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BIODEGRADABLE PACKAGING : A KEY TO ENVIRONMENTAL SUSTAINABILITY

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ABSTRACT

Pollution is a global crisis that has been seen in current times from past few decades. Many kindsof pollution crisis are arising day by day, such as soil, air, water, noise and radioactive pollution. Soil, air and water pollution mainly cause by plastic. Plastic takes approximately 20 to 500 years todecompose. Several types of plastics take different time to decompose. Micro plastic is tiny particles of plastic which is broken down in small pieces or they are conventionally made like that.It is found in ocean which affects marine animals and plants and in food packaging which is toxic, harmful and hazardous to human beings. We have seen throughout the years that plastic bags, foodcontainer, fast food packages and plastic wrappers are just roaming around roads, grounds, land fields, lakes, ponds, rivers and oceans as well. We should opt for alternatives of conventional plastic packages, such as packaging made from plant-based materials, which can also decompose easily in the soil, that shows biodegradable properties. Many plants and materials used for plasticalternatives are discussed in this paper. Different materials and methodology required for makingplant-based packaging are listed in the paper as well. Bio-degradable packaging is not only helpful and doing good to the environment, but also for humans as well, as we consume less micro plastics, and live a healthy life.

Keywords: *Environment, Plastic Pollution, Bio-degradable Packaging*

INTRODUCTION

Plastic pollution is a major issue. There is an estimated 75 to 199 million tons of plastic waste currently in our ocean, with a further 33 billion pounds of plastic entering the marine environment every single day (Nicolle portilla dec 5,2022). Improper disposal of plastic wastes causes plastic pollution and it is hazardous for environment, animals and humans also.

To avoid plastic pollution, we should use biodegradable packages. Biodegradable materials naturally break down back into the earth without producing any harmful byproducts. We use bio polymers, which are substances frequently found in living beings including cellulose, proteinsand starch to make biodegradable packaging. Biodegradable packaging is non-toxic, safe and environment friendly.

Carbon footprint will also be reduced, if packaging is made from recycled products. Certain certification is given on biodegradable packaging. The certification guarantees that, under specificcircumstances and in a per-determined amount of time, the package will completely and safely degrade. We can incorporate biodegradable packaging, such as paper and cellulose has a weak molecular structure so it disintegrates quickly.

The creation of biodegradable packaging uses eco-friendly components, which makes it simpler to recycle. The production of these components consumes less energy, reduces carbon emissions, and is non-toxic, contributing to the fight against global warming. Naturally decomposing packaging could be a better option. Plastic packaging contributes significantly to global garbage production, and replacing it with sustainable alternatives can reduce deforestation and plastic pollution in oceans. Biodegradable packaging will help a lot in businesses also as it increases salesand profit is, which reduces carbon footprint and their impact on environment.

Experts from UNEP clarified that large plastic particles can potentially fragment into pieces smaller than 5 mm in length and infiltrate the ground. These tiny plastic particles can change the composition of the earth beneath our feet and capacity. They can also affect plants by reducing nutrient intake and root growth.

Plastic pollution is the accumulation of synthetic plastic items in the environment to the point where they threaten human populations, wildlife, and their environments. A shift in materials wasbrought about in 1907 with the introduction of genuinely synthetic polymer resins into global tradethrough the creation of Bakelite. by the end of the 20th century, it was discovered that plastic continued to poison a variety of environmental niches, from the sea floor to Mount Everest. Plastics are gaining more attention as a major contaminant because of their various effects, including beingmistaken for food by animals, flooding low-lying areas due to clogged drainage systems, and generating significant visual blight.

Plastic is a polymetric material, meaning that it is large molecules frequently resemble long chainsconsisting of an apparently endless web of interconnected links. Although there are many naturallyoccurring polymers, including rubber and silk, these "plastics" from nature have not been linked to environmental pollution since they do not last in the environment. Synthetic plastics tend to remain in natural ecosystems since they are mostly non-degradable. Additionally, a lot of lightweight, single-use plastic goods and packaging but plastic pollution affects sea life throughoutthe ocean, which even extends to seafood that people eat (September 24, 2018 By: Simon Reddy). Pollution affects sea life throughout the ocean: numerous examples of how our ocean and the variety of species that call it home are dying from the poison of plastic include the gray whale thatperished in 2010 after stranding near Sea turtle with over 20 plastic bags, a golf ball, and other litterin it is stomach, and the harbor seal pup that was discovered dead on the Scottish island of Skye, it isintestines tainted by a small piece of plastic wrapper. The United Nations estimates that at least 800 species globally are affected. (Simon Reddy Sep 24, 2018).

https://www.pewtrusts.org/en/research-and-analysis/articles/2018/09/24/plastic-pollution-affects-sea-life-throughout-theocean#:~:text=It%20is%20estimated%20that%20up,suffocation%2C%20starvation%2C%20and%20drowning.

The presence of plastic debris in the ocean can promote the proliferation of diseases. Scientists found in a recent study that corals exposed to plastic have 89% probability of developing a disease,compared to 4 % chance for those that are not, scientists estimate that by 2050, the weight of oceanplastics will surpass the total weight of all fish in the seas, if immediate action is not made to solvethis pressing issue. (September 24, 2018 Simon Reddy).

Environmental contaminants known as micro-plastics are common in polar areas, isolated islands,and oceans. Because micro-plastics can have negative consequences on ecosystems, exposure to them poses a significant emergent hazard. In order to present a current overview of our knowledgeon the origins, compositions, and harmful effects of micro-plastics in humans and the environment, we have examined the literature in this section. The majority of research on micro-plastics has concentrated on creating standardized techniques for tracking the presence, flow and dispersal of micro-plastics in the environment as well as creating alternatives to micro-plastics. Despite the fact that humans are exposed to micro-plastics through a variety of channels, little is known about the harmful effects of micro-plastics on humans.

Because micro-plastics are so tiny, it is nearly hard to remove them from the environment after theyare released. As a result, nations all over the world are enforcing stricter regulations around micro-plastics. For instance, the EU is implementing a number of initiatives to recycle plastics, create biodegradable plastics, identify hazardous materials in plastics, and

stop the production of marine garbage. (Y Lee, J Cho, J Sohn, C Kim *et al.*, 2023).
Numerous creatures, ranging from tiny finches to blue whales, meet horrifying ends as a result ofconsuming plastic or becoming entangled in it.
Every year, between 12,000 and 24,000 tons of plastic are consumed by fish in the North Pacific,which can lead to intestinal damage and even death. Plastic also moves up the food chain to largerfish, marine mammals, and people who eat seafood. According to a recent study, 25% of fish at Californian markets had plastic in their stomachs, primarily in the form of microfibers.
Plastic trash that floats in the ocean may confuse sea turtles for food. They may suffocate, suffer an internal injury, and pass away, or they may starve to death after consuming too much plastic. Sadly, studies show that half of sea turtles globally have consumed garbage. Reproduction is beinghampered by the widespread plastic pollution on many beaches, according to recent studies.
Each year, thousands of sea-birds swallow plastic. Consuming plastic lowers the stomach's capacity for storage, which results in famine. 60 % of sea-bird species are thought to have consumed plastic fragments, and by 2050, that percentage is expected to rise to 99 %. The fact thatplastic is frequently discovered in the stomachs of dead sea-birds is indicative of the exponential rise in marine debris over the previous four decades.
January 9, 2018 - Amsterdam Dr. Ulrich Wernery does a necropsy on camels once a week. This issomething the director of Dubai's Central Veterinary Research Laboratory has been doing for a long time. He discovers plastic in the stomach of nearly all camels. Not a tiny bit of plastic, but anenormous quantity of plastic. The plastic that camels eat builds up in their intestines, generating greater and larger clumps, because they are unable to digest it. According to estimates, the ingestion of plastic kills one out of every two camels in the United Arab Emirates. The image displays the biggest mass of plastic that Dr. Wernery has discovered, consisting of several hundredplastic bags, rope, and nylon twine that weigh 52 kg. Dr. Wernery is positive that a slender camelhas plastic in it is stomach. The camel feels full from the plastic in it is stomach and begins to eat lessand less. Furthermore, the digestive tract is obstructed by the plastic. Of course, eating plastic doesnot just kill camels; cows, goats, gazelles, and lambs all perish from it.

Camels continue to die of plastic in the desert - Plastic Soup Foundation
Plastic trash is a significant and often disregarded burden to the agriculture sector, with far reachingimplications for food production and safety. Plastic garbage has been a major concern in recent years because of it is inherent incapacity to biodegrade, which has led to numerous environmental issues.
The accumulation of plastic garbage in agricultural regions can have a negative impact on ecosystem function, soil health, and biodiversity. Every year, more than 350 million metric tons ofplastic waste are created. In the absence of policy reforms, the amount of plastic garbage generatedworldwide is expected to quadruple by 2060. In agricultural areas, plastic garbage can contaminatethe soil, making it difficult for plants to properly absorb nutrients and slowing down their growth.Furthermore, the accumulation of plastic garbage might potentially clog irrigation systems.
Every year, more than 350 million metric tons of plastic waste are created. In the absence of policyreforms, the amount of plastic garbage generated worldwide is expected to quadruple by 2060. 3.4million tons of plastic waste in a year, only 30% of it is recycled. (The economic times)

REVIEW OF LITERATURE

In view of increasing plastic pollution, importance should be given to biodegradable packaging, inthis paper we will discuss new ideas and research of biodegradable packaging.

1) Biodegradable Polymers in Food Packaging

This research paper talks about biodegradable polymers such as Starch (hydrocolloid) and produced by agricultural plants, PLA (polylactic acid) is chemical compound derived from D- or L-lactic acid, poly (hydroxyalkanotes) (PHAs) numerous bacteria store PHAs, the most prevalent of which is poly (hydroxybutyrate) (PHB), as carbon and energy stores. PCL polycaprolactone is a cheap cyclic monomer. PCL is frequently utilized in polyurethane formulations as a soft block or compatibilizer because of it is low Tg (glass transition temperature). PCL is readily biodegraded by fungi and enzymes (Chandra and Rustgi 1998, Tokiwa 1977). Cellulose and derivatives are the most prevalent naturally occurring polymer in the world, cellulose is a nearly linear polymer of anhydroglucose. Material properties have also been discussed in this paper such as (1) Gas Barrier Properties (2) GasBarrier and Humidity (3) Water Vapor Transmittance (4) Thermal and Mechanical Properties (5) Compost ability. (P. A. Pawar, Aachal. H. Purwar, 2013)

2) Biodegradable packaging materials from animal processing co-products and wastes

Meat products, account for 40% of global protein consumption. However, waste from meat processing can cause disposal and expense issues. Waste suggested to convert into value added product. Animal waste can be used as a low- cost high quality raw material for producing essentialitems like fish meal, chitin, peptides, bio polymer. Proteins from meat processing wastes and co- products can be used in value added good s through pre-treatment, extraction and downstream processing. We can also generate films from animal wastes, such as collagen films, gelatin films,keratin films. (Diako Khodaei *et al.*, 2021)

3) Active biodegradable packaging for fresh pasta

Environmental problems arise from the usage of petroleum derived, non-biodegradable polymers in food packaging. Their influence on the environment can be lessened by substituting with bio-polymers that are renewable, recyclable. The aim of this research was to create an antimicrobial agent infused, TPS/PBAT blend based active biodegradable packaging for fresh pasta sheets. The primary aim of the microbiological analyses of the pasta and the mechanical and barrier characterization of the films conducted both before and after refrigerated storage was to monitor the effectiveness of the generated material (Talita Pires de Camargo Andrade-Molina *et al.*, 2013).

4) Biodegradable food container from rice straw and sugarcane bagasse with orange peel addition

Plastic garbage, made of polyethylene, polypropylene, polystyrene, PVC, PET, ABS, and other polymers, is difficult to break down and badly damages the environment. Styrofoam, a leak proof, lightweight, and affordable product created from polystyrene, is used for food containers but is noteasily destroyed, leading to the development of biodegradable plastic alternatives using biomass-derived ingredients. This study suggests adding fiber to starch-based food containers, such as bagasse and rice straw, to improve their properties. Active ingredients like antioxidants and antimicrobial, such as Orange peel powder, can also enhance shelf life and preserve food productquality. (E M S E Tibalia *et al.*, 2023).

5) Combination of poly (lactic) acid and starch for biodegradable food packaging

Research is focusing on developing bio - packaging materials from renewable sources that are biodegradable. Starch and poly (lactic acid) are semi crystalline polymers, replacement for non- degradable petrochemical polymers. Their Combinations using blending or multi-layer strategies,their barrier and mechanical properties can examine. Also comparing their properties with pure polymer films. Research also suggest that PLA or starch can also create packaging which is antibacterial or antioxidant by acting as carriers of active ingredients. (Justine Muller *et al.*, 2017).

6) Production of biodegradable plastic film from cassava starch

This study was done in Nigeria. Nigeria is the largest producer of cassava. Use of cassava starch film is promising, they give good appearance, shining without stickiness (Cereda *et al.*,). This studyconcludes that producing a biodegradable plastic film from cassava starch and then determined thestrength, compare them with plastic or paper. (S.L. Ezeoha and J.N. Ezenwanne 2013).

7) Development of an active biodegradable film containing tocopherol and avocado peel extract

Tocopherol, a liposoluble antioxidant, is widely used in food as a primary antioxidant. Recent studies on films made from biodegradable polymers with tocopherol have yielded positive resultsconcerning antioxidant migration when used in food (Byun et al., 2010; Graciano- Verdugo et al.,2010; Lopez *et al.*, 2011; Hwang *et al.*, 2013; Martins *et al.*, 2012). Avocado fruit is rich in phenolderivatives, even residue also contain large amount of phenol (Wang *et al.*, 2010). Study also contains thickness and density test, water vapor permeability test of biodegradable films (J.C.E Fidelis *et al.,*2015).

8) A comprehensive characterization of biodegradable edible films based on Potato peel starchplasticized with glycerol

The production of potato is approximately 70 to 140 thousand tons every year. Potato is a very good source of starch. Potato peels are used in different ways, such as biogas, biofertilizer, animal feed. Potato peels having underlying the water barrier properties, because of this, we can make biodegradable packaging from it is starch. Study says we can make edible films by mixing plasticizer (glycerol). (Albert Linton Charles *et al.*, 2022)

9) Development of biodegradable starch – based foams incorporated with grape stalks for foodpackaging

The wine industry in Brazil is greatly beneficial to it is economy. Estimates suggest that the nationwastes 37.5 million kg of grape stalks annually from it is yearly grape production (Spigno *et al.*, 2008). It is a comparative study of the structures of foam prepared with grapes stalk and without grapes stalk. Study includes many tests such as applicability test, biodegradability, crystallinity. (Juliana B. Engel *et al.*, 2019).

10) Multi-layer and composite films and coatings for active biodegradable packaging

Layered packaging consisting of barrier, active and control layers compared to mono layer materials. Multi-layer structures prepared by co extrusion method. Composite films structures consist of active and matrix molecules. This study covered many methods for preparation of biodegradable films. (Qiankun Wang *et al.*, 2022).

11) Environmental impact of biodegradable food packaging when considering food waste

30% plastics are those packaging material which may never be recycled or reuse without fundamental redesign of the materials used (Ellen MacArthur Foundation, 2017). Paper explores the design characteristic of a multilayered PHA (polyhydroxyalknoate) TPS (thermoplastic starch) food packaging material. Study covered full life cycle of the biodegradable packaging. They also compared of packaging material (Leela S. Dilkes-Hoffman *et al.*, 2018).

12) Biodegradable packaging in the food industry

Packaging is essential for safety of products, such as mechanical injury or chemical or microbiological impacts. Aim of this paper is raising awareness about bio plastic and biodegradablepackaging. In this research paper they include development of bio plastic, bio polymers, isolation of biomass, properties of biodegradable materials, also they discussed about biodegradable products (bags, trays for vegetables and fruit, boxes with lids) (Anita Ivankovic *et a*l., 2017).

13) Chitosan-based biodegradable functional films for food packaging application

Chitin is abundant biopolymer after the cellulose and it is derived from the structural material of crustacean shell waste. Chitin is a great option for biodegradable packaging of food. Firstly extraction (chemical or biological method) of chitin and then convert chitin into chitosan. This study also discusses about properties of chitosan. Chitosan also shows antimicrobial activity againstbacteria, fungi and yeast. Chitosan film fabrication method and coating also discussed by researchers (Ruchir Priyadarshi, Jong-Whan Rhim, 2020).

14) Bio-based materials for food packaging

Biodegradable food packaging is the sustainable or green packaging. Article concludes various bio-based materials and their composites as well bio-based polymers such as cellulose, hemicellulose, chitosan, starch, pectin. They also include bio-based fiber in this paper (Jiaxiu Wang*et al.,* 2022).

15) Biodegradable hydrogel film for food packaging

Hydrogels are highly hydrated and used in water purification, agriculture, due to their resistance to corrosion and strength, glass and metals are very frequently utilized for packaging. The researcher also concludes various types of test such as breathability test (Niladri Roy *et al.*, 2011).

16) Antibacterial biodegradable films based on alginate with silver nanoparticles and lemongrassessential oil- innovative packaging for cheese

Sodium alginate is from the polysaccharides class, also water soluble and enhance their mechanical properties adding plasticizers although silver Nano-particles antimicrobial agents which influence the antibacterial activity, main aim of the research is making a biodegradable packaging which is having antibacterial properties for soft cheese. (Ludmila Motelica *et al.*, 2021).

17) Edible / biodegradable packaging with the addition of spent coffee grounds oil

This research shows biodegradable packaging with the addition of spent coffee grounds oil (SCG), which is waste after consuming coffee. The aim of this study is how the addition of this by-product affects physical, chemical, textural properties of experimentally produced packaging, also concludes that total contain of polyphenol, peroxide value and solubility and swelling degree (Dani Dordevic *et al.*, 2023).

18) Active biodegradable packaging films modified with grape seeds lignin

Polyhydroxyalkanoates bio-degradable polymer, polyhydroxybutyrate is widely used within PHAs. Aim of this study to find out thermal properties, gas permeability, mechanical properties, also thegrapes seeds lignin on various properties of PHB and PHA, grapes seeds lignin have antioxidant effect, antioxidant effect on PHA and PHB film as well as their decompose under favorable condition (Pavel Vostrejs *et al.*, 2020)

19) High strength holocellulose paper from bamboo as biodegradable packaging tape

E-commerce development has led to various types of packaging such as plastic tap, which causes environmental issues, to get rid of this problem we can use high strength paper tap, non-wood paper having poor strength. So, in this research paper has been described as a paper with high strength. Bamboo has been taken as plant material, chemical agent using in this process are Sodium Chlorite-Acetic Acid (SC/AA) Or Peracetic Acid (PAA) in nature they are mild (Park *et al.*, 2017; Zhao *et al.*, 2011). With the help of PAA method we can make paper with higher strength. (Carvalho *et al.*, 2019; Yang and Berglund, 2020).

20) Biodegradable polymers for the production of nets for agricultural products packaging

Nets are widely used in vegetables and fruit is packaging. In this research paper, it is discussed about biodegradable polymer (poly lactic acid). PLA is thermoplastic. In this research, the focus has beengiven on increasing the strength melting point of PLA (Francesco Paolo La Mntia *et al.*, 2021).

MATERIAL AND METHODOLOGY

1. Production of biodegradable plastic film from cassava starch

Cassava starch preparation: Peeling and washing cassava tubers, cassava mix with water, mixturesieved and filtered using a coarse sieve and filter cloth, filtrate settled for 6 hours, again mix withwater and again settled for 12 hours process called starch. Washing, oven dried at 105°C temperature for 4 hours.

Film preparation: Tested for moisture contain using infra-red moisture meter, 12% moisture obtain, 1kg powder of cassava starch 2kg polyvinyl alcohol liquid, 100g talc powder and 100g urea was prepared. Mixture extrude with a blown film extrude (speed 60 rpm) to produce a biodegradable film, film produce in 1 temperature of 190°C, zone 2 temperature of 220°C melt temperature of 200°C, film diameter 300mm.

2. Biodegradable hydrogel packaging

Material: Polyvinylpyrrolidone, Polyethylene Glycol, Agar, Sodium Carboxymethyl Cellulose.

Method: Hydrogel prepared by solution casting method in which consisted of PVP 0.2, CMC 0.8, PEG1.0, agar 2.0, glycerine 1.0 and water 95.0 in W/V %.

Polymer solution was prepared in sealed glass bottles under physical stimulation pressure and heat 15ibs pressure and temperature 120°C for 20 minutes, solution poured in petri dish after cool at room temperature, thin film obtained (Niladri Roy *et al.*,2011).

3. Edible films based on potato peel starch plasticized with glycerol

Material: Carboxymethyl cellulose (CMC), potato peels, glycerol, corn and wheat starch.

Method: Biodegradable films making with the process of response surface method (RSM). Resins prepared in 100 ml beakers using RSM, optimized ratios of potato peel starch (PPS), suggested concentration of 4% w/v as sample C. Glycerol was used as a plasticizer, CMC mixed with plasticizer. Resins were heated, cooled ad dried in oven (50°C, FOR 4 Hour), sample stored in desiccator with silica gel for 48 hours before analysis (Albert Linton Charles et al., 2022).

4. Biodegradable food container from rice straw and sugarcane bagasse with orange peel additionMaterial: Rice straw, sugarcane bagasse, glycerol, orange peel, starch.

Method: Rice straw and sugarcane bagasse grinding, heated in pressure cooker at 100-130°C for 30 minutes. After boiling, biomass and orange peels washed, dried in oven, then powder was sieved and stored in sealed container. Making a dough, rice straw and bagasse powder was mixed with starch as a binder, glycerol as plasticizers and orange peel powder as an additive, using mixer for 10 minutes with stirring speed of 200 rpm, dough prepared after the process is thermos pressing method. 100g dough placed in aluminum mold pressed at 100°C for 3 minutes, the produced container is stored for one day before the testing. (E M S E Tibalia *et al.*, 2023).

CONCLUSION

Biodegradable packaging is sustainable and safe for environment. Bio-packaging is made up from waste animal sources. Alternative use of waste such as coffee oil, rice straw, plant waste, peels by using them as a biodegradable film. Renewable resources including maize oil, sugar beet, sugar cane, grass, and plants are used to make bio plastics. Since traditional plastics have been shown to harm the environment via intensive research and media coverage, bio plastics, which are made from renewable resources and biodegradable components, have the potential to significantly reduce pollution. Bio plastics will soon be used in the production of a wide range of common place goods, such as food service items and packaging, as well as consumer electronics and vehicle parts. Non-degradable plastic causing climate effect because greenhouse gases (GHG) are released throughout the plastic life cycle, plastics pose a threat to the global community's ability to limit the rise in global temperature below 1.5°C. Indeed, the extraction, processing, and production of plastics are all high carbon industries. According to the Minderoo Monaco Commission on Plastics and Human Health (2023) the yearly cost of the plastics industries 1.96 Gt of CO_2 and other greenhouse gas emissions in 2015 was $ 341 billion. When plastic garbage is burned for disposal, harmful chemicals and a substantial amount of greenhouse gas emissions are released into the environment. There are additional green-house gases emissions associated with recycling and other disposal techniques. If they burned they will produce methane gas, carbon dioxide, carbon monoxide gases, gases potent greenhouse effect. They pollute soil and water too. Biodegradable material using as packaging, cutlery using biodegradable packaging will also reduce land pollution, increase the fertility of land, reduce the air pollution and water pollution. Disposing of a plastic bag and a banana peel differs significantly. Even though they are both used to package food, a banana peel decomposes naturally and biodegrades, whereas a plastic bag might stay in a landfill for decades or even centuries, releasing dangerous chemicals or perhaps contaminating the ocean.

Food trash is the purest kind of organic waste and is easily composted. However, a large portion of food product packaging is not. The fact that packaging accounts for 63 % of the solid trash generated in the United States is startling. And this number keeps going up. The food business may use this enormous stream of waste and divert it to compost by switching to bio-degradable plastic packaging, creating nutrient-rich soil. Peels are wasted and there is no use of it so it is better to use them in making bio-plastic. Most of food packaging consist non-biodegradable plastic which affect the environment. Some plastics are non-recyclable. Plastic pollutes ocean and harm sea- creatures.

For our mother nature, use of plastic should be reduced. In this paper, importance has been given to biodegradable packaging and such a process has been included by which bio-plastic can be made.

REFERENCE

1) Charles, A. L., Motsa, N., & Abdillah, A. A. (2022). A comprehensive characterization of biodegradable edible films based on potato peel starch plasticized with glycerol. Polymers, 14(17), 3462.

2) de Camargo Andrade-Molina, T. P., Shirai, M. A., Grossmann, M. V. E., & Yamashita, F. (2013). Active biodegradable packaging for fresh pasta. LWT-Food Science and Technology, 54(1), 25-29.

3) Dilkes-Hoffman, L. S., Lane, J. L., Grant, T., Pratt, S., Lant, P. A., & Laycock, B. (2018). Environmental impact of biodegradable food packaging when considering food waste. Journal of Cleaner Production, 180, 325-334.

4) Dordevic, D., Dordevic, S., Abdullah, F. A. A., Mader, T., Medimorec, N., Tremlova, B., & Kushkevych, I. (2023). Edible/Biodegradable Packaging with the Addition of Spent Coffee Grounds Oil. Foods, 12(13), 2626.
5) Engel, J. B., Ambrosi, A., & Tessaro, I. C. (2019). Development of biodegradable starch-based foams incorporated with grape stalks for food packaging. Carbohydrate Polymers, 225, 115234.
6) Ezeoha, S. L., & Ezenwanne, J. N. (2013). Production of biodegradable plastic packaging film from cassava starch. IOSR Journal of Engineering, 3(10), 14-20.
7) Fidelis, J. C. F., Monteiro, A. R. G., Scapim, M. R. S., Monteiro, C. C. F., Morais, D. R., Claus, T., ... & Yamashita, F. (2015). Development of an active biodegradable film containing tocopherol and avocado peel extract. Italian Journal of Food Science, 27(4), 468-475.
8) Ivonkovic, A., Zeljko, K., Talic, S., & Lasic, M. (2017). Biodegradable packaging in the food industry. J. Food Saf. Food Qual, 68(2), 26-38.
9) Khodaei, D., Álvarez, C., & Mullen, A. M. (2021). Biodegradable packaging materials from animal processing co-products and wastes: An overview. Polymers, 13(15), 2561.
10) La Mantia, F. P., Ceraulo, M., Testa, P., & Morreale, M. (2021). Biodegradable polymers for the production of nets for agricultural product packaging. Materials, 14(2), 323.
11) Lee, Y., Cho, J., Sohn, J., & Kim, C. (2023). Health Effects of Microplastic Exposures: Current Issues and Perspectives in South Korea. *Yonsei Medical Journal*, *64*(5), 301.
12) Motelica, L., Ficai, D., Oprea, O. C., Ficai, A., Ene, V. L., Vasile, B. S., ... & Holban, A. M. (2021). Antibacterial biodegradable films based on alginate with silver nanoparticles and lemongrass essential oil–innovative packaging for cheese. Nanomaterials, 11(9), 2377.
13) Muller, J., González-Martínez, C., & Chiralt, A. (2017). Combination of poly (lactic) acid and starch for biodegradable food packaging. Materials, 10(8), 952.
14) Pawar, P. A., & Purwar, A. H. (2013). Biodegradable polymers in food packaging. *American Journal of Engineering Research*, *2*(5), 151-164.
15) Roy, N., Saha, N., & Saha, P. (2011). Biodegradable hydrogel film for food packaging. Recent Researches in Geography, Geology, Energy, Environment and Biomedicine, 353.
16) Tao, S., Zhang, C., Chen, Y., Qin, S., & Qi, H. (2022). High strength holocellulose paper from bamboo as biodegradable packaging tape. Carbohydrate Polymers, 283, 119151.
17) Tibalia, E. M. S. E., Wintoko, J., & Purnomo, C. W. (2023, November). Biodegradable Food Container from Rice Straw and Sugarcane Bagasse with Orange Peel Addition. In IOP Conference Series: Earth and Environmental Science (Vol. 1275, No. 1, p. 012012). IOP Publishing
18) Vostrejs, P., Adamcová, D., Vaverková, M. D., Enev, V., Kalina, M., Machovsky, M., ... & Kovalcik, A. (2020). Active biodegradable packaging films modified with grape seeds lignin. RSC advances, 10(49), 29202-29213.
19) Wang, J., Euring, M., Ostendorf, K., & Zhang, K. (2022). Biobased materials for food packaging. Journal of Bioresources and Bioproducts, 7(1), 1-13.
20) Wang, Q., Chen, W., Zhu, W., McClements, D. J., Liu, X., & Liu, F. (2022). A review of multilayer and composite films and coatings for active biodegradable packaging. npj Science of Food, 6(1), 18.

Websites :

1) https://shippingchimp.com/blog/10-ecommerce-brands-that-are-crushing-sustainablepackaging-in-2022/
2) https://www.biologicaldiversity.org/campaigns/ocean_plastics/
3) https://www.pewtrusts.org/en/research-and-analysis/articles/2018/09/24/plastic-pollutionaffects-sea-life-throughout-theocean#:~:text=It%20is%20estimated%20that%20up,suffocation%2C%20starvation%2C%20 and%20drowning.
4) https://www.renature.co/articles/plastic-pollution-andagriculture/#:~:text=Plastic%20waste%20can%20pollute%20the,crop%20losses%20and%20 water%20stagnation.
5) india: India recycles only 30 per cent of 3.4 MT plastic waste generated annually: Report - The Economic Times (indiatimes.com)
6) https://keyplastics.ie/6-common-applications-bioplastics/

7) https://www.genevaenvironmentnetwork.org/resources/updates/plastics-and-climate/
8) https://tipa-corp.com/biodegradable-packaging/