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DEVELOPMENT OF ECO FRIENDLY EDIBLE PACKAGING FILMS USING CASSAVA STARCH

***Rasikha, ** Dr.PA. Raajeswari,**

***Assistant Professor, Department of Food Science and Nutrition, Dr. N.G.P. Arts and Science College,**

**** Associate professor (SG), Department of Food Science and Nutrition, Avinashilingam Institute for Home Science and Higher Education for Women.**

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 Cassava starch 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 cassava strach based edible films, by the extraction of cassava starch at lab scale level. The cassava starch films were developed by the incorporation of plasticiser at different concentrations of 4ml and 5ml. 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 attributed to the low moisture permeability in relation with glycerol content, and they exhibited high tensile strength. The cassava starch films were firm and white in colour. There was a limited growth of bacteria and yeasts, but according to safe limits. i.e., 15cfu/gm in combination of both different glycerol concentration of cassava edible films as 7.4cfu/gm in 4ml concentration and 8.6cfu/gm in 5ml concentration of glycerol in cassava starch based films. The cassava films developed out of cassava when observed highlighted that the moisture content of cassava films were less and they tend to exhibit excellent functional properties.

Key words: Edible films, glycerol, plasticiser, cassava 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 includeswheat, 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.

2. 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 is operated by a standard principle that hydraulic transmission of load from the edible film to a separately housed load indicator. The system is said to be 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 are 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).

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

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 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)

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

2.2.4. PUNCTURE TEST

Puncture strength test is used to determine the puncture characteristics of a edible film. Puncture test is generally a compressive test where a edible film produced from cassava 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).

$$\text{Puncture test} = \frac{F_{max}}{A_{cs}}$$

Fmax is the maximum applied force, A**cs** is the cross sectional area of the edge of the cassava 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 cassava starch based edible films (Bennadios et al., 2011).

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

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).

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

2.3. METHOD OF EXTRACTION

The starch was extracted from the selected natural source such as cassava 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 cassava. The cassava (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 cassava is due to the composition of amylose and amylopectin molecules. cassava 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 cassava Peeling of cassava Grating of cassava

Grinding of cassava 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

cassava starch settled at the bottom Add distilled water and stir it Drain the water from the beaker cassava

starch obtained

<u>EXTRACTION OF CASSAVA STARCH</u>

Flow chart - 1

2.4. DEVELOPMENT OF CASSAVA STARCH BASED EDIBLE FILMS

The films were prepared using casting technique. Glycerol was used as a plasticiser. Solutions with glycerol were prepared in different concentrations (4ml, 5ml/100g of starch) and the concentration of starch was kept constant. The resulting mixture solution was heated in sealed conical flasks on a hotplate under continuousstirring to gelatinize starch completely. When the dispersions achieved a temperature of 850C (20% above of the gelatinization temperature) were retired of heat. Subsequently the solutions were cooled at room temperature for around 1 hour to permit that bubbles inside the solution to get dissolved. Cassava starch films were prepared by casting the starch solution in glass Petri dishes. A certain amount of the mixture poured and spreaded on the petri dishes and dried in a convection oven at 280C for 36 hours. After films were separated from the petri dish, translucent films can be seen. The cassava starch based edible films were developed with thedifferent concentration of glycerol such as 4ml and 5ml and analysed for the properties of different concentrations of cassava starch based edible films (J. N. Ezenwanne., 2013).

Cassava starch

↓

Glycerol was added to the cassava starch (4ml and 5ml of glycerol)

↓

Adding water to cassava starch Mixing and heating in the hot plate at 850C

↓

Remove from the hot plate

(after reaching gelatinisation temperature reached) Cooling at room temperature for 1 hour

↓

Pouring of mixture into petri dishes Place in convention oven for 280C for 36 hours

↓

Removal of cassava films from petri dishes

↓

DEVELOPMENT OF CASSAVA STARCH BASED EDIBLE FILMS

Flow chart - 2

3. RESULTS AND DISCUSSION

3.1. EXTRACTION OF EDIBLE STARCH FROM CASSAVA

The edible starch was extracted from the Starch based sources such as Tuber based sources and the yield of starch extraction from the cassava was higher than the other sources. The study that concentrated on use of starch extracted from cassava 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 56% respectively. The grams of starch obtained from potato was 420g 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 cassava.

TABLE I

EXTRACTION OF STARCH FROM CASSAVA

FOOD SOURCES	INITIAL AMOUNT TAKEN (g)	GRAMS OF STARCH OBTAINED (g)	% OF EXTRACTION
Potato	750	420	**56**

3.2. PROPERTY ANALYSIS OF CASSAVA STARCH BASED EDIBLE FILMS

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

Thickness of Films:

From the Table-IV it is evident that the results obtained in the study for Variation - 1 (V1) of cassava starch based edible films in triplicates V1A, V1B, V1C showed 0.54, 0.53 and 0.52 thickness respectively and from Variation - 2 (V2) of potato films in triplicates V2A, V2B, V2C showed 0.78, 0.75 and 0.72 thickness respectively for cassava starch based edible films wang et al., (2008).

The results obtained from the study showed that, the higher the glycerol concentrations in the plasticized cassava starch film, the thicker the film. The thickness of the film obtained from the variation -2 was due to the higher amount of glycerol(5ml) was thicker than the cassava film obtained from 4ml of glycerol films.

3.2.1. Tensile Strength:

The tensile strength of the edible films obtained from the Variation - 1 (V1) of cassava films in triplicates

V1A, V1B, V1C showed 4.89, 4.65 and 4.43 tensile strength respectively. Variation - 2 (V2) of the potato films in triplicates showed 2.74, 2.45 and 2.26 tensile strength respectively. The results obtained from cassava based edible films in variations showed that higher the concentration of the plasticisers, the greater the tensile strength of cassava based films.

Bertuzzi 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 cassava starch based edible films increased with increased plasticiser content as the plasticizer.

3.2.2. Elongation at break

The elongation at break for cassava starch based edible films was evaluated in Table – IV. The values obtained from Variation –1 (V1) of cassava starch based edible films in triplicates V1A, V1B, V1C showed 13.5, 15.8 and 13.6 elongation at break respectively. Variation – 2 of the film (V2) of cassava starch based edible films in triplicates showed 10.2, 10.6 and 10.3 elongation at break respectively.

Wong et al., (2008) reported that strength of cassava starch based edible films decreased with, increased plasticity. Thus it could be observed that the edible films formed from high glycerol concentration (5ml) affected the Elongation at break values than the lower glycerol concentration films (4ml).

3.2.3. Moisture Content

The moisture content of the cassava starch based edible films obtained from Variation - 1 (V1) of cassava starch based edible films in triplicates V1A, V1B, V1C showed 10.9, 10.6 and 10.2 moisture content respectively. Variation - 2 (V2) of cassava starch based edible films in triplicates V2A, V2B, V2C showed 13.7, 13.4 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.

Bettuzzi et al., (2007) reported that, the moisture content of the edible based films from cassava 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 5ml that resulted in the high moisture content than the 4ml glycerol based cassava films. The moisture content that affected the stability of films due to the high amount of moisture of films.

3.2.4. Moisture Permeability:

The moisture permeability of cassava starch based edible films obtained from Variation- 1 (V1) of cassava starch based edible films in triplicates V1A, V1B, V1C showed 14.9, 14.5 and 14.2 moisture permeability respectively. Variation – 2 (V2) of the cassava starch based edible films in triplicates V2A, V2B, V2C showed 11.8, 11.4 and 11.1 moisture permeability respectively. The values obtained showed that moisture gained from variation1(4ml) cassava starch based edible films were lower than the Variation - 2 (5ml) cassava 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 (Alves et al.,

2006). Moisture gained by 4ml glycerol concentration of cassava starch based edible film was lower than that gained by 5ml glycerol concentration cassava starch based edible film.

3.2.5. Puncture Strength:

The puncture test results obtained from cassava starch based edible films was evaluated in the Table - IV. The values obtained from variations of cassava starch based edible films from in triplicates V1A, V1B, V1C showed 147.7, 145.3 and 148.6 puncture strength respectively. Variation - 2 of the cassava starch based edible films (V2) in triplicates were 125.9, 128.4, and 126.7 puncture strength respectively.

The results revealed that the cassava starch based edible films from higher glycerol concentration of 5ml that resulted in the decreased puncture strength than the 4ml 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 sobral et al., (2001).

TABLE II

PROPERTIES OF CASSAVA STARCH BASED EDIBLE FILMS

CASSAVA	Thickness of Films (mm)	Tensile strength (g force)	Elongation at Break (%)	Puncture Test (g force)	Moisture Content (g)	Moisture Permeability (%)
Variation-1(4ml of glycerol)						
Ca1 Ca2 Ca3	0.54	4.89	13.5	125.9	10.9	14.9
	0.52	4.65	13.8	128.4	10.6	14.5
	0.53	4.43	13.6	126.7	10.2	14.2
Variation-2 (5ml of glycerol)						
Cb1 Cb2 Cb3	0.78	2.74	10.2	147.8	13.7	11.8
	0.75	2.45	10.6	145.3	13.4	11.4
	0.72	2.26	10.3	148.6	13.1	11.1

4. 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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