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Effect of Coconut Husk Based Carboxymethyl Cellulose and Commercial Based Carboxymethyl Cellulose for Post-Harvest Preservation of Tomato Fruits

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ABSTRACT: Plant-derived biomass such as lignocellulosic materials is a key input for many biotechnological applications and a secure, sustainable and renewable source of energy for the present and beyond. This research work investigated the effect of Coconut Husk based Carboxymethyl Cellulose (CMC_{CH}) and Commercial based Carboxymethyl Cellulose (CMC_{COM}) for post-harvest preservation of tomato fruits for 40 days in ambient temperature. Standard techniques were used to measure changes in quality parameters during the preservation period. The results showed that coated tomato fruits showed delay in weight loss, increased lycopene content and sugar-acid level. A change in pH level, Total Soluble solid and Titratable acidity was also observed. This suggests that using Carboxymethyl cellulose from coconut husks can extend shelf life of tomato fruits for 40 days with minimal quality deterioration.

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Lignocellulose is the most widely available renewable carbon sources in the world, mainly consisting of cellulose, hemicellulose and lignin. Through hydrolysis, cellulose and hemicellulose can be broken down into sugars which can then be used to create valuable products such as biochemicals, biofuels, and biopolymers. Due to the high nutritional content and health promoting components of tomatoes, they are one of the most commercialized fruits. In other to reduce its perishability, plastic packaging materials are employed to store tomatoes because they have a limited shelf life. However, the need for eco-friendly packaging and depletion of non-renewable natural resources used to make plastics necessitated the search for other solutions. Fruits can now be effectively and environmentally friendly protected from microbiological spoilage, chemical and physical deterioration with edible coatings. Edible films and coatings are promising technology to maintain food quality, safety and improve functionality. They have to meet many requirements, including good organoleptic acceptability, barrier properties, mechanical strength; biochemical, physio-chemical and microbial stability as well as being safe for human consumption; non-polluting and affordability. Besides their preservative properties, edible coatings are formulated with additives such as antioxidants, flavorings and sweeteners to achieve active packaging and enhance nutritional and sensory attributes (Tiwari *et al.*, 2016; Rambabu *et al.*, 2019).

Tomato edible coatings can either be made entirely of biopolymers, such as proteins, lipids and polysacchar ides, or they can be enhanced with extracts of other pl ants that are high in bioactive chemicals to act as ant ioxidants and antimicrobials (Maringgal *et al.*, 2020). Several researches have described edible coverings t hat contain antimicrobial substances like organic acid s, plant essential oils, and polypeptides (Nandane *et a l.*, 2017; Robledo *et al.*, 2018; Tzortzakis *et al.*, 2019)

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These edible coatings deactivate bacteria, lower their populations, and maintain the quality and safety of fu its (Brown *et al*., 2018).

Edible coatings and films can preserve appearance, firmness, moisture and increase the shelf life of fruits because of their barrier properties against moisture and gas transmission, lipid oxidation and controlling enzymatic activities and microbial spoilage (Brown *et al*., 2018; Senturk *et al*., 2018). Edible coatings modify the atmosphere around the fruits; Change the normal gas composition in the fruit, delay respiration rate and production of ethylene thus limiting physiological decay of fruits (Maringgal *et al*., 2020). Furthermore, a study has shown that edible coatings containing antimicrobial agents, for instance, organic acids, essential oils from plants and polypeptides inhibit the growth of microorganisms (Nandane *et al*., 2017). Edible coatings can reduce the enzyme activities; minimize browning reaction and the softening of the texture. In addition, it has the potential to maintain the natural volatile flavour compounds and colour components (Sapper and Chiralt, 2018). The edible coatings protect the food products against various microbial contaminants, reduces deterioration effect (Dong *et al*., 2020), prolongs storage period (Grosso *et al*., 2020; Hasan *et al*., 2020), minimize lipid oxidation and moisture loss of food products (De Pilli, 2020; Kazemian-Bazkiaee *et al*., 2020). Carboxymethylcellulose is a cellulose derivative com posed of the cellulose backbone and its hydroxyl gro ups bound to carboxymethyl groups. It is used as a vi scosity modifier, thickener, and emulsifier in food pr oducts. It is synthesized by the alkali-catalyzed reaction of cellulose with chloroacetic acid. The polar (organic acid) carboxyl groups render the cellulose soluble and chemically reactive. Hence, the objective of the paper is to investigate the effect of using coconut husk based Carboxymethyl cellulose (CMCCH) and Commercial based Carboxymethyl Cellulose (CMCCOM) for post-harvest preservation on the changes quality parameters of tomato fruits.

MATERIALS AND METHODS

Coconut husk was obtained from coconut fruit vendors in fruit garden Port-Harcourt, Rivers state.

Chemicals used for the production of CMC were sodium hydroxide (AR grade), acetic acid,, isopropanol, chloroacetic acid and ethanol. Commercial CMC was purchased from LABO TECH company, glycerol, tween 80 were purchased from sigma company.

Preparation of Cellulose from Coconut Husks: Coconut husks was ground into fine powder and extracted of impurities by soxhlet extraction using ethanol and benzene in a ratio of 1:2 respectively for 5 hours. Extract free coconut husk powder went through acid and alkaline pretreatment using 0.1M HCL and 0.1M NaOH respectively. Further pretreatment was done using sodium hypochlorite until a white mixture was achieved. The mixture was washed thoroughly until neutral pH and dried. The dried cellulose sample was stored in a polyethylene bag for further analysis. 50 gram of cellulose powder was reacted with 1 litre of isopropanol with continuous stirring. 200ml of NaOH (25%) was added to mixture with stirring for 1hr at room temperature. 70g monochloro acetic acid was added for another hour with continuous stirring at 55°C. Mixture was covered with aluminum foil and put in an oven for 3 hours at the same temperature. Slurry was neutralized after 3 hours with 90% acetic acid to pH of 7 and then filtered, washed severally with ethanol and final product Carboxymethyl cellulose from coconut husk (CMC**CH**) was achieved after drying at ambient temperature.

Preparation of Edible Coating: 4 grams of CMC was dissolved in 200ml of distilled water. 0.4ml of glycerol and 2g of tween-80 added to mixture. Mixture was heat and stirred using a magnetic stirrer at 90°C until suspension becomes clear. The same process was repeated for commercial Carboxymethyl cellulose (CMC**COM**).

Tomato Fruits Selection: Tomato fruits at commercial maturity (85% red and 15% reddish orange) were purchased from fruit garden market, (Port-Harcourt, Nigeria) to the laboratory within 1 hour. Fruits were selected on the basis of their semblance in size, color and free of injuries. Selected fruits were washed thoroughly in salt water followed by air drying at ambient temperature.

Treatment: Tomato fruits were carefully selected and divided into three groups based on equal sizes, with each group having the same number of tomato fruit. The fruits were dipped into the prepared coatings and left inside for about 7mins. This process was done for all 3 groups and place in a plastic sieve and kept in ambient temperature for 40 days.

Plate 1- CONTROL (untreated tomato fruits)
Plate 2- treated tomato fruits with CMCCH
Plate 3- treated tomato fruits with CMCCOM

Quality measurements: Tomato fruits were analyzed based on their;

Weight loss- to evaluate weight loss, the sample samples were evaluated for weight loss at weekly intervals until the 40th day.

Weight loss (%) = [(A-B)/(A)] x 100

pH- 5g of tomato juice was mixed with 15ml of water and mixture was filtered after swirling for 5mins. The pH of the sample was assessed using a pH meter (pH model:

Titratable acidity (TA) – Titratable acidity was determined according to the AOAC official method 942.15 (AOAC, 2000). 5grams of tomato juice was diluted in 25ml of distilled water and titrated by 0.1N sodium hydroxide (NaOH) to pH 8.1. TA was expressed as gram citric acid/ kg tomato, according to the following equation:

TA (g citric acid/ kg tomato) = (V X 0.1 X 1000 X 0.064)\m

Where; 0.1 is normality NaOH (N), 0.064 is conversion factor for citric acid, V is the volume of NaOH required (ml) and m is the mass of tomato juice sample used (g).

Total soluble solids (TSS) – this was done using a portable digital refractometer (ERMA, Japan) with a scale of 0-32 °Brix (least count 0.2°Brix) at room temperature (±30°C).

Lycopene- this was done using the method from Ranveer *et al* (2013), with a little modification. 5g of tomato juice was weighed into 200ml conical flask, wrapped with aluminum foil for protection against light. 100ml mixture of hexane-acetone-ethanol (2:1:1) v/v %, was added to flask and agitated for 10mins. 15ml of water was later added with further agitation for another 5mins. Solution was left to separate into distinct polar and non-polar layers and filtered using a whatman filter paper. Lycopene concentration was determined by measuring absorbance of extract at 503nm by UV/VIS spectrophotometer, using hexane as blank. The lycopene concentration was calculated using its specific extinction coefficient (E1%, 1cm) of 3120 in hexane at 503nm. It was expressed as mg/kg of fresh tomato.

Lycopene (mg/kg fresh wt.) = (A503 x 537 x 100 x 0.55) / (5 x 172) = A503 x 34.3

Where; 537g/mol is the molecular weight of lycopene, 100ml is the volume of mixed solvent, 0.55 is the volume ratio of upper layer to mixed solvents 5 grams is the weight of tomato added and $172mM^{-1}$ is the extinction coefficient for lycopene in hexane.

Sugar-Acid ratio: Sugar-acid ratio was calculated by dividing total soluble solid (°Brix) to Titratable Acidity of the given sample under analysis as described by Tigist *et al.* (2013).

RESULTS AND DISCUSSION

Weight loss in tomato fruits coated with CMCCH and CMCCOM was significantly different in comparism with uncoated tomato fruit with values of 31.7%, 43.8% and 65.3% respectively. All treatment showed increase in lycopene content of tomato fruits with concentration of 39.2mg/kg for control on day 1, 56.3mg/kg by day 40, with CMCCOM having the highest concentration of lycopene at 68.53mg/kg and 65.57mg/kg for CMCCH.

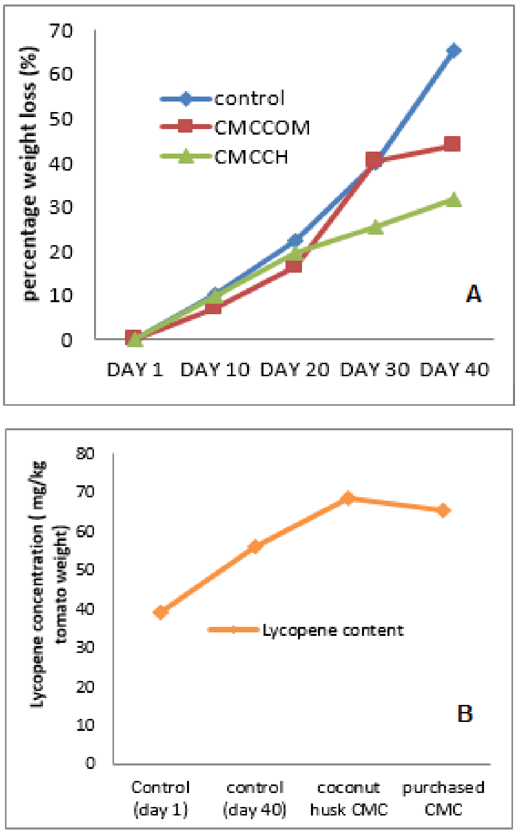

Fig 1: graph showing weight loss of tomato fruits for 40 days storage time (a) and Lycopene content of tomato fruits for 40 days storage time (b).

Total Soluble Solid of tomato fruits was % Brix 4.8^0 on day 1 which decreased to % Brix 4.5^0 by day 40 for untreated tomato fruits, it reduced to 3.8^0 for CMCCH and 3.5^0 for CMCCOM. Titratable Acidity (TA) expressed as gram citric acid /kg of tomato sample was 3.5g/kg on day 1 for the control by day 40, it reduced to a concentration of 1.92g/kg. Tomato samples coated with CMCCH recorded a TiA of 1.54g/kg and 1.66g/kg for coatings from CMCCOM.

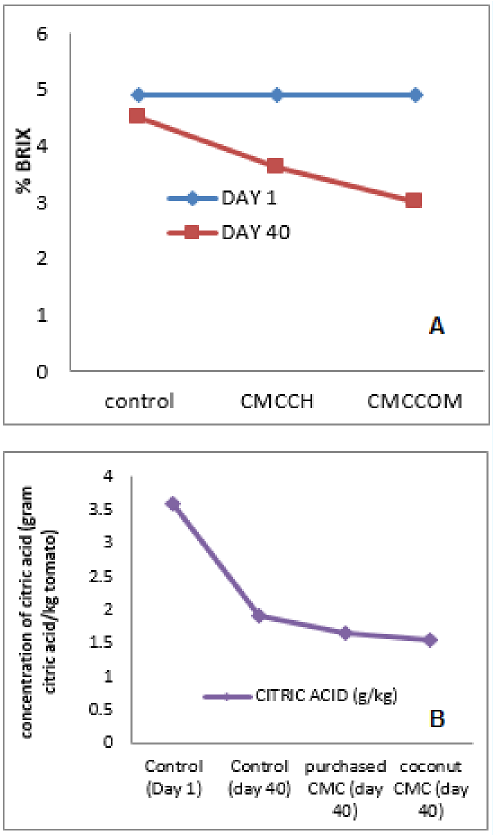

Fig 2: line chart showing TSS of tomato fruits on day 1 and 40th day storage time (a) and citric acid concentration of tomato fruits before and after 40 days (b).

pH level increased with increased storage time. For untreated tomato fruit on day 1 was 5 which increased to 6 by day 40. The tomato fruits coated with edible coating from coconut husk recorded a pH of 6.5 and fruits coated with coating from commercial CMC had a pH level of 7 by day 40. Sugar-acid ratio increased from 1.4 to 2.3 for the control by day 40, 2.5 for edible coating from CMCCH and 2.1 for edible coating from CMCCOM.

Lycopene content: Tomato fruits treated with edible coatings under ambient temperature for 40 days showed an increase in lycopene content for all treatments. However, lycopene content of coated fruits with CMCCOM increased more by 40 days storage time from 39.2 mg kg^{-1} to 68.53 mg kg^{-1} and 65.51 mg kg^{-1} for CMCCH. Weight loss was observed in all fruits but more in uncoated tomato fruits. Edible coatings were able to preserve the shelf life of tomato fruits as compared to uncoated tomato fruit where deterioration was observed from day 25.

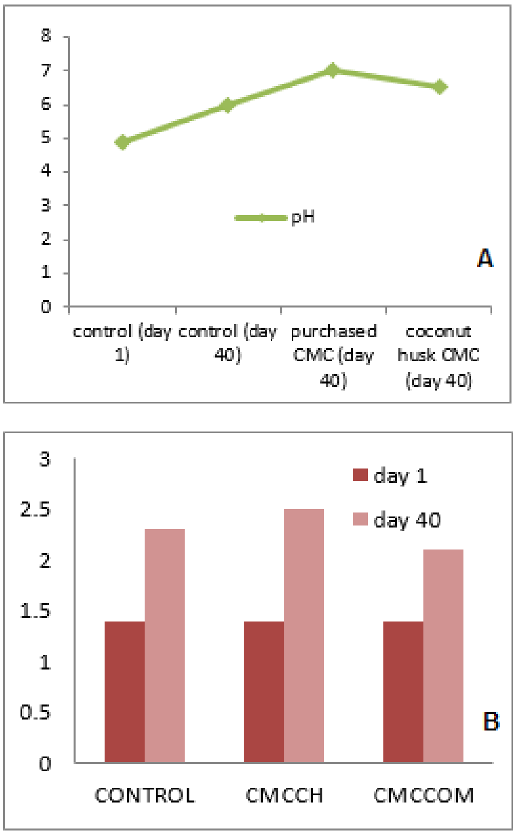

Fig 3: graph showing pH level of tomato fruits on day 1 and 40(a) and bar chart showing sugar-acid ratio of tomato fruits before and after 40 days storage time (b).

Titratable acidity: One of the crucial quality factors that significantly affects and influences how the fruits taste is tomato acidity. With ripening, tomatoes' Titratable acidity diminishes. Because citric acid is metabolized to provide intermediates to the tricarboxylic acid cycle during increases in respiration activity, tomatoes are extremely sensitive to respiration activity after harvest (Khatri *et al*., 2020; Sree *et al*., 2020). The changes in organic acid levels during ripening are caused by an increase in citrate and a decrease in malate, which points to a change in citrate metabolism and a drop in citric acid levels (Kumar *et al*., 2020). In storage, edible coatings keep organic acids active and minimize respiration rates (Li *et al*., 2017). Titratable acidity decreased and of course this comes with an increase in pH level, this can be attributed to the stages of ripening where higher respiration rate occur as ripening advances in which organic acids are used as substrate in respiration process. Although the decrease was more in tomato fruits with coatings from CMCCH, this is to say that edible coating with coconut husk was not able preserve tomato fruits by delaying ripening.

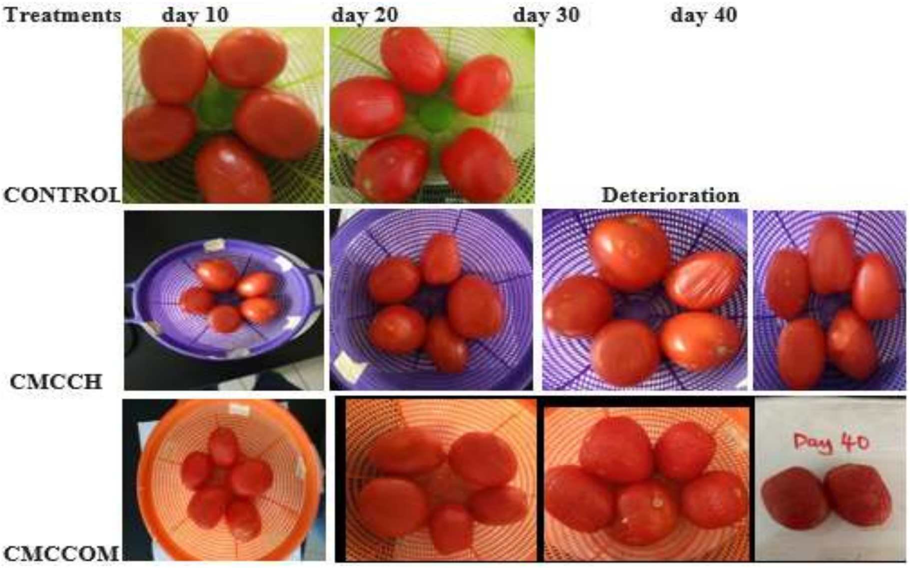

Fig 4: Pictures of tomato fruits in three replicate for 40 days storage time.

Total Soluble Solid: TSS indicated the amount of sugar in the fruits. The level of TSS in tomato fruits decreased with storage period and the highest value was recorded for uncoated tomato fruits as compared to tomato coated with CMCCH and CMCCOM. The decrease in TSS is normal as observed in climacteric fruits because during the process of respiration, sugar molecules are being broken down.

*Sugar-Acid ratio***:** The sugar/acid ratio is the main key characteristics for determining the taste, texture and feel of tomato. It is used to indicate flavor quality of fruits. At the beginning of ripening process, the sugar/acid ratio is low, because of low sugar content and high fruit acid content, this makes the fruit taste sour. During the ripening process, the fruit acids are degraded, the sugar content increases and the sugar/acid ratio achieves a higher ratio. But in this research work, it was observed that the sugar level decreased with a decrease in TA but yet the sugar-acid ratio was higher by day 40 for coated tomato samples. So the decrease in TSS was not significant enough to reduce the sugar-acid ratio.

Conclusion: The main objective of this study was to explore the effect of edible coatings from coconut based Carboxymethyl Cellulose on the preservation of fruit quality of tomato for 40 days. The result of this study indicated that the nutritional quality of tomato fruit was enhanced for coated fruits with respect to weight loss and lycopene content. The sugar-acid ratio indicated a good maintenance of flavor quality of coated tomato fruits even after 40 days storage time. Conclusively, edible coating was able to preserve tomato fruits quality for up to 40 days with minimal deterioration.

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