

Biomaterial: A Sustainable Alternative to Animal Leather and Synthetic Material

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Abstract

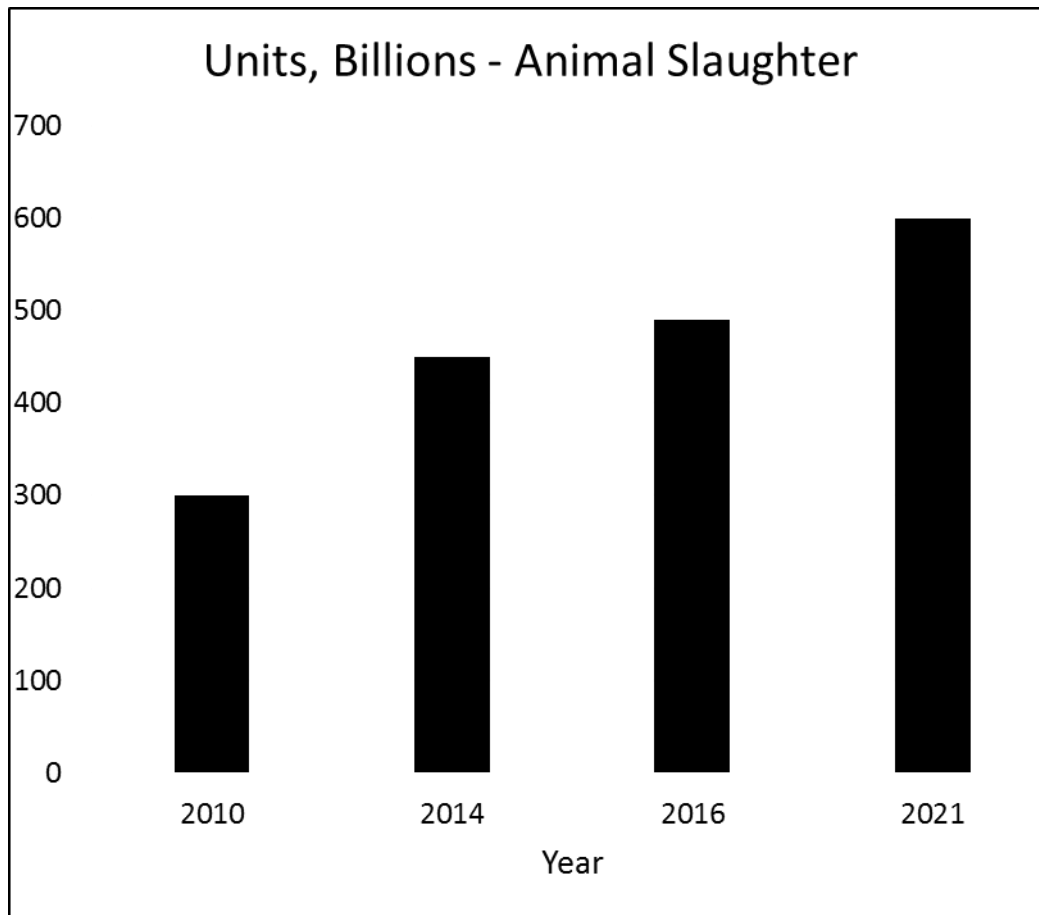
As Fashion industry is considered to be heading the sustainability call and ethical production worldwide. This study introduces the innovative alternative synthetic textiles and leather options for animal and artificial leather in order to achieve environmental sustainability. Leather consumers all around the world are looking forward to part-take in the international initiative to make the industry more eco-friendly. With the use of these leather alternatives a big difference can be made to landfill contributions as the glamour genre is today a significant sector. It involves the process of creating various eco friendly leathers and fabrics using the natural waste derived from our day today use. It is theoretical presentation of model, which brings together the essentials of sustainability and Innovative production methods from waste to design. The purpose of this research is to provide the customers and designers the sustainable option for their clothes, bags and shoes. The core focus is on revamping the raw material waste, production method of leather/ Textile and its treatment.

Key words: Fashion, Vegan, Sustainable, coconut, Leather, biomaterial, Pineapple, Mushroom, Soybean, Textile

I. INTRODUCTION

The leather industry around the globe slaughters around more than billion animals every year. The animals suffer the terrors of rearing live stocks which includes confinement, branding, deprivation etc. The leathers made from other materials which does not include animal skin may be referred to as Vegan leather or faux leather. There are variety of materials which can be used to create vegan leather which may also include synthetic materials like plastic waste, natural waste including fruits and cork etc. (Lasindrang, Suwarno, Tandjung & Kamiso, 2015) Global fashion industry is actively working towards reducing fibre waste. The common synthetic leathers are made of (PVC) Polyvinyl Chloride and (PU) Polyurethane. These are plastic based raw materials and the leather made from them are also called as "Pleather" (Leather made of Plastic). Using Plastic leather may again lead to few questions like, what about the consequences on our environment? They may take more than 1000 years to biodegrade and release dangerous toxins which are extremely harmful. Therefore, we are discussing here about the leather made from natural waste which are biodegradable and safe for environment. These leathers can be derived from fruits, coconuts, pineapple leaves, cork etc. This natural leather

is made from sustainable biomaterial further processed with natural fibres and glues to create leather. Luxury brands are now moving towards up-cycled and sustainable trend (their major aim is to use discarded waste). Designers in the industry look forward to viable alternatives in the global fashion industry and are converting food waste, plant based and textile waste into future fashion impacting the earth and industry in a big way (Anna-Sophie Stübler, Volker Heinz, Kemal Aganovic, 2020).



Graph(1) <https://ourworldindata.org/grapher/animals-slaughtered-for-meat>

We may define Sustainability as a revolution that may affect everyone on this planet and is much more than only environment issues. It is a global shift, transformation & investment for the betterment of the global economy and business. The world corporate is pressurised to move towards the evolution of a more sustainable model. Social awareness is progressively challenging and conversant by the escalating granularity and availability of data, growing social mindfulness is articulated through customer preferences. The sustainable revolution is offering matchless opening to create more sustainable business models, thus providing a great opportunity for the modern history. Misconception regarding the faux or vegan leather being plastic and offensive always prevails in the minds of the consumers, whereas they have more environmental responsible options available. Green fashion is a state-of-the-art that helps Fashion and textile industry develop, advance and with a great vision (Gupta, R, Shukla, 2019).

Sustainability is an extensive discipline, giving the insights to most facets of the social world from commerce, innovation and environment. The modern world is today looking to significantly decrease carbon releases and determine the development of the technologies for the near future. Sustainability leads to ecological mindfulness and prioritizes many industries to

follow to new way of life. Therefore, Sustainability is the upcoming future trend for renewable of garments and textiles sources, decreasing carbon secretions, guarding surroundings and a means of keeping the environment in balance. "Sustainability" can be defined as the study to avoid the reduction of natural resources in order to preserve an environmental balance.

II. LITERATURE REVIEW

SUSTAINABILITY CHALLENGES AND OPPORTUNITIES

Sustainability emphasizes on meeting the requirements of the present-day without negotiating the capacity of future cohorts to encounter their necessities. Sustainability as a concept is made of three pillars: environmental, global economic, and social also known ceremoniously as 3 P's-planet, profits, and people. The various goals of sustainability may include: Reduction of Source- with the change in production and consumption patterns there can be major reduction in pollution and waste management. Ethical/Sustainability-

This is a struggle to meet communal requirements with approaches that can endure to be recycled into the upcoming days forever without exhausting or harming natural resources. Innovation- The emphasis is on developing substitutes for various technologies which are damaging the environment. Cradle-to-cradle design- This includes the conception of products that can be recycled or retrieved, thus ending the cradle-to-landfills cycle of artificial products. Feasibility- The objective is to generate a cost-effective centre that focuses on producing and technologies which are advantageous to the environment, thus growing the promptness at which such technology and product ideas can be applied (Aganovic, 2020).

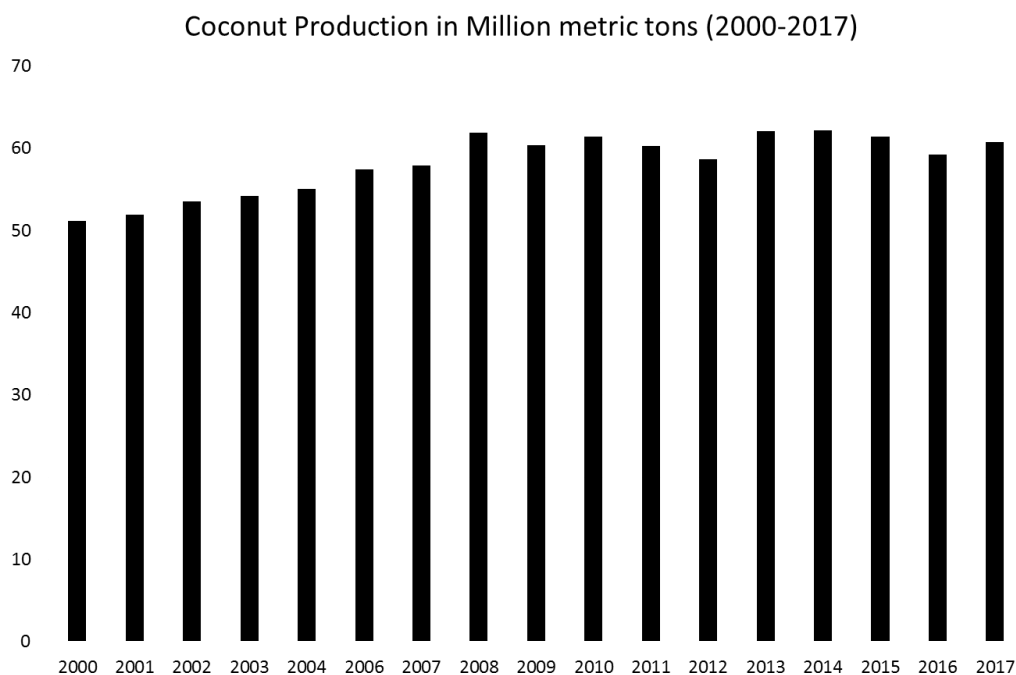
Fashion Industry records greenhouse gas emissions nearly 10% human activity, which can be reduced in many ways. Apparel industry in overall has multifaceted supply chains which makes it difficult to identify the reason for emissions of production, also there is how the clothes are transported and discarded after the consumers do not want them anymore? The Fashion industry is now following micro seasons (Fast Fashion), fashion followers or "Gen Z" are compelled to buy the latest trends due to peer pressure (Odabaş, 2010).

As per the UN, a single pair of Jeans requires at least 1kg of cotton which requires 7,500-10,000 liters of water. <https://unfccc.int/news/un-helps-fashion-industry-shift-to-low-carbon>. The stretchy jeans has become a factor of comfort and necessity these days as a trend and requirement. Elastane which is used to give stretch is synthetic in nature, made of plastic which restricts biodegradation of the material and increases reverse effects on the environment (Norum & Trash, 2015). This means if we are able to upcycle the existing pair of jeans before disposing it in the landfills and create a new look as per the ongoing trend, we might save investing on 1kg of cotton and the entire supply chain. To create Polyester fibers approximately 70 million barrels of oil is used every year. Hence we should switch to recycled polyester which can help reduce the carbon emissions (recycled polyester releases 1/2 to 1/4 of the emissions of virgin polyester). Nevertheless, this is not a permanent resolution, as polyester takes many hundreds of centuries to decay and can lead to evasion of microfibers into the atmosphere. Production of natural and organic material is also not completely sustainable, as they require huge amounts of water, dyes and transport impacting the overall effects of environment (Hanson, 1980).

Some Fashion companies are exploring ways to use wood, fruit, cactus and other natural textile waste materials to create their textile materials which are easily biodegradable once disposed. But the carbon footprint of apparels can be reduced in other ways, too. The buying patterns of the consumers has one of the biggest impact. Sustainable material is directly related to the preservation of environment and ethical future fashion. "Fashion is chunk of the everyday change, this can be very well associated with fast fashion trends and demands. Whether recycling food waste or just connecting the DNA of vegetation to produce inventive new plant textiles, which is going to become the textiles and material for the future in Fashion Industry. Some of the "Circular Systems" inventive technology possibilities to convert plant waste fibres into Fashion leather and Textiles (Gao, Chen, Wang, Liu, Wang, You Ke, Wang, Wang, 2020).

III. CONCEPTUAL FRAMEWORK

Coconut tree is popularly also known as wishing tree as the coconut flesh is edible and the water is drinkable; the fibre on the shell is used to make brooms, foot mats, etc.; the wood is derived from the trunk and the root are loaded with medicinal properties. The total global coconut production is more than 60 metric tonnes, and it is seen there is a rise of around 3% each year

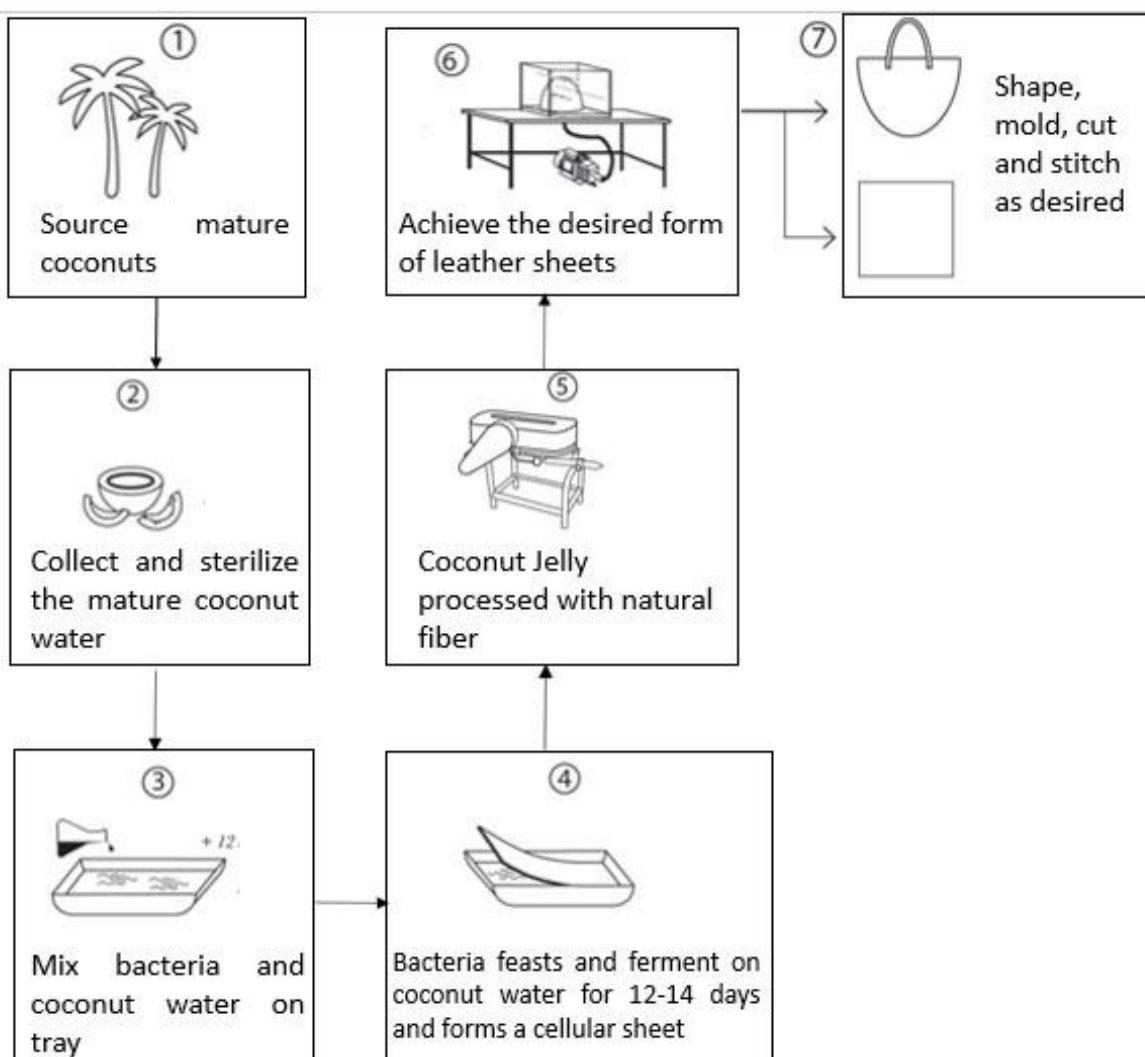


Graph(2) <https://www.statista.com/statistics/577497/world-coconut-production/>

A. COCONUT LEATHER PROCESS:

Coconut leather is made from a conventional coconut jelly formed by fermentation of coconut water which was developed in Philippines known as "Nata de coco", derived from mature coconut milk and coconut water. Bacteria (*Acetobacter xylinum*) is commonly used in the fermentation process. Fermentation leads to jelly like substance which is further sterilised and ready to consume (Nehru Naik, 2017).

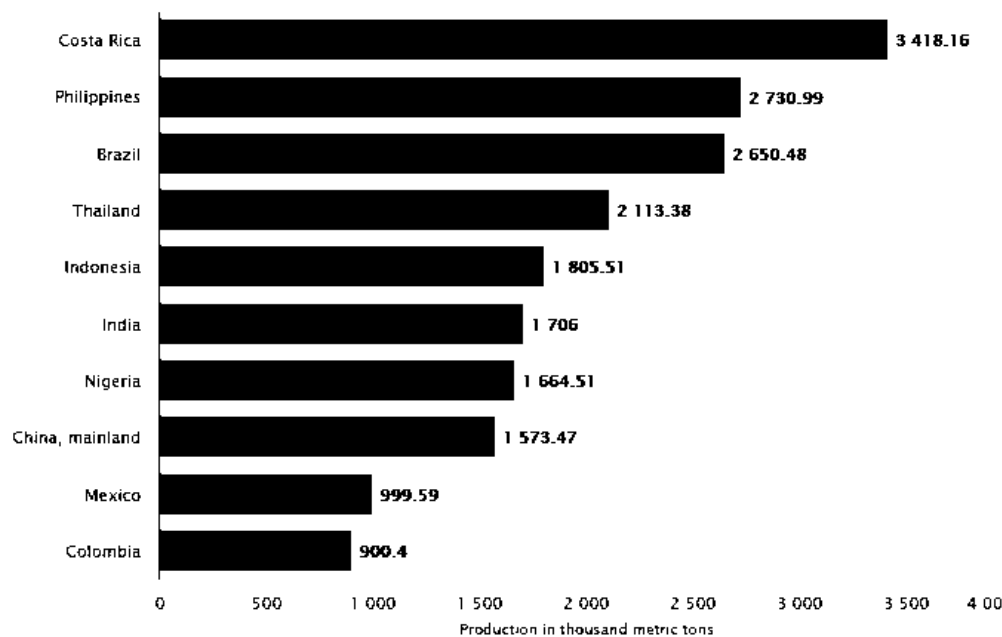
The leather production process alongside the farming from where the matured coconut water is procured and sterilised. For 5-6 days the bacterial culture is incubated. The sterilised coconut water and bacterial culture mixture is laid on trays. The cellulose jelly is formed when the bacteria feasts and ferments for around 12-14 days. This sheet is then sterilised and processed along with the natural fibres like, pineapple, hemp and banana fibre (Banana fibre) suits best in production of coconut leather. India is one of the largest producers of banana (27,575,000 tonnes) and around 980,000 tonnes of dry residue is produced every year. The nature of Banana fibre is lustrous and strong like silk. The coconut sheet formed may vary in thicknesses, the thicker sheets are stronger but difficult to craft and stitch, whereas the thinner ones are easy to handle as they are soft and lean. These sheets can be moulded and given shapes with natural blend of wax and oils. Coconut leather is strong and durable but disintegrates over the period of years naturally without emitting any toxic gases or harm to the soil (Iana Rico, Beatriz Gullón, José Luis Alonso, Remedios Yáñez, 2020).



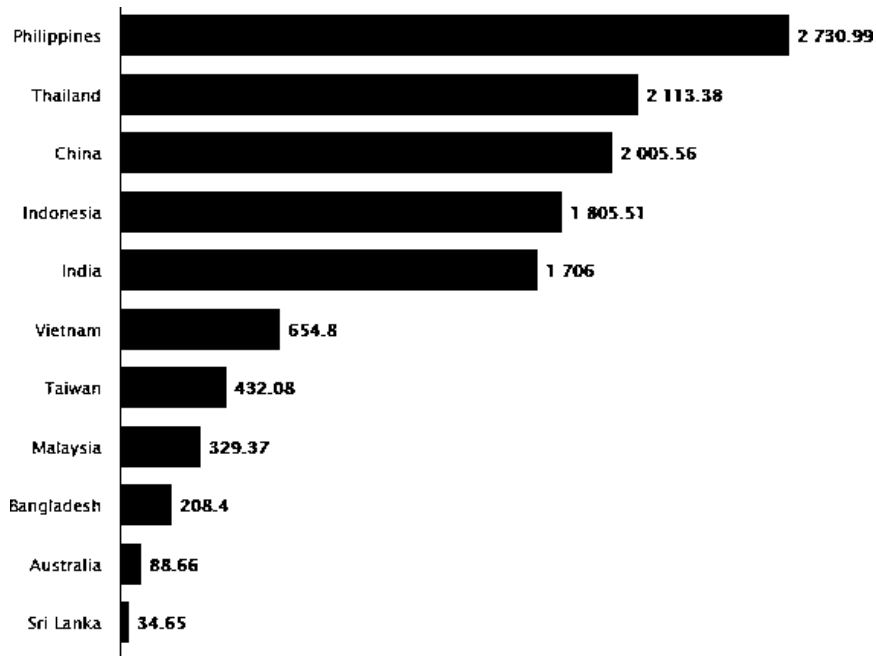
Fig(1)Coconutleatherprocess

PINEAPPLE PRODUCTION & WASTE: Cultivation of Pineapple very time exhaustive. The fruit around 14 to 18 months to reach its full development and is prepared to crop. Tropical regions are best suited to grow Pineapples, which is clearly shown in the graphs below that

massive bulk of pineapple comes from countries with tropical climate (Hongjie Dai, YueHuang,HuanZhang,LiangMa,HuihuaHuang, JihongWu, YuhaoZhang,2019).



Graph(3)ProductionofPineappleintheAsiaPacificregion2018,bycountry/region(in1,000tons)
<https://www.statista.com/statistics/681671/asia-pacific-pineapple-production-by-country/>



Graph(4)the production statistics of pineapples as 2018 data in the Philippines was more than 2.7 million tons. <https://www.statista.com/statistics/681671/asia-pacific-pineapple-production-by-country/>

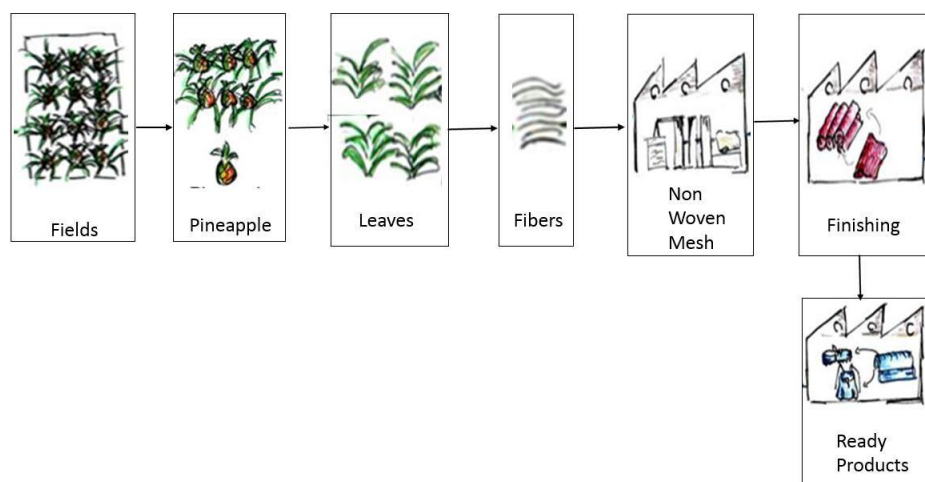
S.No	Parameters	Pineapple pulp	Pineapple waste
1	Moisture (%)	87.3	91.35
2	Ash content (mg/100g)	1.8	0.04
3	Titratable acidity(%)	2.03	1.86
4	Ascorbic acid (mg/100g)	21.5	26.5
5	Reducing sugars(%)	10.5	8.2
6	Non reducing sugars(%)	7.4	8.8
7	Total soluble solids(%)	13.3	10.2
8	Total sugars (%)	8.66	9.75
9	Crude fibre(g/100g-fw)	0.41	0.60
10	Protein(mg/100g)	7.2	10

Table1:PhysicalandchemicalconstituentsofPineapplepulp&waste

B. PINEAPPLE LEATHER PROCESS:

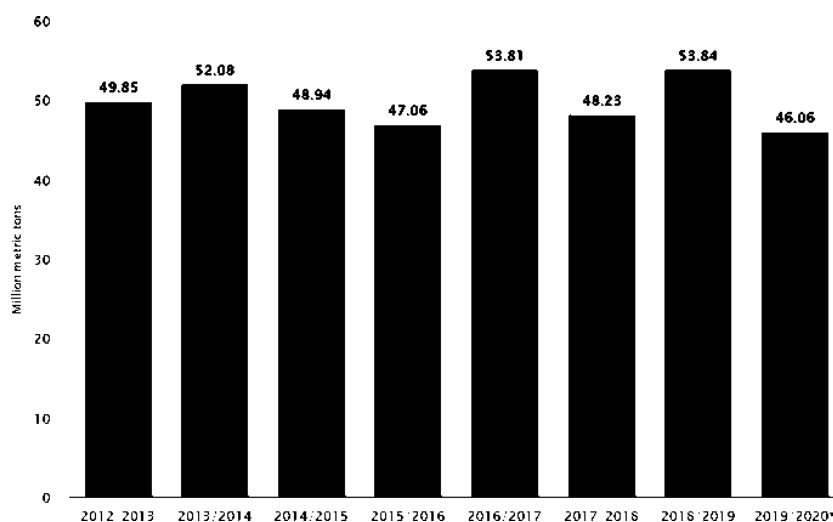
Woven Pineapple textile is an old traditional weaving techniques from Hispanic times. This textile was much hindemand during 19th century, worldwide. However, demand for cheap textiles like cotton increased which ceased the production of Pineapple fabric and it almost disappeared. Also known as “Piñatex” as it is plant textile which can be used as an alternative to animal leather (Nga H.N. Do, Thao P. Luu, Quoc B. Thai, Duyen

K. Le, Ngoc Do Quyen Chau, Son T. Nguyen, Phung K. Le, Nhan Phan-Thien, Hai M. Duong, 2019). As pineapple is one of the most popular food worldwide, the raw material required to produce the leather can be achieved in abundance. In spite of this fruit being exotic its leaves help to derive a wonderful textile (Débora A. Campos, Tânia B. Ribeiro, José A. Teixeira, Lorenzo Pastrana, Maria Manuela Pintado, 2020). These leaves are split and cellulose fibres are extracted from pineapple leaves which are long, stiff, white, creamy and lustrous in nature like silk, further are felted into a mesh (non-woven) [14]. Thermal, mechanical and chemical processes are used to form a net of fibres. This felted textile is further treated with a protective coating. The chemicals involved in this process are least synthetic and the product outcome is much more sustainable when compared to animal leather but not completely biodegradable. It is made from a mixture of Pineapple leaf, petroleum-based resins and PLA (Polylactic acid) also known as bio-plastic which is biodegradable and sourced from renewable resources. Around 16 pineapples can produce 1 m² of pineapple textile which is more cost effective. As this is created as fabric, the roles can be defined and produced as per the requirement of the product manufacturer (Hongjie Dai, Yue Huang, Huan Zhang, Liang Ma, Huihua Huang, Jihong Wu, Yuhao Zhang, 2019). Pineapple leather can be produced in various colours and finishes, including variety of textures and metallic gloss. This leather is supple, light and softer than other faux leathers (Nga H.N. Do, Thao P. Luu, Quoc B. Thai, Duyen K. Le, Ngoc Do Quyen Chau, Son T. Nguyen, Phung K. Le, Nhan Phan-Thien, Hai M. Duong, 2019).



Fig(2) pineappleleatherprocess

GLOBALORANGEPRODUCTION2012-2020



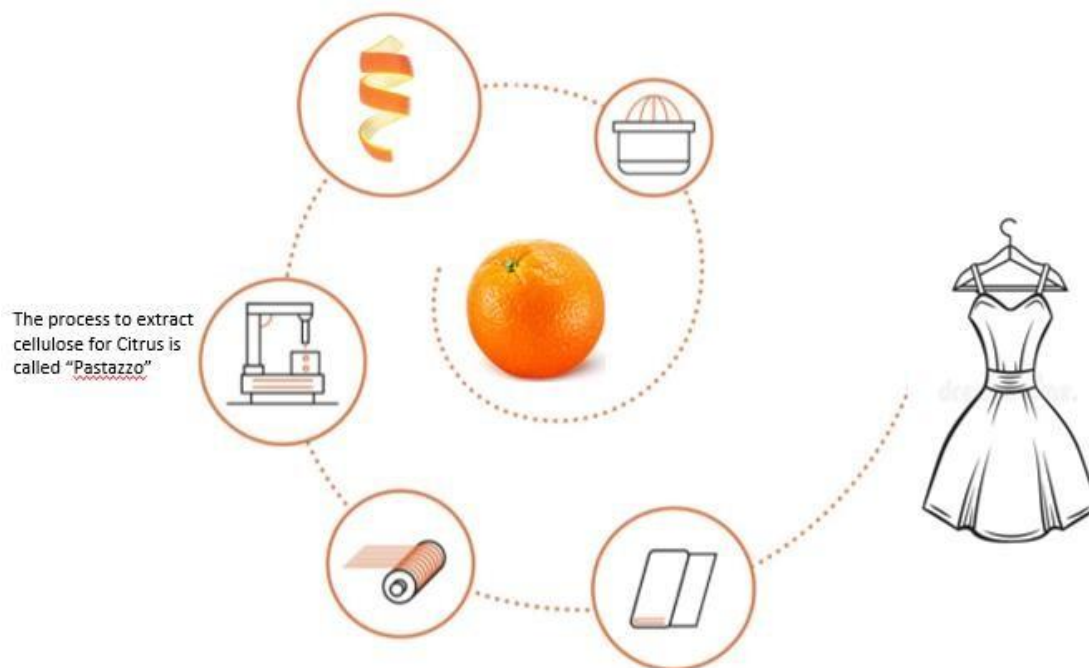
Graph (5) Global orange production 2012-2020 <https://www.statista.com/statistics/577398/world-orange-production/>

C.ORANGESILKPROCESS:

The citrus industry throw-outs 1 shedload of citrus fruit peels yearly. Though the skins are of course decomposable, it still involves a lot of money to discard them appropriately (K.Grohmann and E.A.Baldwin, 1992). Orange peel Fibre, can be used to develop new range of silk fabrics derived completely from waste citrus fruit peels. The peels are treated used as raw material for cellulose extraction is treated by using two different squashing reagents, sodium sulphite and sodium metabi-sulphite (F. R. Marín, C. Soler-Rivas, O. Benavente-García, J. Castillo, and J. A. Pérez-Alvarez, 2007). The main process parameters involve, sulphite agent amount and the reaction period, on the yield of cellulose (W. Widmer, W. Zhou, and K. Grohmann, 2010). The rudimentary celluloses are bleached with oxygen and hypochlorite. The physicochemical description of the cellulose materials derived points towards a decent level of purity, low crystallites, brightness, water retention and reasonable molecular weights (T. Inoue, S. Tsubaki, K. Ogawa, K. Onishi, and J.-I. Azuma, 2010). These celluloses are further spun into the final yarns. The fabric appears and senses like silk; soft and lustrous.

trousontouchwithaluxuriousappearance(Y.Jiang,Y.Du,X.Zhu,H.Xiong, M.W. Woo, andJ. Hu, 2012).

This yarn is not only pretty to feel and look but also has many additional benefits; the fabric has Vitamin C and essential oils which exist in the citrus fruit peel (W. C. Kim, D. Y. Lee, C. H. Lee, and C. W. Kim, 2004). These properties are absorbed in the skin to nourish it and making the fabric feel like soft cream and not making it feel greasy or uncomfortable (D. Mamma, E. Kourtoglou, and P. Christakopoulos, 2008). As these oils are natural in nature, they can survive up to a minimum of 20 washing cycles (M. Pourbafrani, G. Forgács, I. S. Horváth, C. Niklasson, and M. J. Taherzadeh, 2010).



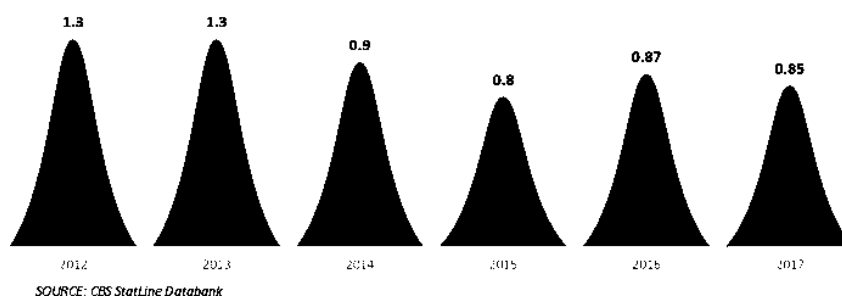
Fig(3) Orangesilk process

Orange peels are grinded and applied to the fabrics to give an Anti-microbial finishing to the textiles (M. M. Tripodo, F. Lanuzza, G. Micali, R. Coppolino, and F. Nucita, 2004). A study mentioned that the sources from citrus fruit peel discards when mixed with sodium bicarbonate, and applied as a coat on the cotton fabric results in properties like anti-odour and anti-microbial properties (E. Mizuki, T. Akao, and T. Saruwatari, 1990). These textiles can be used as Medical fabrics. Textiles made from peel waste may be soft, are good dye absorbents and breathable fabrics (M. Lohrasbi, M. Pourbafrani, C. Niklasson, and M. J. Taherzadeh, 2010). Apart from deriving textiles from the peels, various treatments can also be offered on fabrics like; fragrance finish on fabrics and repellent for mosquitoes (G. Forgács, M. Pourbafrani, C. Niklasson, M. J. Taherzadeh, and I. S. Horváth 2012, Kadam AA, Sharma B, Saratale GD, et al., 2020).

MUSHROOM PRODUCTION AND ITS STATISTICS:

Mushroom is a fungi which has a stalk, top and gills. These fungus are high source of fat and are gluten free in nature. They have very short lifetime and its agriculture is unlike other vegetation's as they lack of chlorophyll (T. L. Hansen, J. E. Schmidt, I. Angelidakis et al., 2004).

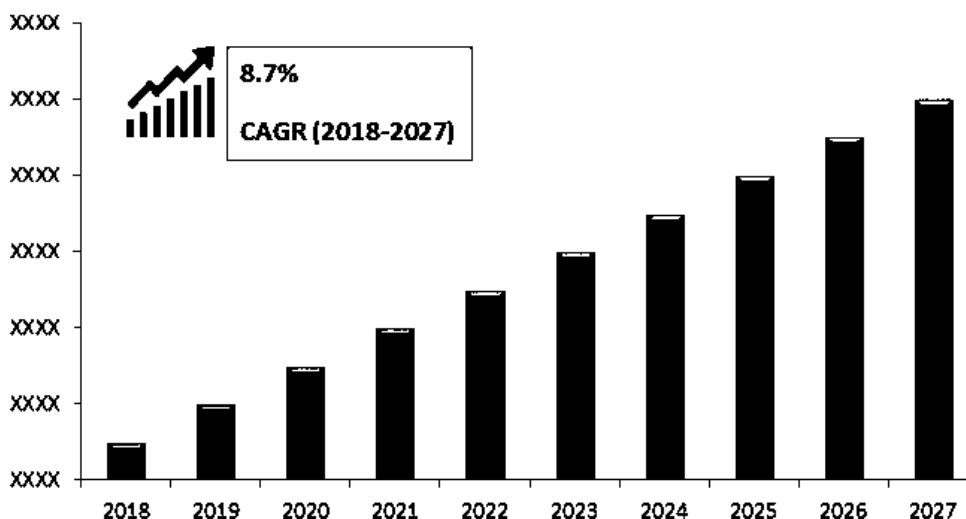
Table: Global Consumer Prices of Mushroom (2012-17)



Graph(6) <https://opendata.cbs.nl/statline/#/CBS/en/>

The world-wide mushroom demand is detecting vigorous development on account of increasing throwaway income and varying eating habits, thus pouring demand for mushroom (Progression in food production in the past few years and increasing developments regarding mushroom is expected to enter mushroom market (Katarzyna Szwedziak, Ewa Polańczyk, 2018).

Mushroom Market Size In the Forecast Period (2018-2027)



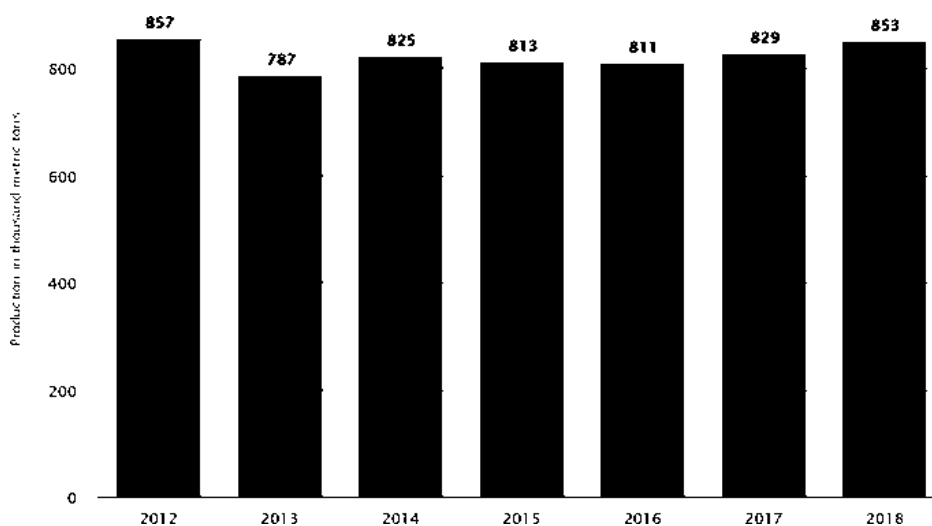
Graph(7) <https://www.theinsightpartners.com/reports/mushroom-market>

As seen in the above graph, mushroom growth has been increasing and is anticipated to rise in the future. The widespread technological advancement, research developments, biotechnological progressions is predictable to increase the production of mushrooms in the future. Also, the major change in food-conscious habits are projecting the growth of mushroom market. There are a few limitations involved, such as, mushrooms have a small life-span but are easy to grow and inexpensive (depends on the type of

mushrooms cultivated). The global mushroom market includes Oyster Mushrooms, Shiitake, Button, Lions Mane and many more... Major Mushroom market is around 5 major regions Asia Pacific, Europe, North America, Latin America and Africa region. Asia Pacific is one of the maximum rising mushroom market (María Elena Valverde, Talía Hernández-Pérez, and Octavio Paredes-López, 2015).

D. MUSHROOM LEATHER PROCESS: This leather is made from the skin of Akamushroom known as (Muskin). It is basically derived from the Phellinus ellisoideus mushroom top and then tanned to give a conventional leather look. No harmful chemicals are used to create the natural look. It is derived from the skin or (vegetative part) of the fungus on which the spores are grown under various humidity and temperatures, then tanned to create a similar look as cow, snake and various other leathers. This process uses very less energy to create eco-friendly and biodegradable leather. Mushrooms are fungus that spreads along the logs in the forests. The roots of mushrooms (Mycelium) grows and spreads by grasping the nutrients available in the environment which makes it strong and lasting. A dense foam like substance called (Mycelial mat) is removed from the log also having a pebble like texture, giving a leather look. The convert this material into fabric, mycelium cells are 1st sourced and arranged on the dish. These cells grow into fibres called (hyphae) by eating cellulose-rich nutrients and best results (dense fibrous network) can be derived if the temperature, CO₂ and humidity is controlled. This fibrous network looks leather like mat. Once this mat grows large enough, it's cut into slices which is then passed through a process that is similar to animal leather giving a tanned look. Mushroom leather is biodegradable and eco-friendly which does not rot like animal leather and also needs no extra chemical or salt treatments. This leather can also be used to create accessories and jewellery. Biomaterial leather quiet a small share in the overall leather market, but is increasing, and investors are eager to support it (Arun INGALE and Anita RAMTEKE, 2010).

E. CACTUS LEATHER: Mexico is one of the highest producer of "Nopal Cactus", which is best suited to create leather material.



Graph (8) Production of "Nopal Cactus" in

Mexico <https://www.statista.com/statistics/912087/mexico-nopal-cactus-production-volume/#:~:text=In%202018%2C%20nopal%20production%20in,ingredient%20in%20numerous%20Mexican%20dishes.>

A complete new and innovative vegan leather created by using cactus leaves into organic, all-natural, cruelty-free leather. This leather is biodegradable, soft, long-lasting, and sustainable in nature.



Image(1) "Nopal Cactus"

The quality of leather is good for creating and using for Fashion items like clothes, accessories, home furnishings like sofa covers, table mats, and even for car furnishings and interiors. The leather is derived from "Nopal Cactus" which is generally grown in deserts and require very little or no water to grow (Karym El-Mostafa 1,2,†, Youssef El Kharrassi, "Nopal Cactus, 2014).

F. SOYBEAN TEX & LEATHER: Waste Produced by Soybean generally dumps directly to the water sewer which leads to environmental problems like; "Eutrophication". As Soybean wastes are major contributors in water pollution, the leftover liquid is boiled for 10 days with sugar, fertilizer, and vinegar and bacteria till it becomes microbial cellulose (widely used in the traditional Philippine dessert nata de coco). This solution is dried to get a sustainable fabric which can be used for making vegan leather. Wastewater from soya (tofu) industries are taken and put it in culture medium. It takes around 10-12 days to convert glucose into cellulosic fibres with the help of the *Acetobacter xylinum* bacteria, forming microbial cellulose sheets can be further processed (compressed, parched, enriched with tinting or coating) to make leather and leather products. Further, the wastewater derived from this process generates very less amount of microbial fuel.

Soya is a by-product of Tofu and is reflected as a man-made cellulosic substance, which means it is required to experience few chemical "experiments" to be converted into yarns from plant. The best thing about this is, the chemicals used in the production process is often re-used to close the loop of production. For producing the soy-fabric, the proteins present in the beans fragmented down by heating them and exposing them to Alkalies and enzymes. They are then filtered and spun into long fine strands of yarns. In some of the cases "Formaldehyde" is used as the "cross-linking agent" in order to bind and increase the length of the fibres and create wrinkle resistant fabric. Use of "Formaldehyde" is not recommended as it is non environmental in nature. Therefore, Soy fabrics are not totally sustainable but can definitely be reflected as more sustainable option than artificial fibres (Samuel N. Nahashon and Agnes K. Kilonzo-Nthenge, 2011).

IV. CONCLUSION:

The current threat by the fabric manufacturing industry is the invasion of micro-plastics into the maritime due to use of polyester fabrics in our day to day life style. Mostly fabrics like polyester, acrylic and nylon are made of 60% plastic content and shed out plastics at every move of theirs. This microfibers are harmful for the marine life as well as the human. More than 1 million of microfibres are released due to washing and dyeing of these textiles entering the human food chain leading to serious diseases like cancer. The fashion industry has continuously been an important area for vegan activists with an aim to help extend

animal welfare and rights, so refining the industry ethics and ecological impact take the industry back to production of vegan alternatives. The vegan world is taking over the artificial textiles and animal leather products.

Many high fashion brands are shifting way with regards to the fabric that are being used in their products (Akpinar, Bostanci, 2009).

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