IJMPR 2022, 6(1), 01-05

International Journal of Modern Pharmaceutical Research
www.ijmpronline.com

ISSN: 2319-5878
IJMPR
Research Article
SJIF Impact Factor: 5.273

EVALUATI0N OF THERMOPLASTICS DERIVED FROM CASSAVA STARCH ON SHELF-LIFE ELONGATION OF TOMATO FRUITS

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Received on: 27/11/2021
Revised on: 17/12/2021
Accepted on: 07/01/2022

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ABSTRACT

Bioplastics are plastics of plants origin that are fully bio-based and biodegradable. The aim of this study is to extend the shelf life of tomato fruits by coating it with derivatives from glycerol-plasticized thermoplastic cassava (*Manihot esculentus*) starch. Starch extracted from cassava was used to prepare thermoplastic edible coating film forming solution using 1.25 g starch, 2.5% acetic acid and 50% (weight of dry starch) glycerol as plasticizer. Prior to coating, the mechanical and physicochemical properties determined on the thermoplastic starch are: Tensile strength, Elongation at break, Water uptake, oil uptake and moisture uptake. Tomato fruits were coated with the prepared thermoplastic starch solution and 0.0015% sodium hypochlorite (positive control) and the shelf lives were evaluated for 30 days and compared with uncoated tomato fruits (negative control). The results obtained signifies that the thermoplastic starch derivatives prepared from cassava starch markedly extended the shelf life of tomato fruit as compared to 0.0015 % sodium hypochlorite by 17 days.

KEYWORDS: Thermoplastic Starch, Tomatoes Fruit, Shelf-life Extension, Edible-coating, Cassava Starch.

INTRODUCTION

Plastics made from renewable resources (plants like corn, potatoes, cassava and algae) that are fully bio-based, and/or biodegradable or compostable are called bioplastics. Cassava is a crop rich in starch and hence used for production of bioplastic. Other starch-rich natural and renewable feedstock successfully used for bioplastic production include pea starch, corn starch, potato starch, fruit and vegetable peels, vegetable fats and oils or microbiota.[1] Consumers usually accept fresh food on the basis of their appearance and organoleptic characteristics, but when the shelf-life is low, it represents a clear problem for their commercial distribution. The increasing interest for fresh-cut fruits consumption has resulted in the development of physical technologies to extend their shelf-life.[2] The traditional method of storage at low temperatures to slow down the fruits metabolism can be used in combination with other strategies, being modified atmosphere packaging (MAP), thermal treatments (blanching and heat-shock), irradiation, UV light and edible films and coatings are the most common preservation methods.[2] Among all these methods, the direct application of edible coatings onto the surface of fresh-cut horticultural products is one of the most studied possibilities. In particular, starch coatings have been widely evaluated for this purpose due to their good oxygen and carbon dioxide barrier, their ability to retard lipid migration and moisture loss while maintaining the sensory and quality of food.[3]

Edible coatings over fruits are used to improve their quality and shelf life.[4] These can also be safely eaten as part of the product and do not add unfavorable properties to the foodstuff.[5] Edible coatings or films can increase the shelf life of tomato fruits and are environment friendly. In recent years, new edible films and coatings have been developed with the addition of various edible herbs and antimicrobial compounds to preserve fresh fruits.[6] Edible coatings prevent loss of firmness and moisture, controls maturation, development and respiratory rate. It also prevents oxidative browning and decrease growth of microorganism in fruits and vegetables for example, Tomato, Cucumber, and Cherries etc.[4] The main purpose of edible coating for fruits is basically to increase the natural barrier, if already present and to replace it in the cases where handling and washing have partially removed or altered it. Moreover, one of the most important things of this edible coating is the fact that they can be eaten together with the fruits and vegetables.[5] Edible coating or edible films provide aesthetic appearance and smooth feel to fruits and vegetables. The aim of this study is to extend the shelf life of tomato fruits by coating it with derivatives glycerol-plasticized thermoplastic cassava starch.

MATERIALS AND METHOD

Materials

Cassava (*Manihot esculentus)* was purchased from Sokoto local market, in Sokoto State, Nigeria. Tomatoes (*Leucopasicum esculentum*) were harvested at mature stage and were carefully selected to be uniform in appearance (weight, shape and colour) and free from any defect. Each fruit was washed with cold water and blotted with towels and allowed to dry in ambient temperature of 30°C. They were then identified as ROMA, at Herbarium in Biology Department of Usmanu Danfodiyo University Sokoto, Nigeria with the voucher number NSA/UI/153. All other chemicals used in this study were of analytical grade and were used without further purification.

Methods

Extraction of Starch

Clean cassava tubers were washed, peeled and grated. The resulting paste was mixed with water and the solution was filtered on a clean cloth. The collected filtrate was then allowed to stand for 6 hours followed by the removal of the supernatant. The white precipitate (starch) was then recovered. The crude starch was purified by using centrifuge at 4000 rpm for 10 minutes. The sediment obtained was further dispersed with 100 cm^3 of distilled water and centrifuged to obtain the pure starch which was then dried in an oven at 50 ^0C to obtain white powder. The starch powder was stored in polyethylene containers at room temperature.[7]

Preparation of Cassava Thermoplastic Starch (TPSc) Films

Method described by Wissinger *et al.*,[8] with little modification was adopted. To the beaker of 100 cm^3 volume, 1.25 g of starch, 50.00 cm^3 of distilled water, 1.2 cm^3 of 5% Acetic acid and 50% (to the weight of the dry starch) glycerol was added as Plasticizer. The mixture was stirred continuously while heating slowly on a hot plate using a magnetic stirrer at a rate of 120 rpm for 10 min. This makes the mixture to boil gently. The mixture started out white in coloured suspension and changes to transparent or translucent and thickens. As the initial white colour of the starch was completely gone and the mixture had gelatinized, the heat was removed. The prepared thermoplastic starch solution was casted by pouring into dried and labeled Petri-dish and dried in an oven at 50^o C for 24 hours.

Determination of Physical Properties of Thermoplastic Starch

Water uptake

The water absorption measurement was carried out at room temperature using ASTM.[9] Dried thermoplastic starch sample was cut into 10 x 10 mm^2 and weighed for initial weigh. The moisture absorption data of thermoplastic starch was obtained by dipping the samples in a water bath containing distilled water for 24 hours at ambient temperature. After that, the samples were removed and wiped off and immediately weighed again as final weight. The water absorption capacity of the thermoplastic starch was calculated using equation (1). The method was replicated three times.

$$\% \text{ Water uptake} = \frac{Final\ weight - Inintial\ weight}{Final\ weight} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Oil Uptake Capacity

Oil uptake was determined using the same method described for water uptake but with arachis oil as the dipping medium. However, the sample was excited and rinsed with absolute ethanol to remove the excess oil, and allowed to dry on a clean filter paper for 10 minutes. The oil uptake of the samples was calculated in percentage by the equation (2) below. The method was replicated three times.

$$\% \text{ Oil Uptake} = \frac{wet\ weight - dry\ weight}{wet\ weight} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (2)$$

Moisture uptake

Two grams of the sample was weighed accurately and placed over the surface of a 70 mm tarred Petri dish. The sample was placed in a large desiccator containing distilled water in its reservoir at room temperature and weight gained by the samples at the end of five days was recorded and the percentage amount of water sobbed by the samples was calculated from the weight differences as seen in equation (3). The method was replicated three times.

$$\% \text{ Moisture uptake} = \frac{Final\ weight - Inintial\ weight}{Final\ weight} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (3)$$

Determination of Mechanical properties

Tensile strength

Tensile strength was performed by elongating the specimen and the load carried by the specimen before breaking was measured. It was calculated by dividing the maximum load by the original cross-sectional area of the specimen as shown in equation. (4) The method was replicated three times.

$$\text{Tensile strength } (MPa) = \frac{F(N)}{A(m)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(4)$$

Where F= measured load before breaking and A = cross-sectional area of the specimen (length x breath).

Elongation at break

Elongation is the percentage increase in length that occurred before the specimen was broken under tension, and can be calculated using the following equation (5). The method was replicated three times.

$$\text{Percentage Elongation} = \frac{L-Lo}{L} \times 100 \text{ -- } (5)$$

Where L is the final length of specimen before breaking and Lo is the initial length of specimen.

Biodegradability Test

The method described by Khoramnejadian *et al.*, (2013) was adopted in testing the biodegradability of resulted thermoplastic starch. The specimen was cut into pieces of 4.0 cm^2. 500 g of soil (having slight moisture content) was collected and stored in a 1000 cm^3 conical flask. Each sample was buried inside the soil at a depth of 2 cm for 7 days under the conditions of the laboratory. The weight of the specimen was measured before and after the testing. The biodegradability test was measured by using Equation (6). The method was replicated two times.

$$\text{Soil biodegradation } (\%) = \frac{Wf-Wi}{Wi} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where: *Wi* and *Wf*, is the initial and final weight of samples.

Thermoplastic Starch Coating of Tomatoes and Shelf life Evaluation

Nine pieces of tomato fruits were selected and grouped into three groups of three tomato fruits each, the first group of the samples were dipped into the prepared coating emulsions for 1 min and drained. Second group of tomatoes were used as positive control samples and were immersed in already prepared 0.015% sodium hypochlorite solution for the same duration of time and the third group were neither coated nor dipped into sodium hypochlorite solution but were washed with distilled water and used as negative control. The treated, positive and negative control tomato samples were dried in ambient conditions for 2 hours. After setting, the tomato samples were stored at ambient conditions in the laboratory for experimental study. The shelf life extension of the tomatoes samples were tested by recording the weight loss for every 3 days interval for 30 days. Observations were made to evaluate the number of days taken for the tomatoes to deteriorate and loose half of its original weight, Physical and subjective data was taken from the population of tomato fruits during the storage period and were compared with the initial weights of the samples to get the percentage weight loss, and calculated using the formula.

$$\text{Percentage weight lost} = \frac{Wf-Wi}{Wi} x\ 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Where: Wi and Wf =initial and final weight respectively.

RESULTS AND DISCUSSION

Characterization of Cassava Thermoplastic Starch

Before coating tomatoes with bioplastic films, several parameters should be employed to analyze the resulted bioplastic in order to know its quality as regard to the application that it is made upon. The parameters that are usually used to analyze a bioplastic are measured such as; tensile strength, elongation at break, moisture uptake, oil uptake and water uptake. These are the most important physical properties of bioplastic for most applications, and are summarized in Table 1.0 below.

Table 1.0: Characterization of Cassava Thermoplastic Starch.

Mechanical/physicochemical properties	**Numerical Values**
Tensile strength (Mpa)	549.67 ± 1.24
Elongation at break (%)	50.00 ± 2.65
Water uptake (%)	83.50 ±1.32
Oil uptake (%)	1.30 ± 0.05
Moisture uptake (%)	58.00 ±1.51

All the numerical values are calculated as Mean ± Standard Deviation of triplicate analysis.

Biodegradable properties

Table 2.0 shows the weight loss experienced by cassava thermoplastic starch after 7 days soil burial test. The weight loss of bioplastic sheets during burial in soil indicates the amount of degradation in natural environment by action of microorganisms. The starch content consumed by soil microorganisms will break the polymer chain thus cause the biodegradation.[10] Table 2.0 showed the initial and final mass of cassava thermoplastic starch that was determined and compared with the conventional petroleum-based plastic.

Table 2.0: Biodegradation Analysis of TPSc with the Conventional Plastic.

Mass of cassava thermoplastic starch (TPSc)				Mass of petroleum-based plastic		
	Ini. (g)	Fin. (g)	Wt. loss (%)	Ini (g)	Fin.(g)	Wt. loss (%)
1	1.08	0.72	33	1.00	0.00	0.00
2	1.12	0.69	38	1.00	0.00	0.00
Avrg.	1.10	0.71	36	1.00	0.00	0.00

The percentage weight loss of cassava thermoplastic starch was found to be 36%, This indicates that 36% of the thermoplastic starch have been consumed by microorganisms in the soil after 7 days, i.e for every 1 g of cassava thermoplastic starch, 36% are degraded in seven days, this can be concluded that 100 % of it would be degraded completely after 3 weeks in soil.[11]

Shelf life Evaluation

Shelf life is an important issue for tomato, and it varies from variety to variety. The variety used for this work has been identified as ROMA, and from the literature the specie ROMA has the shelf life that ranges from 10 to 14 days under normal condition of temperature and pressure Sinha *et al.*,[12] The cassava thermoplastic starch film coated tomatoes showed extended shelf life by 17 days over controls. The increase in shelf life was probably due to the reduction of various gaseous (O_2 and CO_2) exchange from the inner and outer atmosphere. This was similar to the result observed by Yantarasri *et al.*[13] and Alves *et al.*[14] The longest and shortest shelf lives were observed in the first and third groups respectively as shown in figure 1.0 below.

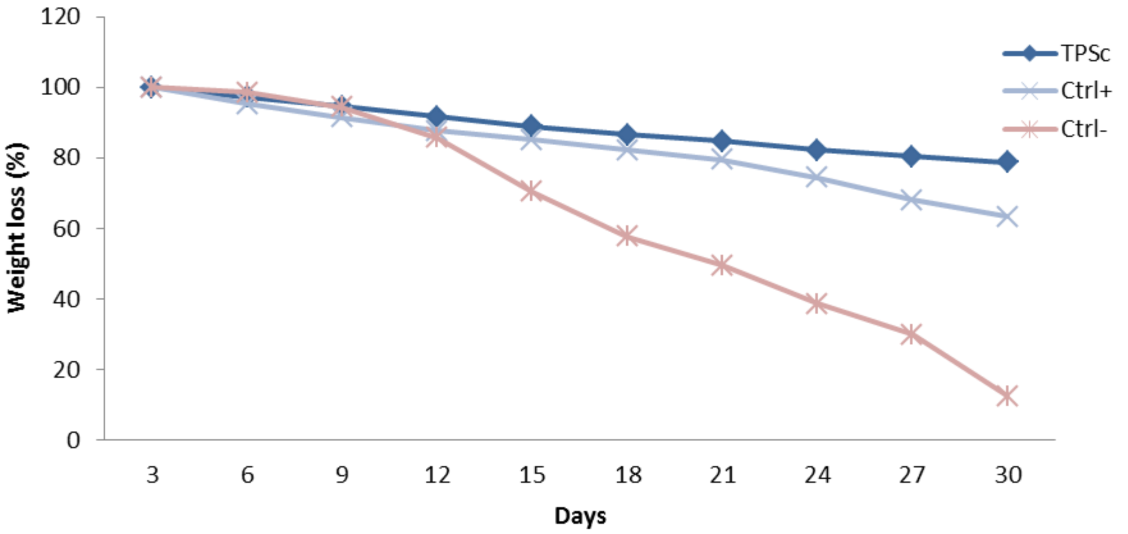

Fig 1.0: Rate of Weight loss of Tomatoes Coated with Thermoplastic cassava Starch and Sodium Hypochlorite.

Figure 1.0 shows the weight loss in percentage of tomato fruits coated with thermoplastic cassava starch with respect to time in days, it can be observed from the figure that the initial weight of the coated samples and controls were 100% for the first three days of experimental study. There was no significant difference in weight loss between 3 – 9 days for all samples but subsequently, the uncoated tomato showed a drastic fall in weight (about 80%) for the 30 days period as compared to TPSc and sodium hypochlorite treated tomato which had 12% and 30% weight loss respectively.

CONCLUSION

Edible thermoplastic starch obtained from cassava tubers extended the shelf life of tomato fruits as compared to the conventional method of sodium hypochlorite and could be a remedy for cheap and effective tomato fruit preservation.

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