**DEVELOPMENT OF ECO FRIENDLY EDIBLE PACKAGING FILMS USING POTATO STARCH**

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**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.

**Key words: Edible films, glycerol, plasticiser, potato starch, microbial load, functional properties.**

1. **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. Potato 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 potato based 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.

1. **MATERIALS AND METHODS**

2.1 RAW MATERIALS

The raw ingredients required for study was chosen based on natural plant sources. These plant sources are easily available and cultivable crops. They are of local origin and raw materials identified for the production of edible films from cheap sources and they are easily accessible. The aim of the study is to produce edible films out of food substances as they are harmless and they reduce the environment load. food sources of natural origin were selected based on their high starch content, especially their amylose and amylopectin. The selected sources are based on two food groups such as, **cereals, roots and tubers.** The cereal based sources selected were Rice and Wheat and the roots and tuber sources selected were Potato and Cassava as per the previous literature studies.

**METHODS**

2.2. EVALUATION OF PROPERTIES OF FILM

The edible films are evaluated for the properties to test for the optimum frameability of the edible films and for the co-relation of characteristics of the edible film.

2.2.1 THICKNESS OF FILMS

Thickness is an important parameter that have some effects on the use of film for the food product to be packaged. Thickness of the edible films developed in variations were measured using screw gauge. Thickness that would affect the mechanical properties such as tensile strength and elongation of the films, which might increase or decrease according to the end use. (Anandito et al., 2013). A screw gauge was employed to measure the thickness of film to the nearest 0.001 mm. Thickness of each edible film 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

2.2.2. TENSILE STRENGTH

Tensile strength is the maximum tensile force that could be withheld by a film. It is one of the most important mechanical properties that forecasts the maximum stress that a edible film sustains before it eventually breaks. Tensile strength shows how the film is stronger in resisting the mechanical damage. Edible films with high tensile strength are needed for food packaging with the main objective to protect foodstuffs from damage during handling, transporting, and marketing (Pitak and Rakshit 2011).Tensile strength was measured using Universal Testing Machine, by dividing the maximum force (F) applied by surface area (A) of edible films (Fransisca et al., 2013).

**Principle of Universal Testing Machine:**

The machine operates by a standard principle is that hydraulic transmission of load from the test sample to a separately housed load indicator. The system is ideal since it replaces the transmission of load through two mechanisms: by levers and knife edges. Load is applied by a hydrostatically lubricated ramp. The pressure from the main cylinder is transfered to the cylinder of the pendulum dynamometer system present in the control panel. The load transfered to the cylinder of the dynamometer ansd is passed through leverage to the pendulum. Displacement of the pendulum that in line with the rack and pinion mechanism which operates the load indicator pointer and the autographic recorder. The deviation of the pendulum represents the absolute load applied on the test specimen (Mechatronics guide, 2013).

t = Fmaks

A

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

2.2.3. ELONGATION AT BREAK MEASUREMENT

Elongation is the maximum extension percentage that an edible film can achieve before it is finally torn. The measurement of elongations for each variations was measured out using Universal Testing Machine where the value of elongation at break was determined by dividing the strain at which the film is torn to the initial length. The extension percentage of the film could be calculated by following equation (Clause et al., 2011)

Elongation at break (%) = Strain when broken (mm) × 100

Initial length

2.2.4. PUNCTURE TEST

Puncture strength test is used to determine the puncture characteristics of a edible film. Puncture test is generally a compressive test where a edible film produced from potato starch is compressed by a probe or other device until the film ruptures to the end. Puncture test was used to determine the strength of edible film.(oliveretal.,2012).

Puncture test = Fmax

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.

2.2.5. MOISTURE CONTENT

The moisture content of the edible films was determined gravimetrically by oven drying at 105°C until constant weight (dry sample weight).The results are expressed as a percentage of the initial film weight, divided by the final weight of film according to the following equation. The triplicate analyses are performed for variations developed from potato starch based edible films (Bennadios et al., 2011).

(%) Humidity = (Initial Weight – 1) × 100

Final Weight

2.2.6. MOISTURE PERMEABILITY

Moisture permeability of the edible films is determined by the water uptake of the films. Initial weight (W0) of the sample edible film was measured. The edible films are soaked in a beaker filled with distilled water for a time period of 10 seconds. The soaked film was then lifted from the beaker 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).

Water (%) = W - W0

W0

2.3. **METHOD OF EXTRACTION**

The starch was extracted from the selected natural source such as potato using the standard procedures. The following procedures such as **peeling, washing, grinding, decanting, sedimenting and drying** were carried out for the extraction of starch from the potato. The potatoes (Solanum tuberosum) were selected for making edible films as they are rich in starch, that exhibits good binding properties. The binding and sheeting properties of potato is due to the composition of amylose and amylopectin molecules. Potatoes were washed, peeled and shredded and they were crushed using electric blender with distilled water and were strained using strainer. The remaining residue that is obtained from straining to which distilled water was added and strained twice. The mixture was left in the beaker undisturbed for certain period of time until entire starch settles down at the bottom. 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

**EXTRACTION OF POTATO STARCH**

**Flow chart - 1**

2.4. DEVELOPMENT OF POTATO STARCH BASED EDIBLE FILMS

The edible films were prepared by casting technique using a mixture containing potato starch. Glycerol was used as plasticizer for the production potato starch based edible films. The mixture of potato starch and glycerol were taken in a beaker and distilled water was added to it. Then the required amount of citric acid was added to the mixture. The entire mixture was filtered with the help of muslin cloth. The mixture was kept in hot water bath at 700C temperature for 10 minutes. If the potato starch was taken as 7.5g then the equal amounts of water had to be taken and 1.5ml of glycerol was added. If the potato starch was taken as 11.5g then the equal 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

**DEVELOPMENT OF POTATO BASED EDIBLE FILMS**

**Flow chart - 2**

1. **RESULTS AND DISCUSSION**
   1. EXTRACTION OF EDIBLE STARCH FROM POTATO

The edible starch was extracted from the Starch based sources such as Tuber based sources and the yield of starch extraction from the potato was higher than the other sources. The study that concentrated on use of starch extracted from potato for making edible films.

**Table I** depicts the data of amount of starch present in the plant based food sources from the different extraction methods used in the present study.

From the above **Table I** it is evident that starch extracted from potato was were 66.6% respectively. The grams of starch obtained from potato was 500g respectively out of 750g of potato. It is because of higher starch content than other selected 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 I**

**EXTRACTION OF STARCH FROM POTATO**

|  |  |  |  |
| --- | --- | --- | --- |
| **FOOD SOURCES** | **INITIAL AMOUNT TAKEN (g)** | **GRAMS OF STARCH OBTAINED (g)** | **% OF EXTRACTION** |
| Potato | 750 | 500 | **66.6** |

* 1. PROPERTY ANALYSIS OF POTATO STARCH BASED EDIBLE FILMS

The results of properties of potato starch based edible films that was evaluated by the testing parameters are presented in the Table IV .

* + 1. Thickness of Films:

From the Table-IV it is evident that the results obtained in the study for Variation - 1 (V1) of potato films in triplicates V1A, V1B, V1C showed 0.35, 0.37 and 0.33 thickness respectively and from Variation - 2 (V2) of potato films in triplicates V2A, V2B, V2C showed 0.48, 0.42 and 0.46 thickness respectively for potato starch based edible films Pali et al., (2004).

The results obtained from the study showed that, the higher the glycerol concentrations in the plasticized potato film, the thicker the film. The thickness of the film obtained from the variation -2 was due to the higher amount of glycerol(2ml) was thicker than the potato film obtained from 1.5ml of glycerol films.

* + 1. Tensile Strength:

The tensile strength of the edible films obtained from the Variation - 1 (V1) of potato films in triplicates V1A, V1B, V1C showed 5.82, 5.64 and 5.26 tensile strength respectively. Variation - 2 (V2) of the potato films in triplicates showed 4.56, 4.75 and 4.84 tensile strength respectively. The results obtained from potato based edible films in variations showed that higher the concentration of the plasticisers, the greater the tensile strength of potato based films.

wales et al., (2003) studied that high glycerol content interfered with the arrangement of the polymer chains and the hydrogen bonding, they also decreased the polymer interaction and physical properties of the films included the flexibility of the film, the tensile strength of Variation – 2 of potato starch based edible films increased with increased plasticiser content as the plasticizer.

* + 1. Elongation at break

The elongation at break for potato starch based edible films was evaluated in Table–IV. The values obtained from Variation –1 (V1) of potato films in triplicates V1A, V1B, V1C showed 15.2, 15.8 and 15.6 elongation at break respectively. Variation – 2 of the film (V2) of potato films in triplicates showed 12.8, 12.5 and 12.3 elongation at break respectively.

Pali et al., (2006) reported that strength of potato starch film decreased with, increased plasticity. Thus it could be observed that the edible films formed from high glycerol concentration (2ml) affected the Elongation at break values than the lower glycerol concentration films (1.5ml).

3.2.4. Moisture Content

The moisture content of the potato starch based edible films obtained from Variation - 1 (V1) of potato films in triplicates V1A, V1B, V1C showed 9.89, 9.65 and 9.43 moisture content respectively. Variation - 2 (V2) of potato films in triplicates V2A, V2B, V2C showed 13.9, 13.6 and 13.1 moisture content respectively. The percentage increase in weight was tabulated and that was taken as a measure of the water absorption of film.

Wales et al., (2003) reported that, the moisture content of the edible based films from potato starch was determined for its properties of the films was affected by the moisture content. The high amount of moisture of films that affected the stability of films due to the high glycerol content that affected the moisture content. Thus it could be observed that, high glycerol concentration of 2ml that resulted in the high moisture content than the 1.5ml glycerol based potato films. The moisture content that affected the stability of films due to the high amount of moisture of films.

3.2.5.Moisture Permeability:

The moisture permeability of potato starch based edible films obtained from Variation- 1 (V1) of potato starch based edible films in triplicates V1A, V1B, V1C showed 12.8, 12.6 and 12.3 moisture permeability respectively. Variation – 2 (V2) of the potato starch based edible films in triplicates V2A, V2B, V2C showed 13.9, 13.6 and 13.1 moisture permeability respectively. The values obtained showed that moisture gained from variation1(1.5ml) potato starch based edible films were lower than the Variation - 2 (2ml) potato starch based edible films.

The moisture permeability a major property of edible films that is related to the structural and mechanical properties of film to enhance product integrity and water resistance (Altiok et al., 2010). Moisture gained by 1.5ml glycerol concentration of potato starch based edible film was lower than that gained by 2ml glycerol concentration potato starch based edible film.

3.2.6. Puncture Strength:

The puncture test results obtained from potato starch based edible films was evaluated in the Table - IV. The values obtained from variations of potato starch based edible films from in triplicates V1A, V1B, V1C showed 96.1, 90.9 and 99.9 puncture strength respectively. Variation - 2 of the potato starch based edible films (V2) in triplicates were 94.1, 90.6, and 92.3 respectively.

The results revealed that the potato starch based edible films from higher glycerol concentration of 2ml that resulted in the decreased 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 amount of plasticizers, and to water molecules absorbed by the samples was at a larger rate, a common phenomenon of edible films, as has been revealed by sloka et al., (2004).

**TABLE II**

**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**  **V2A**  **V3A** | 0.35 | 5.82 | 15.2 | 96.1 | 9.89 | 12.8 |
| 0.37 | 5.64 | 15.8 | 90.9 | 9.65 | 12.6 |
| 0.33 | 5.26 | 15.6 | 99.9 | 9.43 | 12.3 |
| **Variation-2 (2g of glycerol)** | | | | | | |
| **V1B**  **V2B**  **V2C** | 0.48 | 4.56 | 12.8 | 94.1 | 13.9 | 14.7 |
| 0.42 | 4.75 | 12.5 | 90.6 | 13.6 | 14.3 |
| 0.46 | 4.84 | 12.3 | 92.3 | 13.1 | 14.9 |

1. **CONCLUSION**

The edible film is found to have rising growth in the present scenario and they contribute to the reduction of waste and reduce the environment load. The edible films the reduce the carbon foot print. The benefits of edible packaging are they can be consumed along with the food as there is no interference of any chemicals as it is purely from natural sources. They also prevent the accumulation of non - biodegradable wastes. These films can be incorporated with bio active compund contributing to the nutritional and therapeutic effects. Thus, Bio based edible films are strong, feasible and toxin free films which is not only favourable for human beings but also protect other living organisms resulting in reducing the environmental pollution. Thus, the present study is a small foot print towards innovation by utilising the excess starch available which is low cost locally available with extra nutritional benefits thus reducing the effect of artificial chemicals that would affect the health by interacting with the food. The roots and tuber based film such as potato that exhibited excellent film making properties.

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