DEVELOPMENT OF ECO FRIENDLY EDIBLE PACKAGING FILMS USING POTATO STARCH

Abstract

The edible packaging is a new icon in the era of modern packaging. The researchers and food scientist recognise edible packaging as a novel concept in packaging for improving product stability. The potato based edible films were developed as an alternative for plastic packages and they confer nutritional benefits as when consumed along with the food. The development of potato strach based edible films, by the extraction of potato starch at lab scale level. The potato starch films were developed by the incorporation of plasticiser at different concentrations of 1.5ml and 2ml. The edible films developed using glycerol as plasticiser is said to increase the flexibility and plasticity of film. The films developed were tested for its functional properties such as thickness, tensile strength, elongation at break, moisture permeability, moisture content, puncture strength. The overall results showed that potato starch based edible films absorbed less moisture and they also attributedto the low moisture permeability in relation with glycerol content, and they exhibited high tensile strength. The potato starch films were firm and white in colour. There was a limited growth of bacteria and yeasts, but according to safe limits. i.e., 10cfu/gm in combination of both different glycerol concentration of edible films as 4.8cfu/gm in 1.5ml concentration and 5.2cfu/gm in 2ml concentration of glycerol in potato based starch films. The potato films developed out of potato when observed highlighted that the moisture content of potato films were less and they tend to exhibit excellent functional properties.

Keywords: Edible films, glycerol, plasticiser, potato starch, microbial load, functional properties.

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I. INTRODUCTION

Edible films can be defined as a thin layer of material which can be consumed and provides a barrier to humidity, air and movement of layer of liquid that affects the food. Edible film packaging is a new type packaging and protect food from the contamination. They are beneficial than the use of plastic packaging that lead to environmental damage. Edible film that is used to coat food, or they are placed between components that functions as a barrier to mass transfer such as water, oxygen, and fat. Edible films can be combined with a food any other functional compounds that enhance the quality of colour, aroma, and texture of the product, as well as to control microbial growth. An edible and biodegradable film is developed from food derived ingredients using wet or dry manufacturing process. The edible film that creates a protective layer, acts as a barrier between the food surface and spoilage causing factors there by enhancing the shelf life of food. Starch is one of the most frequently used for edible films production and they can be obtained from large number of raw materials, its production costs are cheap, it is renewable and they are biodegradable and has the ability to form films. Starch from different sources has found to have excellent film-forming agent, that includes potato, barley, wheat, tapioca and rice. cassava starch is used for preparation of biodegradable films. Glycerol is used as a plasticizer in the edible films to increase the flexibility and plasticity of the film. These films that posses excellent functional properties and antimicrobial effect that contribute to good film making properties. Different kinds of starch have been widely used to prepare the films and cassava starch based edible films that showed less microbial load. The main advantage of edible films over synthetic film is that they can be consumed with the food. The advantage is that edible films as they are thrown off, they get degraded and they contribute to the reduction of environmental pollution.

II. MATERIALS AND METHODS

Raw Materials: The raw materials needed for the study were selected based on naturally occuring plant sources. These plant sources can be grown and are widely available. They have been identified as affordable raw materials from local sources that can be easily used for the creation of edible films. They have been identified as affordable raw materials from local sources that can be easily used for the creation of edible films. The study's objective is to create edible films using food ingredients because they are eco-friendly and safe. Natural food sources were chosen because of their high starch content, particularly their amylose and amylopectin levels. The sources that were chosen are based on two dietary classes, such as cereals and tubers and roots. According to the guidelines, the roots and tuber sources chosen were potato and cassava, while the cereal-based foods chosen were rice and wheat.The aim of the study is to produce edible films out of food substances as they are harmless and they reduce the environment load as per the previous literature studies.

Methods

1. **Evaluation of Properties of Film**: The edible films are evaluated for the properties to test for the optimum frame ability of the edible films and for the co-relation of characteristics of the edible film.

    - **Thickness of Films:** Thickness is a crucial factor that influences how much film is used to package food products. Utilizing a screw gauge, the thickness of the edible films produced in various configurations was measured. Thickness that could change depending on the ultimate use, potentially increasing or decreasing the mechanical qualities of the films, such as tensile strength and elongation. (2013) Anandito et al. To the nearest 0.001 mm, the thickness of the film was measured using a screw gauge. Each edible film's thickness was was measured at room temperature (230C and 45% RH) and average was taken from three random measurements.

$$t = m/Ad$$

Where: m - Mass of the edible film, A - Area of the edible film, D - Density of the edible film

- **Tensile Strength:** The maximum tensile force that a film is capable of withstanding is known as its tensile strength. It is one of the most significant mechanical characteristics that predicts the highest stress an edible film can withstand before breaking. Tensile strength demonstrates how much better the film is at withstanding mechanical harm. With the primary goal of preventing food from being damaged during handling, transportation, and marketing, edible films with high tensile strength are required for food packaging (Pitak and Rakshit 2011).Using a universal testing machine, the tensile strength of edible films was calculated by dividing the maximum force (F) applied by the surface area (A) of the films (Fransisca et al., 2013).

  Principle of Universal Testing Machine: The machine's operating premise is the hydraulic transmission of load from the test sample to a separate load indicator housed in a separate compartment. The technology is great because it does away with the use of knife edges and levers for the transmission of load. A ramp that is hydrostatically lubricated applies load. The control panel's pendulum dynamometer system's cylinder receives pressure from the main cylinder by way of this mechanism. Leverage is used to transfer the load to the dynamometer's cylinder and then to the pendulum. displacement of the pendulum that swings in sync with the rack and pinion system that drives the autographic recorder and the load indication pointer. The absolute load is represented by the pendulum's deviation. (Mechatronics guide, 2013).

$$t = \frac{Fmaks}{A}$$

  Where: t - tensile strength (MPa), Fmaks - force of tensile strength (N), A - sample surface area (cm2)

- **Elongation at Break Measurement:** Elongation is the maximum extension percentage that an edible film can reach before being ripped is known as elongation. The value of elongation at break was calculated by dividing the strain at which the film is ripped by the initial length. The measurement of elongations for each variation was carried out using a universal testing machine. The following equation (Clause et al., 2011) can be used to compute the film's extension percentage.

$$\text{Elongation at break (\%)} = \frac{\text{Strain when broken (mm)}}{\text{Initial length}} \times 100$$

- **Puncture Test:** The puncture characteristics of an edible film are ascertained using a puncture strength test. A potato starch-based edible film is crushed by a probe or other instrument during a puncture test, which is often a compressive test, until it breaks (oliveretal.,2012).

$$\text{Puncture test} = \frac{\text{Fmax}}{\text{Acs}}$$

  Fmax is the maximum applied force, A**cs** is the cross sectional area of the edge of the edible film located in the path of the gap.

- **Moisture Content:** The oven drying of edible films at 105°C until the weight (dry sample weight) remained constant, the moisture content of the films was quantified gravimetrically. According to the following equation, the results are represented as a percentage of the original film weight divided by the end film weight. For variations created from edible films based on potato starch, triplicate analyses are carried out (Bennadios et al., 2011).

$$(\%)\ \text{Humidity} = \frac{(\text{Initial Weight} - 1)}{\text{Final Weight}} \times 100$$

- **Moisture Permeability:** The amount of water that the edible films absorb determines how permeable they are to moisture. The sample edible film's initial weight (W0) was determined. The edible films are placed in distilled water-filled beaker and left there for 10 seconds. The film was then removed from the water and then weighed to calculate wet weight (W). The sample was soaked back in the beaker, then it was lifted continuously after every 10 seconds and then weighed again and again for repeated intervals. The procedure is performed until standard weight of the film is attained. The edible film is then saturated with water and it showed the maximum percentage of moisture permeability. The water absorbed by the edible film is measured using the following equation (Diosetal.,2012).

$$\text{Water } (\%) = \frac{W - W_0}{W}$$

2. **Method of Extraction:** Using the prescribed methods, the starch was extracted from the chosen natural source, such as a potato. The starch from the potato was extracted using the following processes: **peeling, washing, grinding, decanting, sedimenting, and drying.** Potatoes (Solanum tuberosum) are high in starch, which has excellent binding qualities, they were chosen to create edible films. The molecules of amylose and amylopectin give potatoes their binding and sheeting abilities. The potatoes were cleaned, peeled, and diced. They were then pulverized in an electric blender with distilled water and filtered. the leftover residue that is collected after straining twice with distilled water added. Untouched, the concoction was left in the beaker. Distilled water is added to the beaker containing starch and it was stirred well. The Water was gently poured off and drained from the beaker, Pure starch obtained was used for edible film.

Raw potatoes
↓
Peeling of potatoes
↓
Grating of potatoes
↓
Grinding of potatoes with electric blender (add distilled water)
↓
Straining of liquid by strainer
↓
Allow the mixture of starch to settle in the beaker for 5 minutes
↓
Drain the water from beaker
↓
Potato starch settled at the bottom
↓
Add distilled water and stir it
↓
Drain the water from the beaker
↓
Potato starch obtained

Flow chart 1: Extraction of Potato Starch

3. **Development of Potato Starch Based Edible Films:** The edible films were created using a casting technique and a potato starch-based combination. Potato starch-based edible films were produced using glycerol as a plasticizer. Distilled water was added to the potato starch and glycerol mixture that had been placed in a beaker. The mixture was then supplemented with the necessary amount of citric acid. Muslin cloth was used to filter the entire mixture. For 10 minutes, the mixture was heated to 700C in a hot water bath. If 7.5g of potato starch were used, 1.5ml of glycerol had to be added along with the same amount of water. If 11.5g of potato starch were used, the equivalent amounts of water have to be taken and 2ml of glycerol was added. The cast was prepared and the mixture was poured on the cast and dried at room temperature for 48 hrs. After the films were dried they were peeled off and stored. The potato based edible films were developed with the different concentration of glycerol such as 1.5ml and 2.5ml and analysed for the properties of different concentrations of potato starch based edible films.

Potato starch
↓
Adding of glycerol (1.5ml and 2ml of glycerol)
↓
Dissolve in distilled water (11.25g in 90ml and 7.5g in 85.75ml)
↓
Adding 1 g of citric acid
↓
Filter through muslin cloth
↓
Mixing of mixture by glass rod on hot plate for 400C for 5 minutes
↓
Heating in water bath (700C for 5 minutes)
↓
Casting of films
↓
Drying at 48 hours at room temperature
↓
Removal of edible films from petri dishes

Flow Chart 2: Development of Potato Based Edible Films

III. RESULTS AND DISCUSSION

1. **Extraction of Edible Starch from Potato:** The yield of starch extraction from the potato was higher than that from the other sources. Edible starch was extracted from starch-based sources such tuber-based sources. The study that focused on using potato starch extraction to create edible films. Data on the amount of starch found in plant-based food sources from the various extraction techniques utilized in the current investigation are shown in Table 1.

   It is clear from Table 1 above that the starch extracted from potatoes was 66.6% in each case. Out of the 750 grams of potatoes, 500 grams of starch were extracted. According to the increased starch concentration extracted compared to other chosen plant-based sources, as per the literature studies.

   The results obtained from the extraction starch are in concardence with the study conducted by Walstra., (2003) proving that edible starch was composed of amylose and amylopectin, which was primarily derived from extraction of starch from roots and tubers like potato.

Table 1: Extraction of Starch from Potato

Food Sources	Initial Amount Taken (g)	Grams of Starch Obtained (g)	% of Extraction
Potato	750	500	**66.6**

2. **Property Analysis of Potato Starch Based Edible Films:** The findings of the testing parameters used to evaluate the edible films made from potato starch are shown in Table 2.

- **Thickness of Films:** According to Table 2, the results of the study for Variation 1 (V1) of potato films in triplicates (V1A, V1B, V1C) showed 0.35, 0.37, and 0.33 thicknesses, respectively, and for Variation 2 (V2) of potato films in triplicates (V2A, V2B, V2C) showed 0.48, 0.42, and 0.46 thicknesses, respectively, for edible films made of potato starch. Pali and others (2004).

  The study's findings indicated that the thickness of the plasticized potato film increased with glycerol content. The film's thickness was determined by variation -2 was due to the higher amount of glycerol(2ml) was thicker than the potato film obtained from 1.5ml of glycerol films.

- **Tensile Strength:** The tensile strength of the edible films made from the potato film Variation 1 (V1) in triplicates (V1A, V1B, and V1C) was 5.82, 5.64, and 5.26, respectively. The tensile strength of the potato films in variation 2 (V2) in triplicates was 4.56, 4.75, and 4.84, respectively. The results from different potato-based edible film formulations demonstrated that the potato-based films' tensile strength increased with plasticizer content.

  Wales et al. (2003) found that high glycerol content interfered with the positioning of the polymer chains and hydrogen bonding, as well as reducing the polymer interaction and physical properties of the films, which included the flexibility of the film and the tensile strength of Variation - 2 of potato starch-based edible films increased with increased plasticiser content as the plasticizer.

- **Elongation at Break:** In Table 2, the elongation at break for edible films based on potato starch was assessed. The results of the Variation -1 (V1) of potato films in triplicates V1A, V1B, and V1C indicated 15, 2, 15, 8, and 15, 6, respectively, elongation at break. Potato film variation number two (V2) in triplicates displayed 12.8, 12.5 and 12.3 elongation at break, respectively.

  According to Pali et al. (2006), as flexibility increased, potato starch film strength dropped. Consequently, it was possible to see that the edible films made with high glycerol concentration (2 ml) had an impact on the Elongation at Break values more than the films made with low glycerol concentration (1.5 ml).

- **Moisture Content:** The edible films made from potato starch and derived from the triplicates of Variation - 1 (V1) of potato films (V1A, V1B, and V1C) had moisture contents of 9.89, 9.65, and 9.43, respectively. The moisture content of the potato films in Variation 2 (V2), in triplicates V2A, V2B, and V2C, was 13.9, 13.6, and 13.1 respectively. The weight gain as a percentage was calculated and used as a gauge for how much water the film absorbed.

  According to Wales et al. (2003), the moisture content of edible films made from potato starch was measured since it had an impact on the films' characteristics.

Because of the high glycerol content and thus high moisture content, films were less stable due to their high moisture content. The high glycerol concentration of 2 ml caused a higher moisture content than the 1.5 ml glycerol-based potato films, as could be seen from the results. Because films have a high moisture content, this has an impact on their stability.

- **Moisture Permeability:** Potato starch-based edible films with moisture permeability of 12.8, 12.6, and 12.3 were developed from Variation-1 (V1) of potato starch-based edible films in triplicates (V1A, V1B, and V1C). The edible films made from potato starch in variation 2 (V2) showed moisture permeability of 13.9, 13.6, and 13.1 in triplicate, respectively. According to the results, moisture gained from Variation 1's (1.5ml) potato starch-based edible films was less than that gained from Variation 2's (2ml) edible films.

  The structural and mechanical qualities of the film are connected to the moisture permeability, a key characteristic of edible films that improves product integrity and water resistance (Altiok et al., 2010). The amount of moisture that a potato starch-based edible film with a 1.5ml glycerol concentration gained was less than a film with a 2ml glycerol concentration.

- **Puncture Strength:** The evaluation of the edible film based on potato starch puncture test findings is provided in Table 2. The results of three triplicates of different edible films made from potato starch exhibited puncture strengths of 96.1, 90.9, and 99.9, respectively. In triplicates, Variation 2 of the edible films (V2) based on potato starch were 94.1, 90.6, and 92.3, respectively.

  The findings showed that the potato starch-based edible films from higher glycerol concentrations of 2ml resulted in lower puncture strength than the 1.5ml glycerol concentration, the reduction of the puncture force in the edible films was due to the incorporation of increased amounts of plasticizers, and water molecules were absorbed by the samples at a higher rate, a common phenomenon of edible films, as has been revealed by sloka et al., (2004).

Table 2: Properties of Potato Starch Based Edible Films

Potato	Thickness of Films (mm)	Tensile strength (g force)	Elongation at Break (%)	Puncture Test (g force)	Moisture Content (g)	Moisture Permeability (%)
Variation-1(1.5g of glycerol)						
V1A	0.35	5.82	15.2	96.1	9.89	12.8
V2A	0.37	5.64	15.8	90.9	9.65	12.6
V3A	0.33	5.26	15.6	99.9	9.43	12.3
Variation-2 (2g of glycerol)						
V1B	0.48	4.56	12.8	94.1	13.9	14.7
V2B	0.42	4.75	12.5	90.6	13.6	14.3
V2C	0.46	4.84	12.3	92.3	13.1	14.9

IV. CONCLUSION

In the current scenario edible films are found to be expanding and they help to reduce waste and the environmental load. The carbon footprint is reduced via edible films. The advantage of edible packaging is that since it is made entirely of natural ingredients, there are no chemicals to interfere with it when ingested with food. Additionally, they stop the buildup of non-biodegradable trash. These movies may include bioactive ingredients that enhance their nutritional and medicinal effects. Thus, bio-based edible films are durable, practical, and toxin-free, which benefits humans while also protecting other living things and lowering environmental pollution. Therefore, the current study is a tiny step towards innovation by utilizing the excess starch that is readily available, cheap cost locally available with additional nutritional benefits therefore decreasing the influence of synthetic chemicals that would have a negative impact on health by interacting with the food. The film made from roots and tubers, like potatoes, showed exceptional filmmaking qualities.

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