PREPARATION AND EVALUATION OF BIODEGRADABLE BIOPLASTIC FROM FISH SCALES AS A SUSTAINABLE ALTERNATIVE TO CONVENTIONAL PLASTICS

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ABSTRACT :

Plastic is a product that is highly used in modern life for its convenient and durability in holding things. On the other hand, plastic poses a threat to the environment due to its non- renewable nature and difficult to decompose. Because of this, bioplastics are surfaced as a solution and is more beneficial to the environment. Bioplastic is easy to dissolve, decompose in water and soil within weeks. Fish waste like scales and shells are being disposed as a waste all over the world. Bioplastics made from fish scales is a biodegradable material by utilizing chitin. Bioplastic are a form plastic derived from renewable resources such as corn starch, gelatin, glycerol, vinegar and fish scale. In fish scales, chitin and chitosan is present which has a high potential to be made into plastic. It has faster decomposition, smaller carbon footprint and reduce the fossil fuel resources. This research is about recycling fish waste into useful bioplastic which is environmentally friendly, economical, healthy and also reduces the usage of petroleum derived product by using bioplastic instead of plastic.

Key words :- Bioplastic, Biodegradable, Fish scale, Chitin, Plasticizers

INTRODUCTION :-

Plastic play a vital role in modern life, being used in extensively in packaging and residential environments and among other industries. It has been estimated that more than 50% of fish tissue including fins, heads, skin and viscera are discarded as wastes. Every year about 20 million tons of fish waste are discarded around the world. In the year 2000, more than 60% of total world underwent some form of fish processing. Many researchers around the world carried out research on turning food and fish waste into useful by- products for daily use. Because of this, Bioplastics have emerged as a solution and are thought to be more beneficial for packing than plastic.

Bioplastics made from fish scales are highly durable and can convert waste into useful product. Fish scales contain chitin and chitosan which is very useful for preparation of bioplastic. It has faster decomposition, smaller carbon footprint and it reduces the use of fossil fuel resources. Bioplastics can be prepared from different natural resources like starch, cellulose, chitosan, gelatin, collagen, proteins and agricultural or fishery wastes.

Plastics contributes to approximately 10% of discarded waste. Depending on their chemical composition, plastics and resins have varying properties related to containment absorption. plastic is useful for daily necessities, but is very harmful to the environment and it takes 500 years to decompose. For this, researched prepared bioplastics made from waste into useful bioplastic which is biodegradable in water and soil within weeks completely. The increasing production and dispose of plastic have become a very major environmental problem, encouraging researchers to develop sustainable and alternative biodegradable bioplastics **(Geyer et al, 2017).**

Bioplastics will be a new plastics generation made from raw materials such as corn starch, gelatin, glycerol, vinegar and fish scale powder which will strengthen the bioplastic and gives more stability to the product. In fish scale bioplastic, fish scale provides natural collagen and structure protein to strengthen the bioplastic base, corn starch acts as the primary polymer network that forms solid plastic structure when heated, gelatin works alongside starch as an extra binder and gelling agent to improve hardness and unity, glycerin acts as a plasticizers preventing the dried plastic from cracking by making it soft and flexible, vinegar (acetic acid) breaks down the starch molecules so they mix smoothly and bond tightly into a uniform material.

Biodegradable plastics can contribute to a sustainable society through the use of renewable resources and contribute to the reduction in CO2 emissions. The biodegradable plastics offer new end - of – life management options, such as anaerobic digestion or composting, that have lower or no negative impacts on the environment **(Ramadhani and Firdhausi, 2021).** Bioplastics is an easy process and can be dissolved in water and degrade in soil completely within 3 to 4 weeks.

Synthetic plastics tend to remain in natural ecosystems since they are mostly non- biodegradable. As a result, plastic waste has accumulated in rivers, lands and oceans, creating serious environmental pollution. Every year, millions tons of plastic waste enter aquatic ecosystem and harms the marine fishes and animals and other wildlife. The accumulation of synthetic plastic products in the environment to the extent where they jeopardize animals, human populations, and their habitats is known as plastic pollution **(Moore, 2024).**

Bioplastic made from fish scale powder is very durable and can lift weight more than starch based bioplastic. This study explores the possibility of employing fish scales to produce bioplastic. A strong understanding of the system being studied is necessary for a good experimental design **(Bevans, 2019).**

Bioplastics are considered one of the most promising alternatives to conventional because they are prepared from biodegradable and renewable biological resources and can be degraded with in weeks. The use of waste materials for bioplastic production also supports the concept of a circular economy by converting waste into valuable products instead of disposing of it **(European Bioplastics, 2023).**

Converting fish scales into biodegradable bioplastics is an environmentally friendly approach that helps reduce waste while producing useful materials (**Arvanitoyannis & Kassaveti, 2008).** Fish scales are considered waste but they contain collagen which is helpful in preparing bioplastics. By converting fish scales into powder using chemical treatment which extracts chitin from fish scales. Since fish scales are readily available as a waste product, they provide a low – cost and renewable source of biomaterials for sustainable applications **(Nagai & Suzuki, 2000).**

MATERIALS :-

The materials used for the preparation biodegradable bioplastic from fish scales are fish scale powder, gelatin, glycerol, vinegar, corn starch and (NaOH) Sodium hydroxide and distilled water. Fish scale powder acts as a primary raw material and it contains chitin which helps in preparation of bioplastic. Corn starch acts a secondary biodegradable polymer to enhance the strength and stability. Gelatin improves the film- forming ability and mechanical properties. Glycerol is a plasticizers to improve the flexibility and reduce brittleness. Vinegar (acetic acid) was used to adjust the pH of the bioplastic and stabilize the mixture. The laboratory equipment and glassware used in this research included conical flask, beaker, hot plate, filter paper, funnel, aluminum foil, measuring cylinder, grinder, stainless steel. These equipment and materials ensures the proper processing, mixing, heating, casting and drying the mixture gives the perfect bioplastic.

METHODOLOGY:-

Collection of samples:-

The fish scales were collected from local market in siddipet district, which were transported to the laboratory. Scales from commonly available species were selected because they are rich in collagen and chitin which is suitable for bioplastic preparation.

Preparation of fish scales :-

The collected fish scales were washed and cleaned thoroughly with water to remove dirt, mucous and other impurities and then rinsed with distilled water. Then dry the fish scales under the sun for 2 to 3 days to remove moisture.

Chemical Treatment :-

Take the dried fish scales and soak them in (NaOH) sodium chloride solution. This process was intended to remove the proteins and other substances that attached to the fish scales. Then wash the soaked fish scales with water until NaOH solution was removed.

Heating process :

Then heat the NaOH removed fish scales on hot plate at 80 degrees. Then grind the heated fish scales into powder and incubate it for 2 days in a steel container and close it with muslin cloth secured with rubber band for sufficient air.

Preparation of film forming bioplastic :-

Fish scale powder contains chitin and is the best raw material for bioplastic process. Take a clean steel container add water and plasticizers such as glycerol, gelatin, corn starch and vinegar with fish scale powder and heated at 90 degrees and stirred it for thirty minutes using a stirrer on hot plate. Then cast the mixture onto the aluminum foil and allow it to dry in room temperature for two days or in a hot air oven until all the moisture had evaporated. Then peel of the bioplastic film and store it in a clean and dry place for further physical and biodegradability tests.

Flow chart:-

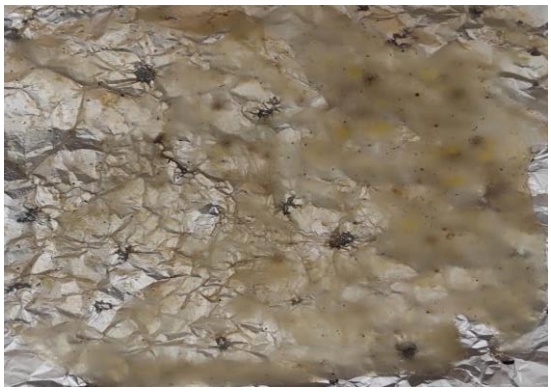
Result :-

The fish scale contain collagen and chitin which is suitable for bioplastic preparation. The fish scales powder was successfully converted into a biodegradable bioplastic film using plasticizers such as gelatin, glycerol, vinegar and corn starch by the casting method. Throughout the process noticeable changes occurred from initial mixing to the formation of the final bioplastic film. Initially, the mixture reaction is cloudy white suspension after adding fish scale powder, corn starch, gelatin, vinegar, glycerol and water. The ingredients were uniformly dispersed by continuous stirring to avoid lumps in the mixture. Then the mixture initially transformed into smooth, thick and glossy gel indicates proper bioplastic film.

The appearance of the mixture changed from opaque suspension to a slightly translucent, viscous solution. Then the hot mixture was immediately poured onto the aluminum foil and spread uniformly to a thin bioplastic film. No major cracks or brittles or separation of ingredients were observed during casting. The mixture was air dried for two days to obtain a thin bioplastic film. The bioplastic film exhibited a smooth and glossy appearance with pale cream color. After drying, the bioplastic film formed a sheet that can be removed carefully removed from the aluminum foil.

The fish scales powder add strength to the mixture, corn starch is a secondary source and adds structure to the bioplastic, gelatin gives viscosity and film forming agent, glycerol improves the flexibility and vinegar helps improve the mixing of the ingredients.

Overall, the preparation process demonstrated that the fish scale powder can be effectively utilized as a raw material for biodegradable bioplastic. The developed bioplastic film possessed acceptance physical appearance, color, thickness and sufficient flexibility. No major cracks and brittles were observed while peeling of from the aluminum foil.



Water absorption treatment:-

The water absorption test is carried out to determine the amount of water absorbed by the prepared fish scale bioplastic after immersion in water.

The dried biodegradable bioplastic film is taken in 2×2cm for water absorption test. Then take heat and cool water in a beaker and slowly immerse the bioplastic in the water. Left it in a cool temperature for days and observe it daily and record its water absorption

Fig :- immersing bioplastic film in water

Day 1 :- The bioplastic starts absorbing water slowly and slight swelling observed. The film remained flexible and intact.

Day 3 :- water absorption rate increases and moderate swelling observed, edges soften.

Day 4 :- The bioplastic sample became more translucent and erosion were noticed.

Day 7 :- The sample started to dissolve and indicating good biodegradability and water absorption properties.

The water absorption test showed that the fish scale bioplastic gradually absorbed the water and swelling. The film started to loosen and the edges of the film started to soften. After four days the film became more flexible and translucent with minor erosion on surface of the film. The film started to loose its mechanical strength and fragile on fifth day. The separation of film into small pieces on the edges were observed. After that the bioplastic continued to absorb the water and slowly started to dissolve in water. This shows that the fish scale bioplastic has good water absorption ability and dissolves completely in water within weeks without harming environment, marine animals and eco – friendly.

Discussion :-

Bioplastics are polymers that can be produced biologically, biodegradable or from renewable resources referred to as bio – based materials according to review article of **Rosenbloom et al**., (**2022).** Bioplastics from fish scale powder has great biodegradation ability. It dissolves in water completely in weeks and doesn't harm the marine animals because the materials are bio – based and eco friendly. Fish are the best raw material for the preparation of bioplastic which gives strength and durability more than starch based bioplastic.

In the study of **Mojibayo & samson (2020)** the researchers used a beaker which is filled with starch and vinegar was added and also additional glycerol was added to the bioplastic. The plasticizers which were added to the bioplastic is biodegradable in water and doesn't affect the environment, water and marine animals.

The biodegradable bioplastic prepared from fish scales demonstrated that fish waste can be effectively converted into useful and eco friendly material. This research demonstrates the idea **waste – to – wealth** by converting discarded fish scales into biodegradable bioplastic. It reduces environmental pollution, eco friendly while promoting sustainable resource utilization. The addition of plasticizers improves flexibility and strength to the fish scale bioplastic.

Marine and fresh water fish scales can be successfully converted into biodegradable bioplastic films with good properties by **surya et al (2023).** Fish scale contain chitin and collagen which can be converted into gelatin and is an excellent material for fish scale bioplastic. It gives strength and flexibility to the bioplastic mixtures and helps in holding more weight and fast dissolving properties. Fresh water fish contain at least 6% to 7% of chitin in fish scales. So, converting bioplastic may gives the flexibility. Marine fish contains 10% to 50% of gelatin which can be more useful in bioplastic preparation.

Thammahiwas, Riyajan, and kaewtatip (2017) these researchers found that adding fish scale powder into wheat gluten - based bioplastics may add more strength and helps in controlling the degradation rate of the bioplastic. Adding corn starch in the place of wheat also gives the strength to the bioplastic.

The chemical treatment with Noah solution is to remove the proteins and other properties which gives the perfect gelatin in fish scales and helps in the preparation of biodegradable bioplastic. **Hou et al (2022)** demonstrated that collagen extracted from fish scale can be converted into environmentally friendly polymeric materials. Film thickness, biodegradable test are to convert the bioplastic into packaging material. These are the tests to ensure the barrier properties, thickness and weight of the things it holds.

Biodegradability test shows that the bioplastic can be totally immersed and dissolved in water within weeks without harming the environment and marine animal. This research, as a result the product is strong, flexible and translucent. It dissolves in water in weeks and does not require external physical force to breakdown. While previous research states that fish scales needed to bind with plasticizers alone but, adding more water based powders which enhances the physical and chemical properties of bioplastic and strengthens it will give the more appropriate product of fish scale bioplastic.

Conclusion :-

Thus the bioplastic using fish scales was produced successfully with all desired properties. The bioplastic produced from such resources was found to be highly acceptable. It has smooth texture, well responsive as a physical barrier, low cost of production and is biodegradable. The chitin present in fish scale played a major role for the preparation of bioplastic. The water absorption test proves that the fish scale bioplastic is completely dissolved in water within 3 weeks. Although, further improvements in mechanical strength, water resistance and large scale production are required. Overall, the research shows the importance of converting waste to wealth as a fish processing by – products into value – added biodegradable bioplastic. It reduces waste, ensures sustainability, environmentally friendly and resource conservation.

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