DEVELOPMENT OF ECO FRIENDLY EDIBLE PACKAGING FILMS USING POTATO STARCH

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ABSTRACT

The edible packaging is a new trendsetter in the era of modern packaging. The researchers and food scientist recognise edible packaging as a useful alternative or addition to conventional packaging to reduce waste and to create novel applications for improving product stability. The rice based edible films were developed as an alternative for conventional packages providing the nutritional benefit as when consumed along with the food. The development of rice based edible films, by the extraction of rice starch at lab scale level. The films were developed by the employment of plasticiser at different concentrations of 1.5ml and 2ml. the films developed using glycerol as plasticiser in filmogenic solution 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 rice starch based edible films absorbed less moisture and they also contributed to 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 growth of bacteria and yeasts, but within the permissible limits and standards 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 good functional properties.

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

1. INTRODUCTION

Edible films are defined as a thin layer of material which can be consumed and provides a barrier to moisture, oxygen and solute movement of the food. The material can be a complete food coating or can be disposed as a continuous layer between food components.Edible film packaging is a relatively new and environmental friendly food preservation technique compared to the use of plastic packaging that tends to damage the environment. Edible film that is used to coat food, or 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 additive to enhance the quality of colour, aroma, and texture of the product, as well as to control microbial growth.An edible and biodegradable film is one which is typically produced 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 thereby enhancing the shelf life of coated food. Starch is one of the most frequently used biopolymer for edible films production due to the fact that could be obtained from large number of raw materials, its production costs are cheap, it is renewable and biodegradable biopolymer that has the ability to form films.Starch from different sources has been studied as a potential film-forming agent, including that from potato, barley, wheat, tapioca and rice. Potato starch is used for preparation of biodegradable plastic films. Glycerol is used as a plasticizer in the filmogenic solution to increase the flexibility and plasticity of the film. Antimicrobial, plasticizing and dispersing effect in biodegradable/edible films and to improve the mechanical properties, water vapour permeability and they contribute to the good elongation properties for its possession as good film making properties.The starch films are used as a promising kind of commercial preservation films for extending the shelf of food. 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 synthetics is that they can be consumed with the packaged products. There is no package to dispose even if the films are not consumed they could still contribute to the reduction of environmental pollution.

2. MATERIALS AND METHODS

2.1 RAW MATERIALS

The raw materials required for the study was choosen 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 development of edible films are of low cost sources and they are easily accessible.The purpose of the study is to develop 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 affects the use of film in the formation of the product to be packaged. Thickness of the films was measured using screw gauge. Thickness also affects 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 film thickness to the nearest 0.001 mm. Thickness of each film was measured at room temperature (230C and 45% RH) and expressed as an average of three random measurements.

$$t = m/Ad$$

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

2.2.2. TENSILE STRENGTH

Tensile strength is the maximum tensile force that could be held by a film. It is one of the most important mechanical properties that reflects the maximum stress a film sustains before it eventually breaks. Tensile strength shows the film strength in resisting the mechanical damage. Edible films with high tensile strength are needed for food packaging industry that aims to protect foodstuffs during handling,transporting, and marketing (Pitak and Rakshit 2011).Tensile strength was measured using Universal Testing Machine where the value of tensile strength was determined by dividing the maximum force (F) employed with the surface area (A) of edible films. Tensile strength could be calculated using the following equation (Fransisca et al., 2013).

Principle of Universal Testing Machine:

The principle of operation of the machine is by hydraulic transmission of load from the test specimen to a separately housed load indicator. The system is ideal since it replaces transmission of load: through levers and knife edges. Load is applied by a hydrostatically lubricated ram. Main cylinder pressure is transmitted to the cylinder of the pendulum dynamometer system housed in the control panel. The cylinder of the dynamometer is also of self - lubricating design. The load transmitted to the cylinder of the dynamometer is transferred through leverage to the pendulum. Displacement of the pendulum actuates the rack and pinion mechanism which operates the load indicator pointer and the autographic recorder. The deflection of the pendulum represents the absolute load applied on the test specimen (Mechatronics guide, 2013).

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

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 broken / torn. The measurement of elongations 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 broken to the initial length. The extension percentage of the film could be calculated by equation (Clause et al., 2011)

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

2.2..4. PUNCTURE TEST

Puncture strength test is used to determine the puncture or rupture characteristics of a material. It is measured using puncture tester. Puncture test is generally a compressive test where a material is compressed by a probe or other device until it ruptures. Puncture test was commonly used to determine the strength of a material such as film, rubber ormembrane(oliveretal.,2012).

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

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

2.2.5. MOISTURE CONTENT

The moisture content of the films was determined gravimetrically by oven drying at 105°C until constant weight (dry sample weight).The results can be expressed as a percentage of the initial film weight, according to equation. At least triplicate analyses needed to be performed per variety and formulation (Bennadios et al., 2011).

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

2.2.6. MOISTURE PERMEABILITY

Moisture permeability is determined by the water uptake of the films. Initial weight (W0) of the sample film was measured. Then, the films are soaked in a flask filled with distilled water for 10 seconds. The soaked film was then lifted from the flask and weighed to obtain wet weight (W). The sample was soaked back in the flask, then it was lifted after every 10 seconds and weighed again and again. The procedure is performed continuously until a constant weight of the film is attained. The film saturated with water gives the maximum percentage of moisture permeability. The water absorbed by the film is measured using the formula, (Diosetal.,2012).

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

2.3. METHOD OF EXTRACTION

The starch extraction from the selected plant sources such as rice, wheat, potato and cassava, were carried out using the standard procedures.The method of extarction was similar for all sources. The following procedures such as **peeling, washing, grinding, decanting, sedimenting and drying** were carried out for the extraction of starch from the plant sources.The potatoes (Solanum tuberosum) were selected for making edible films as they are rich in starch, exhibits good binding properties. The binding and sheeting properties of potato is due to the presence of amylose molecules.Potatoes were washed, peeled and shredded and the shreds were crushed using electric blender with distilled water and were strained using finely spaced strainer. To the residue, distilled water was added and strained twice. The mixture was left in the beaker undisturbed until entire starch particles settles down at the bottom. Distilled water is added to the beaker and stirred. Water was gently poured off and decanted 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 tea strainer

↓

Leave the mixture to settle in the beaker for 5 minutes

↓

Decant the water from beaker

↓

White starch settled at the bottom

↓

Add distilled water and stir it

↓

Decant 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 films were prepared by casting technique using a film-forming solution containing potato starch. Glycerol was used as plasticizer. The mixture of dry starch, water and glycerol was taken in a beaker. Distilled water was added to it. Then the required amount of 1g of citric acid was added to the solution. The entire mixture was filtered with the help of muslin cloth. The mixture was mixed with the help of glass rod on hot plate at 400C for 5 minutes. Now the mixture was kept in 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 entire solution was poured on the cast and was left for drying at room temp 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 rice 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

<u>DEVELOPMENT OF POTATO BASED EDIBLE FILMS</u>

Flow chart - 2

3. RESULTS AND DISCUSSION

3.1. EXTRACTION OF STARCH FROM FOOD SOURCES

The starch was extracted from the Starch based sources such as Cereal based and 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 potato starch as a primary source of Starch for making edible based 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 rice, wheat, potato and cassava were 46.7%, 40%, 66.6%, 56% respectively. The grams of starch obtained from rice, wheat, potato, cassava were 350g, 300g, 500g, 420g respectively out of 750g of food sources. Potato shows higher percentage of extraction (500g) compared with other starch sources. It is because of higher starch content than other selected plant based sources as per the literature studies.

The results obtained in the present study are in par with the study conducted by Walstra., (2003) proving that starch was composed of amylose and amylopectin, which was primarily derived from extraction of starch from roots and tubers like potato, with the largest source of starch. Starch is the major carbohydrate reserve in plant tubers and seed endosperm where it is found as granules, each typically containing several million amylopectin molecules accompanied by a much larger number of smaller amylose molecules.

TABLE I

EXTRACTION OF STARCH FROM FOOD SOURCES

FOOD SOURCES	INITIAL AMOUNT TAKEN (g)	GRAMS OF STARCH OBTAINED (g)	% OF EXTRACTION
Rice	750	350	46.7
Wheat	750	300	40
Potato	750	500	**66.6**
Cassava	750	420	56

3.2. PROPERTY ANALYSIS OF POTATO BASED STARCH FILMS

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

3.2.1. 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 due to the higher amount of 2ml of glycerol was thicker than the rich film obtained from 1.5ml of glycerol films.

3.2.2. Tensile Strength:

The tensile strength of the potato starch based edible films obtained from the Variation - 1 (V1) of potato films in triplicates V1A, V1B, V1C of potato films in triplicates 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 for potato based edible films showed that higher the concentration of the plasticisers, the less 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 cohesiveness and they most likely affected the crystallinity and other physical properties of the films included the flexibility of the film, the tensile strength of Variation – 2 of potato starch based edible films decreased with increased plasticiser content as the plasticizer.

3.2.3. 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, whereas plasticity increased. Thus it could be observed that the 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 potato starch edible based films as 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 films in triplicates V1A, V1B, V1C showed 12.8, 12.6 and 12.3 moisture permeability respectively. Variation – 2 (V2) of the potato 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 films were lower than the Variation - 2 (2ml) wheat films.

The moisture permeability a major property of films that is related to the structural and mechanical properties of film and the presence of components in the films, since potential applications may require water insolubility to enhance product integrity and water resistance (Altiok et al., 2010). Moisture gained by 1.5ml glycerol concentration of potato film was lower than that gained by 2ml glycerol concentration potato film.

3.2.6. Puncture Strength:

The puncture test of potato starch based edible films was evaluated in the Table-IV. The values obtained in the study from Variation - 1 (V1) of potato films in triplicates V1A, V1B, V1C showed 96.1, 90.9 and 99.9 puncture strength respectively. Variation - 2 of the film (V2) and the triplets of potato films are 94.1, 90.6, and 92.3 from triplets of potato films respectively.

The results revealed that the higher glycerol concentration of 2ml that resulted in the decreased puncture strength of potato film than the 1.5ml glycerol concentration of potato films, the reduction of the puncture force was observed as the consequences of the incorporation of plasticizers, and to water molecules absorbed by the samples, a common phenomenon of edible films, as has been revealed by sloka et al., (2004).

TABLE II

PROPERTIES OF BASED POTATO STARCH 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

4. CONCLUSION

The global edible films and coatings market is expected to witness steady growth owing to increased use of clean label strategies by food producers. The reason for the bump in the growth of edible films and coatings in their use as an excellent solution to reduce the carbon foot print. The benefits of edible packaging are increased their acceptability by the food and packaging manufacturers and this factor is boosting revenue growth of the global edible films and coating market. Thus, the biobased 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 edible films thus produced can be consumed along with the food as there is no interference of any chemicals as it is purely from natural sources. The roots and tuber based film such as potato that exhibited excellent film making properties .

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