Review of Papers on Sustainable Approaches.

Sustainable approaches in terms of Bio plastics, Bio leathers and Natural dyes.

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Abstract: Sustainability as a concept has gained a lot of importance in the recent times. Textile industry being one of the largest contributors to the degradation of the Earth, is turning to make its processes clean and Sustainable. The whole concept of sustainability has given rise to many new concepts and innovations in the terms of materials and processes. It has also led to a rise in new innovations in products and going back to more sustainable ways of making products. A few examples of the same are natural dyeing, biodegradable bio plastics and bio leathers. Nowadays, products which cause minimum harm to the environment are popularized more and more. Many people have come up with new solutions to the problems caused by conventional non-biodegradable materials. The possibilities of such materials are endless. This paper is a review of similar approaches, which were published in various journals.

***Index Terms* – sustainability, bio plastics, bio leathers, natural dyes.**

I. Introduction

We see that veganism as a whole has developed as a trend and boomed to a larger concept and style of living in the recent years. Similar is the case of the natural dyes. The concept of being one with the nature and consuming natural resources is becoming very popular. This is also due to the fact that the environmental harm caused by all of the synthetic dyeing activity and that of using harmful chemicals to treat and make conventional leather and plastic has gone too far and is also responsible many irreversible and destructive changes around us. Bio products have become popular along with all the natural products that already exist as a response to these changes. Many materials like biodegradable bio plastics and bio leathers have been given more and more attention due to the fact that sustainability is not just a mere terms but actually the need of the hour.

3.1 Review 1- Ethical Consumers' Awareness of Vegan Materials: Focused on Fake Fur and Fake Leather

With an increase in ethical awareness, people have begun to criticize the unethical issues associated with the use of animal materials. This study focused on the transition of global consumers' awareness toward vegan materials and the relationship between the interest in ethical subjects such as animals, the environment, and vegan materials. For this purpose, consumers' posts about fur/fake fur and leather/fake leather uploaded on Google and Twitter from 2008 to 2019 were utilized, and the Term Frequency-Inverse Document Frequency (Tf-idf) value was extracted using Python 3.7. Furthermore, the worldwide Google keyword search volume of each word was analyzed using Smart PLS 3.0 to investigate global consumers' awareness. First, with time, consumers began relating animal materials such as fur and leather to topics such as animal rights, animal abuse, and animal protection. Second, as interest in "animal welfare" increased, interest in "fake fur" also rose, and as interest in "cruelty free" increased, interest in "fake fur", "vegan fur", and "vegan leather" also increased. Third, as consumers' interest in the "environment" increased, interest in vegan materials such as "fake fur" and "fake leather" decreased. However, as interest in "eco" increased, interest in "vegan leather" also augmented.

Inhumane practices like that of killing of animals for their fur, leather and testing out products has been a major focus of the activists. This criticism has reached its peak since the release of animal liberation in 1975, which states that animals have rights and humans have a moral obligation towards them. Activists and critics have blatantly and out rightly spoken against this issue ever since. This resulted in the development of a morally and ethically conscious customer and owning of 'faux' fur and leather garments became a symbol of animal rights' activism.

The industries that manufacture the fur and leather are seen as to have very inhumane conditions, which include poor breeding conditions, inhumane slaughter of these animals and the usage of heavy toxic chemicals for conversion of the skin to leather and to prevent the skins from rotting. Eventually these harmful and toxic chemicals are sent out to the oceans and create even more problems towards the ecology of the environment. Several civic groups and the animal protection group PETA (People for the Ethical Treatment of Animals) strongly encourage animal-friendly production process such as the substitution of animal fur for vegan materials. A few steps taken by the governments are as follows, the entire world entering the EU countries have enforced regulations on fur restrictions. For example, England has banned fur breeding since 2000 and Austria since 2004. The Netherlands, the second-largest mink producing country in the EU, passed the law on banning fur breeding in 2012 and declared that all mink farms be closed by 2024.

The research related to vegan fashion and alternative materials, case studies, and/or survey data statistical analysis were conducted for the empirical study. As an alternative approach, this study incorporated the macroscopic data from online sources such as social media and Google search. With the development of the Internet, public opinion about social phenomena is well illustrated in social media posts and used as an alternative way of collecting data. This study specifically focused on artificial fur and artificial leather, which are the materials used for vegan fashion. This study is focused on the change in consumer awareness on the use of animal nature materials (fur and leather) versus alternative vegan materials (artificial fur and leather). For this purpose, past and present social big data was compared.

In conclusion words like 'fake fur', 'fake leather', 'animal cruelty-free' etc., which were linked to the popularization of vegan and animal cruelty free products were ranked the highest in the order of the searches as recorded by Google. This concludes that the awareness about these materials and about the conditions of the working of the leather and fur factories have given rise to a new market i.e. the vegan and cruelty-free market.

3.2 Review 2- Kombucha Leather Durability: Sugar Concentration's Effect on Bacterial Cellulose

Due to the rising popularity of the vegan and cruelty-free materials, new forms of these materials are sought after. Many alternative forms of materials with cellulose and carbon content have given rise to artificially grown leather. One of the many approaches is the use of Kombucha, an age old fermented Chinese drink that is made of tea. Through the same process that this familiar beverage is made, there is also the less familiar production of a polymeric bacterial cellulose pellicle that floats on the surface of the culture. This and other forms of bacterial cellulose are the subject of research for several different applications. Bacterial cellulose has potential for use in medicine, textiles, and as a food additive. The tensile strength of kombucha's leather-like material grown in different sugar concentrations was measured and statistically analyzed. The groups grown in higher sugar concentrations were found to withstand significantly more force before tearing than those grown in low sugar concentrations. Photographs of the pellicles of each group were also taken and compared at 400x magnification

The method used was, thirty bacterial cellulose pellicles were grown under the same conditions but with varied sugar concentrations. Three 3.78L batches of black tea were brewed in reverse osmosis filtered water. Once cooled to 25°C 32oz (0.946L) of store bought Kombucha (GT's Gingered Kombucha) was added as an a bacterial growth starter resulting in a total volume of 4.726L. Each bottle was covered with tissue paper fastened with a plastic ring. Bottles were arranged sequentially so that no neighboring bottles were immediately adjacent to other bottles of the same group. After three weeks of ambient daylight and temperatures kept 18°C-22°C bacterial cellulose pellicles were removed from the surface of each bottle and separated into their groups and allowed to dry on wax paper.

Next, force transducer was used to measure durability of three groups of bacterial cellulose pellicles. Force was applied until the pellicle was torn apart and maximum value was recorded. In the few cases where the range of the force transducer was maxed out and the pellicle still did not tear, those values were not included in the statistical analysis.

The result showed statistically vast deviations in terms of the readings. However two of the samples did not tear and were not considered in the final result. The conclusion to this experiment is that the samples with the highest number sugar groups required the maximum amount to tearing force, two of the samples of the same group maxed out the force and did not tear. Though the result showed a successful attempt at making of the leather from kombucha, various questions regarding addition of additional chemicals and coloring agents are still not clear and need a thorough research.

3.3 Production of Pectin-Cellulose Biofilms: A New Approach for Citrus Waste Recycling

Plastics production has increased enormously in the past 100 years, and a global production of 322 million tons was reported by Statista for 2015. This vast number of plastic products caused severe plastic pollution by now and they are typically made from non-renewable sources. On the contrary, bio plastics are made from renewable sources or they are biodegradable; in the best-case scenario, they are both. Today, biopolymers are produced from cultivated crops; however, the land used for bio plastic is still negligible. An example for a bio based and biodegradable material that is built up of different biopolymers, with no land use, is citrus waste. Citrus waste is a globally abundant and environmentally challenging waste that is underutilized. Among citrus fruits, sweet oranges are the most commonly grown tropical fruits worldwide. USDA forecasted 45.8 million tons of sweet orange production for 2015/16. Industrial orange processing, for example, orange juice production generates about 50–60% residue of the original mass of the orange. This vast quantity of waste is high in organic matter content (approx. 95% of total solids) and water (approx. 80–90%) and has a low pH (3-4) and inappropriate handling could cause severe damage to the environment. Orange waste also contains pectin, soluble sugars, hemicelluloses, cellulose, starch, protein, lignin, ash, fat, and flavonoids, which have been shown to be beneficial to many yet imperfect disposal and recovery applications. These compounds on the other hand could be interesting for bio plastics applications. Orange waste has already been applied as a reinforcement in petrochemical or bio based matrices. In all of these cases, the authors reported increased mechanical properties of the products compared to the neat polymer. The increased mechanical properties are most probably the direct effect of the present cellulosic fibres. However, pectin, the major component of orange peel, seems to have no significant effect in the above-mentioned composites. Nevertheless, pectin-based composites have been prepared with different reinforcing substances and cellulosic plant fibres have certainly been of great interest because of their favorable mechanical properties as a potential substitute for glass fibres in bio composites. Cellulose reinforced pectin composites have been developed, for example, for tissue engineering applications and for food packaging applications from commercial sources. However, there is no study on directly using cellulosic fibres and pectin obtained from citrus waste to prepare a biofilm.

While citrus waste is abundantly generated, the disposal methods used today remain unsatisfactory: they can be deleterious for ruminants, can cause soil salinity, or are not economically feasible; yet citrus waste consists of various valuable polymers. This paper introduces a novel environmentally safe approach that utilizes citrus waste polymers as a bio based and biodegradable film, for example, for food packaging. Orange waste has been investigated for biofilm production, using the gelling ability of pectin and the strength of cellulosic fibres. A casting method was used to form a film from the previously washed, dried, and milled orange waste. Two film-drying methods, a laboratory oven and an incubator shaker, were compared. FE-SEM images confirmed a smoother film morphology when the incubator shaker was used for drying. The tensile strength of the films was 31.67 ± 4.21 and 34.76 ± 2.64 MPa, respectively, for the oven-dried and incubator-dried films, which is within the range of different commodity plastics. Additionally, biodegradability of the films was confirmed under anaerobic conditions. Films showed an opaque appearance with yellowish color.

The biofilms made from orange waste show similar physical properties as do some of the commodity plastics. It was observed that the drying method did not make a difference for mechanical and thermal properties of the films but resulted in a more uniform surface. The films were also biodegradable under anaerobic conditions. The main constituents of the biofilms, pectin and cellulosic fibres, suggest an application where biodegradability is as important as strength, such as a short-lived packaging material. Generally, the properties are promising, although further characterization and improvements are necessary in order to achieve the desired features, less hygroscopic characteristics, for example. Finally, production of biofilms from orange waste not only opens up opportunities for the production of environmentally friendly biomaterials but also could be a solution for the challenges arisen upon disposal of orange waste.

3.4 Review 4- Bacterial Cellulose and Emulsified AESO Bio composites as an Ecological Alternative to Leather

The tannery industry faces several challenges associated with high environmental impact, scarcity of raw materials and increasing consumer demand for environmentally friendly products. The worldwide production of leather is approximately 20 billion square feet per year. To produce 1 ton of leather, 6.7 tons of raw skin, 57,000 litters of water, and 3.35 tons of chemicals are required. Worldwide, for bovine skin, 370 billion liters of water are consumed annually, generating 6.5 million tons of solid waste. This research intends to contribute to the reduction of the animal hide dependency by the development of composites from bacterial cellulose (BC) as structuring material and activated vegetable oils as a flexibilizing, mechanical reinforcing and hydrophobizing agent. BC is a biopolymer produced by bacterial fermentation that consists exclusively of a three-dimensional structure of pure cellulose nanofibers. Chemically, BC is identical to vegetable cellulose but the nano-scale of its fibres offers a significantly higher surface area. Regarding its application in the textile and footwear sectors, the first proof of concept of the use of BC as an alternative to leather emerged in the 1990s, in the Philippines. In the last decade, the designer Suzanne Lee has expanded the possibility of using BC in the manufacture of clothing and footwear, by resorting to the handmade production of BC, which is washed, adjusted to a predefined form, dried and dyed. Since then, other studies have mainly focused on comfort and appearance, overlooking important properties such as breaking strength, elongation at break or hydrophobicity.

This research is an investigative study on the development of bio-based composites comprising of bacterial cellulose (BC), as obtained by static culture, and acrylated epoxidized soybean oil (AESO) as an alternative to leather. AESO was first emulsified; polyethylene glycol (PEG), polydimethylsiloxane (PDMS) and perfluorocarbon-based polymers were also added to the AESO emulsion, with the mixtures being diffused into the BC 3D nanofibrillar matrix by an exhaustion process. Scanning electron microscopy (SEM) and Fourier transform infrared (FTIR) spectroscopy analysis demonstrated that the tested polymers penetrated well and uniformly into the bulk of the BC matrix. The obtained composites were hydrophobic and thermally stable up to 200 ◦C. in regards to their mechanical properties, the addition of different polymers lead to a decrease in the tensile strength and an increase in the elongation at break, overall presenting satisfactory performance as a potential alternative to leather.

This work provided a straightforward method to prepare BC composites with high potential for applications as a replacement for leather. We have successfully prepared composites based on BC, emulsified AESO resin, PEG, and PDMS- and perfluorocarbon-based polymers through a simple strategy to enhance the flexibility and hydrophobicity of the BC. Based on SEM observations and FTIR analysis, all the tested polymers penetrated well and uniformly into the BC matrix. The obtained composites showed hydrophobicity with the highest values of WCAs obtained for the composites with the perfluorocarbon-based product. Regarding the thermal and mechanical properties, it was found that the composites presented lower thermal stability and tensile strength, although they are stable up to 200 ◦C and most of the composites can be applied in uppers for shoes. Further optimization of the process may improve its performance through improved control of the polymerization reaction. Hence, this work opens new perspectives for potential applications of BC in the footwear industry.

3.5 Status of natural dyes and dye-yielding plants in India

Indians have been considered as forerunners in the art of natural dyeing. Natural dyes find use in the coloring of textiles, drugs, cosmetics, etc. Owing to their non-toxic effects, they are also used for coloring various food products. In India, there are more than 450 plants that can yield dyes. In addition to their dye-yielding characteristics, some of these plants also possess medicinal value. Though there is a large plant resource base, little has been exploited so far. Due to lack of availability of precise technical knowledge on the extracting and dyeing technique, it has not commercially succeeded like the synthetic dyes. Although indigenous knowledge system has been practiced over the years in the past, the use of natural dyes has diminished over generations due to lack of documentation. Also there is not much information available on databases of either dye-yielding plants or their products. This article reviews the availability of natural dyes, their extraction, applications, mordant types, advantages and disadvantages.

According to the paper to understand the concepts of natural dyes and dye-yielding plants, there are three basic questions to be addressed: Why only certain plants are able to yield dyes? How does the plant benefit by producing dyes? What is the evolutionary explanation for production of dyes? Answers to the first two questions can be substantiated with two further questions, i.e. 'Why do plants have so many different col ours?' and 'what purpose might they serve for the plant?'.

Green in most leaves is surely the most ubiquitous plant color. The green pigment chlorophyll in leaves helps capture the sun's energy and converts it to chemical energy, which is then stored and used as food for the plant. Colors in flowers are adaptations that attract insects and other animals that in turn pollinate and help the plants reproduce. Some plants have colorful fruits that attract animals to eat them, thus inadvertently spreading the plant's seeds as they do so. Scientists believe that other pigments may help protect plants from diseases. Despite what we know about the role of a few of the thousands of plant pigments, the role of most colors in plants remains a mystery to us till date. Although plants exhibit a wide range of colors, not all of these pigments can be used as dyes. Some do not dissolve in water, some cannot be adsorbed on-to fibres, whereas others fade when washed or exposed to air or sunlight. It remains a mystery, why plants reward us with vibrant dyes. India has a rich biodiversity and it is not only one of the world's twelve mega diverse countries, but also one of the eight major centres of origin and diversification of domesticated taxa. It has approximately 490,000 plant species of which about 17,500 are angiosperms; more than 400 are domesticated crop species and almost an equal number their wild relatives. Thus, India harbors a wealth of useful resources and there is no doubt that the plant kingdom is a treasure-house of diverse natural products. One such product from nature is the dye. Natural dyes are environment-friendly, for example, turmeric, the brightest of naturally occurring yellow dyes is a powerful antiseptic which revitalizes the skin, while indigo gives a cooling sensation. After the accidental synthesis of mauveine by Perkin in Germany in 1856 and its subsequent commercialization, coal-tar dyes began to compete with natural dyes. The advent of synthetic dyes caused rapid decline in the use of natural dyes, which were completely replaced by the former within a century3.

However, research has shown that synthetic dyes are suspected to release harmful chemicals that are allergic, carcinogenic and detrimental to human health. Ironically, in 1996 Germany became the first country to ban certain azo dyes4. In this article, we review the origin of natural dyes, plants and animals yielding dyes, chemical nature of these dyes, their advantages with limitation, technology involved with natural dyes production and present status of these dyes.

Fortunately, nowadays, there is increasing awareness among people towards natural products. Due to their non-toxic properties, low pollution and less side effects, natural dyes are used in day-to-day food products. Although the Indian subcontinent possesses large plant resources, only little has been exploited so far. More detailed studies and scientific investigations are needed to assess the real potential and availability of natural dye-yielding resources and for propagation of species in great demand on commercial scale. Biotechnological and other modern techniques are required to improve the quality and quantity of dye production. Due to lack of availability of precise technical knowledge on the extraction and dyeing technique, it has not commercially succeeded like synthetic dyes. Also, low color value and longer time make the cost of dyeing with natural dyes considerably higher than with synthetic dyes. The paper concludes with the statement that there is an urgent need for proper collection, documentation, assessment and characterization of dye yielding plants and their dyes, as well as research to overcome the limitation of natural dye.

II. RESEARCH METHODOLOGY

The methodology used for this research is that of reviewing. The papers on sustainability were downloaded from various journals. They were read thoroughly and then notes regarding the same were made. Conclusions were drawn based on the interpretation of the papers.

III. RESULTS AND DISCUSSION

The first paper reviewed gave me an insight into the consumer's behavior and response to the direct stimuli of the irreversible and damaging changes caused by the leather and fur industries and also the inhumane treatments given to the animals. The article provides us with the data and its synthesis from Google analytics. It shows the direct relationship between the consumers, their values regarding cruelty-free, vegan products and the way these products pave way to a major market segment.

The second paper reviewed was about Kombucha leather durability and the effect sugar concentration on bacterial cellulose. This article was about the formation of vegan leather using a fermented drink called Kombucha. The samples were developed by making a mixture of tea, to which store made Kombucha, which had already had the bacteria required, as a starter for the formation of the bacterial cellulose with varying the sugar concentration. The aim of this study is to measure the tearing strength of the samples formed. It was found that the samples made with highest concentration of sugar made the toughest material, hence the tearing force is greater.

The third paper reviewed was that of the production of the pectin cellulose biofilms, or bio plastic made out of orange waste. The article states about the problems caused by plastics, in terms of waste and disposability, whereas the waste from common kitchen products can be converted to something close to plastic, with the excellent advantage of it being compostable and degradable as well. The choice of orange for this experiment was due to the fact that orange is a very easily and abundantly produced tropical fruit, whose skin have pectin. Orange waste has been investigated for biofilm production, using the gelling ability of pectin and the strength of cellulosic fibres. A casting method was used to form a film from the previously washed, dried, and milled orange waste. Two film-drying methods, a laboratory oven and an incubator shaker, were compared. FE-SEM images confirmed a smoother film morphology when the incubator shaker was used for drying.

The fourth paper reviewed was that of how bacterial cellulose when treated with AESO or Acrylated Epoxidised soybean oil can be an alternative to leather. The article is about the investigative study conducted by emulsifying AESO and then buffing it to the surface of the bacterial cellulose. The results were that the emulsified AESO penetrated the cellulose completely and the final material had a hydrophobic quality. The fabric also displayed a few mechanical characteristics of leather.

The fifth paper reviewed was that of the availability of the natural dye sources and their indigenous processes of application in India. This article talks about the various source of dyes and classes of dye, which can be used with or without mordant. It also talks about how indigenous knowledge of these dyes can help us to combat the damaging and deteriorating effects of the synthetic dyes.

The conclusion drawn by reviewing these articles is that there is a solution for most of the problems in the world and technology along with futuristic approach towards reality helps us to have solution-driven works. The technology developed in these articles was something that can solve most of the problems related to deteriorating and damaging effects of the leather, fur and synthetic dyeing industries. The harmful chemicals used cause an irrevocable effects on the environment. The articles gave me an insight as to how to overcome these problems with alternative materials. On the other hand, they also gave me insights about the process and the properties of these alternative methods. These alternatives give a long-term solution to the problems of waste management and other problems related to the environment.

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