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Development of an active coating-based gum (*khaya senegalensis*) enriched with lemongrass essential oil (Cymbopogon citratus) for the post-harvest preservation of tomatoes (Solanum lycopersicum) at Room Temperature (24±2 °C)

TOURE Naka*[1], ASSOI Sylivie*[1], CISSE Mohamed[1] OUMAROU Diadie Halima[2]

1 *Laboratory of Biotechnology and Valorization of Agroresources and Natural Substances, Department of Biochemistry-Genetics, UFR Biological Sciences, Pelefero Gon Coulibaly University, Côte d'Ivoire*

[2] *Laboratory of Research in Hygiene and Food and Nutritional Sciences, Abdou Moumouni University, Niamey*-Niger

**Corresponding author, Email address: tnakan@yahoo.fr*
***Corresponding author, Email address: assoisylvie@gmail.com*

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Abstract: Edible coating technology has been found to be an effective method of post-harvest preservation. In developing countries, edible coatings and other post-harvest technologies are often limited by their high cost. Aims: The study aimed to evaluate the effect of edible coatings prepared from inexpensive and locally available materials on the post-harvest quality of tomatoes during storage. Thus, different edible coating formulations were prepared at the site by varying the concentration of cailcedrat gum. The tomatoes, after harvest, were cleaned before being coated with the gels formulated from the gum. They were stored under ambient conditions (24 ± 2 °C and 84 ± 2% RH) for 25 days with evaluations every 5 days. The results showed that the coatings significantly delayed [$p<0.05$] changes in firmness, weight loss, rot count, total soluble solids, pH, and color compared to uncoated control fruits. These results suggest that the application of essential oil-enriched cailcedrat gum has the potential to extend the shelf life of tomatoes while preserving their quality. In short, the coatings produced can be proposed as an alternative and effective method for slowing down ripening and extending the shelf life of tomatoes.

1. Introduction

The tomato (Solanum lycopersicum L.) is a staple of the Mediterranean diet and one of the most widely consumed food products. Tomatoes are one of the most widely traded crops, and the second most important after potatoes, with annual production of 186,821,216 tonnes in 2020 (FAOSTAT, 2022). It transcends geographical borders and is grown all over the world for local and industrial consumption. It is used in a variety of ways for human consumption, raw as a salad, in sauces or processed into manufactured products (Yéo *et al.*, 2021). It is an essential export crop (Poojitha, 2023). Its attractiveness, linked to its colour and shape, is a powerful asset. It is grown for its fleshy red fruits, which are highly sought after and eaten by all ages, for their organoleptic qualities and nutritional value, which have a number of positive effects on our health. Its attractive appearance, linked to its colour and shape, is a powerful asset. It is a good source of vitamins A, B, C and E (Tripathy and Mallikarjuna Rao, 2020). In addition, tomatoes contain various bioactive compounds such as carotenoids, chlorophyll, organic acids, flavonoids, lycopene and phenols, which provide health benefits by reducing the risk of heart disease (Domínguez *et al*., 2020). Fruit and vegetables are essential for food and nutritional security, and tend to stimulate world trade and economic growth (Rosegrant *et al*., 2024).

In Côte d'Ivoire, tomato production plays a very important economic role for the population (Soro *et al*., 2007). In 2020, its annual production was 47,283 tonnes, ranking it 7th in West Africa (FAOSTAT, 2022). Unfortunately, between 30% and 40% of tomato production is lost after harvest due to a lack of appropriate preservation techniques, resulting in significant economic losses and the release of pollutants into the environment (Torres-León *et al*., 2018). Fruits and vegetables are perishable commodities that suffer the highest post-harvest losses, ranging from 28% to 55% of total production, resulting in an annual loss of around $750 billion (Karoney *et al*., 2024). This substantial loss not only affects food security by reducing the availability of nutritious food, but also compromises UN Sustainable Development Goal (SDG) 2 "Zero Hunger" by limiting access to fresh produce. French In addition, global climate change is expected to reduce fruit and vegetable production by 0.3% in developed countries and 5% in developing countries by 2050 (Smith and Glauber, 2020), which could affect MDG 2. Post-harvest fruit losses can occur due to a variety of factors, such as poor handling, lack of pre-cooling, inadequate storage temperature control and microbial pathogens (Lieu *et al*., 2024). Indeed, fruits have a very short shelf-life after harvest due to several factors. Their climacteric nature makes them susceptible to rapid deterioration caused by biochemical and physiological, resulting in nutrient loss and economic damage (Huang *et al*., 2023). At the same time, the world's population is increasing and is expected to reach around 10 billion by 2050 (Anonymous, 2021). The agri-food industry also faces major challenges in maintaining the quality and volume of perishable products, from harvest to consumption. These challenges stem mainly from microbial spoilage, oxidative degradation and sensory deterioration, which compromise food safety, present health risks and reduce consumer appeal (Aayush *et al*., 2022). In recent years, consumer demand has shifted considerably towards healthier, more sustainable food choices, with a clear rejection of products containing synthetic additives in favor of fresh, natural alternatives. This trend is compounded by growing environmental concerns, including the reduction of plastic use and food waste. To meet the needs of future generations, we need to increase the availability of food. Increased production, optimized distribution and reduced losses can increase the availability and accessibility of food (Loukili *et al*., 2022; Taibi *et al*., 2024; Azzouzi *et al*., 2025). To reduce tomato losses and extend shelf life, new preservation methods need to be explored. Among sustainable and innovative alternatives, the application of edible coating gels to fruit and vegetables, by slowing internal metabolism and limiting the penetration of external agents, is a practical approach (Wang *et al*., 2024). Over the past four decades, edible coatings or films (ECFs) have attracted considerable attention as a promising solution for reducing post-harvest losses of fruit and vegetables (Liu *et al*., 2024). ECFs have been used to limit the use of chemical or synthetic treatments, improving consumer health by reducing the potential use of these compounds (Blancas-Benitez *et al*., 2022). Edible coatings are thin, advanced layers of consumer products. Edible coatings are thin layers of consumable materials applied to food surfaces. They act as effective barriers against moisture loss, oxygen penetration and microbial spoilage (Karnwal *et al*., 2025). These coatings play a crucial role in food preservation, extending shelf life, improving quality and reducing spoilage for many perishable products. Various materials are used to prepare these coatings. They are extracted from animals and plants (Kumar *et al*., 2021). They are generally composed of natural polymers, such as polysaccharides, proteins or lipids, combined with plasticizers, emulsifiers and other bioactive components, to create a protective barrier capable of slowing down gas transmission and moisture loss, while preserving the appearance of the product during storage (Azzaoui *et al*., 2016; Ahmed *et al*., 2022). Thus, edible coatings are expected to exhibit desirable characteristics, such as biodegradability, compostability, use of renewable resources, antimicrobial activity, as well as a packaging structure based on a network of hydrogen bonds, offering a better barrier against oxygen, moisture and solute migration (Yuvaraj *et al*., 2021). Thus, among these natural polymers polysaccharides is widely used to preserve fruit quality, due to its film-forming ability, non-toxicity, biocompatibility and biodegradability. However, it has certain limitations, including poor mechanical properties and high hydrophilicity (Jiang *et al.,* 2023). For fresh produce coatings, polysaccharides are generally combined with lipids to improve mechanical strength and water barrier properties, and thus optimize moisture retention in fresh produce (Yadav *et al*., 2022). Numerous studies have been carried out on the combination of guar gum with other polymers and additives to improve the performance of composite gel coatings (Goswami *et al.,* 2024; El Azzouzi *et al*., 2022). These composite gels impart essential properties such as texture, viscosity, flavor release, appearance and water regulation to today's food products (Salehi *et al*., 2020). Promising results were obtained by applying a composite coating of gum arabic (GA) and carboxymethyl cellulose (CMC) to tomatoes, prolonging the ripening phase, delaying senescence and increasing fruit acceptability for 20 days (Shakir *et al*., 2022). In this work, the aim was to evaluate the effect of edible coatings prepared from inexpensive, locally available materials on tomato post-harvest quality.

2. Methodology

2.1. Matériel vegetal

- The tomato (Cobra variety) was harvested from a market gardener in the Abidjan region, on the road to Dabou, at the ripening stage. It was taken to the Laboratory of Food Biochemistry and Technology of Tropical Products (LBATPT) at Nagui Abrogoua University, where it was sorted before testing (Figure. 1d).

-Khaya senegalensis gum was randomly collected from the university site using a knife. It was then taken to the laboratory at Peleforo Gon Coulibaly University (UPGC), where it was sorted to remove all impurities (tree bark, leaves, sand, etc.). The exudate was then dried in an oven at 50°C for 24 hours (Ofori-Kwakye *et al*., 2010). It was then ground using a blender (China) to obtain a slightly fine powder, and the gum itself was extracted. (Figure 1a, 1b, 1c).

- Lemongrass leaves: Cymbopogon citratus was harvested at the UPGC and taken to the university's laboratory, where it was dried in the shade for a week.

2.2 Collection, purification, and characterization of Khaya senegalensis gum

Crude samples of Khaya senegalensis gum was randomly collected from the university site using a knife and purified as described by Oliveira-Alcântara *et al*. (2020)·. with some modifications. The nodules were dried at 50° for 8 h in an oven (Memmert UN160) until they became brittle (Ofori *et al*., 2010), ground to a fine powder, dissolved in distilled water (1:3, w/v) with stirring for 24 h at room temperature (24 ± 2 °C), filtered through muslin cloth, precipitated with 96% ethanol (1:3, w/w) to recover the cashew gum polysaccharide (CGP). This CGP was washed twice with ethanol (Moreira *et al*., 2020), dried at 50 °C for 10 h (Hasnain *et al*., 2018), ground, sieved through 80 µm, and stored at room temperature in hermetically sealed containers. The yield of the purified sample was calculated as follows.

2.3. Collection of Cymbopogon citratus leaves and essential oil production

Leaves (5 kg) were collected from the botanical garden of the Peleforo Gon Coulibaly University, dried at room temperature (28 ± 2 °C) for at least seven days, and cut into small pieces of 4 to 8 mm in length. The essential oil (EO) was extracted by steam distillation using a Clevenger-type apparatus for 3 h. After drying on anhydrous magnesium sulfate, the EO was stored at 4 °C, protected from light, until use (Olayemi *et al*., 2017)

2.4. Preparation of the edible coating solutions

The coating formulation solutions (with and without EO) were prepared according to a modified method of Adjouman *et al*. (2018). The CGP (10%, 15%, and 20%) (Daisy et al., 2019) coating solutions were prepared by redissolving CGP in distilled water by stirring at 80 °C for 20 min, followed by the addition of 30% glycerol (g/g of gum) as a plasticizer. For the formulations containing Cymbopogon citratus essential oil (Athayde *et al*., 2016) (EO, final concentration 0.2%, g/g of gum), the glycerol-gum solutions were prepared in distilled water to 80% of the final volume as described above. The EO emulsion was prepared by mixing EO with 5% soya lecithin (mg/g of EO) in water (20% of the final volume) for 5 min at 15000 rpm using an Ultra-Turrax T25 Basic (IKA Werke, Staufen / Germany). The gum solution and EO emulsion were mixed at 750 rpm for 10 min at room temperature to obtain the EO-CGP (10%, 15%, and 20%) coating solutions.

2.5. Application of coatings to tomatoes

The washed and dried healthy tomatoes were divided into 11 groups according to the coating solutions and treated using the dipping method described by Kumar *et al*. (2021) with some modifications. Each group was immersed in the appropriate treatment solution for 5 min (Peralta-Ruiz *et al*., 2020), while the control group was immersed in distilled water (**Figure 1**). The residual coating was allowed to drip off and air-dried for 60 min at ambient temperature (24 ± 2 °C). This process was repeated twice to ensure that the edible coating component was applied to the surface of the tomato. After drying, each of the coated tomato groups was randomly divided into 2 groups of 60 tomatoes and stored at a controlled (13 °C, 89 ± 2% RH) (Mohammed *et al*., 2021) (Haier WS190GA) and room (24 ± 2 °C, 84 ± 2% RH) temperatures. Room temperature was chosen to simulate conditions commonly found in tomato sales. During the 25 days of storage, the quality attributes of the tomatoes were assessed every 5 days and, in each group of 60 tomatoes, 30 fruits were preserved intact for weight loss, and color, while the other 30 fruits were used for firmness measurement, pH, titrable acidity, and total soluble sugars analysis. For day 0 measurements, fruits were analyzed after dipping in the distilled water.

2.6. Physico-chemical study of coated tomatoes

Determining weightloss

Weight loss was determined according to the method described by Athmaselvi *et al*. (2013). Three tomatoes from each batch were sampled and the mass of coated and uncoated (control) tomatoes was recorded after coating drying (T0) and then every five days for 25 days (T1, T2, T3, T4 and T5). Cumulative mass losses were calculated using the following formula :

$$\Delta M\ (\%) = \frac{Mi - Mf}{Mi} \times 100 \qquad \text{Eqn. 1}$$

With : ΔM: Mass loss; Mi: Initial mass; Mf: Final mass.

(a) **(b)** **(c)**

(d)

Figure 1: Biological material (a : Arbre de *Khaya senegalensis*; b : Exsudat de *Khaya senegalensis*; c : *Khaya senegalensis* gum et d : tomatoes

Determining the firmness of tomatoes

Three tomatoes from each treatment were cut into small pieces and 50 g were crushed using a 500 W Moulinex faciclic glass blender (LM310E10, China) (Flores-López et al., 2024) and centrifuged at 5000 rpm for 20 min at 4 °C (Thermo Fisher Scientific, Sorvall ST16R, 230/8A) (Onyegbula *et al.*, 2023) to obtain the juice. Total soluble solids (% Brix) were measured on the concentrated juice of each treatment using a combined Brix-acid dual scale digital refractometer model PAL-BX-ACID 91 (ATAGO, France) after adding 1or 2 drops of the juice on the prism surface. For titratable acidity (% acid), the juice of each treatment was diluted (5 g of juice in 25 mL of distilled water) before the reading was taken (Sree et al., 2020). The pH was determined using a pH meter (pH 340i/SET, Germany) by immersing the electrode in diluted tomato juice. The tomato maturity index (MI) was calculated as reported by Peralta-Ruiz *et al*. (2020).

Decay rate

The decay rate was determined using the counting method described by Lanhuang et al. (2022). It is the ratio of the number of tomatoes bearing at least one infection to the initial number. The decay rate (DR) expressed as a percentage was obtained using the formula:

$$TP\ (5\%) = \frac{NI}{NT} \times 100 \qquad \text{Eqn. 2}$$

With TP: decay rate; NI: number of spoiled samples and NT: total number of samples.

Determination of tomato colour

The color change of the tomato surface was evaluated using a Minolta CR-10 Plus COLOR READER (Konica Minolta, Japan) handheld colorimeter at ambient temperature (28 ± 2 °C). Average readings were taken at three different points on the surface of each of the 6 tomato fruits (Flores-López *et al*., 202 3). The color scale values of the control and the coated tomato samples were determined in terms of L*, a*, and b* (L* = light/dark; a* = green/red; b* = blue/yellow), and ΔE (color change).

2.7. Analyses statistiques

For the statistical processing of the results, a multivariate analysis was carried out using IBM SPSS version 22 statistics on the physico-chemical parameters of the coated tomatoes. The separation of means was evaluated using the Newman Keuls test at the 5% threshold.

3. Results and Discussion

3.1. Firmness

The firmness of tomatoes (coated and uncoated) decreased gradually over the 25 days of storage at room temperature (Figure 2). Overall, tomato firmness fell from 35.16±1.27N (day 0) to 9.59±0.41N on the 25th day of storage. A much greater reduction was observed in the uncoated tomatoes (controls) than in the coated tomatoes. In addition, the type of gum used also affected the loss of firmness differently. With the control tomatoes, around 61% of firmness was lost after just 5 days' storage at room temperature. However, when the tomatoes were coated, around 49% (GK10%) of the tomatoes' firmness was maintained after the same storage time. The reduction in firmness of the controls was significantly different ($P<0.05$) from the coated tomatoes from day 5 to day 25.

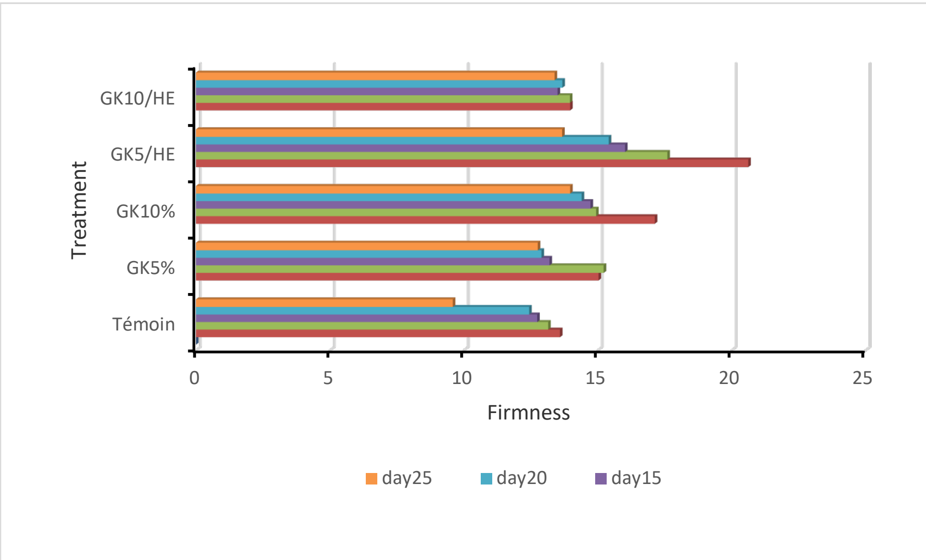

Figure 2. Effects of treatments and storage times on firmness at 24 ± 2 °C:

Firmness is a key factor influencing consumer acceptability and is affected by time, processing, and their interaction during storage (Kumar *et al*., 2021). Loss of mass and moisture are the main causes. Significant loss of firmness reduces the quality and market value of the fruit. Tomatoes are moisture-sensitive fruits that lose firmness during ripening, reducing their shelf life (Xylia *et al*., 2021). Firmness is an indicator of significant changes in the enzymatic activities of polygalacturonase and pectin methylesterase, which are directly associated with the breakdown of pectins, which mainly contribute to product firmness (Changwal *et al*., 2021). Indeed, the activity of hydrolase and pectinase enzymes decreases the firmness of tomatoes by causing degradation of the cell wall structure (Saekow *et al*., 2019). In this study, a loss of firmness was observed in both coated and uncoated tomatoes, but it was significantly higher ($p < 0.05$) in uncoated fruits. This decrease in firmness may be due to faster ripening, leading to early softening. This softening is due to the weakening of cell wall composition, structure, and materials. The evaluation of tomato firmness by Abhirami *et al*. (2020) showed that samples coated with 10% rice bran wax retained their firmness for 27 days of storage, while uncoated tomatoes lost their firmness and deteriorated after 1

3.2. Weight los

Figure 3 shows the evolution of weight loss in coated and uncoated tomatoes over 25 days of storage. There was a progressive increase in weight loss over time. It rose from 0% on day one to 9.02 ± 3.32% on day 25. For all treated tomatoes, with the exception of the GK5% and GK5/HE assemblies, weight loss in coated tomatoes was significantly greater ($p < 0.05$) than in controls up to day 20^{e} of storage. However, after 25 days, the weight loss of the controls was 7.63%, compared with 5.76% and 5.8% respectively for the GK5% and GK5/HE mounts. The weight loss of the controls was significantly different ($p < 0.05$) from that of the GK5% and GK5/HE coatings after 25 days. The GK5-based coating solutions, however, significantly ($p < 0.05$) reduced weight loss compared with the other samples and controls during storage at room temperature. The GK5% treatment (5.76%) was the most effective in maintaining tomato weight after 25 days' storage..

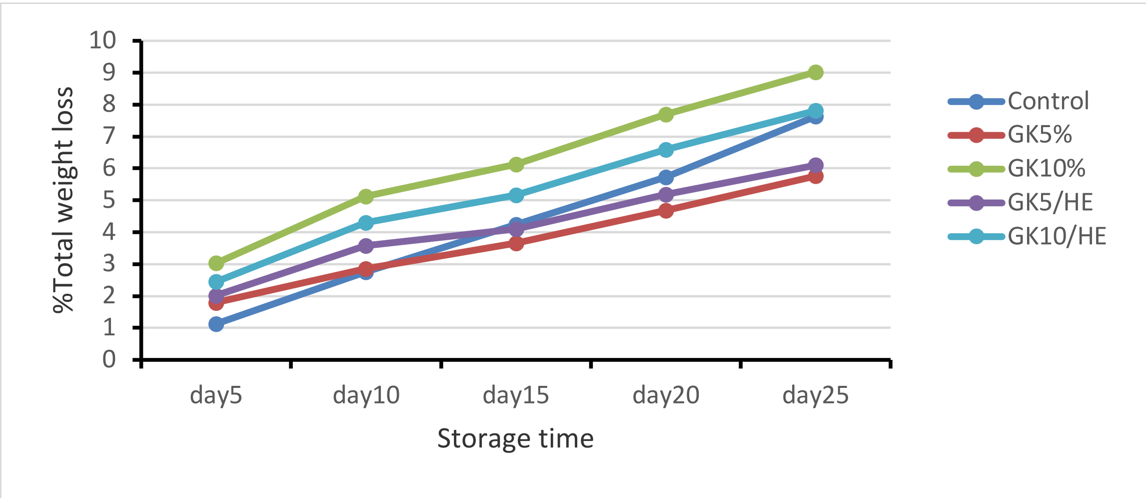

Figure 3. Effects of treatments and storage times on Weight loss at 24 ± 2 °C:

In the present study, the delayed weight loss recorded for coated tomatoes could be attributed to the effect of the coating as a semi-permeable barrier against gases, moisture and solute movement. Indeed, the edible films reduced respiration, which contributed to slower activity of cell wall-degrading enzymes and weight loss, while providing a protective covering over the stem scars that acts as a barrier to moisture outflow from the tomato (Yadav *et al.,* 2022). The extent of this loss varies with the type of coating, storage temperature, relative humidity and storage time (Kumar et al., 2021). All coated samples showed an effective reduction in mass loss, in contrast to uncoated samples. A similar trend was observed for other coated fruits, such as tomatoes (Kondle *et al.,* 2019). The reduced weight loss of fruit coated with these gels could be attributed to their hydrophobic properties.

3.3. Number of decays

For tomatoes coated with GK, fruit loss was reduced when the coating solution was enriched with essential oils. Tomatoes coated with 10% GK and 10% EO showed the best performance in terms of rot reduction. Indeed, there was no rot after five days of storage. However, after 25 days of storage at room temperature, the number of rots increased to 3.57% for GK10/HE and 10.71% for GK10% (Figure 4). A significant difference ($P < 0.05$) was observed for these coatings on days 15 and 20. Overall, it should be noted that coating tomatoes with GK reduces rotting during storage.

Tomato quality declines during storage due to their high susceptibility to microbial deterioration. In our study, early rotting of processed tomatoes after 20 days of storage could be due to internal shocks during transport. The increase in rotting after 15 days' storage could be attributed to the coatings. The coatings formed a semi-permeable film around the fruit, blocking respiration and modifying the internal atmosphere. These results are in line with those of Kumar *et al.* (2021), who showed that edible coating formulations prepared from whey protein isolate, xanthan gum and clove oil delayed senescence and ripening of whole tomatoes up to day 15 of storage. The modification of respiratory phenomena in the coated tomatoes and the arrest of ripening processes in the controls favored the production of water in the tomatoes, which in turn favored the proliferation of micro-organisms responsible for rotting. Numerous studies have confirmed the great potential of edible coatings to reduce rot and microbial load. In addition to maintaining sensory quality and bioactive compound content, edible coatings reduce microbial contamination and improve tomato shelf life.

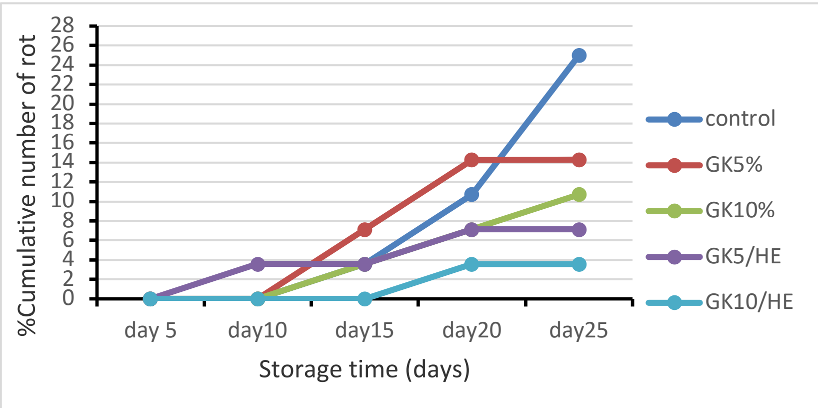

Figure 4. Effects of treatments storage times on decays at 24 ± 2 °C

3.3. Color

The color difference ΔE* increased across the board, whether the fruit was coated or not. Tomato color difference ΔE* increased from 0 (day 0) to 22.27 ± 1.23 (day 25) during storage. The color difference was significantly greater ($P < 0.05$) in uncoated (control) tomatoes than in coated tomatoes. Indeed, control tomatoes showed a significant color difference, with 19%, followed by GK5/HE, after only 5 days of storage at room temperature. The GK5%-coated tomatoes showed the smallest color differences at this stage, with increases of 3.92% and 15.10% respectively. However, after 25 days, the GK5/HE treatment was the most effective in maintaining color difference, with respective increase rates of 19.82% and 21.12%. Significant differences ($P < 0.05$) were observed in GC-coated tomatoes from 0 to 15 days. In tomatoes coated with GK, it should be noted that ΔE* increased as the percentage of GK in the coating gels increased. GK5% effectively maintained the color difference after 5 and 25 days of storage with the rates of increase 15.10% and 21.13% respectively at room temperature. However, when GK coating solutions were enriched with HE, GK5/HE showed better performance in maintaining ΔE* after 25 days with 21.12% increase at room temperature (Figure 5). Significant differences ($P < 0.05$) were observed from day 0 to day 10. Overall, it should be noted that the GK coating gels were able to maintain the difference in tomato color during storage. One of the main factors that attracts consumers' attention is color. Consumers prefer tomatoes that are deep red and uniform in color. Color is the first and most important quality attribute perceived by consumers in food packaging. It is often seen as an indicator of overall pack quality and influences consumers' judgement of other attributes, such as flavour (Kumar *et al*., 2021). Studies have shown that chlorophyll content decreases with increasing carotenoid and lycopene content during storage. During ripening, chlorophyll degradation and increased lycopene synthesis lead to the appearance of a characteristic color (Farooq *et al*., 2023). The ΔE* value indicates the color intensity (saturation) of the sample. Coating tomatoes with gum gels delayed color change, probably due to increased levels of CO_2 and decreased levels of O_2, a key substrate for ripening enzyme activity (Cruz *et al*., 2018). In fact, the edible coating acts as an oxygen barrier, slowing down enzyme activity and delaying the changes associated with tomato ripening. Various reports show that edible coatings are effective in reducing ethylene production in tomatoes. Sherani et al (2022) explained that edible coatings based on aloe vera gel and olive oil had barrier properties that reduced transpiration rates, which are responsible for the fruit's metabolic activity, thus helping to preserve its color.

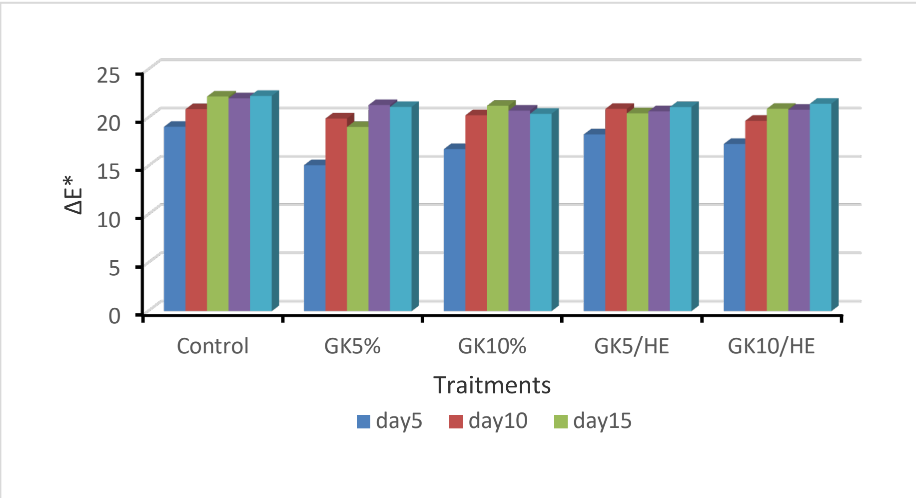

Figure 5: Effects of treatments and storage times on **ΔE***at 24 ± 2 °C

3.4. pH values of coated and uncoated tomatoes at different storage times

The pH of both coated and uncoated tomatoes increased gradually over 25 days of storage at room temperature (Table 1). In general, a decrease in pH was observed on day 5, followed by a progressive increase up to day 25 for all tomatoes. Thus, the pH rose from 5.04 ± 0.07 on day 0 to 6.10 ± 0.01 on day 25. This increase was more pronounced in uncoated (control) tomatoes than in coated tomatoes. The control tomatoes showed the highest pH value (5.54), which increased by 9.92% after 10 days of monitoring at room temperature. In contrast, the coated tomatoes showed an increase of 9.32% (5.51). Meanwhile, the lowest pH values were observed for GK5/HE (5.44), a decrease of 7.94%. After 25 days, however, GK5% samples demonstrated the best pH maintenance performance (5.92), representing a 17.46% increase, whereas the control group exhibited a 21% increase, reaching a pH of 6.10. A significant difference ($P < 0.05$) was observed in the control group during storage. The pH of the tomatoes increased during storage. These results are similar to those of Firdous *et al*. (2020), who reported that edible coating solutions containing 80% aloe vera gel and a 2% calcium chloride treatment increased the pH value slightly, from 4.98 to 5, after a 30-day storage period. This shows that the biochemical reactions leading to ripening and decay were slowed down by the aloe vera gel coating. However, Won et al. (2018) reported that the pH of tomato samples was not affected by chitosan coating, nor by chitosan incorporated into grapefruit seed extract, nor by storage temperature (10°C or 25°C).

Table 1. pH of tomato fruits coated with cashew gum during storage at different temperatures at Room Temperature (24±2 °C)

Traitments	Time					
	day0	day5	Day 10	Day 15	day20	day25
Control	5,04±0,07^{d,A}	4,92± 0,05^{e,A}	5,54± 0,00 ^{c,A}	5,93± 0,03^{b,A}	5,96± 0,00^{b,}	6,10± 0,01^{a,A}
GK 5	5,04±0,07^{d,A}	4,85± 0,02^{e,A}	5,46± 0,00 ^{c,A}	5,79± 0,05^{b,AB}	5,90± 0,07 ^{a,AB}	5,92± 0,00^{a,C}
GK 5 +HE	5,04±0,07^{d,A}	4,89± 0,02^{e,A}	5,44± 0,00 ^{c,A}	5,83± 0,03^{b,AB}	5,87± 0,03 ^{ab,AB}	5,94± 0,01^{a,B}
GK 10	5,04±0,07^{d,A}	4,92± 0,02^{e,A}	5,51± 0,00^{c,}	5,83± 0,03^{b,AB}	5,85± 0,01^{b,B}	5,97± 0,02^{a,C}
GK 10 +HE	5,04±0,07^{d,A}	4,92± 0,05^{e,A}	5,47± 0,02^{c,A}	5,78± 0,03^{b,AB}	5,88± 0,05^{a,AB}	5,93± 0,01^{a,BC}

Means ± deviations, assigned to different letters in the same column and row, are significantly different at the 5% threshold according to the Newman Keuls test. nd: not determined. Means ± deviations, affected by lowercase and uppercase letters, are statistical tests carried out according to treatments and storage days respectively. T Con: Shelf life; Control: uncoated tomatoes; GK5%: tomatoes coated with 5% gum khaya; GK10%: tomatoes coated with 10% gum khaya; GK5/HE: tomatoes coated with 5% gum khaya and lemongrass essential oil and GK10/HE: *tomatoes coated with 10% gum khaya and lemongrass essential oil.*

3.5. titratable acidity

Table 2 shows the evolution of titratable acidity of coated and uncoated tomatoes over 25 days of storage at room temperature. Overall, the acidity of controls and GK-coated tomatoes remained stable. Tomato titratable acidity fell from 0.53 ± 0.04 (day 0) to 0.27 ± 0.01 on day 25^{e} of storage. This reduction was significantly greater in control tomatoes than in coated tomatoes ($P < 0.05$). Both control and GK10/HE-coated tomatoes showed a significant reduction in acidity, with a 13.20% loss of acidity after 10 days of storage at room temperature. However, when storage time reached 25 days, controls showed 49% acidity loss, while GK10% coated tomatoes (30.19) showed the best performance in terms of acidity maintenance. The significant difference ($P < 0.05$) was revealed between 10 and 15 days of storage. In the case of GK-coated tomatoes, it should be noted that after 10 days' storage at room temperature, 5% GK maintained 7.55% of the initial acidity. After 25 days, 10% GK showed the best performance (30.19%) in terms of acidity retention. However, when the GK coating solutions were enriched with essential oil (HE), the GK10/HE mixture showed better results in terms of tomato acidity maintenance. Indeed, the reduction in acidity was 32% after 25 days of storage at room temperature. The significant difference ($P < 0.05$) was observed between 10 and 15 days. In general, GK-based coatings reduced the loss of titratable acidity in tomatoes during storage, with over 50% of acidity retained...

The titratable acidity of tomatoes decreases with ripening. Tomatoes are very sensitive to post-harvest respiratory activity, as citric acid is metabolized to provide intermediates for the tricarboxylic acid cycle as respiration increases. Alterations in organic acid levels during ripening are due to an increase in citrate levels and a decrease in malate levels, suggesting a variation in citrate metabolism and a reduction in citric acid levels (Kumar *et al*., 2022). In contrast to pH, acidity decreased with storage time for controls and different coatings, but the decrease was more marked for uncoated tomatoes. A similar observation was also reported by Abhirami *et al*. (2020), who indicated that coatings-maintained acidity by reducing the rate of respiration, thus limiting the consumption of organic acids. However, Khatri *et al*. (2020) reported that tomatoes coated with aloe vera, chitosan or a mixture of aloe vera and chitosan had significantly higher acidity values than uncoated tomatoes. The available literature indicates that the different edible coatings used can maintain higher acidity values due to their potential to reduce metabolic activities related to respiration rate.

Table 2. Titratable acidity of tomato fruits coated with cashew gum during storage at Room Temperature (24±2 °C)

Treatments	Time					
	day 0	day 5	day 10	day 15	day 20	day 25
Control	0,53± 0,04 [a,A]	0,46± 0,02 [b,A]	0,38± 0,02 [c,A]	0,38± 0,02 [c,A]	0,38± 0,02 [c,A]	0,27± 0,01 [d,D]
GK 5	0,53± 0,04 [a,A]	0,53± 0,04 [a,A]	0,49± 0,02 [a,A]	0,40± 0,01 [b,A]	0,36± 0,01 [bc,AB]	0,35± 0,03 [c,C]
GK 5 +HE	0,53± 0,04 [a,A]	0,53± 0,02 [a,A]	0,48± 0,00 [a,A]	0,39± 0,02 [b,A]	0,37± 0,01 [b,AB]	0,34± 0,02 [b,C]
GK 10	0,53± 0,04 [a,A]	0,53± 0,04 [a,A]	0,47± 0,06 [a,A]	0,40± 0,01 [b,A]	0,39± 0,01 [b,AB]	0,37± 0,00 [b,BC]
GK 10 +HE	0,53± 0,04 [a,A]	0,53± 0,03 [a,A]	0,46± 0,02 [ab,A]	0,43± 0,07 [b,A]	0,37± 0,02 [b,AB]	0,36± 0,01 [b,BC]

Means ± deviations, assigned to different letters in the same column and row, are significantly different at the 5% threshold according to the Newman Keuls test. nd: not determined. Means ± deviations, affected by lowercase and uppercase letters, are statistical tests carried out according to treatments and storage days respectively. T Con: Shelf life; Control: uncoated tomatoes; GK5%: tomatoes coated with 5% gum khaya; GK10%: tomatoes coated with 10% gum khaya; GK5/HE: tomatoes coated with 5% gum khaya and lemongrass essential oil and GK10/HE: *: tomatoes coated with 10% gum khaya and lemongrass essential oil*

3.6. Soluble total solids (°brix).

The evolution of the soluble solids content of coated and uncoated tomatoes over 25 days of storage at different temperatures (in 5-day intervals) is shown in Table 3. The rate of soluble solids increased with storage time. The increase was more marked for controls, with a high percentage increase

(24.90%) compared to coated tomatoes, after 25 days of storage. For tomatoes coated with GK, the increase was less pronounced than for controls after 25 days' storage. The increase was observed for all GK percentages used for the coating gels. The GK10% treatment showed the lowest soluble sugar value (4.95) compared with the GK5% treatment and controls after 25 days. The addition of essential oil to GK reduced the evolution of soluble solids over the 25-day period. The addition of EO therefore had a positive effect on the evolution of soluble sugars compared with coatings without EO. The GK5/HE treatment (4.80) had lower soluble sugars than the GK10/HE treatment and the controls. Statistical analysis revealed significant differences at the 5% level. However, no significant differences were revealed between treatments and non-treatments ($p > 0.05$).

TSS (total soluble solids) represents the taste quality of food and is used as an indicator of ripening, as well as indicating the quantity of soluble minerals and sugars present in fresh fruit (El-Serafy *et al.,* 2019). At 15 days post-harvest (dph), the TSS content of tomatoes stored at 4 °C and 14 °C was significantly higher than that of tomatoes stored at 24 °C (Figure 1b), likely due to the suppression of respiration at lower temperatures (Fawole *et al.,* 2013). This suggests that low temperatures play a role in maintaining TSS levels in tomatoes (Li et al., 2025). These results align with those of Thole *et al.* (2021), who found that raising the temperature from 18–20 °C to 26 °C reduced the shelf life of 41 tomato genotypes by approximately 4 days and increased their susceptibility to disease**.**

Table 3. Soluble total solids of tomato fruits coated with cashew gum during storage at Room Temperature (24±2 °C)

Traitments	Time					
	day 0	day5	day 10	day 15	day 20	day 25
Control	3,83± 0,30 c, A	4,35± 0,1 b,A	4,74± 0,01 ab,A	4,80± 0,03 ab,A	4,97±0,27 a,A	5,10± 0,25 a,A
Gk 5%	3,83± 0,30 c, A	4,41± 0,31 ab,A	4,65± 0,05 a,A	5,00± 0,65 a,A	4,97±0,32 a,A	4,97±0,02 a,A
Gk 10%	3,83± 0,30 c, A	4,37± 0,55 a,A	4,83± 0,06 a,A	4,84± 0,14 a,A	4,87±0,67 a,A	4,95± 0,80 a,A
Gk 5% + he	3,83± 0,30 c, A	4,07± 0,12 ab,A	4,60± 0,05 a,A	4,72± 0,27 a,A	4,77±0,07 a,A	4,80± 0,1 a,A
Gk 10% + he	3,83± 0,30 c, A	4,43± 0,29 ab,A	4,70± 0,15 a,A	4,87± 0,17 a,A	4,75± 0,7 a,A	4,98± 0,30 a,A

Means ± deviations, assigned to different letters in the same column and row, are significantly different at the 5% threshold according to the Newman Keuls test. nd: not determined. Means ± deviations, affected by lowercase and uppercase letters, are statistical tests carried out according to treatments and storage days respectively. T Con: Shelf life; Control: uncoated tomatoes; GK5%: tomatoes coated with 5% gum khaya; GK10%: tomatoes coated with 10% gum khaya; GK5/HE: tomatoes coated with 5% gum khaya and lemongrass essential oil and GK10/HE: tomatoes coated with 10% gum khaya and lemongrass essential oil

Conclusion

The overall aim of this study was to develop an edible coating based on cauliflower (Khaya) gum for the post-harvest preservation of tomatoes. This study determined the ability of coatings to preserve the quality and extend the post-harvest shelf-life of fresh tomatoes. Results showed that coatings were able to retard changes in weight, firmness, titratable acidity, color evolution and percentage rot compared with uncoated control fruit, when stored at room temperature. In short, these coatings can be proposed as an alternative and effective method for slowing down ripening and thus extending the shelf life of tomatoes.

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