New Sustainable Materials for the Fashion Industry: The Button in the Circular Economy

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Abstract. Fashion is a waste industry, but it is in a phase of change and transition to sustainability, including consciousness around the excessive use of natural resources to produce inputs for clothing and accessories. In this article, we focus on the problem of waste and sustainable innovations for the fashion industry, adopting ethical and linear solutions to the principles of a circular economy that abandons the current production process of extraction, production and disposal, consuming finite resources already in Imminent risk of raw materials, a fact that came to light during the Covid-19 pandemic. The circular economy is the process that may assist in this transition, the method consists of the circularity of the products, the reuse and proper management of waste generated during each stage of development of a product. The buttons are essential items for clothing, an ancient invention that maintains its function and form to this day. The only change in the production of this accessory was the material employed in production, if in the early days the materials were natural; Currently plastic is the main raw material. Its impact on the environment is ignored, despite the amount existing in relation to each piece of clothing that is discarded incorrectly in urban waste containers. In this article, the problem was addressed around current materials and proposed the development of biodegradable buttons from eating waste. The study was based on the foundations of the circular economy and the design thinking methodology for new product development, rapid prototyping was used as a means of materializing research, resulting in an experimental product.

Keywords: Biodegradable buttons · Circular economy · Sustainable fashion · Food waste · New sustainable materials

1 Introduction

To address sustainability in the fashion industry, it is immediately possible to verify that there are not many studies beyond comparisons between fast fashion and slow fashion, or the approach around natural materials. Being sustainable is not just about using organic cotton or recycled textiles, it is necessary to reflect on all the procedures adopted in the creation, development and production applied to fashion design. Approaching the production chain in a holistic way, all stages and transparency around each one, especially in relation to waste management and reverse logistics for an effectively more sustainable fashion.

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They are strategies, concepts and methods that aim at ethics for success in the fashion industry. A literature review was carried out that links the different research topics with the aim of stimulating reflection from the industry, professionals, and students, bringing a new perspective on the topics covered. Demonstrating the existence of other solutions to the challenges of the industry and fashion design, balancing innovation, transparency and sustainability.

There are different approaches to fashion sustainability. However, few studies establish the relationship with transparency, possible and relevant between innovation and sustainability for fashion products whose vision can be applied to the fashion industry and avoid misunderstandings, called Greenwashing.

The research can be useful for understanding the circular economy applied to industry, for ethical and transparent innovation within the fashion area, avoiding design without purpose, just for the new and without thinking about the future impact of products on the planet.

Circular fashion is a concept that involves all phases of the process, from conception, development, production, waste management, consumption and reverse logistics of any fashion product. Thus, sustainable actions must start at the initial stages, with the choice of raw material and care not to nullify the neutrality of inputs with polluting processes, invalidating the sustainability of the final product. However, it does not end in the consumption phase, reverse logistics is mandatory, so that circularity occurs, with recycling and return to the production chain as raw material. The awareness of the need for sustainability in the fashion industry is global, but society has a fundamental role in this process. It sounds simple, but the transition depends on joint action, transparency and new laws to create a collective conscience. It is necessary to consider the four pillars of sustainability, the environmental, the economic and the cultural; and the society that makes the connection between each one, therefore, socio-environmental, socioeconomic and sociocultural. Society incorporates identity, cultural and emotional approaches into sustainability, making the process more humanized.

The industrial revolution, despite bringing the development and technology we currently have, also got us used to the linear process of extracting, producing and disposing, so imagine that since 1760, a date suggested by historians, we have discarded tons of toxic material in the air, water and on the ground, every year until today. Wasn't it predictable that one day the planet would reach its limit? A lot of continuous work is needed to reach the cradle-to-cradle method in the fashion industry, let's start with the assessment of the product's life cycle, following the circular economy point of view, incorporating and linking all production phases.

In this article, we address innovative sustainable strategies for the manufacture of products, from the perspective of the life cycle, considering the ethics and transparency of processes, and exalting the importance of waste management to respond to the principles of the circular economy. All of these are important strategies for the real sustainability of the fashion industry.

As part of a qualitative and exploratory research, based on the literature review methodology, the article begins with the design thinking approach for the development of new products, a brief discussion on the problem of buttons in linear economy, followed by transparency and ethics in fashion, linked to the circular economy and the methodology

for the production of biodegradable buttons, waste management in fashion and finally with the cradle to cradle method, where the research explores new strategies for the fashion industry, in order to frame the argument and contribute to the understanding that it is possible to build fashion with innovation, transparency and sustainability.

2 Development of New Materials from the Perspective of Thinking Design

The Design Thinking approach seeks to satisfy the needs and desires of consumers through constant innovation in products and services. In this process, it is used focused on the circular economy, as it organizes the development process and leverages it [1]. Design has been the driver of innovation, dodging its trivial product development function to expand and commit to the innovation process. Recognizing that any business or company should use this method as a benefit for optimizing products and services. We currently understand Design Thinking as a way of thinking that leads to transformation through innovative solutions, valuing interdisciplinary work to create value and purpose.

For success and correct application, the principles on which the DT is based must be followed, such as the human-centered approach, products and services need to be experienced from the user's perspective, considering the needs and desires of real people and minimizing the negative impacts on the environment, being updated within the concepts of the circular economy. Design Thinking is a collective and collaborative process, therefore, at all stages of the process, as many interested parties as possible should be included (stakeholders), keeping the project's humanized and sustainable focus. Until the experimentation stage, countless varieties and possibilities of ideas/solutions are considered, some will not be successful, despite this, making mistakes is an important part of every creative process, innovation arises from the search for solutions to errors. Visualizing concepts promotes association and reduces the complexity of ideas. The images synthesize and clarify, as well as the rapid prototyping that supports the analytical process and the improvement of initial ideas. The holistic view must be considered throughout the innovation process, products and services belong to an interactive and reciprocal system.

The Evolution 6^2 Model of Design Thinking was developed by Katja Tschimmel and used in the development of projects, every creative process is an evolutionary and interactive process, between people and situations (Fig. 1).

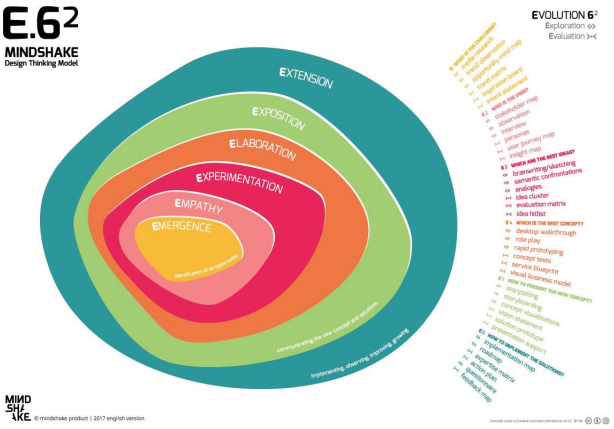

Fig. 1. The evolution 6^2 model of design thinking, Source: Katja Tschimmel.

The graphical solution indicates that each phase of the model is related to the other phases in interaction and coexistence cycles.

According to Katja, the method originates in the designers' mindset, remaining spontaneous even under pressure, and at the same time, analytical and empathetic, rational and emotional, methodical and intuitive; making it possible to make ideas tangible using empathy in problem solving. It is an optimistic concept that accepts uncertainty and failure (Fig. 2).

DESIGN THINKING: EVOLUTION 6²		
1	Emergence	*Identify an opportunity or a challege*
2	Empathy	*Know the context and define a project*
3	Experimentation	*Generate ideas and develop concepts*
4	Elaboration	*Materialize and validate solutions*
5	Exposition	*Communicate new concepts and solutions*
6	Extension	*Putting things into action*

Fig. 2. Stages of the creation process based on the design thinking, Source: Author.

Using this method to develop innovative and sustainable solutions in relation to new materials for the fashion and design industry, we cannot leave aside the concepts of the circular economy in product design. to achieve sustainability, we can consider an assessment based on four needs: being ecologically correct, economically viable, socially fair and capable of preserving the local cultural wealth [2].

Consumption, specifically of fashion products, increases excessively and counts on the participation of consumers in this process [3]. According to Mahlmeister [4], taking jeans as an example, in representation of a fashion product that transcends centuries, and became a fashion icon, acquiring new social representations and renewing its aesthetic meaning, totally decoupled from its technical characteristics. Therefore, current society, according to Baudrillard [5], seeks personal satisfaction in the act of consuming and must

become aware of this uncontrolled act and its consequences for the planet. According to Solomon [6] the purchase of a product happens most of the time for the symbolic value of its basic function. In Kotler's [7] view, consumerism makes it possible to study consumer behavior and the product's life cycle after acquisition until disposal.

Fashion is considered the second most polluting industry on the planet, as opposed to being the second that employs the most, one in six people in the world work at some point in the value chain [8]. The relationship and importance that fashion has to influencing the way of life is significant and important, current fashion is recognized for the speed and continuous change of relations in contemporary society [9]. Humanity is in a period of mandatory transition, the natural limits of regeneration of the planet have been reached, the influence of the fashion industry must be used for this transformation, and the fashion cycle has countless phases and transition periods that remain each shorter and shorter [10],

According to Manzini [11] the principles to which the new concept of fashion must be submitted, it must include the creation of products/services that can replace the current ones, proposing sustainable practices in their production process to the user's lifestyle. The Life Cycle Design (LCD) was defined by Manzini & Vezzoli [12] with the aim of reducing the environmental impact related to the product's life cycle. Cradle to Cradle or C2C, this expression was the title of a book-manifesto [13], which states that resources are managed in a circular logic of creation and reuse, creating and recycling unlimitedly.

These concepts should already be applied in the school and university environment where students have been involved in significant experiences strongly related to society and problems identified by them, redefining, researching, developing, prototyping and testing, towards ethical and sustainable solutions. The main motto being human centeredness added to environmental impact, the Design Thinking methodology explores the development of active listening skills, agile thinking and design skills, in a continuous way where failure is part of the rapid learning process.

This concept aims to move away from the previous process of evolution and change, where the industry ended up creating a business model called fast fashion, characterized by speed in production and the almost immediate disposition of products in stores following the latest trends [14]. A phenomenon that caused a gigantic increase in the demand for (low quality) products, consequently, there was an increase in the exploration of natural resources, extraction and production of raw material needed for the manufacture of textiles and other accessories used by the fashion chain. This led to a shortening of the product's life cycle, which led to the generation of excess waste, resulting from the mass disposal of products [14].

3 The Problem of Buttons and Linear Economics

Although the history of the buds is uncertain, evidence appears in approximately 3,000 BC, they already existed in the Indus Valley, located in South Asia during the Kot Diji epoch (c. 2800–2600 BC). Other ancient specimens have been found in the Tomb of the Eagles in Scotland (2200–1800 BC), as well as in the Bronze Age in China (c. 2000–1500 BC) and in Ancient Greece and Rome. According to the scholar Ian McNeil [15], initially the buttons were used as decoration and not as a closing mechanism.

The history of the functional button originated in Germany from the same period, spread throughout Europe along with the evolution of clothing. In the twelfth century, buttons appear closer to the current ones, they became a piece of desire; for they were made with metals and precious stones, used in the cuffs of clothes as a highlight. At their height in the 18th century, they acquired luxury status and were made by goldsmiths as jewelry. But around 1760, in the same century and the beginning of the industrial revolution, the button lost its nobility, being produced in cheap materials and in scale.

According to Ellen MacArthur Foundation [16], the waste generated must be reused to create a circular economy that benefits everyone. In contrast to the linear economy, the current organizational form of society, based on the growing exploration and extraction of natural resources, aiming at greater production and trade, in which these products are used and discarded at the end of the production cycle.

The extract, produce and waste economic model is currently reaching the limits of nature. The linear format has been considered unfeasible, reaching an unsustainable level of maintenance for this model. Humanity suffers some consequences, such as the growing scarcity of natural resources, increased pollution, and human vulnerability to the planet's weather.

Fig. 3. Representation of the productive process in the linear economy, Source: Author.

Fashion and temporal trends have always encouraged the concept of disposables, each new season presents several new products, encouraging consumption and disposal, based on the idea of the need to have the "last fashion product". Thus, becoming one of the world's industries that most degrades the environment [16].

One of these resources extracted in huge quantities is oil, a non-renewable natural resource, its use poses a great risk to the environment from the extraction, transport, refining process, to consumption, with the production of gases that pollute the atmosphere. Plastic is one of the petroleum derivatives, this polymer takes about 450 to 500 years to decompose in nature and recycling is considered the most complex among materials. Polyester is also an artificial polymeric fiber from petroleum and the most used product in the fashion industry today, in addition to the problem of releasing microplastics during washing, there is its degradation time.

Plastic is very present in fashion, whether in fabrics such as polyester or buttons, these functional accessories and present in virtually all garments, end up being ignored in terms of their environmental impact. Therefore, we approach the theme in relation to the buttons' environmental impact and propose the experimental development of biodegradable and compostable accessories. The research is based on the hypothesis that for every garment that is incorrectly discarded, at least 5 synthetic buttons are present.

The accessory usually associated with articles of haberdashery has its useful life interconnected with the durability of the clothing product, when a garment is discarded the

item follows the process. According to data from the Portuguese Environment Agency – APA [17], in 2020 around 5.279 million tons of waste were collected, with around 200 thousand tons of textiles being discarded in this year's urban waste containers (Fig. 4).

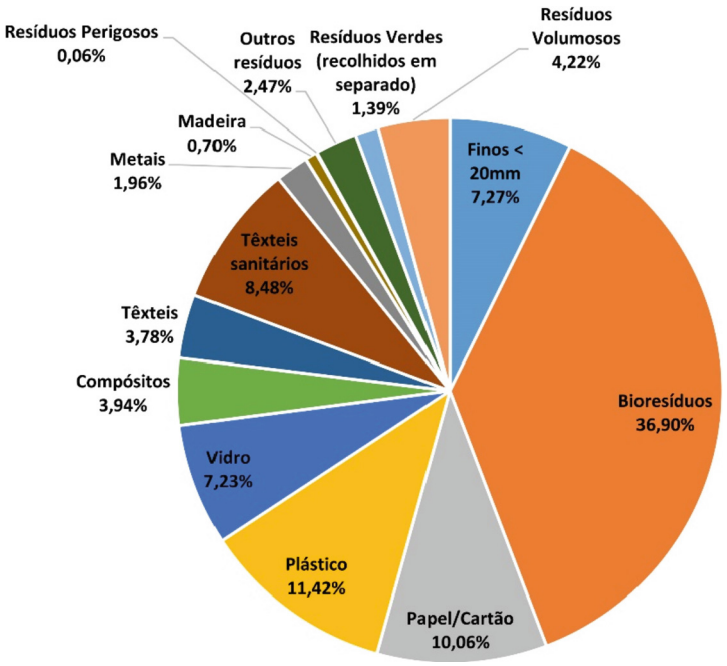

Fig. 4. Physical characterization of urban waste produced in continental Portugal in the year 2020, Source: Portuguese Environment Agency - RARU 2020.

This article aims to investigate the sector of innovation in new sustainable materials through organic raw materials from food and plant residues without commercial value. Aiming at the experimental development of buds with biodegradable and compostable properties. Assuming the need to propose new alternatives, manufacturing methods and materials, defended by Fletcher and Grose [18], and developing new materials to replace the petroleum-based polymers and resins currently used, according to Manzini [11].

The uncontrolled manufacture and consumption of fashion products have generated tons of waste, especially post-consumption, which is caused by the disposal of products at the end of their life cycle. The fast fashion industry accelerated the cycle and drastically increased clothing disposal, both due to the low quality of the raw material and to the accentuated shift in fashion trends, the main driver of consumerism.

In the contemporary world and with the help of consumers and excessive and everyday consumption, fashion is established a momentary life cycle for the products. Along with every discarded piece of clothing we will find the buttons essential to construction and functionality in the apparel industry. Due to its small size and low cost, its potential environmental impact is not given due importance when not properly disposed of.

The button is usually the functional part of the garment, allowing it to be easily closed or opened. Usually produced in plastic material, derived from petroleum, it can be produced in metal or metallic alloys, wood and other materials. This study aims to raise hypotheses about a more sustainable production for this accessory.

Thus, bibliography was used for data collection and theoretical content analysis in search of knowledge by comparison and synthesis, with the objective of practical application of results and raising of hypotheses. The history and the present in the production of buttons was studied. Through analysis and observation of the content, prototypes were developed on an experimental basis, using the methods of Design Thinking and applying the acquired knowledge.

4 Transparency and Ethics in Sustainable Fashion

There are several differences between ethical, sustainable fashion and transparency. These concepts are often misused to refer to fast fashion, the new wave in the fashion industry that has nothing to do with ethics and sustainability. Although it is not possible to unanimously define ethics, as this assessment depends on a personal point of view about morally acceptable behavior, the transparency of companies that make up the fashion industry can leave the assessment to the consumer; through the open disposition of the processes used internally.

Looking holistically within the concept of slow fashion, we can say that everything is ethical, from environmental concerns to labor rights and supply chain transparency. Ethical fashion has a broader concept, it is necessary to observe a series of implicit values, cultural and commercial perceptions and subjective points of view, the work is left to the consumer and their consumption choices. To generate this autonomy, it is necessary to access company data, without them it is not even possible to believe their statements regarding the ethics and sustainability of their products and services.

A mistake often made by companies is to make statements about their products without reliable bases or transparency in information, known as Greenwashing, when an entity or organization massively invests time and money in marketing actions to associate its actions with good environmental practices in speeches rather than taking action to minimize negative environmental impacts.

According to the Victoria and Albert Museum [19] in London, as the textile industry expanded, following technological developments that lowered prices and mass production, the fashion industry left its trail of destruction with the aim to produce fabrics, prints, colors and synthetic fibers based on chemical agents that contaminate the soil, air and water. The need for mass manufacturing keeps the fashion segment in the top five polluting list of the 21st century. How to prevent the continuation of this damage? was one of the questions that the curators of the exhibition “Fashioned from Nature” in the British capital wanted to provoke.

Of the 300 pieces exhibited at the exhibition, some intentionally morbid, they reveal 400 years of worrying history, with the aim of stimulating reflection on the link between fashion and the environment. At the entrance to the exhibition held in 2018, some pieces stand out, such as a black cape made of twisted cock feathers, a hat decorated with a fox’s tail, a dress in fine white cotton, decorated with 5,000 beetle wings and to hold the

internal structures of the armed skirts, an essential material was the whale fin, an animal decimated in Europe at that time (Fig. 5).

Fig. 5. Pair of earrings from 1870, made with the severed head of hummingbird skirts. Available at: https://www.fashionstudiesjournal.org/reviews-2/2019/1/25/exhibition-review-fashioned-from-nature.

According to Victoria and Albert Museum [19], ethical fashion is a generic term used to describe the practices of design, production, retail, and fashion purchases on ethical principles. It covers a range of issues such as working conditions, exploitation, fair trade, sustainable production, the environment, and animal welfare. As it is not possible to be ethical in just one point of view, the term is holistic and, like sustainability, it must cover the process from beginning to end.

> *The fashion sustainability process pressured the industry to change, but an inspiring and exciting change was expected, but conventional environmental approaches focus on what not to do, when in fact we need a break from the productive mode. If we human beings really want to prosper then we will have to learn the concepts of the circular economy: using products as nutrients, which by imitating natural metabolism extinguishes waste. Eliminating that concept means designing things—products, packaging, and systems—from scratch as feed for another system. It means that the valuable nutrients contained in materials shape and determine design: form follows evolution not just function." (Braungart & McDonough, 2013, p.69).*

The fashion industry uses a high and constant flow of natural resources to rapidly produce fashionable clothes, contributing to the depletion of fossil fuels used in the production and transport of textiles and clothing. Freshwater reserves are also declining due to the irrigation of the rapidly growing cotton crop. The industry is seeking ever greater scalability, introducing ever greater amounts of pesticides and synthetic fibers into the soil, preventing land use through poisoning or large textile waste dumps.

These can be catalysts for unprecedented advances, questioning the entire system in a clear and objective way, showing knowledge in the discussions for improvement. It is this creative and scientific symbiosis that triggers the ability to define new scenarios in the sustainable textile chain. Fashion designers and fashion companies must reconcile product development with nature conservation. (Fletcher & Grose, 2011, p. 32).

Ethical fashion considers the entire life cycle of the product, the impacts of the use of raw materials, design and production on the environment, workers and communities where it is being produced, including consumers and the return of this product in the end of service life. Slow Fashion is the movement that represents and unifies environmental, social, economic and cultural concerns. The term "slow fashion" was created by professor and consultant at the Center for Sustainable Fashion Kate Fletcher [20].

In terms of the fashion industry, the use of organic materials such as organic cotton or bamboo and the insertion of new fibers such as hemp and nettle, among many others, is what the industry and ethical fashion brands are doing. The main reason is because these materials require less water and chemicals to grow. The circularity or reuse of waste and all raw materials that have already impacted the planet with their extraction is also an ethical innovation, as nothing should be discarded.

The Life Cycle Design (LCD) was defined by Manzini & Vezzoli [21] with the purpose of reducing the environmental impact related to the product's life cycle, considering the entire process of creating and producing a product and the interference in the environment. Thus, the methods for the development of a sustainable product must be associated with the LCD and the project creator must pay attention to each of the phases of the product's life cycle [22].

5 Circular Economy as a Fashion Production Method and System

According to the Ellen MacArthur Foundation [23], the circular economy is a viable alternative that seeks to redefine the notion of industrial development, focused on benefiting the entire society. For the process, it is extremely necessary to decouple economic activities from the consumption of non-renewable resources and their disposal. Supporting the transition to renewable energy sources, the circular model builds economic, natural and social capital. Based on three principles:

- Eliminate waste and pollution from the beginning
- Keep products and materials in use
- Regenerate natural systems

It is not possible to approach circular fashion without reference to circular economy, circular economy refers directly to an industrial economy that is intentionally restorative; intends to rely on renewable energy; minimizes, tracks and eliminates the use of toxic chemicals; eradicating waste through thoughtful design [23].

Circular economy is a concept that implies the extended use, for as long as possible, of all products and their components, keeping them in circulation and being environmentally efficient and safe. This system looks at waste with raw materials for other processes.

After the product is discarded by the consumer, according to Manzini & Vezzoli [21] and the principles of circular economy should be the restoration of the product's functionality or any of its components, through recycling where the raw material returns to the initial process, avoiding the use of natural resources.

Within the circular economy, there is the cradle-to-cradle approach [13], which consists of observing two types of cycles: biological and technical (Fig. 6).

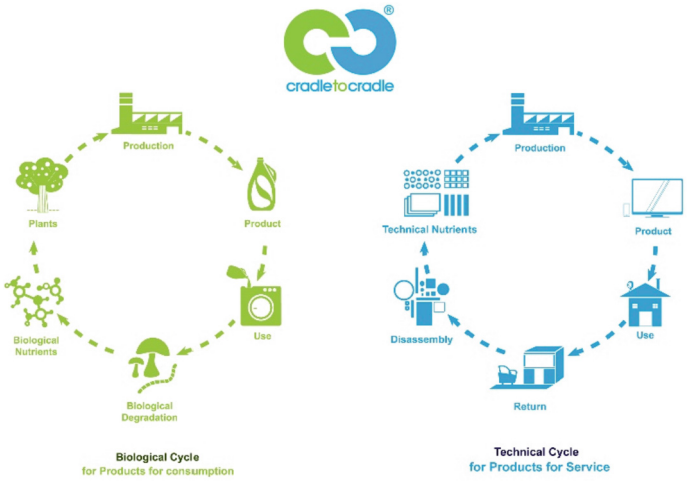

Fig. 6. Representation of the circular economy process based on the Cradle to Cradle® system, Source: Cradle to Cradle: Create and recreate unlimited [2].

In the biological cycle, circularity is possible when biodegradable components are used, which can later decompose naturally in the environment; this is the case of wool, silk, cotton, etc. In the technical cycle, technical components that cannot be decomposed naturally in nature and must be recycled separately, such as nylon, polyester and plastics, among many others made synthetically, are part of the technical cycle.

To maintain circularity, it is important to be aware of the type of materials used in a given product, which can contribute to its recycling. When the product uses different types of materials, natural and synthetic, they must be clearly identified, allowing the easy separation of each part or correct reuse. Design plays an important role in this process due to its holistic and cross-pollinated point of view [24, 25].

Even in the recycling process, the logistics and stages of the process must be analyzed, from transport to the pre-production of materials to be recycled, so that the impact on the environment is not greater than the disposal itself [21]. Logistics is an important factor for the circular economy, as displacement can make the environmental impact greater than the benefits of its recycling, requiring local planning and treatment of waste.

According to Manzini & Vezzoli [21], fashion products are discarded for reasons of cultural and aesthetic obsolescence. It is advisable to consume timeless products, durable materials that can be reworked, avoiding premature disposal, according to Kazazian [26]. The designer has an important role at this point, that of designing products with possible aesthetics, longevity, useful and durable.

When addressing the circular economy, the Ellen MacArthur Foundation asserts that we all must intervene whether governments, businesses or individuals. We are talking about a new way of designing, making and using things, regenerating natural systems, managing waste and reinventing everything in our cities [23].

In a circular economy, economic activity aims to contribute to the general maintenance of society and the system. The concept is broad and recognizes the importance of the concept working at any scale, whether it is for large or small businesses, for organizations and individuals, globally and locally.

According to Fletcher & Grose [18] the world market executes processes based on low-cost economy and high profits, following the concept of programmed obsolescence; producing cheap, low-quality, highly disposable products; without considering the social and environmental impacts of the products. The transition to a circular economy and the reduction of negative impacts of the linear economy, it is necessary to change the system in the long term, generating economic opportunities and providing environmental and social benefits.

Based on these statements, we can define the Circular Economy as a regenerative system, where there is a reduction in the input of resources, waste, emission and leakage of energy and deceleration.

The life cycle of the products must contribute. move towards a positive global development and attend to the well-being of all humans involved in the system, considering that the circular way of thinking and working, in particular the circular way, does not restrict but new opportunities for the fashion sector and the textile industry.

6 Methodology of Experimental Production of Biodegradable Buttons

Created by Braungart and McDonough [2], the Cradle-to-Cradle theory (from cradle to cradle) is one of the dimensions of Circular Economy. Addressing the idea of creating and recreating unlimitedly, using biodegradable materials they become food for biological cycles or technical materials that are kept in closed circuit cycles, in a constant recycling process. The biological and technical cycles defended in Cradle to Cradle (Fig. 3) illustrate and exemplify how processes should act in concurrency with the user and the environment.

Consumption takes place only in biological cycles, where food and other biologically based materials (such as cotton and wood) are designed to return to the system through processes such as composting and anaerobic digestion. These cycles regenerate living systems, such as the soil, which in turn provide renewable resources for the economy.

The degradation of materials is altered by environmental conditions, occurring over a certain period and presenting one or more processes (biotic or abiotic), corresponding

to an irreversible process that causes changes in the material's structure and evaluated by the loss of physical properties [27].

A qualitative and exploratory bibliographic research was carried out, following the concepts of circular economy [13]. Qualitative bibliographic research was carried out [28], exploratory, with an analytical-descriptive approach to the study of materials and their production processes [29]. The interpretation of the collected material follows methods of content analysis and interpretation [30]. Comparative research for analysis and synthesis of ideas. Theoretical analysis and experimental tests with the application of Design Thinking methods for the development of new products [1]. The experimental procedure used methods of rapid prototyping in the laboratory, where the substrates of food waste and the polymer were pulverized, using a disk mill, for molding silicone molds and a high temperature oven were used.

7 Results and Discussion

The initial experiment was conducted in a domestic environment and replicated in an academic laboratory. The usability of the developed products is like that of industrialized articles, their durability was initially determined by the 5A washing method, following NP EN ISO 6330:2002. For commercialization, the scalability of the entire process is necessary, maintaining its circular and sustainable characteristics.

Fig. 7. Prototypes of sustainable and composed buttons produced from organic residues, Source: Author.

The experimental sample (Fig. 7) was produced from food waste from household consumption, with the aim of reusing the by-product of the food industry. According to the Cradle to Cradle™ concept, all materials involved in industrial and commercial processes, whether technical or biological, must feed the chain at the end of their life cycle. Design must be thought of in terms of products with positive impact and reduction of negative impacts through their effectiveness [13].

Therefore, biodegradability is an important indicator in evaluating the ecological performance of materials and proper to a given environmental condition [31, 32].

(…) ecodesign is a "project or project (design) model, guided by ecological criteria. The term presents itself, therefore, as the expression that synthesizes a vast set of design activities that tend to address the themes posed by the environmental issue starting from the starting point, that is, the redesign of the products themselves. (MANZINI; VEZZOLI, 2008, p. 17).

This is an opportunity to unite innovation and sustainability, using more sustainable materials, rethinking products and production processes, using labor and fostering the local economy, thinking collectively and less about the individual, contributing to the appreciation of local culture. Embracing the circular economy is one of the most tangible possibilities for achieving these goals and for developing ecological awareness.

8 Implications

Design based on Cradle to Cradle understands nature's safe and biological productive processes as inspiration for the technical flow of industrial materials, eliminating the concept of waste [13]. For the question of the experimental product, determine the degradability, compostability, as well as determine its useful life, strength and environmental impact; tests will be required following current regulations. According to the Ellen MacArthur Foundation, the current extract, produce and waste economic model is reaching its limit and the circular economy is the alternative to redefine the notion of development.

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