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FABRICATION OF CATTLE EDIBLE AND BIODEGRADABLE FOOD PACKAGES

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ABSTRACT

Food packaging is becoming a big threat for world due to huge amount of non-biodegradable plastic bags. Most probably, edible food packaging system will be the best solution of it. Though human edible plastics are found in some advanced countries, in Bangladesh, edible food packages would be harmful to human digestion because of the polluted surroundings or environment. Keeping that in mind, cattle edible food packages would be more suitable for Bangladesh as Bangladesh has a large cattle population. Moreover, in Bangladesh as well as in the whole world, a huge portion of single use plastic comes from food packages. Considering all these situations, in this experimental paper, cattle edible composite film was developed which was biodegradable, antimicrobial, and oxidation resistant and can act as active food package. It is a composite film made with Gelatin, food-grade glycerin, rice straw and grass extract which can replace non-biodegradable food packages.

INTRODUCTION

A type of packaging appropriate for animal consumption is edible packaging. Edible packaging is by definition a thin layer that is created separately as a thin sheet or film and afterwards wrapped over the food surface. The former is called as edible coating, and the latter is called as edible film (Jeevahan et al., 2020). Edible food packages extend the shelf life and add nutritive value (Petkoska et al., 2021). It has been estimated that the world's population will reach 9.8 billion by the year 2050 (Adejumo and Adebiyi, 2020). Increased population in developing nations will cause a 70% increase in the demand for food (Amorim, et al., 2019). By 2050, the total meat production is estimated to reach 200 million tons, a 76% increase (Khanet and Duke, 2001). Therefore, an obvious increase in livestock production is expected (+36%) along with the need for feeds (Alexandratos and Bruinsma, 2012). Moreover, diet changes are also expected with a shift from cereals to foods containing a lower calorie content, such as fruits and vegetables, and to livestock products such as meat, fish, egg and dairy products. As a result, food systems, which include production, distribution, and utilization of food are being influenced by downstream pull forces (dietary changes and urbanization) and upstream push forces (farming intensification and technologies). However, despite significant progress in farming technologies, in several countries challenges that include hunger, health risks and environmental degradation continue to persist. With the industrial revolution, plastic was one of the most important innovations of the 20th century. But in the twenty-first century, plastic has emerged as one of the dangerous environmental. Nearly 300 million tons of plastic is manufactured worldwide every year and what's more worrisome is that only 10–13% of plastic products are recycled. Single-use plastics make up almost 40% of all plastics used. Plastic bags, straws for soft drinks, soda and water bottles, and nearly all food packaging are among these products. The convenience and safety of some single-use products have improved. Plastic water bottles are a prime example because they are bought one million times each minute globally (Scarr and Hernandez, 2019). But plastic bottles are used once and then thrown away. Most of the food is served and packed in a single-use manner, which has become the norm.

This problem is more acute in developing countries, especially in the 11th most densely populated country in the world, Bangladesh. A two-year study carried out in the capital city, Dhaka, and other major cities like Rajshahi, Chattogram, and Sylhet showed that 87,000 tons of SUP (single-use plastics) were discarded each year, and almost 96% of SUP waste was produced by plastic containers of food (food packages) and personal care products. Besides, nearly 36% of the SUPs are neither biodegradable nor recyclable. Consequently, it is high time more environmentally friendly and biodegradable alternatives replaced regular food packaging (Noyon et al., 2022). That's where cattle edible food packages come in. Easily accessible and economical chemicals and cattle food extracts (Cynodon dactylon, known as Bermuda grass or Durva grass), rice straw etc are used in making these types of packages. The important thing is that these packages retain the primary characteristics of food packaging, like being light in weight and chemically stable. Additionally, edible food packaging includes active food packaging material that prolongs the shelf life of goods.

On top of that, as the number of cattle in Bangladesh is about 23.4 million, these packages can be an affordable alternative nutrient source for cattle. This study performs an assessment of developing cattle edible composite film to substitute typical food packages and becoming a feasible option for cattle food in Bangladesh. Here a gelatin based composite film is manufactured which can be replaced by single use non-biodegradable food packages. Natural polymers can be broadly classified into polysaccharide- and protein-derived polymers. Gelatin based films are protein derived. (Ramachandraiah and Hong, 2022). Edible polymers have a very wide range of applications in biomedical field including drug delivery, tissue engineering, regenerative medicine, protein release, wound dressing, biomedical devices, etc. also (Kouhi et al., 2020). A multi-cross-linked biodegradable film containing gelatin, dialdehyde oligo-chitosan (DOC), and polyvinyl alcohol (PVA), with some good mechanical properties, was fabricated via a facile process (Chen et al., 2021). An investigation was done on the production of arrowroot starch (AS) films utilizing solution casting and glycerol (G) in various plasticizer ratios. The physical, mechanical, and structural properties, along with other properties of the manufactured films, were assessed. Glycerol was added to the AS film-making solution to lessen the films' fragility and brittleness. Film thickness, moisture content, and water solubility all increased in response to an increase in glycerol concentration, whereas density and water absorption decreased. G- plasticized AS films had significantly lower tensile strength (Tarique et al., 2021; Said et al., 2022).

The possible use of gelatin-based film made from several gelatin sources as a biodegradable food packaging material was explored. The features of single gelatin-based films have been compared to those of active gelatin-based composite films. The total solid (TS) amount in each film significantly impacted the physical characteristics of gelatin-based films, such as color, thickness, and biodegradability. While compared to mammalian and marine gelatin films, poultry-based gelatin films offered more excellent mechanical and light barrier qualities. This research provided information on gelatin-based film characteristics, mechanical properties, and physical characteristic.

METHODOLOGY

MATERIALS

Gelatin is a collagen, which makes up most of the protein in the skin, bones, and white connective tissues of animals, is converted into this protein by partial hydrolysis. Gelatin was used because it produces coatings that are consistent, clear, reasonably flexible, and easily absorbed by water. These coatings are perfect for making photographic films (Shubhra, 2013). The difference between coating and edible films are obtained in solid laminates then applied to foodstuff while coatings are applied in liquid method (Falguera et al., 2011).

Gelatin was collected from Sigma Aldrich, Bangladesh. But just gelatin can't make the film enough viable because of its poor mechanical properties, especially in a wet state. That's why food-grade glycerin was used. It is a carbohydrate and enhances the mechanical properties of the film. Here food-grade glycerin was selected instead of non-food grade glycerin selected to keep the film edible. This food-grade glycerin was bought from SR Laboratory Care BD. The green grass and the rice straw was used as the fiber of the composite film which made the film stronger. The grass was collected from local field.

FABRICATION OF FOOD PACKAGES

Firstly, 1g of grass, 1g of rice straw and 200g of water were measured with a weight scale (Analytical Balance, Cap.:0.0001-310, Model: PS.P3.310, Brand: P-Scale). Then a mixture of grass and water was prepared with the blender. This mixture was filtered through a cloth into a beaker. The stock solution was heated at 600°C for 25 minutes on an electric stove (Induction Cooker, Model: VSN-1204, Brand: Vision).

After heating 5 minutes, 10g of gelatin and 1.5g of glycerin were measured and mixed with the grass-water mixture. During this heating process, the solution was stirred continuously with a spoon. If it was not stirred, there would have been residue on the bottom of the pan. After the solution became considerably concentrated, it was poured into a non-stick surface as a skinny layer. Then it was kept in the dark for 48 hours at room temperature without any disturbance. After 72 hours, a thin film layer formed on the non-stick surface. Finally, it was separated from the non-stick surface very carefully. Non-stick surface was used so that it could be separated easily.

CHARACTERIZATION

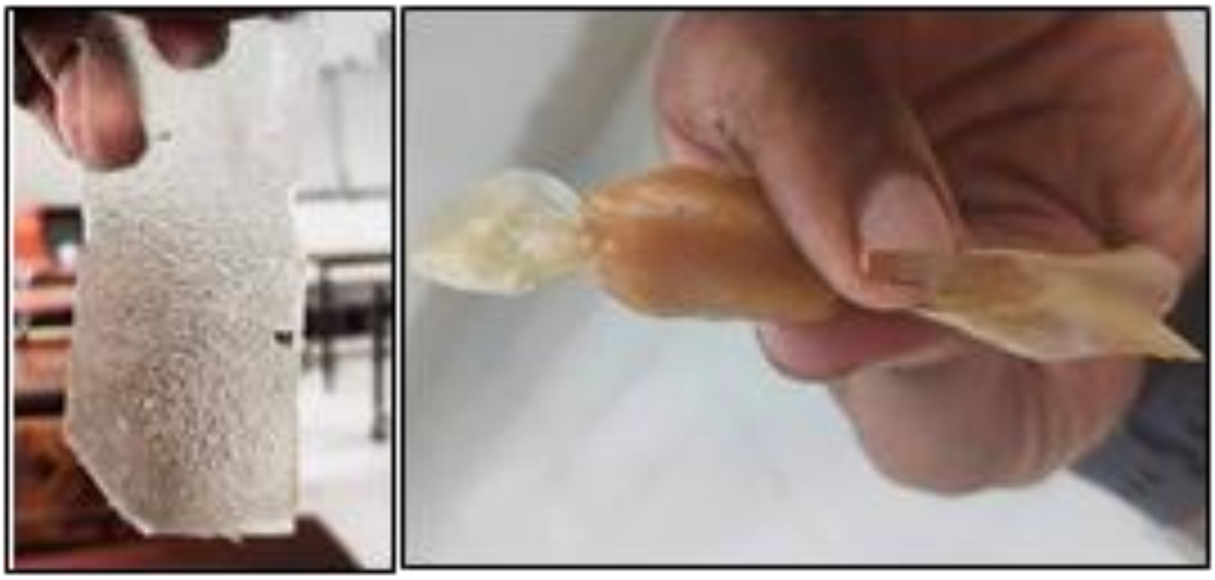

Figure 1 A view of the resultant composite film

After getting the resultant film, some properties of the film were tested for biodegradability, thickness, melting point, moisture content, and cattle edibility. Firstly, a part of the film was cut off. After measuring the weight, its weight was 1.65g. Later this film was kept in a pot of soil at a 5-inch depth. The weight of the product was measured at 7 days intervals. By using this data, the biodegradability of the film was found by using ASTM D5526 method. Then a screw gauge was used to measure the thickness of the composite film. Now the temperature at which any solid starts to melt is the melting point of the material. Here the melting point of the film was measured through heating and measuring temperature when it started melting. The primary methods used for moisture content measurement was loss on drying. For this a part of the film was cut off to determine moisture content. After that, this portion of the film was taken in a beaker. Then the beaker was put in muffle furnace maintaining the temperature at 100°C. During this process, the weight of the film was taken at 5 minutes intervals. Finally, by using this data, moisture content was determined. To measure the melting point, a part of the film was taken in a beaker. A thermometer was also kept in the beaker. Afterwards, the beaker was put on a heater, and the temperature was increased very slowly. After some time, when the film started melting, the temperature was noted. During this heating process, it was to be aware that the temperature should not be increased very quickly so that the film would not ignite instead of melting. Finally, for making sure it was cattle edible the film was cut into small pieces. Then it was mixed with husk and rice straw and put in front of a cow. And the cow had not any health effect after consume it. The biodegradability and moisture absorption tests were performed through soil burial test and water absorption tests respectively for following similar procedure described in Noyon et al., 2022.

RESULTS AND DISCUSSION

THICKNESS AND AREA MEASUREMENT

For the packaging materials, thickness and area measurements are very important. A suitable thickness of packaging film not only increases the barrier performance of packaging materials, but also effects the seal quality of packaging. The thickness of the composite film was 0.08-0.15 mm. The thickness of the film was measured with a screw gauge. The present plastic bags in the market are roughly 0.05 to 0.1 mm thick, whereas this composite film had a thickness of 0.08-0.15 mm. The thickness of the film differed from place to place because the surface of the non-stick pan was not perfectly plain. The total area of the film was calculated by measuring the radius of the two circular films. The radius was about 7.5 cm. The total cost of the 0.02 m² film was 8 BDT which is 6-7 times higher than the typical plastic bags. But the production cost can be reduced by bulk manufacturing and more research (Brezmes and Breitkopf, 2018).

Table 1. Thickness and Area Measurement

Parameters	Measured Data
Thickness	0.08-0.15 mm
Radius	7.5 cm
Area	0.02 m^2

MOISTURE CONTENT TEST

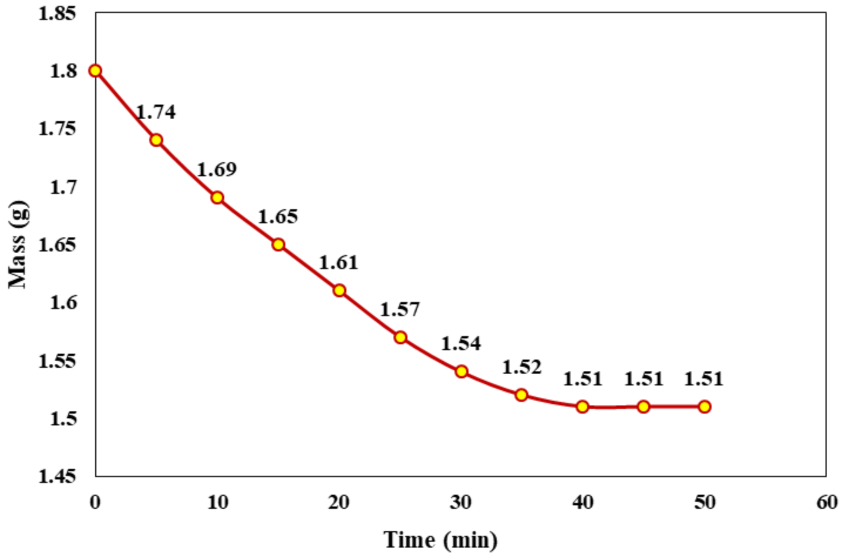

Figure 2 Depletion of mass of the composite film at 100°C for moisture content measurement

The physical qualities of a food package, such as its form, color, and texture, as well as its flavor, weight, and cost, as well as aspects that affect the product's shelf life, freshness, quality, and resistance to bacterial contamination, are all greatly influenced by its moisture content. Direct contact with liquids from precipitation, washing or cleaning, or other situations that allow liquid to directly infiltrate barriers is the major contributor to moisture problems in storage and packing. The initial weight of the sample was 1.8g. It was gradually decreasing with time when it was placed in a muffle furnace maintain 100°C constant temperature. After 40 minutes the weight of the sample becomes saturated and there was no weight loss upto 50 minutes. The final weight was found 1.51g. So, the weight loss percentage was 16.11%. Weight loss of the film was happened because of the moisture contents present in the composite film (Chen et al., 2022; Noyon et al., 2022).

BIODEGRADABILITY TEST

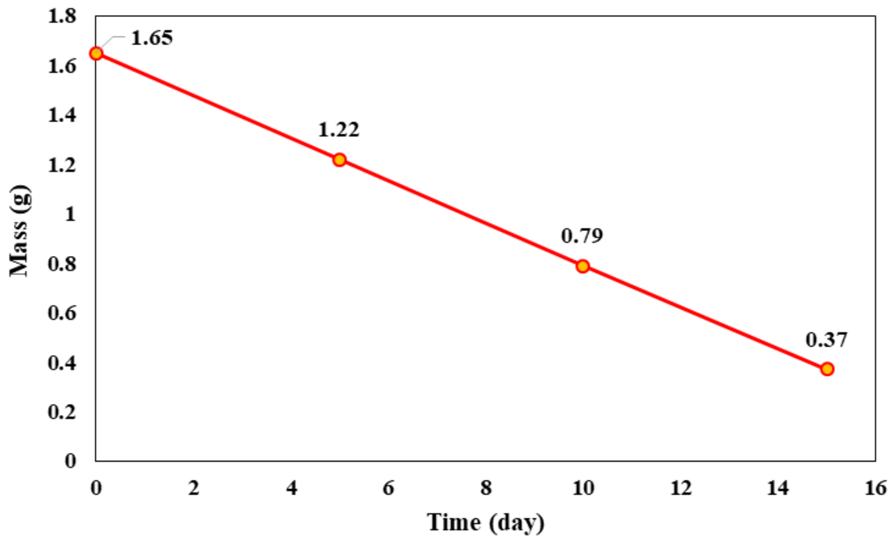

Figure 3 Biodegradability test of the film

Figure 3 described the weight loss for the composite film following soil burial testing. The test was conducted for 15 days maintaining 5 days interval. The initial weight of the sample was 1.65g. After 15 days of soil burial, weight of the sample was 0.37g. So, the weight loss was found 77.58%. The rapid biodegradability of edible gelatin, glycerin and grass caused by enzymatic activity by various microorganisms. It ensures the significant biodegradability of the composite films. The edible packaging film have greater biodegradability than one of the recent study related to packaging material (Noyon et al., 2022).

WATER ABSORPTION TEST

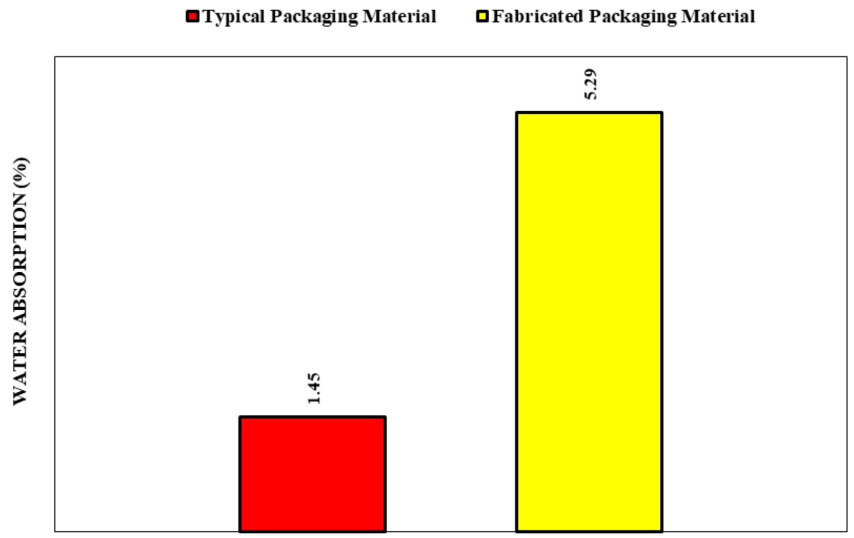

Figure 4 Water absorption of the packaging film

The quantity of water absorbed by the moistened surface of packing materials is measured as water absorbency. When packaging materials have absorbed too much liquid, they will lose their strength, form, and functionality. This test helps identify the minimum moisture content required for the corrugated board and other packaging materials to preserve their tensile strength and product-protective capabilities. Some polymers have a predisposition to naturally absorb water. Superabsorbent polymers are becoming more popular in advanced applications in the construction and medical fields, among others, but at the same time, thermoplastics' ability to absorb moisture has changed how they are processed and how they behave. The ability of a plastic or polymer to absorb moisture from its surroundings is known as moisture/water absorption. One of the pure packaging material (LLDPE) absorb 1.45% of water (Noyon et al., 2022). The percentage of water absorption for the fabricated composite film was 5.29%. So, the water absorption of the composite film was 3.64 times higher than typical packaging material. These are explained by the fact that the ingredients used in composite films has a higher polarity and is therefore more hydrophilic than typical packaging material. According to water absorption test result, the water absorption behavior of composite film promotes the biodegradability of the produced composite films at their end of life.

CONCLUSION

This investigation looked at the consumption patterns of single-use plastics globally and in Bangladesh. An appropriate replacement for non-biodegradable food packages was chosen based on realistic criteria. The intended product was developed as efficiently as feasible. Following investigation, it was discovered that the product's qualities matched the criteria that had to be satisfied. The water absorption percentage was 3.46 times higher than typical packaging material, which promotes biodegradability. Finally, a biodegradable cattle edible food package was developed, enabling the packaging of foods like chocolate. More research and industrial mass production can significantly reduce costs. Changing the amount of materials used can also further enhance the film's qualities. The process of cross-linking is a very efficient way to improve the film's mechanical stability and barrier properties. To do this, a number of functional groups can make use of proteins. Working along with their reactive side groups, functional groups achieve this usage. To enhance the characteristics of films, chemical methods including acids, alkalis, and cross-linking agents can be used. Chain structure expansion and increased protein interaction both boost tensile strength. Besides, additional testing can be performed to determine the product's viability, including tensile strength testing, water solubility tests, and other qualities. Finally, substantial research should be conducted to get an acceptable resultant film.

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