. Just thinking about it. I’m wearing this stuff. It’s tea-fermented! Sounds innovative.” As discussed earlier, informing consumers about the nature of the material and its benefits was expected to get them more interested in acquiring products made of BC.

**Fashionability.** Fashionability of the bag was discussed by participants in terms of its eco-friendly nature and “vintage” appearance. They suggested that these product attributes were currently “trendy.” Some comments on these included: “Sustainable fashion is really blossoming
right now” and “people are more open to being environmentally-friendly, organic.” One of the participants noted: “If it’s a byproduct of the tea fermentation process and that tea is really ‘in’ and trendy right now, people might think “oh, my bag’s made out of tea.” An eco-friendly attribute was considered “high-end” by another participant who stated that she liked the material more because of this.

**Suitability to lifestyle and values.** Suitability of the bag related to personal lifestyle and values was discussed by many participants, in terms of personal or consumer interest towards organic, eco-friendly, vegan, “animal-friendly” and “cruelty-free” products and more conscious perspectives on environmental and societal issues. In the words of a participant, “There are a lot of vegans who don’t like buying leather products, and like, sometimes, it’s hard to find things, and you’re not sure whether they are real or fake. Then, sometimes, the fake leather looks really bad, so this would be a good alternative.” Another participant stated that “a lot of environmentally-conscious people are into earthy tones and things that look natural, so, [they] would definitely buy it.”

**Appropriate Product Categories for BC**

According to participants, BC material would be more appropriate for accessories than for clothing. After viewing images of clothing and shoes made of BC during the focus group discussions, participants stated that they “loved,” “would wear” or would purchase the shoes, both men’s and women’s. The jacket was also found to be acceptable, although there was general agreement that it would be a little restrictive, similar to a leather jacket in that regard. Other clothing items shown, such as the skirt and the vest, were not perceived as being comfortable to wear because they looked “stiff.” Participants further suggested a number of products the BC material could be successfully used for, including wallets, one-strap bags, backpacks,
“outdoorsy” or travel bags, camera bags, belts, bigger totes, shopping bags, watch bands, chokers, and accents and trims.

**Focus Group Discussions Summary**

Several intrinsic attributes were identified, including: design features, style, color, material, texture, thickness, weight, translucency, and smell. BC material was described, among other characteristics, as paper-like or leather-like, similar to the findings during sensory evaluation. The material of the bag was described as worn-looking and, while some participants disliked it, other thought the bag looked vintage, considered to be an advantage. Darker colors were preferred for the bag. The material was described as textured with distinct surface patterns, similar to the findings of the sensory evaluation. This was seen by many as a unique feature.

The thinness of the material was considered to be shortcoming, seen as the underlying cause of several other negative attributes, such as the material’s flimsiness, translucency, and low durability and quality. Layering the material was suggested as a method for improving its thickness and other material properties. Since the smell of the material, described by many as unpleasant and vinegary was a major concern, improving or getting rid of the smell was recommended for acceptability of the bag. Some participants did like the smell because it evoked nostalgic feelings of old places and items.

Six functional attributes were identified, including durability, water and stain resistance, colorfastness, abrasion resistance, and creasing. The material was not perceived as durable because it was thin and delicate. Concerns were raised about the performance of the material and the bag in terms of different environmental conditions (e.g., in the sun, rain, cold), water and stain resistance, colorfastness, and creasing of the material when folded and pressed.
Several marketing attributes were identified, including target market, the material’s name, and product background information. The bag was suggested as more appropriate for the younger generation and more likely to be embraced by consumers who led environmentally-conscious lifestyles and preferred vegan and organic goods. Participants expressed willingness to pay $20-35 for the bag. Special emphasis was placed on the idea that information about the source of material and the sustainable nature of products made from it should be relayed to consumers during marketing, because they might be more willing to acquire such products if such facts were known. Use of the name ‘bacterial cellulose’ was not recommended in marketing the product, because consumers would likely to find it unappealing, especially the ‘bacterial’ designation. Other names, such as “bioleather” and “Kombucha leather” were suggested.

Three social-communicative attributes were identified, including uniqueness/novelty, fashionability, and lifestyle and values. The uniqueness of the bag was described in terms of the textured surface and the tea-fermented source of the material. The fashionability of the bag was related to two aspects, its vintage appearance and its eco-friendly nature. The bag would be suitable to the lifestyles of consumers who are drawn to eco- and animal-friendly and “cruelty-free” products. BC material was found to be more appropriate for accessories (e.g., totes, travel bags, watch bands) than for clothing.
CHAPTER 5. CONCLUSIONS AND IMPLICATIONS

This chapter presents discussions of the research results and implications, significance and contributions of the study, along with its limitations and future research directions. This research examined consumer perceptions of bacterial cellulose, a novel sustainable material, and its suitability for use in fashion products. Specifically, the study was completed to:

a) understand how consumers perceive and characterize BC material based on the senses of touch, sight, smell, and hearing;

b) identify the areas for material improvements and the potential barriers and motivations for consumer acceptance of products made of BC; and

c) evaluate acceptability of bacterial cellulose as a novel material for fashion products from a consumer perspective.

The research employed an embedded mixed methods research design. Data were collected during six focus group sessions that included quantitative sensory evaluation of BC material and qualitative focus group discussions. The sample included 33 female students. The nature and origin of the BC material was not revealed to participants until the end of the focus group sessions. BC material is new, and therefore not possible to acquire from outside sources, so for this study the researcher developed BC material using a Kombucha fermentation method. The material was used to prepare swatches for sensory evaluation and to construct a shoulder bag to stimulate discussion in focus group sessions.
Theoretical and Methodological Contributions

Theoretical Contributions

Based on a systematic review and content analysis of extant research on apparel evaluative criteria (Abraham-Murali & Littrell, 1995; Eckman et al., 1990; Fiore & Damhorst, 1992; Jeong & Lee, 2014; Swinker & Hines, 2006), a new framework for Fashion Product Evaluation (FPE) was developed. The need for an integrated framework became apparent, as review of previous studies revealed a broad array of evaluative criteria often classified into various overlapping and unclear dimensions. For example, while some researchers have classified only product structural and physical characteristics as intrinsic attributes (Swinker & Hines, 2006), other have also included attributes related to product performance, quality and aesthetics (e.g., comfort, fit) under this category (Fiore & Damhorst, 1992, Jeong & Lee, 2014). Appropriateness, coordination, and approval of others are additional examples of attributes classified by researchers in different categories (Abraham-Murali & Littrell, 1995; Eckman et al., 1990). For instance, Eckman et al. (1990) identified 17 evaluative criteria grouped into aesthetic, usefulness, extrinsic and performance and quality dimensions. Abraham-Murali and Littrell (1995) used physical appearance, physical performance, expressive, and extrinsic dimensions to classify 19 apparel attributes.

The proposed FPE framework is a comprehensive classification system that integrates evaluative criteria or product attributes, into four mutually exclusive and clearly defined dimensions: (a) intrinsic attributes; (b) functional attributes; (c) marketing attributes; and (d) social-communicative attributes. Law-like propositions have been developed defining each dimension and guiding the classification of evaluative criteria. Development of law-like generalizations is an important step toward theory development (Hunt, 2002). Each dimension
addresses a distinct group of product attributes and is enabled by different interactions between the product and producer, consumer, and society/culture. The framework was tested and validated in this study as useful for evaluating fashion products.

The FPE framework was used in this study for developing questions for the semi-structured focus group discussion guide as well as for analyzing the focus group data, using the four dimensions as priori coding categories. The framework was useful for understanding how consumers perceived BC products and what product aspects were important. It is helpful in identifying and addressing the gaps between consumer needs and desires and product attributes. The framework can be effectively used by businesses for development and evaluation of new fashion products and helping with marketing decisions. To develop successful products, it is important to understand how consumers evaluate them and what criteria they use in the process (May-Plumlee & Littrell, 2006). Researchers can use the framework to study consumer evaluation and purchase decisions of fashion products at the point of purchase or in laboratory settings. The framework can also be employed for evaluating consumer needs related to specific apparel and other goods that could then serve as design criteria for developing innovative products.

Methodological Contributions

Sensory evaluation of textiles and apparel has traditionally focused on senses of touch and sight, with tactile and thermal comfort receiving particular attention (Balaji et al., 2011; Phillippe et al., 2003). The term ‘sensory’ often is used interchangeably with ‘tactile’ or touch sensation in scholarly textile and apparel publications. This study was the first to conduct a complete sensory evaluation of a fashion product that took into account the senses of sight, touch, hearing, and smell—all the human senses, except for taste.
In this study, a new three-part method for holistic sensory evaluation of fashion products was developed and used to understand consumer perceptions of novel bacterial cellulose material. The method was carefully documented, described, and successfully tested. Holistic sensory evaluation of materials and fashion products is essential because of the increased importance of new materials (e.g., bio-based materials) and rapid development of wearable technology and smart textiles and clothing (Lehmann et al., 2018; “Smart Textiles”, 2017). As novel materials and non-textile components, often with unusual sensory characteristics, are incorporated into fashion products, tactile and/or visual evaluation only may be insufficient for capturing and assessing the complete sensory characteristics of products. As wearable technology and new materials gain more prominence, smell and sound may also be experienced with plastics, wires, solar cells, or unconventional material used in fashion products.

The three parts of the sensory evaluation can help in gaining a broader understanding about a material or product studied, by adding additional layers of insightful information. Generating attributes that describe the material/product in the Part One of the sensory evaluation is particularly valuable in gaining fundamental information about material characteristics as perceived by potential consumers. Moskovitz (2008) justifiably stated that “attributes constitute the fundamental form of information by which the researcher taps into the mind of the consumer and …understands how they perceive the products and …why a particular product is acceptable or not acceptable” (p. 173). In Part Two of the sensory evaluation, rating the intensities and liking of particular attributes can help in determining the magnitudes of the attributes experienced (e.g., not too rough or extremely rough) and whether particular attributes are liked or disliked. For Part Two, if a suitable list does not already exist, a product- or material-specific list of attributes must be developed by an expert panel. Part Three of the sensory evaluation helps
Introducing novel sustainable materials in the fashion industry may present some challenges. Novel materials may exhibit different characteristics based on their production processes, fiber sources, or other factors. Conducting consumer evaluation of novel materials and products made of them could be invaluable in understanding these factors and identifying areas for material improvement or emphasis in marketing such products. Sensory evaluation could be of significant help to more broadly and fundamentally understand the characteristics of novel materials, based on consumer perspective (Meilgaard et al., 2007).

Researchers can apply the sensory evaluation method documented in this study to assess new materials developed for fashion products or other consumer goods as well as for existing textiles and apparel products. Clothing, accessories, and other products, especially wearable technology items and smart clothing, could benefit from using this sensory evaluation method. Businesses might also find the instrument useful in conducting evaluation of new products and materials during product development stages, to help them improve their products before they are introduced into the marketplace.

**Practical Contributions**

Novel bio-based materials such as BC may help the fashion industry to become less reliant on non-renewable, petroleum-based material sources and other natural resources (Kozlowski et al., 2016). Other environmental impacts related to production and consumption of fashion products, such as waste generation, may also be alleviated by use of bio-based materials (Cao, Wool et al., 2014; U.S. Department of Agriculture, n. d.). There has been a substantial number of research studies related to BC applications in a variety of fields, ranging from
biomedical engineering to cosmetics and food (Gama et al., 2013). In the fashion industry, there has been little effort toward broadening the knowledge base related to BC beyond a limited number of studies examining material production processes and designing products made of BC material (Freeman et al., 2016; Lee, 2011; Lee et al., 2014; Smail, 2016; Wood et al., 2015).

This study contributes to the limited body of existing research on BC in the textiles and apparel field in several ways. The study provides a methodological documentation of BC production processes using a Kombucha fermentation method, including specific inputs, fermentation conditions, growth time frames, harvesting, dyeing, and enhancement of the material. In addition, the study documents the process of designing a BC-based fashion product, including use of conventional apparel assembly processes and equipment, as well as laser-cutting technology. The knowledge regarding BC material production methods and product design can be useful for researchers and industry practitioners as they further develop manufacturing technologies based on this novel and sustainable material and commercialize BC-based products.

The main practical contribution of this study lies in conducting consumer evaluations of BC and providing valuable insights about consumer perceptions of BC material and BC-based products and assessing overall BC acceptability for fashion products. This is the first research that examined these aspects related to BC. Understanding consumer perspective on the use of BC in fashion products is of utmost importance, because consumers themselves ultimately decide whether new products succeed or fail by either accepting or rejecting them (Stone & Farnan, 2017). Examining consumer perceptions is especially important in the case of BC because, as a novel material, BC has no commercial precedent in the fashion industry, and is different from other materials in the market because of its origin and production method. Understanding how consumers perceive the material properties and BC-based products can help with identifying and
addressing issues before introducing BC products to the market. This study advances the knowledge base on BC in the textiles and apparel field in the specific areas described below.

**Recommended Improvements of BC Material**

**Material thinness.** Thinness was found to be an important issue for BC material. Material thinness was the underlying reason for several other unfavorable characteristics, such as flimsiness, low durability, and translucency. Structure that is more substantial, weight, and durability were preferred for the bag, and increasing the thickness of the material to make it sturdier and more durable was suggested. Increasing material thickness, the dimension between the material top and he bottom (Bubonia, 2014), should be one of the priorities for companies planning to introduce BC to the market, at least for fashion accessory applications. Layering the material was found to be a favorable method for increasing its thickness. Reinforcing the material with other fabrics (as with the canvas interlining of the bag) is also acceptable; the applicability of this method will depend on specific product types.

Other methods for increasing material thickness should be explored. Modifying the BC growth medium to obtain thicker material could be a possible solution. Experiments could be carried out with various ingredient changes (e.g., adding sugar) to identify a more optimum combination with respect to generating thicker cellulose sheets. Increasing the BC growth period should also be considered. For example, the fermentation period could be increased to five weeks instead of four to allow the cellulose to grow thicker. However, longer growth periods might result in microorganism nutrient depletion or oxygen insufficiency, limiting cellulose growth (Shah et al., 2013).

While thicker material was found to be important for use in accessories, thinner material may be acceptable for other applications, e.g., film-like products, jewelry, or appliques. It is
important to consider that, when evaluating a fashion accessory such as a bag, participants’ perceptions may have been affected by their comparison of the material to leather. While the majority of participants appeared to view the material thinness unfavorably, most of them liked the material thinness when evaluating the swatches during the sensory evaluation. Consumer perceptions of the material seem to be product-specific.

It is also important to conduct objective evaluation of BC material durability using standardized tests. For example, material breaking strength and elongation could be evaluated through ASTM D5034-09 (2017), a method for testing woven and nonwoven textiles. Wood et al. (2015) found that the tensile strength and elongation of BC was higher than most nonwoven fabrics used for consumer goods, while the tearing strength and stiffness was similar. However, in that study different production method was used for developing BC material. An objective evaluation would help in assessing whether the actual material durability is consistent with consumer perception of low durability.

**Translucency.** The translucency of the BC material was another characteristic found to be of major concern among potential consumers, and three-fourths of the participants described the material as see-through, translucent, sheer, or transparent. The high intensity rating for this attribute confirmed the finding, and the low liking rating showed that translucency was considered an unfavorable characteristic. These findings were echoed in the focus group discussions.

Material opacity was associated with higher perceived quality, especially for fashion accessories such as bags. Although a few studies have addressed BC production and evaluation of BC material for fashion products (Lee, 2011; Wood et al., 2015), material thinness and opacity has not been addresses. Increasing the thickness of the material, as well as layering it or
using support fabrics might be possible improvements. In addition, other BC production methods should be explored. This could include finding ways of developing inherently opaque BC sheets, perhaps through addition of other substances into the growth medium. Subjecting material to additional treatment processes after harvesting or applying environmentally-friendly paints or other product on the material surface could also be explored. It should be noted that the translucency of the material could be a positive characteristic for some product applications, e.g., book covers, name tag holders, and jewelry.

**Unpleasant odor.** Because of the presence of vinegar during BC fermentation process, the developed material tends to acquire a distinct smell. Although purification and other treatment processes (see Chapter 3) help to reduce the odor intensity, some odor is still retained by the final material. Smell can stir emotions, memories and the mood, and evoke positive and negative feelings towards products and places (Solomon & Rabolt, 2009). This smell, variously described as off-putting, unpleasant, or simply bad, was found to be a major concern because participants did not like the vinegary, sour odor. In contrast, the smell was positively perceived by some participants because it evoked nostalgic feelings reminding them of old things and places. However, it is likely that the majority of consumers would not like the odor.

For BC products to be accepted in the market, the smell of the material must be improved or eliminated. Efforts could focus on: (a) finding ways to reduce or replace the use of vinegar during BC fermentation; and (b) eliminating the smell by adding various scented substances such as essential oils or various extracts. Care should be taken to ensure that added ingredients would be compatible with the BC growth medium and not interfere or inhibit the fermentation process. In addition, only environmentally-friendly substances should be used to ensure that the final
material is truly sustainable. To keep the material production costs reasonable, the cost of such additional substances must also be considered.

**Skin-like appearance.** BC obtained through the fermentation of green and black tea naturally exhibits a tan color. Almost half the participants described the material as skin-like, an effect created by the material’s tan color and wrinkly and textured surface. In contrast, the reddish material used for the bag was viewed positively because it was associated with leather-like appearance, a more acceptable look.

Color is a key consideration in selection of apparel and other fashion products (Stone & Farnan, 2017), so to be successful in the market, BC products should be offered in a variety of colors. Inherently colored BC material may be developed by adding natural dyes to the fermentation medium. Wood et al. (2015) successfully used natural dyes (e.g., saffron, beet, and turmeric) and blue artificial dye to develop inherently colored BC material. A color variety may also be achieved by dyeing the material using sustainable dyes or dyeing processes after harvest. Lee (2011) reported changing BC color by a process of iron oxidation, as well as creating patterns on the material using fruit and vegetable staining. Use of digital printing technology to impart color and patterns on BC surface should also be explored, as should hand-printing methods for creating patterned textiles. Etching patterns on the surface could also be achieved using laser-cutting technology. In this study, laser-cutting and etching were successfully used to create floral designs on the front of the bag (Figure 3.10).

**Worn appearance.** Another issue with the BC material was its weathered or worn-looking appearance. While the worn look is not an inherent part of newly-developed material, it can be acquired later by some materials, possibly due to abrasion or chemical modifications in the material. The back of the bag evaluated by participants appeared more worn than the other
parts, and whitish, wrinkly lines were present on the surface of this material piece. It would be important to thoroughly examine the causes for these changes in some BC sheets to help prevent or control the weathered effect. Various experiments and test methods (e.g., abrasion resistance, weathering) could be employed to evaluate the material and quantify its properties. This would contribute to understanding of how BC properties are similar or different from other materials such as woven fabrics, leather, etc. A better understanding of BC properties might allow discovery of necessary solutions for issues such as weathering in some materials.

It should be noted that a worn or distressed look can appeal to consumers who favor unique, vintage, and one-of-a-kind products. To satisfy the needs of this consumer segment, it might be possible to develop BC sheets with either a ‘new’ or a worn-looking appearance, similar to new and distressed jeans. Regardless of the material type, it is important to conduct material testing described above.

**Favorable BC Characteristics**

**Texture.** Defined as “look and feel” of a material (Stone & Farnan, 2017, p. 13), texture was perceived as one of the positive attributes of the BC material. The natural pattern of lines and ridges on the material surface was seen as a unique characteristic. Such surface patterns are inherent to BC material; they form naturally during the material drying stage. This aspect could be emphasized in marketing of BC products. For example, a note or a tag could be included with the product to identify the material and explain that its unique texture, varying from product to product, is naturally formed on the surface.

Because some consumers may prefer a smooth texture, various methods directed toward achieving smooth BC material should be explored. For example, pressing or stretching instead of hanging and air-drying wet material could be explored. Various surface treatments of dry
material could also be examined. Developing BC materials with different surface textures could make it more comparable to leather, usually made in a number of texture varieties, including grainy and smooth. Imparting various textures on the BC surface is also a possibility. Stencil-like tools could be used for adding various textures to the material as it dries, perhaps to produce customized and personalized material for consumers.

**Novelty.** BC material has been described as unique and novel. Uniqueness or novelty has been found to be an important evaluative criterion for fashion product (Eckman et al., 1990; Fiore & Damhorst, 1992). Uniqueness of BC is strongly tied to the material’s surface texture, as discussed above. It has also been identified as unique because it is different from other materials and products offered in the market. Since BC has not yet been commercialized, no BC products are currently available. The fact that the material is obtained through tea or Kombucha fermentation process is another aspect through which BC is described as novel. Emphasizing such characteristics of the material in marketing of BC-based products could possibly appeal to a wider range of consumer segments.

**Motivation for BC Products’ Adoption**

Several factors motivating acceptance of BC products have been identified. Sustainability of the material has been found important to potential adoption of BC products. Previous studies have indicated that consumers are becoming increasingly aware and interested in sustainable products (Gam & Banning, 2011; Gleim et al., 2013; Ma, 2017). Based on findings, BC products would most likely be found appealing by consumers interested in eco- and animal-friendly, vegan, and organic products. Marketing of BC products should therefore place special emphasis on the sustainable nature of the material, perhaps by featuring the renewable and bio-based nature of the material, as well as its biodegradability and compostability.
Consumers interested in vintage fashion may also be motivated to acquire BC products with worn appearance. Vintage and eco-friendly products were described as trendy and fashionable by the participants in this study, and these characteristics can serve as additional motivating factors with respect to interest in and acceptance of BC products. As discussed earlier, the uniqueness of the material was also seen as a major motivating factor. These findings might be transferrable to other novel sustainable materials for fashion products, since they highlight consumer motivations for acceptance of sustainable products.

**Barriers for BC Products’ Adoption**

Several factors have been identified as potential barriers to adoption of BC products. While the perceived negative characteristics of BC material described above could prevent them from being accepted, these characteristics are tangible or inherent aspects of the material, and modification and improvement of such characteristics could result in eliminating these barriers. Intangible factors that could act as barriers for BC acceptance include: (a) the name of the material, bacterial cellulose; and (b) a lack of consumer knowledge about the material. The name of the material, specifically the ‘bacterial’ designation, was found to be a deterrent factor and not recommended for use in product marketing. Instead, ‘bioleather,’ ‘Kombucha leather’ and other names emphasizing the source of the material and its sustainable nature were recommended.

Lack of knowledge and awareness of consumers about the BC material and its sustainable nature was found to be a potential barrier to acceptance of BC fashion products. Previous studies have also found the lack of consumer knowledge about sustainable products and their benefits to be barriers for their acceptance (Gleim et al., 2013; Kozar & Hiller Connell, 2015; Moon et al., 2013). In this study, after learning about the nature of BC material, participants expressed a greater interest in the material and the bag, and seemed more willing to
adopt products made of BC. In marketing BC products, it is important to develop avenues for providing consumers with concise information about the material and its sustainable qualities. Material information could be provided in the stores in the form of informational signs, interesting tags, or notes attached to BC products giving a brief explanation about the material and its unique properties. Digital media can be effectively used for this purpose. For example, videos showing the BC development process can be displayed next to BC products in stores, on websites, and in social media. Because of its unique production methods and disposable nature, BC provides a great opportunity to communicate information about its tea-based source and benefits as a novel material that does not harm the environment. Effective strategies based on these ideas could be developed to create consumer labeling.

Acceptability of BC for Fashion Products

As a novel sustainable material still in a development stage, BC presents great potential for use in a wide range of sustainable fashion products. Although a number of issues related to BC material have been identified, the material was found in general to be acceptable for products that are more typically made of leather and other leather-like materials. Based on the material acceptance ratings, BC was found to be a suitable material for fashion accessories such as shoes, belts, bags, etc. When presented with images of clothing and shoes made of BC, while the research participants showed great enthusiasm for the shoes, there was a consensus that the material was not very suitable for clothing because it was perceived to be stiff and constrictive. With additional research and material modification, BC might become suitable for use in design of sustainable clothing; however, although in this study it was not found to be acceptable for clothing.
With respect to age group, based on the feedback from the research participants, BC products may be more appealing to the younger generation, because older participants were viewed as more traditional in their choices and not open to accepting new products such as BC-based goods. The sample population of this study was made up solely of female students, the majority aged between 19 and 21 years. It would be important to examine older generations’ perspectives on BC material and its applications for fashion products, and such age group information would be important for companies thinking of introducing BC products to market.

In terms of price, participants were willing to pay up to $35 for the shoulder bag, and this might be a consideration for companies making BC products. However, participants in this study were college students, and members of market segments with higher disposable income might be willing to pay more. In terms of lifestyle and values, BC products are more likely to be adopted by consumers who prefer organic, natural, and environmentally- and animal-friendly goods. Consumers of vintage products would also be expected to be more interested in products made of BC. The results of the study indicate that there may be a potential market for BC-based products, especially in the fashion accessories category (e.g., bags, shoes). This information may be useful in devising appropriate marketing strategies to businesses planning to introduce BC products to the marketplace. Understanding consumer perspectives and specific target markets can help producers and retailers to offer fashion products that meet consumer expectations and needs (Bubonia, 2014). In addition, it may encourage researchers, businesses, or entrepreneurs to work more rigorously towards developing industrial production methods for BC commercialization.

Conclusions

In this research, consumer evaluations of a BC-based product led to identifying consumer attitudes and motivations for accepting BC-based products, as well as product characteristics and
other aspects that could act as barriers. Combined with material evaluation findings, product evaluation helped in gaining a broader understanding of consumer perspective with respect to BC products. The research findings may serve as stepping stones for further research related to BC as well as other sustainable materials and products. The insight gained in the study may be helpful to researchers studying BC or other sustainable material development and applications in the fashion industry. Scholars interested in consumer acceptance of sustainable products may also find the study beneficial. Businesses or entrepreneurs planning to introduce BC-based products to the marketplace can also find the results of this study useful.

This study was the first to examine and identify both favorable and unfavorable BC material characteristics, based on consumer evaluations, and to recommend areas for improvements and future research. Motivations for and barriers to accepting BC products have also been identified, and overall acceptability of BC for fashion products has been assessed and discussed. Table 5.1 presents identified favorable and unfavorable characteristics as well as motivating factors and barriers to acceptance and adoption of BC products.

Table 5.1

*Consumer perceptions of BC material and its application for fashion product*

<table>
<thead>
<tr>
<th>Favorable Characteristics</th>
<th>Unfavorable Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Texture - natural ridges/patterns</td>
<td>• Material thinness</td>
</tr>
<tr>
<td>• Novelty</td>
<td>• Translucency</td>
</tr>
<tr>
<td>o Bio-based nature</td>
<td>• Unpleasant odor</td>
</tr>
<tr>
<td>o Tea-based, Kombucha-fermented</td>
<td>• Skin-like appearance</td>
</tr>
<tr>
<td></td>
<td>• Worn appearance</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Motivations for Adoption</th>
<th>Barriers for Adoption</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Uniqueness</td>
<td>• Material name - ‘bacterial’ cellulose</td>
</tr>
<tr>
<td>• Vintage-looking</td>
<td>• Lack of consumer knowledge and understanding the benefits</td>
</tr>
<tr>
<td>• Sustainable</td>
<td></td>
</tr>
<tr>
<td>• Environmentally- and animal-friendly</td>
<td></td>
</tr>
</tbody>
</table>
Limitations and Future Research Directions

As a novel material for fashion products, BC presents an abundance of research directions, ranging from cultivation of the material, to improving its properties, and designing with it, to examining consumer behavior, marketing, and assessment of environmental impacts of BC-based products. A number of specific directions for future research based on this study have been identified. For example, the identified unfavorably-perceived BC characteristics revealed an important need for further experimentation and improvement of the material to make products based on it more acceptable to consumers.

Research efforts could focus on increasing the material thickness, and evaluating its characteristics with respect to other material properties such as flexibility, durability, strength, and translucency. Since material thickness requirements may vary among different potential products, the optimal thickness would depend on the intended use. The unpleasant odor of the material warrants experimentation as well for finding ways of masking or eliminating it. Experiments could also focus on developing color variations of the material using environmentally-friendly methods and natural dyes. Either inherently-colored material could be grown or the raw material could be dyed after harvesting. Material stain resistance and colorfastness should also be evaluated to address concerns raised in the study. Conducting other textiles testing (e.g., air permeability) using standard methods is also necessary for a new material such as BC. Testing would help to establish specifications for the material, which is important for its wider adoption in the fashion industry.

Studying the surface texture of the material could be another research direction. While some participants in the study described the material as rough, others described it as soft. This could be due to different expectations when evaluating BC and comparing its properties to
different materials as a reference point: woven fabric vs. leather vs. plastic (Meilgaard et al., 2007). Further, individuals could differ in their sensory perceptions because of differing sensitivities of sense organs or because of differences in mental treatment of the sensations due to lack of familiarity with particular sensation (e.g., odor, texture) (Meilgaard et al., 2007).

Studies could focus on these differences in relation to perceptions of texture. Other participants described the texture as rough and soft at the same time. More evaluation could be conducted to understand the reasons for this discrepancy and improve the material, if necessary. Research could also focus on developing BC material more similar in texture to leather. Many participants in the study indicated that the material is leather-like, while others likened it to plastic or paper. Studies evaluating BC material properties in comparison with leather and other leather-like materials could also be carried out to assess its similarity to these materials and suitability to replace them in consumer products.

Several issues related to BC, and identified by other researchers, were not addressed in this study. These remain important areas for further investigation. For example, there are major issues in commercialization of BC with respect to production scale and cost difficulties (Pourramezan, Roayaei, & Qezelbash, 2009). The hydrophilic nature of BC (high absorbency of moisture and water), usually considered an advantage in other fields, remains a major issue for fashion products. Lee et al. (2014) have experimented with applying polylactic acid (PLA) nanofiber coating on BC surface for reducing its absorbency. Continued efforts are necessary in this area of research (Lee, 2011). Another extremely important research direction would be to assess the environmental impact of BC material and products made of it, considering the material’s entire life cycle from cultivation to end-of-life stage. A sustainability certification
process could be considered for the material. Studies should also focus in the area of cost analysis and feasibility of BC production on commercial scale.

The limitation of this research also presents future research opportunities. Its main limitations are related to the BC development method, the sample used, and the particular BC product used. The BC material evaluated in this study was produced through Kombucha fermentation methods using a specific set of ingredients and procedures. Since production of BC through other methods and using other procedures may result in material with somewhat different properties. Thus, future research could focus on examining BC material produced through different cultivation methods, e.g., using different amounts of ingredients, substituting some new ingredients (e.g. using other sources of carbon than sugar), and changing fermentation time, etc. For example, Freeman et al. (2016) substituted the sugar with culled sweet potatoes sucrose to grow BC. Another limitation is that only a single product, a women’s shoulder bag made of BC, was evaluated in this study. The type of product might have influenced participant perceptions, so future research could focus on evaluating other kinds of fashion products, perhaps, by selecting the type through a more systematic approach.

The sample population in this study included only female undergraduate and graduate students. As gender and age have been shown to play an important role in consumption patterns for environmentally-friendly and socially-responsible products may vary (Austgulen, 2016), future research could focus on evaluating BC use by other populations, e.g., males or older age groups. Other socio-demographic factors such as income and education level in relation to BC acceptance could be evaluated. BC is a promising renewable material with unique properties (Gama et al, 2013). With further research and material improvement, BC has the potential of
joining the new wave of innovative materials leading the way towards more sustainable future of the fashion industry.
REFERENCES


APPENDIX A. IRB APPROVAL OF RESEARCH

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Date: 9/9/2016

To: Amine Ghalachyan
31 MacKay

CC: Dr. Elena Karpova
1072 LeBaron Hall

From: Office for Responsible Research

Title: Consumer Perceptions of Bacterial Cellulose as a Sustainable Material for Apparel Products: Focus Group and Sensory Evaluation

IRB ID: 18-365

Study Review Date: 9/9/2016

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

- (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where
  - Information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
  - Any disclosure of the human subjects' responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

The determination of exemption means that:

- You do not need to submit an application for annual continuing review.

- You must carry out the research as described in the IRB application. Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans will need to be submitted and approved before proceeding with data collection.

Please note that you must submit all research involving human participants for review. Only the IRB or designees may make the determination of exemption, even if you conduct a study in the future that is exactly like this study.

Please be aware that approval from other entities may also be needed. For example, access to data from private records (e.g., student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. An IRB determination of exemption in no way implies or guarantees that permission from these other entities will be granted.
APPENDIX B. INVITATION E-MAIL FOR STUDY PARTICIPATION

Subject: New fashion fabric research – your opinion is needed!

Hello!
We have developed a new material for clothing and accessories and would like to know what you think about it as a potential consumer. Please consider participating in a focus group discussion to share your opinion on this material and a handbag made of it. Focus group discussions will be held on campus, in MacKay or Lebaron Hall, and last for an hour.

As a token of our appreciation, you will get a $5 Caribou coffee gift card to treat yourself to a nice cup of zebra mocha or a healthy smoothie.

If you decide to participate in our study (we really hope you do!), please reply to this email to sign up for a focus group session convenient for you. Here are the available sessions:

- Friday, February 3, 1-2:15pm
- Tuesday, February 7, 3-4:15pm
- Wednesday, February 8, 9:30-10:45am
- Wednesday, February 8, 4-5:15pm
- Thursday, February 9, 11am-12:15pm

You can participate in this study only if you are a female of at least 18 years of age. If you have any questions, don’t hesitate to reply to this e-mail or call me at --- --- ----.

Thank you for considering this request!
# APPENDIX C. FOCUS GROUP SESSION PROTOCOL

<table>
<thead>
<tr>
<th>1. Introduction, Consent, Demographic</th>
<th>Greet participants, thank them for coming, quick introductions</th>
</tr>
</thead>
<tbody>
<tr>
<td>---</td>
<td>• Introduce self</td>
</tr>
<tr>
<td>---</td>
<td>• Go-around: your first name and major</td>
</tr>
<tr>
<td>Introduction</td>
<td>Introduce the study</td>
</tr>
<tr>
<td>Consent</td>
<td>• This study is for my dissertation. We have developed a new</td>
</tr>
<tr>
<td>Demographic</td>
<td>leather-like material to be used in apparel-related</td>
</tr>
<tr>
<td>---</td>
<td>products such as jackets, shoes, bags, etc. I will tell</td>
</tr>
<tr>
<td>---</td>
<td>you more about the material later in the session, after</td>
</tr>
<tr>
<td>---</td>
<td>we have talked about it a little bit. (Do not mention</td>
</tr>
<tr>
<td>---</td>
<td>that material is “eco-friendly” or called bacterial</td>
</tr>
<tr>
<td>---</td>
<td>cellulose).</td>
</tr>
<tr>
<td>---</td>
<td>Today’s session will have 3 parts. This is the 1st part</td>
</tr>
<tr>
<td>---</td>
<td>(introduction, consent form and demographic information)</td>
</tr>
<tr>
<td>---</td>
<td>2nd part: will involve a sensory evaluation process that</td>
</tr>
<tr>
<td>---</td>
<td>I will explain in detail when we start it. This will be</td>
</tr>
<tr>
<td>---</td>
<td>an individual activity.</td>
</tr>
<tr>
<td>---</td>
<td>3rd part: will involve group discussion. I will have a</td>
</tr>
<tr>
<td>---</td>
<td>number of questions to guide the discussion. *This part</td>
</tr>
<tr>
<td>---</td>
<td>will be audio-recorded* with your permission. This will</td>
</tr>
<tr>
<td>---</td>
<td>allow me to concentrate on the discussion instead of</td>
</tr>
<tr>
<td>---</td>
<td>taking notes. It will also allow a later transcription</td>
</tr>
<tr>
<td>---</td>
<td>and analysis of the text for uncovering the most accurate</td>
</tr>
<tr>
<td>---</td>
<td>findings.</td>
</tr>
<tr>
<td>---</td>
<td>Consent process (go over it, answer questions, signing)</td>
</tr>
<tr>
<td>---</td>
<td>• All your responses will be kept confidential. No names</td>
</tr>
<tr>
<td>---</td>
<td>will be included in any reports resulting from this study.</td>
</tr>
<tr>
<td>Background info form</td>
<td>Participants individually complete background information</td>
</tr>
<tr>
<td>---</td>
<td>form</td>
</tr>
<tr>
<td>2. Sensory Evaluation</td>
<td>Provide material swatches to each participant for</td>
</tr>
<tr>
<td>Evaluation</td>
<td>individual examination.</td>
</tr>
<tr>
<td>---</td>
<td>• Explain parts 1-3 - complete individually</td>
</tr>
<tr>
<td>---</td>
<td>- if any comments, please add on the last page</td>
</tr>
<tr>
<td>3. Group Discussion</td>
<td>• Ask permission to start audio-recording</td>
</tr>
<tr>
<td>Discussion</td>
<td>• Show the bag, give 3-5 minutes to examine/pass around</td>
</tr>
<tr>
<td>---</td>
<td>• Group discussion - use focus group discussion</td>
</tr>
<tr>
<td>---</td>
<td>guide to lead discussion</td>
</tr>
<tr>
<td>---</td>
<td>• Thank participants, hand out gift cards</td>
</tr>
</tbody>
</table>
APPENDIX D. INFORMED CONSENT DOCUMENT

Research Title: Consumer Perceptions of a New Material for Apparel and Accessories
Investigators: Armine Ghalachyan and Dr. Elena Karpova

This form describes a research project to help you decide whether or not you wish to participate. Your participation is completely voluntary. Please ask any questions about the study or this form before deciding to participate.

Introduction
The purpose of this study is to examine consumer perceptions of a new material for apparel and accessories. The material is produced through fermentation of Kombucha, a fermented tea beverage. You are invited to participate in this study because you are a female of 18 years of age or older. You should not participate if you are younger than 18. Participation in this study is not expected to cause any risk or discomfort to you. As a token of our appreciation, you will receive a $5 Caribou coffee gift card.

Description of Procedures
You will be asked to participate in one focus group session. During the session, you will examine and evaluate a material sample and a product made of this material. The next step will involve a guided group discussion to get more in-depth opinions. The group discussion will be audio-recorded for further analysis. The entire session is expected to last approximately 60 minutes.

Participant Rights and Confidentiality
You may choose not to take part in the study or to stop participating at any time, for any reason, without penalty or negative consequences. You can skip any questions that you do not wish to answer. To ensure confidentiality, your responses will be anonymous: they will not be linked to your name or any other identifiable information. Signed consent forms will be kept confidential to the extent permitted by applicable laws and regulations and will not be made publicly available. However, federal government regulatory agencies (e.g., U.S. Environmental Protection Agency), auditing departments of Iowa State University may inspect consent forms.

Questions
You are encouraged to ask questions at any time during this study. For further information about the study, contact Armine Ghalachyan (--- --- ----) or Dr. Elena Karpova (--- --- ----). If you have any questions about the rights of research subjects or research-related injury, please contact the IRB Administrator, (515) 294-4566, IRB@iastate.edu, or Director, (515) 294-3115, Office for Responsible Research, Iowa State University, Ames, Iowa 50011.

Consent and Authorization Provisions
Your signature indicates that you voluntarily agree to participate in this study, that the study has been explained to you, that you have been given the time to read the document, and that your questions have been satisfactorily answered. You will receive a copy of the written informed consent prior to your participation in the study.

Participant’s Name (printed) __________________________________________________________

Participant’s Signature ___________________________ Date ___________________________
Background Information

1. Your age _______

3. Your ethnicity (check all that applies to you):
   ___ American Indian or Alaska Native
   ___ Asian
   ___ Black/African American
   ___ Hispanic/Latina
   ___ Native Hawaiian or Other Pacific Islander
   ___ White/ European American
   ___ Other, please specify_________________
   ___ Prefer not to answer

4. Your year in college:
   ___ Freshman
   ___ Sophomore
   ___ Junior
   ___ Senior
   ___ Graduate
   ___ Other, please specify_________________

5. Your academic major: _____________________________________________

6. In a typical 3-month period, approximately how many clothing and accessory items do you purchase?
   Number of items ____________

7. In a typical 3-month period, approximately how much money do you spend on clothing and accessories?
   $______________

Thank you!
Sensory Evaluation – Part 1

*Sensory evaluation* is a method of studying people’s perceptions of products and materials based on the senses of *sight, smell, taste, touch and hearing*.

1. Please examine the material provided to you.

2. In the table below, write down any characteristics you can think of that describe this material based on the senses of *Sight, Hearing, Smell, and Touch* (E.g., for yogurt, you could write: smooth, pink, watery, runny, slushy, fruity, etc.).
   - It’s OK to include both negative and positive characteristics.
   - Describe the material itself, not your liking or preference for it.

<table>
<thead>
<tr>
<th>Sight (Appearance, look)</th>
<th>Hearing (Sound, noise)</th>
<th>Smell (Aroma, odor)</th>
<th>Touch (Handfeel, tactile)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Now, evaluate the material you just examined using the attributes provided below.

1. Circle the appropriate number to indicate the intensity of each attribute on a scale of 0-5 (0 = Not at All; 5 = Extremely).
2. Check the appropriate box to indicate how much you like or dislike each attribute.

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Indicate the intensity of each attribute for this material</th>
<th>Indicate how much you like or dislike each attribute for this material</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not at all</td>
<td>1</td>
</tr>
<tr>
<td>Uneven color</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Dull appearance</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Non-uniform appearance</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Leather-like appearance</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Plastic-like appearance</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Spotted, speckled</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Wrinkly</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Translucent, see-through</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Vinegary-smelling</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Spicy-smelling</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Sweet-smelling</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Pleasant-smelling</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Overripe fruity-smelling</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Ammonia/urine-smelling</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Thick</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Heavy</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Sticky</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Soft</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Rough, textured</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Stiff, rigid</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Vinyl-like feel</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Dry</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Squeaky</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Paper-like-sounding</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Vinyl-like-sounding</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
</tbody>
</table>
Sensory Evaluation – Part 3

Please answer the following questions related to the material you just evaluated.

1. Overall, how much do you like or dislike this material?  
   (1 = Dislike extremely; 5 = Like extremely)
   
   Dislike extremely  
   Like extremely

   1  2  3  4  5

2. How acceptable do you think this material is for clothing (e.g., vest, jacket)?  
   (1 = Not at all acceptable; 5 = Very acceptable)

   Not at all acceptable  
   Very acceptable

   1  2  3  4  5

3. How acceptable do you think this material is for accessories (e.g., bags, belts, shoes)?  
   (1 = Not at all acceptable; 5 = Very acceptable)

   Not at all acceptable  
   Very acceptable

   1  2  3  4  5

4. Do you have any comments or suggestions about the characteristics or the use of this material? Please provide them below.
APPENDIX G. FOCUS GROUP DISCUSSION GUIDE

Focus group “rules” and introduction

I am going to show you a product made of the same material. I would like you to examine it and discuss it as a group. I will have several questions to guide our discussion. Before we begin, please keep in mind:

- You are free to express any opinion / perception you have whether it’s positive or negative.
- There are no right or wrong answers. I am looking for your honest opinions.

Questions

1. What do you think about this bag? [after it was passed around the group]
2. What do you like or dislike about the bag? Why?
3. What are your thoughts on the:
   3.1 Appearance/visual characteristics of this product?
   3.2 Functional/usability aspects?
   3.3 Quality/durability aspect of this bag?
4. What advantage or disadvantage do you see in owning/using this bag?
5. Would you use/try a bag like this? Why?
   5.1 Would you use different products made of this material? What products? Why?
   5.2 Would you use it if you saw others use products made of this material?
6. What are your thoughts about a bag (this design or different design) made of this material in relation to your lifestyle, needs, values?
7. Do you see any difficulties in having and using a bag (or another product) made of this material?
8. Do you know anyone who uses products made of the same material?
9. What would your friends or others close to you say if they saw you using this product?
10. Do you think consumers would buy a product made of this material (like this bag)? Why do you think so?
   10.1 What recommendations do you have to improve products made of this material?
           To improve material itself?
11. I want to show your pictures of other apparel products made of this material (vest, etc.). What are your thoughts about these? Would you use these products? Why? Why not?

12. This material is produced through tea (Kombucha) fermentation.
   
   12.1 Do you know what Kombucha is? Have you tried Kombucha before? Have you heard about materials made of fermented teas that can be used for clothing and accessories?

13. This material is called bacterial or microbial cellulose, because bacteria produce the material’s fibers during tea fermentation process.
   
   13.1 What are your thoughts about that?
   
   13.2 How does the name of the material make you feel? How does it change your perception of this material and the bag? How do you think others will react to the name?

14. This material and the handbag are considered to be eco-friendly, 100% biodegradable, and are not expected to pollute the environment during production or disposal.
   
   14.1 What are your thought about this? Does this change any of the opinions you expressed before? Will it affect the opinions of other consumers?

15. How else this material might be used? What other uses do you see for it?

16. What additional comments do you have?
APPENDIX H. IMAGES OF PRODUCTS MADE OF BC

Sources of images:
Jackets: http://fashioningcircuits.com/?p=2127
Men’s and women’s shoes: http://www.news.iastate.edu/news/2016/04/26/sustainableclothing
Vest: https://www.aatcc.org/pub/aatcc-news/newsletters/1117a/