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PRODUCTION OF EDIBLE BIOPLASTIC (TOFFEE WAPPERS) BY USING CORN (*Zea mays)*, POTATO (*Solanum tuberosum*) AND RICE (*Oryza sativa*) STARCH

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ABSTRACT

Bioplastics are the plastics derived from natural sources like corn starch, biomass, sugar cane, food waste etc. Unlike fossile fuel based plastic, they are entirely or partially bio-degradable as a result of which they are less harmful to the environment. Bio based plastic are extensively used for the production of cutlery, bowls and straws, however their cost and performance cannot match with that of chemically derived plastics. The rationale of this study is to develop starch based bioplastic from food material for which corn, potato and rice starch were used. Due, to high tensile strength, fair biodegradability and low moisture content resulted in the production this combination resulted in the production of stable bioplastic which was also enriched with fair amount of carrot powder and tulsi extract. The developed film was also blend with glycerine which was used as a plasticizer showing consistency and promising results. The results of the study produced an eco-friendly alternative to conventional petro-based chemical plastic polymer with a futuristic application as edible food wraps (toffee wappers) were produced. However, more awareness programs are required to create awareness for production and use of bioplastic, which in near future will be an essential tool for minimizing use of petro based chemical plastics.

KEYWORD: Bio Degradable, Bioplastic, Corn starch, Rice Starch and Potato Starch

Plastics have an importance role in today's world as they are widely used for various applications like in the production of polythene bags, cold drink bottles, toys, containers etc. (Bayer *et al*., 2014) This has led to rise in the annual production of petroleum based plastic, which has also been a major cause for the emission of dangerous gases leading to many environmental problems (Emadian 2017). Due, to its non-degradable nature its use has become limited which further led to emergence of a news concept known as "Bioplastics" which refers to plastics made from starch, cellulose, chitson and protein renewable biomass (Azahari *et al*., 2011). More precisely a Bioplastics is a plastic that is made partly or wholly from polymers derived from biological sources such as sugar cane, potato starch or the cellulose from trees straw and cotton (Meshram 2022). Bioplastics are not just one single substance they comprise of a whole family of materials with differing properties and applications. The European Bioplastics is defined as a plastic material which is either bio-based, biodegradable or a combination of both features (Izquierdo and Krochta 2008). The research and development of biodegradable bioplastics formed with raw materials from agricultural origin has been a new concept which has gained attention in recent times ecologically safe sustainable industrial development. Many different natural biopolymers derived from the agricultural product or by-product are proposed for the formulation of biodegradable and edible bioplastic these commonly include use of polysaccharide, protein, and lipids (Fakhoury *et al.* 2012; Guerrero *et al.* 2011, Lopattananon *et al.* 2012). One of the biggest advantage of using these products is that they are fully biodegradable, renewable and non-toxic for the environment. Use of edible ingredients in formulation of bioplastic makes it edible and formation of an edible biofilm on the food product makes it easier for preservation distribution and marketing (Matta *et al.* 2015). One important component which is widely used for polymer production is starch, as the production of starch-based bioplastics is quite simple, and it is widely used for packaging applications. Starch is highly suited for bioplastic production due to its tensile property and the addition of eco-friendly polyesters makes it more suitable. It is a carbohydrate which contains great amount of glucose units, combined together by glycosidic links (Marichelvam *et al.*, 2019). Starch is whitish in color, does not contain any specific taste or odor, it is non-toxic, biologically absorbable and semi-permeable to carbon dioxide.Pure starch is white in color and the starch powder does not possess any specific taste or odor. Furthermore, pure starch cannot be dissolved in cold water or alcohol. It is non-toxic, biologically absorbable, and semi-permeable to carbon dioxide (Ceseracciu *et al*., 2015). The linear and helical amylose and the branched amylopectin are the two types of molecules present in starch. Both amylose and amylopectin content of starch may vary from 75 to 80% by weight, depending on the

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type of plant used. Starch has the property of becoming soluble in water after being heated, after which starch becomes a paste and the viscosity is also increased. High amylose starch is a smart reserve for use as an obstruction in packing materials. Due to the low price, renewability, and decent mechanical properties, it was used to produce decomposable films to partly or completely substitute the plastic polymers (Wang *et al.*, 2002). The current investigation uses combination of rice, corn and potato starch for the production of edible bioplastic, due to high amylose content in the starch source the tensile property of the bioplastic was found to be high, the study will be a great assert for countries where environmental conditions affect economy. The prepared bioplastic was found to be soluble in water and degradable in soil, which makes it perfect for environmental use and such bioplastics in future can be used as a potent source of packing material.

MATERIALS AND METHODS

For preparation of the Bioplastic, corn, potato and rice starch were extracted in the laboratory. Food Glycerine, Citric acid and gelatin were used as plasticizes, Carrot powder and tulsi was used as a flavouring agent and Stevia was used as a sweating agent. For, preparing bioplastic following steps are being followed-

Extraction of Starch

For extracting starch from corn manually firstly, 100 gm of corn was washed and boiled with water for about an hour. After this the corn was grounded in motar with 100 ml water. Mixture was filtered and remaining solid portion was reused, the process was repeated for five times, after which blend was allowed to settle in beaker for 10 minutes. About 100 ml water was added to the mixture and water was removed after repeating process for 4 to 5 times. Approximately, 40 gm starch was obtained from 100 gm corn starch, similarly rice and potato starch were also extracted (Table 1).

Table 1: Physical and Chemical Properties of Starch

S. No.	Properties	Corn Starch	Rice Starch	Potato Starch
1.	Moisture (%)	10.8	11.4	17.5
2.	Ash Content	0.32	0.29	0.35
3.	Protein (%)	0.38	0.43	0.06
4.	Fat (%)	0.32	0.04	0.01
5.	Fiber (%)	0.10	0.12	0.13
6.	Amylose (%)	29.4	33.6	22.3
7.	pH	6.7	6.8	6.0

Preparation of Bioplastic Film

Due, to good mechanical property and water solubility, food glycerol was used as a plasticizer. The bioplastic film was prepared in following manner:

(1) Firstly, 300 ml distilled water was taken in a beaker.

(2) To this, 10 gm of extracted each corn, rice and potato starch were added.

(3) 10 ml of citric acid and 10 ml of food glycerine were added to the preparation in the beaker.

(4) 3 gm of Carrot powder (*Daucus carota sativus*) ,flavouring agent 5gm of stevia and 2 gm of Tulsi extract (*Ocimum tenuiflorum*) were added to the mixture.

(5) The mixture was then stirred at a rate of 180 rpm for 10 minutes, after which the mixture was heated in hot plate at 100 degree and was manually stirred for 70 minutes continuously.

(6) The sample was then poured in teflon glass plate and was spread uniformly, after which it took 3-4 days to dry and cast film was removed.

Characteristicks of Bioplastics

Certain important characteristicks like tensile strength, thickness, moisture content, water solubility, water contact angle, sealing property and biodegradability of bioplastic were tested.

(1) The tensile strength test was performed using Testometric Machine M 350 10 CT in accordance to ASTM D882, where initial grip separation was 50 nm. and cross head speed was 50 nm/minute (Salarbakshi, *et al.*, 2013). Cut samples from film were subjected for recording tensile strength (MPa).

(2) The thickness of bioplastic was measured by using thickness guage.

(3) The sample was cut into piecies after which it was weight, then the sample was kept in oven at 110 degree C until fixed dry weight was acquired, the film was subsequently given 5 repetitions and the moisture content was measured accurately (Kim *et al*., 2017).

Moisture Content in %= Initial weight of sample-Final weight of sample/Final weight of sampleX100

(4) The film sample was cut in to pieces, and were weight, after which sample was immersed in 100 ml distilled water and fixed agitation was carried at 180 rpm for 6 hours, lasting portions were filtered for 6 hours. The samples were then dried in hot air oven at 110 degrees until an immediate fixed weight was found (Gaspar *et al.*, 2005). Percentage of total soluble material was calculated as:

$WS\% = [(W_0-W_F)/W_0]X100$

Where WS is the solubility in water W_0 is the weight in beginning and Wf is the final weight of bioplastic

(5) The specimen was cut into pieces found near the root of plants rich in nitrogenous bacteria, 500g. soil was kept in a container along with samples, two samples were prepared . One was kept at 2cm depth while the other was kept at 3cm depth respectively. The biodegradability test was measured by following equation-

$Weight\ Loss\ (\%) = [(W_0-W)/W_0]X100$

where W_0 and W are the weight of samples before and after test.

(6) For seal production, bar Sealing Technique was applied where heat is applied for moulding sealing layer to produce a molten state.

RESULTS AND DISCUSSION

The high content of pectin, hemi cellulose, cellulose and lignin in the carrot powder make it fit for making edible bioplastic. Carrot is one of the important root vegetables which is rich in dietary fibers and contains optimum functional components having many beneficial health effects. It contains about 50% of Beta-carotene which is highly beneficial for skin and eye (Sharma *et al*., 2012). At the same time tulsi extract was also added to the bioplastic film, it is widely considered to be a tonic for the as it is used for treating different conditions and its fresh flowers are used for treating bronchitis, it is widely used for protecting the skin from various damages caused by free radicals, it is also used for lowering uric acid level of body (Bhasin *et al*., 2023). Due to the positive effects of these ingredients on body the current study uses these components for the first time in the production of bioplastic. The addition of food glycerine in the bioplastic makes it rigid and less pialable (Eerhart *et al.,* 2012). Because of its brittleness the polymer can be molded into any shape like spoon, straws and cups as per wish (Figure 1). However, in the present study the polymer was used to prepare candy (toffee) wappers which will allow direct consumption of the candies (Yaradoddi *et al*, 2022).

Several studies across the globe report the production of bioplastic from different components as in 2017 Patel and Parvathi reported the production of edible bioplastic from tropica starch by using red cabbage as a pH indicator. Lubis *et al.*, (2018) produced bioplastic from jackfruit starch using glycerol as plasticizer. Hasen *et al*., (2018) used Chitosan and yellow pumpkin starch for production of bioplastic where castor oil was used as a plasticizer. Marichelvan *et al.*, (2019) used combination of corn and rice for the production of bioplastic. Another study by Arikan (2019) reported the production of bioplastic from potato peel waste. Yaradooddi *et al.*, (2022) reported the use of orange peel for the production of bioplastic, similarly Ashfaq *et al.,* (2022) used papaya for the production of biodegradable and edible film to counter plastic waste generation. Chalermthai, *et al.* (2023) reported the production of edible Bioplastic from Spirulina. The current study is a genuine and first attempt to produce bioplastic from a combination of rice, potato and corn starch by using food glycerine as a plasticizer. Since the study reports formation of edible bioplastic or (toffee wrapers) so, ingredients which can increase the medicinal benefits of the biofilm were added so that a strong platform can be laid for research on this topic in the coming time. Various properties of bio plastics have been analyzed as which are important to narrate the stability of bioplastics. Results of the test are following-

Tensile Properties

Tensile strength may be defined as the strength which is required to break bioplastic film. The sample reported tensile strength of about 12.5 MPa, Youngs Modulus of about 0.182 GPa and elongation of about 7.2 %. The presence of glycerol in the film made it more flexible by reducing the inter molecular bond and by modifying the mechanical properties of the bioplastic. It is also reported that mechanical resistance of film against rupture can be improved by impregmentation of the rice starch (Larotonda *et al*., 2004). The starch cross linking of ether or ester linkage among hydroxyl clusters in starch molecules can decrease density and can improve mechanical property of the bioplastic (Woggum *et al*., 2014).

Thickness of Bioplastic

The thickness of bioplastic was measured at 10 different places using a thickness gauge, after which average was taken. Various studies on thickness of bioplastic report thickness value of cornstarch film to be somewhere around 0.15 nm (Ghasemloue *et al.*, 2013) whereas, thickness ranging between 53-63 micron was reported from potato, rice, wheat, gelatin and sorghum respectively. However, in the current study thickness of about 270 microns is reported which is attributed to the used of rice, potato and corn starch respectively (Fakhouri *et al*., 2015).

Moisture Content

This current study reports moisture content of about 12.2% which is considered to be on low side. Studies suggest that the use of rice starch decreases the hydrophilicity of the bioplastic, which further reduces the moisture content thus, increasing the shell life of the bioplastic (Kavoosi *et al*. 2013).

Water Solublity

Water solublity is one of the main characteristics which is used to distinguish starch type to film formation method. The amount of amylose in starch is a key factor in deciding the solublity of starch in water. The current study reports water solublity of about 12% in synthesized bioplastic which is considered to be optimum for a bioplastic (Fakhouri *et al*., 2015, Martelli *et al.*, 2012).

Biodegradablity

Biodegradablity test was successfully conducted by taking two samples respectively. The weight loss registered in the sample indicated the biodegradation of the compound by microorganisms. Samples buried in different depth show approximately same degradation rate. The weight of sample before and after the test was found to be 0.452 gm and 0.285 gm respectively.

Sealing Nature of Bioplastics

It is evident that plastic can be sealed at molten or melting conditions and a range of temperature is set as an acceptable sealing temperature which can create a good seal is decided. In the present study, samples were inspected manually and were reported to have excellent sealing properties and can be used for making plastic bags, cups, plates, toffee wrapers etc.

Advantages of Using Bioplastics

Bioplastics offer a number of advantages because of which the product has gained popularity in recent times (Meshram 2022):

(1) It can be consumed with the product and can be disposed easily, hence are eco-friendly

(2) They are produced from renewable edible ingredients and are expected to degrade more easily than chemical plastic.

(3) They can easily enhance oraganoleptic properties by providing flavour, color and sweetness to them.

(4) They can serve as food supplements and can be applied to heterogeneous foods.

(5) They are trailed to prevent deteriorative inter-component moisture and solute migration in food like pizzas etc.

(6) This can function as carrier for antimicrobial and antioxidant agent.

(7) They can be used for micro encapsulation of food flavouring and can be used in multi layer food packaging.

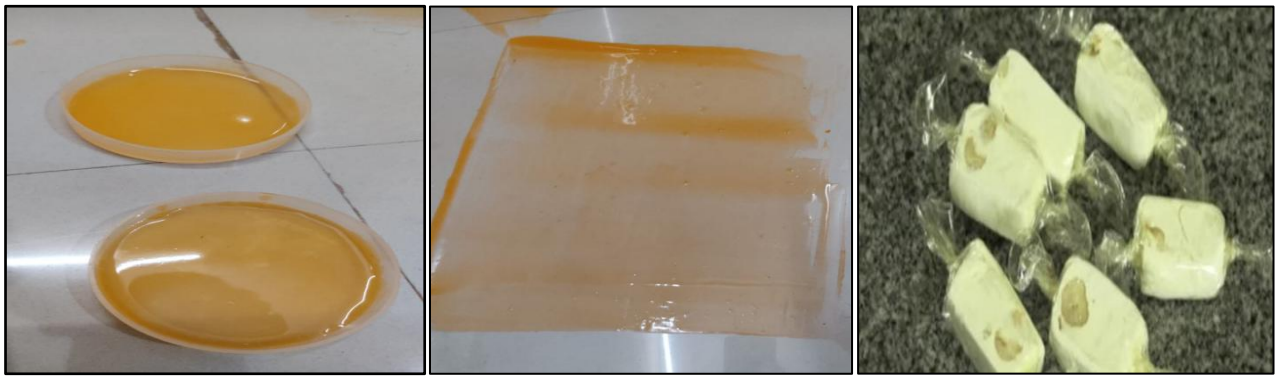

Figure 1: Preparation of Bioplastic Film and Toffee wappers

CONCLUSION

Most of the countries across the globe are struggling with the accumulation of plastics which due to its non-degradable nature create big environmental issues. One of the ways to overcome this problem is by producing bioplastics from different sources like

carbohydrate, proteins and lipids. The study concludes that combination of corn rice and potato starch which serves as one of the best option for the production of bioplastic. The bioplastic produced from this study shows fair tensile strength, solubility and low moisture content and makes the bioplastic fit for making plastic bags. The produced bioplastic also shows fair biodegradability and sealing property. Apart from this component with medicinal benefit like carrot powder and tulsi have been added to make the bioplastic even better for human consumption. In the current sanario, due to regular awareness program conducted for limiting the use of chemically derived plastic the production and use of bioplastic is increasing day by day. Thus, by employing methods for converting agriculture and other waste for the production of bioplastic great economic potential can be derived in the 21st century.

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