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Circular Economy for Sustainable Fashion: From Food to Fashion

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Abstract

The paper aims to analyse an increasingly problem connected with the generation of waste created along the entire food industry chain and transform it in an opportunity. The reuse of this waste to produce fashion items it gives new life to the waste itself. This is the principle of the circular economy. In order to be competitive companies are today facing the needs to change the entire production model by trying to extract the maximum value that each resource has at its disposal, avoiding the creation of waste. The shift from the linear model to the circular one needs social and economic instruments that regulate its functioning as well as the sensitization of the entire social system. The transition to this circular model has become of fundamental importance and one can no longer afford to procrastinate.

In the research particular attention is paid on the possibilities of recovering by-products, through the analysis of 5 best practices: Orange Fiber, Duedilatte, Vegea, Piñatex and S. Café. The paper investigates the innovation in fashion industry using waste from food in order to transform what is considered waste into a new resource creating value.

The paper hast two main research questions:

- How to reduce the impact of pollution creating by the food industry with the help of fashion industry?
- What is the contribution of food and fashion industries to the circular economy?

Food and fashion, apparently so far apart, are today collaborating more and more in creating new value, helping our planet to reach sustainable long-lasting goals. At the same time, they are promoting a fundamental shift from traditional fashion to sustainable fashion, able to apply the principles of reduce, reuse and recycle for offering to consumers new opportunities for a sustainable approach to fashion demand.

Keywords: circular economy, fashion Industry, food industry, linear economy, sustainable development
JEL: H41

The Limits of the Linear Economy

From about 1910 onwards there is the birth of the so-called mass production, characterized by a standardized production and an unskilled labour force that must perform basic and monotonous actions. The affirmation of this production is facilitated mainly by two factors: the first is related to the increasing economic wealth of the population. The second one regards instead the intuition from the industries of the fact that the quantity of the products sold and the unit cost of the good are inversely proportional, to the increase of the first ones the unit costs decrease.

It is therefore inevitable that we try, as much as possible, to put products on the market, so that we can reduce production costs and create profits. All this is facilitated by technological innovation, which leads products to obsolescence in less time to stimulate consumers to buy again. The model of economic growth thus becomes characterized by the thought of producing and consuming, thanks also to the help of advertising, that allows not to decrease demand by creating new desires in consumers and products are replaced not because they are broken, but because of their planned obsolescence.

During this period there has been a lowering of the prices of resources which has thus facilitated economic development in developing countries. Costing little resources, not having great obstacles in finding them, having a limited cost for the disposal of waste and having an approach oriented to maximizing profit, it has come to the creation of what is the current system of waste of raw materials.

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This market economy characterized by the continuous use of materials and waste of end products, besides being one of the major causes of pollution and subsequent global warming, is also extremely inefficient and expensive.
The linear model is also called “take-make-dispose” model, characterized by the fact that the process follows a single direction: the material is extracted, processed to create a product, it is sold and finally a waste is created to be disposed of when the object is no longer working (Gazzola et al., 2020b).
Another limit linked to the take-make-dispose model concerns the continuous global extraction of natural resources, which continues to grow. It is estimated (Fig.1), that the total extraction of resources will be about 80 billion tons in 2020 and over 100 billion tons in 2030, more than double in 30 years (Bleischwitz et al., 2010).

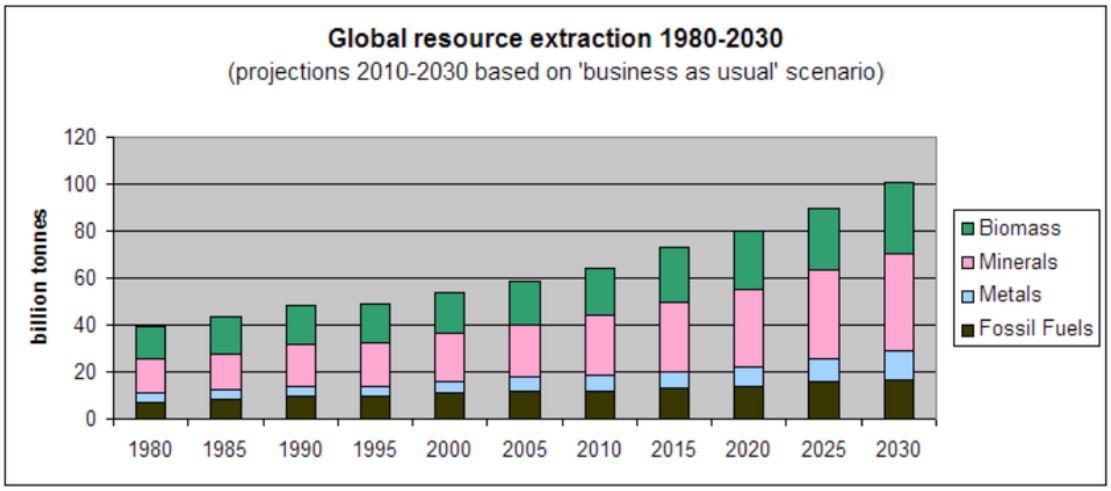

Figure 1. Global Resource Extraction 1980-2030
(Source: Bleischwitz et al., 2010)

The consequences of this increase are not few: first, it is increasingly common for minerals to be found in isolated locations and this leads to higher risks and more intensive use of energy for extraction which will inevitably lead to higher costs. In fact, since the beginning of the century, prices for natural resources have grown exponentially as well as being characterized by strong volatility, which, in the long run, can lead to moderate economic growth and increased risk exposure on the part of companies. To aggravate the situation, in addition to the increase in prices of natural resources, is the increase in the commodity prices, particularly in: food, non-food agricultural goods, metals and energy. It must be remembered that, since land resources are not unlimited, there are more and more constraints related to environmental protection and a greater commitment by governments to implement regulations to reduce and assess negative externalities.
Another factor to consider is the demographic increase expected for the next few years; as can be seen from the graph below (Fig. 2), the world population continues to grow in 1927 we were about 2 billion in 1927, currently we are about 7.7 billion, and in 2050 we expect to reach 9.7 billion people, reaching 11 billion in 2100 (United Nations, 2019).

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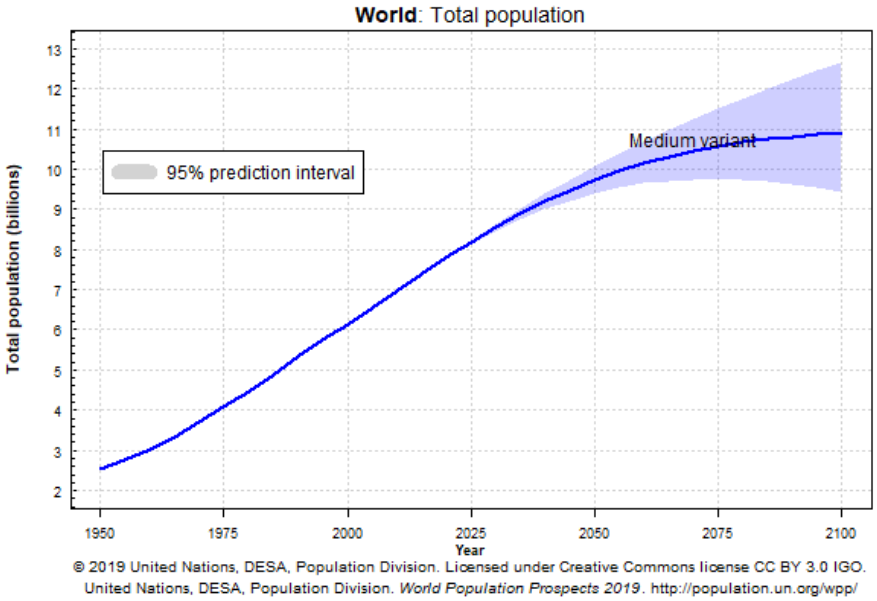

Figure 2. Expected Population Growth
(Source: United Nation, 2019)

Literature Review: The Transition to Circular Economy

The linear model is no longer sustainable. There is a need to start a change at the beginning of the production chain, trying to increase the production efficiency of natural resources and reducing inputs as much as possible. At the same time downstream with a change in the output process and avoiding unnecessary waste, trying to give a new life to the products where possible (Gazzola et al., 2020a). It's absolutely essential to push towards an energy transition, making greater use of renewable energy wind and solar, thus abandoning the use of energy from fossil fuels. The decarbonization of the economy is a turning point to decrease the release of Co2 into the atmosphere and consequently curb the phenomenon of global warming, to the benefit of the survival of ecosystems.
All this can be implemented through a transition to a circular economic model, aimed at creating value and using resources more efficiently in order to reduce the environmental impact. (Buchmann-Duck & Beazley, 2020). The transition to this model is made possible thanks to innovation in the field of technology and the consequent progress in the company (Brunner & Rechberger, 2015). This economic model is not as intense as an opposite system to the linear one, but it is an approach that develops as a consequence of the crisis of the linear one (Iacovidou et al., 2017). In particular it tries to transform some disadvantages of the latter into possible strengths. One of the cornerstones of circular thinking is to rethink the notion of "waste" which must, where possible, be transformed into a new resource capable of creating new value (Jeyanthan & Ilankumaran, 2019).
The circular economy can be defined as a repairing and self-regenerative economy that aims to try to draw maximum utility and value from both finished products and individual raw materials (Mhatre et al.,2021). It is to be considered an evolutionary thought, unlike the classical one, which was characterized by an abuse of natural resources and an orientation towards increasing profits. Choosing this type of production system involves reworking all the stages of the production cycle and at the same time focusing on the entire supply chain involved in it.
A 2019 survey of the European Commission shows that 85% of EU retailers surveyed report an increase in sales of sustainable products in the last five years, while 92% of EU retailers surveyed predict an increase in sales of sustainable products over the next five years (European Commission, 2019). This confirm the change in consumer behaviour and the sensibility to the principles of the circular economy (Edbring, Lehner & Mont, 2016).
A real example of this need can be offered by the Overshoot day, the day on which humanity consumes all the resources produced by the planet throughout the year (Shirinov, 2021). The overshoot day is calculated by comparing the ecological footprint of a country's citizens (that is the volume of biologically productive land and water that a person would need to generate the resources they exploit and reabsorb the waste and emissions produced) with the Earth's global capacity to reproduce natural resources for each inhabitant (Papagiannis et al., 2018). More than half of the human ecological

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footprint is represented by the carbon footprint, from 1970 to the present day the global carbon footprint is duplicated. The actual development is unsustainable. In 2021 the day is marked 29 of July, in 2020 was marked on 22 August, slipped by about three weeks due to the Covid-19 pandemic compared to the year 2019 when the day wad on 29 July. The first year in which this day was included was 1971, and the day fell on 21 December; since then, especially in recent years, the date has always been brought forward (https://www.overshootday.org.) If the situation remains the same, the time it would take the land to regenerate the resources used annually corresponds to about one year and eight months. At the moment more than half of what can be regenerated during the twelve months is being used, we are using the energies of 1.6 planets Earth.
In this framework the paper shows 5 best practices of circular economy where the waste on one side can become row material on the other (Pavione et al., 2020).
The two main research questions are:

- How to reduce the impact of pollution creating by the food industry with the help of fashion industry?
- What is the contribution of food and fashion industries to the circular economy?

To discuss the questions, we have considered five case studies and the information that are published on their web site and in some articles.

Food Waste and Circular Economy

The circular economy model is based on the so-called three “R’s”: Reduce, Reuse, Recycle. The first of the three principles concerns increasing efficiency in the production or use of products by consuming fewer resources, less energy and materials and thus reducing waste production. In particular, the reduction in the creation of waste can be defined as the set of activities and measures that can be implemented in a preventive manner to the generation of waste following the use of a material or a product.
The issue of over-production of household and non-household waste has for years become an emergency which the European Union seeks to address through the implementation of targeted actions. As can be seen from the graph below (Fig.3) over 10 years, for almost all countries except Norway and Germany, the percentage of waste generated annually has decreased. At a general level we can see how the European Union has gone from an annual production of 518 kg per capita of waste in 2008 to a production of 492 kg per capita in 2018. The generation of these quantities of waste is the consequence of years of production and subsequent unsustainable consumption (Eurostat, 2020).

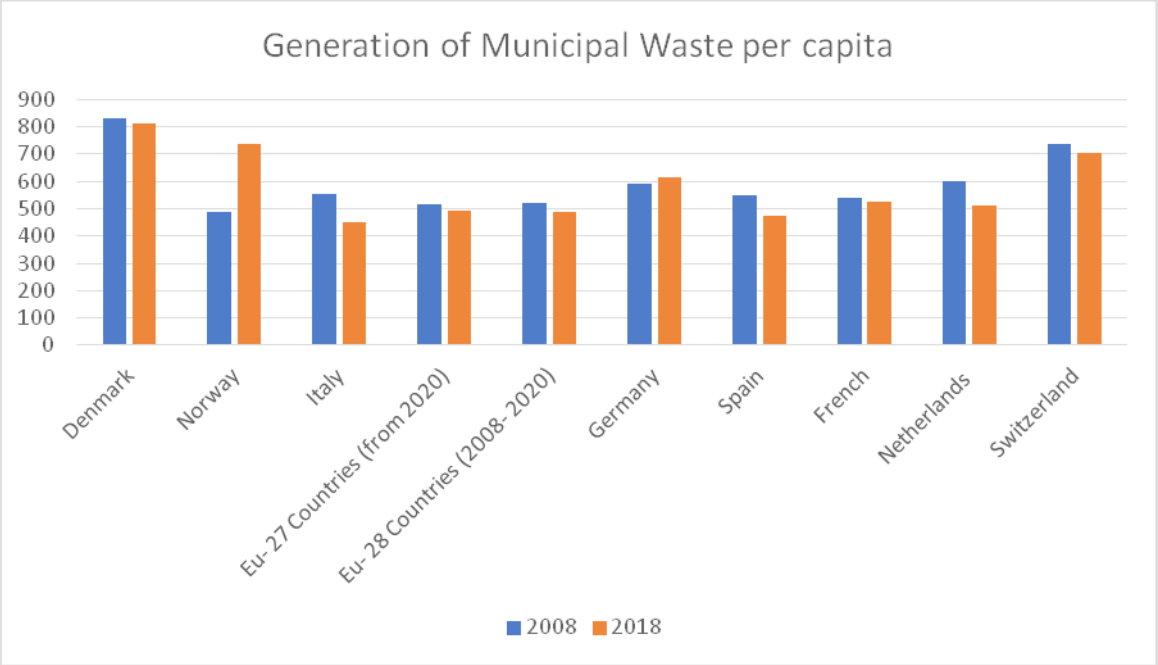

Figure 3. Annual Waste Generated, Kilograms per Capita (Source: own re-elaboration)

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The principle of reuse refers to “any operation by which products or components that are not waste are reused for the same purpose for which they were conceived” (Cialani et al., 2016). The reuse of products has considerable environmental benefits as it, first of all, reduces the amount of waste and the emissions emitted by them, prevents pollution, requires fewer resources, less energy and less manpower, compared to the production of new outputs from virgin materials. Also, from an economic point of view it provides advantages, leading to savings for both the consumer and the producer and the creation of jobs during collection and renewal.

The principle of recycling refers to “any recovery operation by which waste materials are reprocessed into products, materials or substances, both for the original purpose and for other purposes. It includes the reprocessing of organic material but does not include energy recovery and reprocessing into materials to be used as fuel or for filling operations” (Cialani et al., 2016). The recycling system makes it possible to take advantage of resources that are still usable, thus reducing the amount of waste that must be processed and/or disposed of and their consequent impact on the environment. Furthermore, by reducing the use of new raw materials, energy is saved, gas emissions are reduced, and pollution is reduced.

Although the Circular Economy is associated with this last principle, it is not always the best technique from the point of view of sustainability compared to the other two, in terms of material efficiency and profitability, since some types of output either cannot be subjected to the recycling process or only for a limited number of times (Rockström and Sukhdev, 2016; Fassio & Tecco, 2019).

Reuse, repair and refurbishment have a local or regional dimension and are able to avoid or reduce packaging, transport costs and transaction costs by maintaining the property of the good. In contrast, recycling has a global dimension and operates according to the principles of industrial production (economies of scale, specialisation and use of the cheapest labour)” (Cialani, et al., 2016). This type of production model involves a control of all stages of the production cycle. This occurs through the three fundamental principles indicated by the Ellen MacArthur Foundation:

- Principle 1: Preserve and enhance natural capital by controlling limited deposits and balancing the flow of renewable resources
- Principle 2: Optimise the return on resources through the circulation of products, components and materials of the highest value, at all times, in both biological and technical cycles
- Principle 3: Identification and elimination of negative externalities that can discourage the system’s effectiveness (https://ellenmacarthurfoundation.org)

The first principle is that when the system needs to use resources, it must define which resource to benefit from, giving priority to those processes and technologies that use renewable or better performing resources.

The second principle highlights the distinction between two different cycles, biological and technical. The first manages biological nutrients, that means those renewable nutrients that are reintegrated into the biosphere so that they can be used, through decomposition, as input in a subsequent cycle and generate new value. The second, the technical one, on the contrary, concerns non-renewable resources and therefore not suitable for reuse in the biosphere.

Products derived from technical materials must be designed to circulate as much as possible. Optimising resource efficiency through tighter internal cycles (e.g., through maintenance) helps to store more energy and value, as well as orienting a design aimed not only at recycling but also at renovation and regeneration.

Finally, the last principle has the objective of trying to reduce the occurrence of damage to systems such as food, mobility, health and the consequent negative externalities such as air and water pollution and the release of toxic substances that can harm the environment and the economic system.

These three principles are to be considered as principles of action, which are in addition to the basic characteristics, which will be indicated below, that define a circular economy:

- Design-out of waste. It is essential that the change takes place already in the design and planning phase so that at a later stage recycling or product restructuring actions can be implemented, so that as much value as possible is recovered, minimizing the energy input required. When designing a new product, it is necessary to classify materials into “biological” and “technical”, the former is non-toxic and through composting can be reabsorbed by the environment, while the latter (polymers, alloys and other artificial materials) can be recovered and recycled.
- Strengthening resilience through diversity. In a context, such as the current one, so changeable and where uncertainty prevails, the circular model must be ready to face possible difficulties. This can be achieved through strategies of modularity, flexibility, and adaptability, trying to enhance and exploit the difference between the various resources and actors in order to build resilient systems. These features, besides allowing easier maintenance or repair, would also help to extend the useful life of a product as much as possible.
- Use of energy from renewable sources. With this type of economic model, an attempt is gradually being made to abandon the use of fossil fuels. In addition to a question of environmental protection, an abandonment of fossil fuels

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is essential for the type of industrial production that wants to become independent from external energy sources, so that exposure to market price volatility can also be reduced (Rockström et al., 2009).

- Thinking in a systemic way. "It is important to think systemically, analyse and design non-linear, evolutionary and feedback-rich systems" (Toni, 2015). This means thinking about the totality of the system, and not individually the parts of which it is composed, and how it relates to infrastructure, the environment, the economy and the social context. Therefore, think with a holistic vision to understand how the elements interact and influence each other.
- Sharing. Through the implementation of the circular model, we try to go beyond the concept of consumption and possession of the good that has characterized the last century, to be based on a different use of goods with the creation of platforms for participation and sharing economy. These platforms make it possible to discourage the under-use of a good by using the product for longer (even if you do not own it) and in the same way to reduce the creation of unnecessary products.
- Actions in cascades. The sequential relationships between the various phases of the life cycle of a product/service and its sectors must be considered, using waste as input in a new production process. In some cases, through the reintegration in a new cycle of products that have reached the end of their life, the value of the latter is higher than what was their initial end, this development is called upcycling (Spengler & Schröter, 2003).

"Starting from food to develop a paradigm shift in a circular way means bringing back attention to communities, to the quality of relationships and to the substance of behaviour. It means not only dealing with what keeps us alive, but also exploring complex territories that relate to sociality, personal and public identity, and the spirituality of each human being. It means recognising the central role of food for our survival and the sustainability of our planet, its value for human health, well-being and prosperity" (Fassio & Tecco, 2018).

According to the United Nations Environment Programme (UNEP, 2016) The production and the consumption is too high, if we continue in this way by approximately 2050 we will need to replenish 180,000 billion of natural sources on the planet.

The situation of waste will become very difficult. In 2010, the amount of waste generated was 3.5 million tonnes per day, in 12 months 1.3 billion tonnes. The forecast for 2100 is of 4 billion tonnes (Hoornweg & Bhada-Tata, 2012).

The ratio between the food available at the beginning of the chain and the amount of food waste produced along the whole chain varies according to the reference groups, also according to the different preservation methods and the amount of edible part of the food, as can be seen from fig. 4, for example by analysing the different percentage of waste produced between potatoes (22%) and fruit and vegetables (41% and 46% respectively).

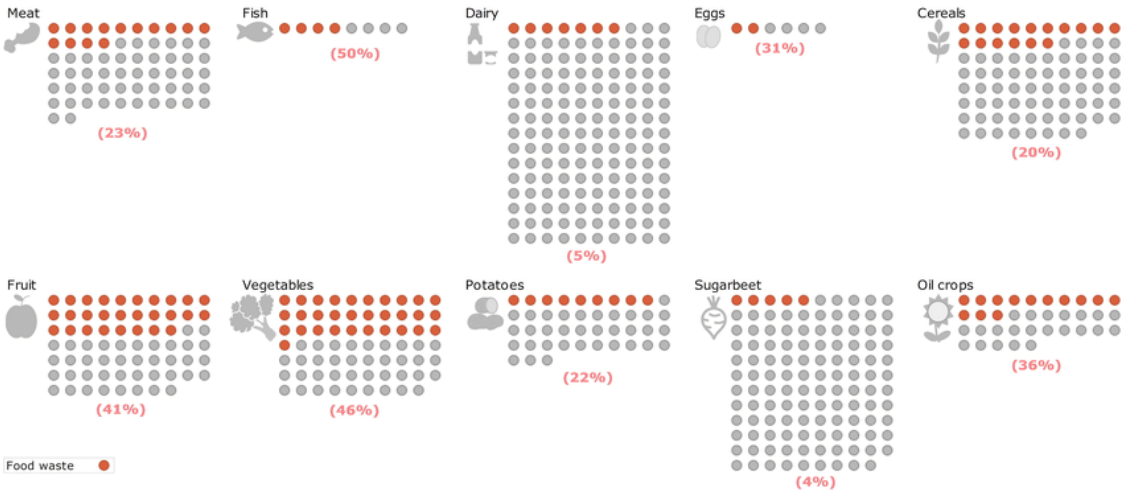

Figure 4. Relationship between Food Available at the Beginning of the Food Supply Chain and Food Waste along the Entire Food Supply Chain (Source: European Commission, 2020)

Food waste brings with it impacts both on the environment and on food and nutritional security, as well as having significant economic impacts and ethical and moral implications. At the corporate level, for example, waste is linked to a company's poor reputation, and at the community level it is generally recognized as socially unacceptable.

Stimulating the reduction of waste in the food chain for a company means being able to increase its efficiency along the

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value chain as well as having reduced costs both for the company itself and for consumers. It could also lead to limiting competition on water and land resources in middle-income countries, making them usable in other ways. (FAO, 2019).

The Five Case Studies

Orange Fiber

It is a Sicilian start-up born from an idea to create a fabric from oranges, a typical fruit of both the Sicily region. The idea was to create a sustainable fabric using waste and making up for the suffering caused by the disposal of this waste in the citrus fruit sector in their area.
The entrepreneurs' collaborated with the Materials Chemistry laboratory at the Polytechnic University of Milan to test its feasibility, obtaining a patent and in 2014 the first prototype, and thanks to other funding they were able to build a pilot plant to extract the cellulose.
The entire process has been patented thanks to all the partners present along the entire supply chain, from agrarians to squeezers (http://orangefiber.co).
During the pressing of an orange, about 40-50% of its original weight is represented by a juice composed of essential oils used by the food or cosmetics industry. The remaining 50-60% is represented by waste. At an Italian level, between 700 thousand and almost 1 million tons of by-product are generated each year depending on production (Ardolino, Boccia & Arena, 2020).
The company cooperates with the squeezers and those in charge of the transformation, where they directly plant their transformation system, then it is sent to the spinning and weaving partners and finally the white background fabric is sent to the brands. All these processes, except for the pilot plant, are not done internally but rely on partners.
The first product was a twill, they focused on the world of silk, then they created a poplin (a fabric in which cotton is the master) and finally a jersey, which is more elastic. It is interesting to note how more products can be developed from a single yarn. Their first client was Salvatore Ferragamo, with whom they signed a contract in 2016.
This production will contribute to sustainable consumption and production and strengthen the means of implementation for sustainable development, as well as protecting and promoting the use of our land's resources in a sustainable way.

DuediLatte

The idea starts from an Italian woman. One morning when she was preparing her classic milk coffee by opening the fridge, she found the milk had expired. So, she wondered if it was possible to make a fabric from milk waste (https://antonellabellina.wixsite.com/duedilatte). Doing some research, she discovered that already in the '30s an Italian engineer had managed to synthesize the first fiber starting from milk. In that case it was milk for food and the resulting fiber was a very raw fiber that was used for padding, even soldiers' uniforms. Taking an example from that process, the entrepreneur completely renewed the transformation process. Today we start from what is a waste milk, therefore agri-food waste that would be destined for pulping, which is instead totally recovered and processed so that casein, the main protein in milk, becomes a noble textile fiber, since the process makes the resulting fabric soft, light and fresh.
All stages of processing are carried out in a completely natural way, without the use of detergents or chemicals. The produce 1 kg of milk fiber is necessary 1 liter of water; to produce 1 kg of cotton it's necessary 10000-20000 liters of water (WRAP, 2017). The factory run on solar energy reducing the company's CO_2 emissions.
The fabric is 100% natural as it obviously comes from milk and organic as it does not use chemicals even the dye the use comes from natural products. Moreover, it is antibacterial and hypoallergenic.
The fabric is extremely soft and also moisturizes and nourishes the skin. The fabric is resistant and elastic even after being washed many times.
The company is continuing to make research and create innovation. They use rice milk to create a vegetable fiber perfect also for vegan. This is also an extremely performing fiber, with the characteristic of protecting the skin through the filtration of ultraviolet rays. It is a 100% biodegradable fiber, coming from the treatment of rice proteins and cellulose. Or they have created a yarn from coffee processing waste.
In Italy, about 30 million tons of milk are wasted every year, through its project Duedilatte uses what is a surplus, a cost in the food industry in an output and a resource for the textile industry.

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Vegea

Vegea, is an Italian start-up born in 2016 which deals with the creation of vegetable leathers from marc waste. In one of his projects noted the problem of a lack of an alternative to animal and synthetic skins, as even those called eco-skins tend to be derived from oil and therefore during their production process and disposal, they create damage to ecosystems. He started to produce Wineleather (the name of the fabric produced by the company) using marc, which is a renewable raw material derived from the persistent process of wine and is present in huge quantities, they do not use polluting substances and do not use oil (as it happens during the production of synthetic leathers). The transformation process starts with the extraction of grape juice and the separation of the marc which are stages of wine production and are followed by the wineries. Here then comes into play Vegea, which dries the pomace so that it does not biodegrade and is preserved so that it can be used even after 2/3 years from the date of drying. Thanks to this drying phase there is no need to wait every year for the harvest period. Their production process is characterized by a low environmental impact: first of all, they use marc, which is a renewable raw material derived from the persistent process of wine and is present in huge quantities, they do not use polluting substances and do not use oil (as it happens during the production of synthetic leathers).
There is no waste of water, as there is no use (in the production of one-meter square of leather of animal origin about 240 liters are usually used). (https://www.vegeacompany.com).
They are able to keep production costs low since they can use machinery already existing in the animal and synthetic leather production companies, to which, however, specific modifications and additions will be made to adapt them perfectly to their production process. Another important aspect is that by not using the raw material from animals, they do not affect the fauna and have no impact on the environment or on man, something that other companies have during the leather tanning process, with the use of acid substances and heavy metals.
The International Organization of Vine and Wine (OIV, 2016) shows that as many as 26 billion liters of wine are produced each year in the world, from this production process 6.5 billion kg of grape pomace can be obtained to produce potentially 2.6 billion square meters of each year.
Wineleather gives new life to this by-product and can be used to produce products applicable to all sectors of leather goods, bags, accessories, shoes and furniture.
In 2020, the shoes and bags of the special collection, containing only sustainable garments, of the colossus H&M have been made with the fabrics of Vegea.

Piñatex

The start-up is called Ananas Anam, which then gave birth to the creation of Piñatex®, born from the idea of the Spanish founder, a consultant in the leather goods sector. During a business trip to the Philippines in the 1990s, she was shocked by the toxic impact of mass production of this product, so she began her search for a sustainable alternative. During this journey, she was attracted by the abundance of raw material, and took inspiration from an ancient local tradition.
The production process to arrive at the finished product starts from the harvesting of the fruit by local growers, and the leaves that come from the waste of the plant are accumulated in long bundles and through the hulling process the fibers are obtained. These are then cleaned and dried. Once dried, any possible residual impurities are removed by means of a machine. Once a sort of fiber is obtained, it is mixed with a corn-based polylactic acid and a non-woven net is obtained through a machine, which is the basic element of each assortment. The treated fibers undergo manufacturing and dying processed in local factories, while the subsequent finishing processes are carried out either in Spain or Italy (https://www.ananas-anam.com/about-us/).
Every year about 25 million tons of pineapple leaves is thrown away, representing a cost for farmers, so much so that in some places they don't know what to do with them. Pineapple is the second most popular fruit in the world and if we consider only the Philippines accounts for 10% of the world's pineapple cultivation, which is about 2.5 million. That would make about a hundred and eighty million square meters of Piñatex, that represents about 450 million skins of cow just to put in perspective. To make 1 square meter of Piñatex, it needs about 16 pineapple plants, which corresponds to about 480 pineapple leaves (Hijosa, 2015).
A plant has one pineapple and possible about 30 to 40 leaves around the pineapple. For the farming communities means extra income. By extracting these fibers, it can have a huge percentage of biomass (the part of the leaf that has all the nutrient) that can become natural fertilizer or biofuel, which is the most expensive thing they have to buy and in addition nothing is wasted.
The company has already received number of awards, for example in 2016 the Award for Material Innovation from the

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Arts Foundation UK or in the previous year the Innovate UK women in innovation award.
No fertilizers or pesticides are used during the process and no additional land or water is required, as is the case in the production process of synthetic leather where toxic chemicals are also used.
It is an ecological, cruelty-free and biodegradable product. The finished material is resistant, flexible and the output is diversified on the basis of thickness and is used not only in the fashion industry but also as leather to create handbags, shoes and clothing for the furniture industry and is also used in the automotive sector. In addition to having a strong positive impact on the environment, the company also has social impacts, in fact it supports the agricultural communities in the Philippines, providing additional income for farmers.
Currently working with several designers, brands to create their collections such as Hugo Boss, Puma, Camper and many others.

S.Café

The S.Café was born in Taiwan by the creator and founder, owner of a Singtex textile company. He created the S.Café® brand that produces ecological fabrics starting from the reuse of coffee waste. The idea was born together with his wife, when one day at the café they witnessed a gentleman asking if it was possible to take the coffee grounds waste home with them. So jokingly his wife said that she had to use the coffee grounds to make the fabrics and eliminate bad smells, and that's when the idea was born. Together with a research team, more than four years of research and an investment of $1.7 million in 2009, S.Café®, the first yarn made from coffee grounds, was founded.
The innovative process used by the company involves the use of high pressures, low temperatures by mixing coffee residues on the surface of the yarn, transforming its characteristics. The process uses less energy and takes less than half the drying time compared to a cotton transformation process.
To get to the final product, the company used another technique already used by them, which is the recycling of plastic bottles. From the recycling of the bottles, it obtains the polyester which is joined together with the coffee residues previously roasted and together they form the yarn which through a machine creates the finished fabric which will be used for the creation of garments. At the moment of roasting the coffee bean tends to swell, thus widening the space inside the coffee and in the following phase the water, which has high temperatures, eliminates all the substances that obstruct the spaces so as to make the bean functional at its maximum (https://scafefabrics.com/en-global).
Coffee is one of the most drunk beverages in the world. When a cup of coffee is drunk, only 0.2% of the bean has been used, the remaining part is bottom which is thrown away and then ends up in a landfill and produces CO2 (Riccio, 2017).
After drying, extraction and grinding the grounds are then mixed with the extrusion of yarn and made in a whole- new material. In addition, during the transformation process another percentage of coffee essential oil is extracted, which can be used in other production sectors to recover 100% of the coffee consumed.
Coffee grounds that are left usually disposed of or the grounds are placed in the refrigerator next to smelly wardrobes or used as a compost, but through cross-industry cooperation they gathered disposed coffee grounds.
The output obtained is a high-performance fabric that protects against ultraviolet rays, managing to condition the body depending on external temperatures. The grounds unique core structure and pores are the key to its superior function.
The innovation of this fabric is to be able to capture unpleasant odours It has found great application in sportswear, where it has been found to use materials with a considerable presence of perfluorinated, environmentally harmful substances that facilitate elasticity and permeability in the garment.
When we exercise the pores of the coffee grounds capture the odour our bodies produce as they passed through the fabric trapping and isolating the odours. These pores increase the exposure of the fabric surface to the air, so the sweat on the fabric is also wicked away rapidly.
The company has worked with hundreds of clothing brands including Asics, Timberland and New Balance. S.Café® has as a fundamental principle at the base of its business the respect and preservation of the land.

Conclusion

The companies analyzed use waste from different foodstuffs and have to act on different stages of the relevant supply chains that produce the various food by-products. Most of the cases mentioned do not develop the whole process internally but rely on partners for the transformation of the product. All five company cases are employed in the fashion sector, and some of them, in particular Duedilatte, Vegea and Piñatex, find application in other sectors such as furniture and automotive.
The Table 1 shows a comparison of the five companies from the different perspectives:

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1. the food that they recycle;
2. the phase of the supply chain;
3. the head quarter of company;
4. the production process that the companies make;
5. the sector in addition to fashion where the final product is used.

Table 1. Benchmarking among the Companies Analyzed (Source: own re-elaboration)

	Food	Supply Chain	Origin	Process carried out internally	Sectors of application
Orange Fiber	Orange	Transformation	Sicily (Italy)	They rely on partners	Fashion
DuediLatte	Milk	Production	Milan (Italy)	Internally	Fashion, forniture, automotive
Vegea	Grapes	Production	Rovereto (Italy)	They rely on partners	Fashion, forniture, automotive
Piñatex	Pineapple	Post-harvest	Philippines and Spain	They rely on partners	Fashion, forniture, packaging, automotive
S.Café	Coffee	Consumption	Taiwan	Internally	Fashion

Food and fashion look so far but if they can collaborate, they can reduce on one side the problem of waste in the food industry and the other side they can improve the innovation in the fashion industry.

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