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SHELF-LIFE EXTENSION OF TOMATO FRUITS USING THERMOPLASTICS FROM SWEET POTATO STARCH (*Ipomoea batatas*)

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ABSTRACT

Bioplastics are plastics made from plants that are fully bio-based and bio compostable. The study is aimed to extend the shelf life of tomato fruit by coating with a thermoplastic starch film made from sweet potato starch. Thermoplastic edible coating films were prepared and used to coat the tomato fruits. The shelf lives were evaluated for 30 days. Sweet potato thermoplastic starch was prepared with 1.25g of starch extracted from sweet potato tubers, 2.5 % and 50 % acetic acid and glycerol respectively of the weight of dry starch. The characterization of sweet potato thermoplastic starch was conducted and the parameters analyzed and results obtained were: Tensile strength (1285 Mpa), Elongation at break (30 %), moisture uptake (49 %), oil uptake (0.2 %) and water uptake (35.5 %). The shelf-life of tomatoes coated with sweet Potato thermoplastic starch (TPSp) formulation was extended by 20 days over controls.

Keywords: Edible-coating, Shelf-life extension, Thermoplastic Starch, Tomatoes fruit

INTRODUCTION

The shelf life of food is defined as the time taken for a stored product to remains suitable for consumption and is normally determined by the degree of softening, wrinkling and deterioration of fruit. The most important traits for commercially grown tomatoes is the post-harvest shelf life which can be shortened as a result of rapid over-ripening caused by various factors such as changes in temperature and exposure to pathogens (Dang and Yoksan, 2014). The most widespread and tricky problem in food industry is how to maintain and control fresh quality, growth of spoilage and pathogenic microorganism in fresh cut fruit like tomato. The way out to this problem is edible coating (Rojas-Grau *et al.,* 2007). Edible coating provides an extra protective covering for fresh fruits and vegetables. Thermoplastic edible coatings or edible films has been used for centuries in preserving food products in the food industry. (Jamie, 2012) Edible coatings have been used in China since 12th century. The invention of waxing on fruits was not until 1922, which was the first time it was commercially applied on fruits and vegetables (CPMA, 2019). Recently, various edible coatings were applied successfully for preserving fruits and vegetables such as orange, apples, grapefruit, cherries, cucumber, strawberry, tomato and capsicum (Salleh, 2013). Preservation of tomato's quality at any time in marketing is one of the major difficulties when the fruit is stored at ambient temperature. Pathogen attack is a great constraint in the spoilage of tomato in storage. Many fungi and bacteria cause deterioration in the fruits and result in a massive loss of quantity and quality of the tomato fruits (Patel and Patel, 1991). So, it is very important to reduce post-harvest losses of tomato along the supply chain.

Starch is used as a first material for a broad range of green materials. Starch is a very important source for the development of biodegradable plastic edible coating (Sharma, 2017). Virtually all biodegradable plastics available in the market are been made from either starch-based material (slightly modified starch, alone or cross-linked with natural or synthetic biodegradable polymers) or from polylactic acid which originates from the fermentation of a starch feedstock (Bastioli, 2001).

Native starch is not suitable as a packaging material, because it cannot be shaped into films with enough mechanical properties (high percentage elongation and tensile strength) and is too sensitive to water. Therefore, starch must be modified, either by plasticization, blending with other materials, chemical modification or combinations of them before they can be applied as biodegradable plastics (Ali, 2015). In order to reduce the post-harvest losses of tomatoes, numerous means of storage techniques were investigated in this research

MATERIALS AND METHODS

Materials

Sweet potato was purchased from Shehu shagari central market, in Sokoto state, Nigeria. Tomatoes (*Leucopasicum esculentum*) were harvested at mature stage and cautiously selected to be uniform in appearance (colour, weight and shape) and free from any defect. Each fruit was washed with cold water and disinfected with 0.5 % sodium hypochlorite solution, and blotted with towels and allowed to dry in ambient temperature of 35 °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.

Extraction of Starch from Sweet Potato Tubers

Sweet potato tubers were washed, peeled and grated. The resulting pastes were mixed with water and the solutions were filtered on a clean muslin 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 ^oC to obtain white powder. The starch powder was stored in polyethylene containers at room temperature (Musa *et al.,* 2013).

Preparation of thermoplastic starch films

Method described by Wissinger *et al.,* (2016) was adopted. To a 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 180 rpm for 10 min. This brings the mixture to a gentle boil. The mixture started out white in colored suspension and changes to transparent or translucent and thickens. As the initial white color of the starch was completely gone and the mixture had gelatinized, the heat was removed. The prepared thermoplastic starch solutions were casted by pouring into dried and labeled Petri-dishes and were 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 2004). Dried thermoplastic starch sample was cut into 10 x 10 mm^2 and weighed (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 (final weight). The water absorption capacity of the thermoplastic starch was calculated using equation (1). The procedure was done in triplicate.

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

Oil Uptake Capacity

Oil uptake was determined using the same method as described for water uptake but with arachis oil as the dipping medium. However, the samples were 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 procedure was done in triplicate.

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

Moisture uptake

Two grams of the potato thermoplastic starch was weighed accurately and placed over the surface of a 70 mm tarred Petri dish. The samples were 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 procedure was done in triplicate.

% Moisture uptake

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

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 procedure was done in triplicate.

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

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 breaks under tension, and can be calculated using the following equation (5). The procedure was done in triplicate.

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

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 specimens were cut into pieces of 4.0 cm^2. Soil having slight moisture content (500 g) 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) and result was compared to conventional petroleum base plastic. The procedure was done in triplicate.

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

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 tomato's samples was 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.

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

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

RESULTS AND DISCUSSION

Characterization of Potato Thermoplastic Starch

Moisture uptake, tensile strength, oil uptake, elongation at break, and water uptake are the most important physical properties of bioplastic for most applications, and are summarized in Table 1.

Table 1: Results for the characterization of sweet Potato thermoplastic starch

Mechanical/physicochemical properties	Numerical Values
Tensile strength (Mpa)	1285.1 ± 5.10
Elongation at break (%)	30.00 ± 2.00
Water uptake (%)	49.00 ± 1.50
Oil uptake (%)	0.20 ± 0.26
Moisture uptake (%)	35.50 ±1.20

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

Biodegradable Properties

Table 2 shows the weight loss experienced by potato 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 split the polymer chain thus cause the biodegradation (Khoramnejadian *et al.,* 2013). Table 2.0

showed the initial and final mass of potato thermoplastic starch that was determined and compared with the conventional petroleum-based plastic.

Table 2: Biodegradation Analysis of Potato Thermoplastic starch with the Conventional Plastic

Mass of Potato thermoplastic starch (TPSc)				Mass of petroleum-based plastic		
	Ini. (g)	Fin. (g)	Wt. loss (%)	Ini (g)	Fin.(g)	Wt. loss (%)
1	1.05	0.69	34	1.00	0.00	0.00
2	1.20	1.06	12	1.00	0.00	0.00
Avrg.	1.13	0.88	23	1.00	0.00	0.00

The percentage weight loss of sweet potato thermoplastic starch was found to be 23 % (i.e., in every 1 g of sweet potato thermoplastic starch, 23 % are degraded after seven days) the remaining 77 % of the thermoplastics will still be in the soil for the main time before it finally degrades with time. this can be concluded that 100 % of it would be degraded completely after 4 weeks and 3 days in the soil (Moongngarm, 2013).

Shelf-life Evaluation

Shelf life is an important issue for tomato, and it varies from variety to variety. The variety used for this work was identified as ROMA, and from literature the specie ROMA have the shelf life range from 10 to 14 days under normal condition of temperature and pressure (Sinha *et al*., 2005). The coated tomato samples (group 1) showed extended shelf life by 20 days over controls. The increase in shelf life was possibly due to the reduction of various gaseous (O_2 and CO_2) exchange from the inner and outer atmosphere. This was similar to the finding of Yantarasri *et al.* (1994) and Alves *et al.* (2007). The shortest and longest shelf lives were observed in group 3 and group 1 respectively as shown in Figure 1.

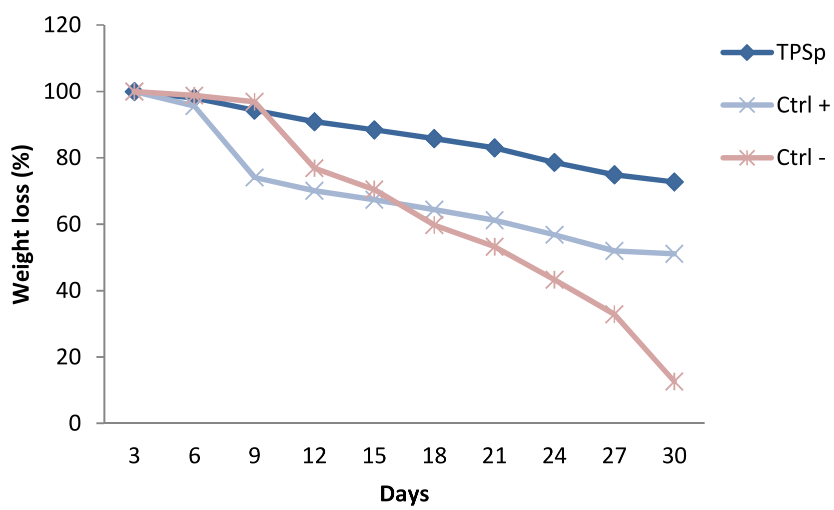

Figure 1: Weight loss of Tomatoes Coated with Thermoplastic potato Starch with respect to time.

Figure 1 showed the weight loss in percentage of tomato fruits coated with sweet potato thermoplastic 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 % from the first three days of experimental study up to 9 days where the weight reduced to 98 %, but negative control loosed about 10 % of its weight from 9 days to 12 days. From 12 to 27- and 30-days negative control was found to loosed weight drastically of about 80 %, while coated and positive control samples loosed only 12 and 30 % respectively. This indicates that sweet potato thermoplastic starch edible coating is the best method for the shelf-life extension of fruits and vegetables.

CONCLUSION

Edible thermoplastics obtained from sweet potato starch are suitable alternative to other form of tomato preservation in leu of its observed ability to extend the shelf life of tomato fruits as compared to the conventional method of sodium hypochlorite.

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