



## **SHELF-LIFE STUDY OF SOME PHYSICO-CHEMICAL INDICES OF GUM ARABIC COATED LARGE FRUITED RED BELL PEPPER (*Capsicum annum* L.)**

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### **ABSTRACT**

The study investigated some changes in the physicochemical parameters of red bell pepper (RBP) coated with Gum Arabic (GA) at different concentrations under an ambient storage condition. The treatments consisted of four (4) different concentrations (50000ppm, 100000ppm, 150000ppm and 200000ppm) by dissolving 5, 10, 15 and 20g GA in respective 100 milliliters of distilled water. Data obtained were subjected to analysis of variance and differences in means were examined using Tukey at 95% confidence level. Significant differences ( $P \leq 0.05$ ) were observed in the firmness, colour, ascorbic acid, titratable acidity, pH, total soluble solids, decay and weight loss percentages of the coated red bell peppers relative to the control. RBP coated with  $10 \times 10^3$  ppm had more retention of the evaluated physicochemical indices during and after nine days storage period. Successive firmness and colour values throughout storage times for the 10,000-ppm coated samples suggested a better GA concentration for coating red bell pepper for days in a rather ambient storage condition.

**Keywords:** Red bell pepper, Gum Arabic, Coating, Storage

### **INTRODUCTION**

Large fruited bell pepper (*Capsicum annum* L.) has gained over the years consumer interest in Nigeria thanks to its being a good source of antioxidants and its possible culinary usage in fresh cut salads (Maria *et al.*, 2015). *C. annum* remains the world's third most popular vegetable crop after tomatoes, having thick flesh and low-calorie content despite being rich in nutrients, especially vitamin A and vitamin C (Raturi, *et al.*, 2019). Bell peppers are generally considered as a balanced source of most essential nutrients, with high content of vitamins, important antioxidants, flavonoids and phytochemicals (Maria *et al.*, 2015). According to Sharma, *et al.* (2018) bell pepper is one of the most popular horticultural commodities cultivated throughout the world. In Nigeria, there are three major types of pepper commonly: large fruited sweet peppers (Tatashe), the medium corrugated fruited hot pepper (Rodo) and the small-fruited with chilly/red pepper (Shombo) (Dipeolu and Akinbode, 2016). Bell peppers are currently gaining much attention due to possible links to prevention of certain types of cardiovascular diseases, atherosclerosis, cancer, hemorrhage, delaying of ageing process, avoiding cholesterol, improving physical resistance and increasing appetite (Marin *et al.*, 2014). In many developing countries, postharvest losses of pepper generally is as high as 45% due to improper postharvest handling (Kitinoja and Kader, 2015); and In bell pepper, postharvest losses of 28.6% and 38.7% have been reported during dry and wet seasons respectively in Nigeria (Tsegay *et al.*, 2016).

Due to mishandling, lacks of storage and transport facilities in the country, most of the bell peppers are wasted. In the harvesting season there is a glut of fruit in the market. In these day's farmers cannot get reasonable price, so it becomes imperative to prolong the shelf life of



the fruit in the best interest of farmer, community and consumers as well (Kitinoja and Kader, 2015).

Many techniques such as low temperature and high relative humidity, controlled and modified atmosphere packaging among others have been adopted for minimizing postharvest losses of fruits and vegetables, however, the quality of fresh produce still a major challenge for the food industry (Sonti, 2019). Edible coatings have many advantages over other techniques, but only when the coated produces are stored at proper temperatures. They can act as moisture and gas barriers, control microbial growth, preserve the color, texture and moisture of the product, and can effectively extend the shelf life of the product (Lelgut and Deisy, 2020).

Gum Arabic (GA), obtained from stems or branches of *Acacia* species, is the most common polysaccharide used in the industrial sector as coating material due to its unique emulsification, film forming and encapsulation properties which has received the highest toxicology safety status by the joint FAO/WHO Expert Committee on Food Additives (Anderson and Eastwood, 2019; Motlagh *et al.*, 2016). Overall quality and shelf life of fruits and vegetables is reduced by several factors including water loss, enzymatic browning, texture deterioration, senescence processes and microbial growth, among others (Rojas-Grau *et al.*, 2018). Gum Arabic as a biopolymer is an edible coating material which have proven to prolong the shelf-life of many fruits through their antibacterial, antifungal and antioxidative properties. Gum Arabic are drought tolerant and grow abundantly in about fourteen (14) Northern States of Nigeria which includes Borno, Yobe, Jigawa, Kano e.tc (Ali *et al.*, 2017). When used as an edible coating, Gum Arabic showed some positive results as it significantly delayed ripening of cold-stored apples (El-Anany *et al.*, 2021). However, recent studies show's that Gum Arabic (GA) is not only used to enhance shelf-life but also to maintain postharvest quality of mature-green tomatoes for up to 20 days during storage at 20°C (Ali *et al.*, 2017). Due to paucity of data, the need to study the shelf-life potentials of gum Arabic on the quality and shelf-life extension of large fruited red bell pepper during storage is hereby investigated.

## **MATERIALS AND METHODS**

### **Experimental Materials and Their Sources**

Fresh large fruit of red bell peppers commonly called "Tartashe" in Hausa language was purchased during its glut period between February-March from Yankaba fruit and vegetable market. The pepper fruits were sorted in terms of size, absence of skin damage, visible absence of microorganisms, physiological maturity and intense red color and then washed under running tap. Before treatment was initiated, the fruits were washed with a solution of 0.05% sodium hypochlorite for 3minutes and then air-dried at ambient temperature (Nasrin *et al.*, 2018). All chemical and reagents used were of analytical grades.

### **Gum Arabic and Coating Treatments**

Gum arabic (GA) coating solutions was prepared in different concentrations of 50000ppm, 100000ppm, 150000ppm and 200000ppm by dissolving 5, 10, 15 and 20g GA in respective 100 milliliters of distilled water. The solutions were stirred under low heat (40°C) for 60min on a magnetic stirrer/hot plate, then filtered to remove any undissolved impurities using a vacuum flask. After cooling to 20°C, glycerol monostearate (1.0%) (Sigma) was added as a plasticizer to improve the strength and flexibility of the coating solutions. The pH of the solutions was maintained at 5.6 using 1N NaOH. Bell pepper was immersed in each concentration for 2-3 minutes to ensure a uniform and entire surface coatings, while the control red bell peppers were dipped in purified water (Nasrin *et al.* 2018).



### **Physiochemical analysis**

The percentage firmness, total soluble solids, pH, weight loss, color, titratable acidity and Ascorbic acids were determined in accordance with the analytical protocols of the AOAC (2019) on the fresh bell pepper before and after coating.

### **Determination of Weight Loss**

The weight of ten (10) large fruit of red bell pepper were taken at day 1 and at the end of each storage interval. The difference between initial and final fruit weight was taken as total weight loss during that storage interval, calculated and expressed as percentages of fresh weight loss.

### **Determination of Fruit firmness**

Firmness for the fruit was determined by measuring the amount of force (N) to puncture a hole in the fruit on each sampling day, using an Instron Universal Testing Machine with 6.00mm plunger tip, Single Column Model (Norwood, MA, USA) interfaced with a computer. The machine was set for maximum compression with a speed of 20mm/min as described in the protocols of Zapata *et al.* (2018).

### **Determination of Total Soluble Solids and Ascorbic Acid**

Total soluble solids were determined for the large fruit bell pepper from each treatment following the homogenization in a blender and juice from the fruit was used to determine the total soluble solids (TSS) using a WAY-2S Abbe Digital Refractometer. Ascorbic acid contents were estimated using the dye 2, 6-dichlorophenol–indophenol titration (DCPIP).

### **Decay percentage**

The decay percentage of coated and uncoated red bell pepper was calculated as the number of decayed fruits divided by initial number of all fruit multiplied by 100 (El-Anany *et al.*, 2021).

### **Determination of Titratable Acidity**

Titrateable acidity was determined according to AOAC method (2019). 10ml each of water extract from 5% weight of the large fruited red bell pepper juice was dispensed into a conical flask followed by 3 drops of 1% phenolphthalein solution. The mix was then titrated against 0.1M sodium hydroxide from the burette until rose pink colour observed for few seconds to minute. The titrateable acidity was expressed as gram of citric acid/L sample extract according to the equation: Titratable acidity (g citric acid/L) =  $V \times 0.1 \times 1000 \times 0.064 / W$ . where 0.064 = conversion factor for citric acid; 0.1 = Molarity of NaOH, W = weight of sample used, V = Titer value.

### **Determination of pH**

The PH of the red bell pepper samples were determined using the method described in the official method of analysis of Association of Analytical Chemists (AOAC, 2019). The pH of the sample was measured using electronic PH meter by dipping the electrode in a 10% suspension of the red bell pepper sample.

### **Determination of Fruit Color**

The color intensity of the red bell pepper coated in different concentration of the gum arabic were measured using a chromometer (Konica Minolta Colour Measuring System (Chroma meter CR 410, Minolta Ltd., Japan) and measured as Hunter's colour values L\*, a\* and b\* with Hue angle and chroma calculated as described by McGuire, (1992).

### **Data Analysis**

All data collected were subjected to one-way Analysis of Variance., the difference between treatment means was compared using Tukey's test at 5% (= 0.05) level of significance.



## RESULTS AND DISCUSSION

### Weight Loss

Weight loss as shown in Table 1 below represents the reduction of the respective weights of the GA coated bell pepper relative to the initial weight just after coating and drying. Although, the proportion of weight loss in coated and uncoated samples were directly proportional to the storage time, the highest weight loss in the 50,000ppm and 100,000ppm coated red pepper were 17.15 and 20.53% after 9th day of storage. This result is in consonance with the work of Asgar *et al.* (2010) while study on tomato edible coating efficiency of physiochemical retention. At day 9 of the storage time, the percentage weight losses were greater than 50% in both 150,000ppm and 200,000ppm GA coated red bell pepper and above 80% loss in the uncoated samples. This could be due to heat generated from anaerobic respiration and also some evidential cracks of the film on the samples during storage. The coating materials used in this research reduced the rate of weight loss compared to the control sample. This could be attributed to vapor pressure and limited respiration rate of the GA. The reduction in weight loss was probably due to the effects of the coating as a semi-permeable barrier against O<sub>2</sub>, CO<sub>2</sub>, moisture and solute movement, thereby reducing respiration, water loss and oxidation reaction rates (Asgar *et al.*, 2010 and Nasrin *et al.*, 2018).

**Table 1:** Effects of Gum Arabic Coating on Weight Loss of Red Bell Pepper during Storage

Concentration (ppm)	Weight Loss (%)			
	Days after Storage			
	1	3	6	9
0.000	0.00	10.72±1.00 <sup>a</sup>	74.87±2.55 <sup>g</sup>	84.26±2.05 <sup>b</sup>
50000	0.00	2.77±1.10 <sup>e</sup>	5.88±1.10 <sup>h</sup>	17.15±1.10 <sup>f</sup>
100,000	0.00	3.30±0.50 <sup>c</sup>	9.66±0.50 <sup>e</sup>	20.53±0.50 <sup>c</sup>
150,000	0.00	5.94±0.35 <sup>f</sup>	11.89±0.35 <sup>b</sup>	50.64±0.35 <sup>g</sup>
200,000	0.00	7.64±0.55 <sup>g</sup>	15.12±0.55 <sup>d</sup>	54.79±0.55 <sup>e</sup>

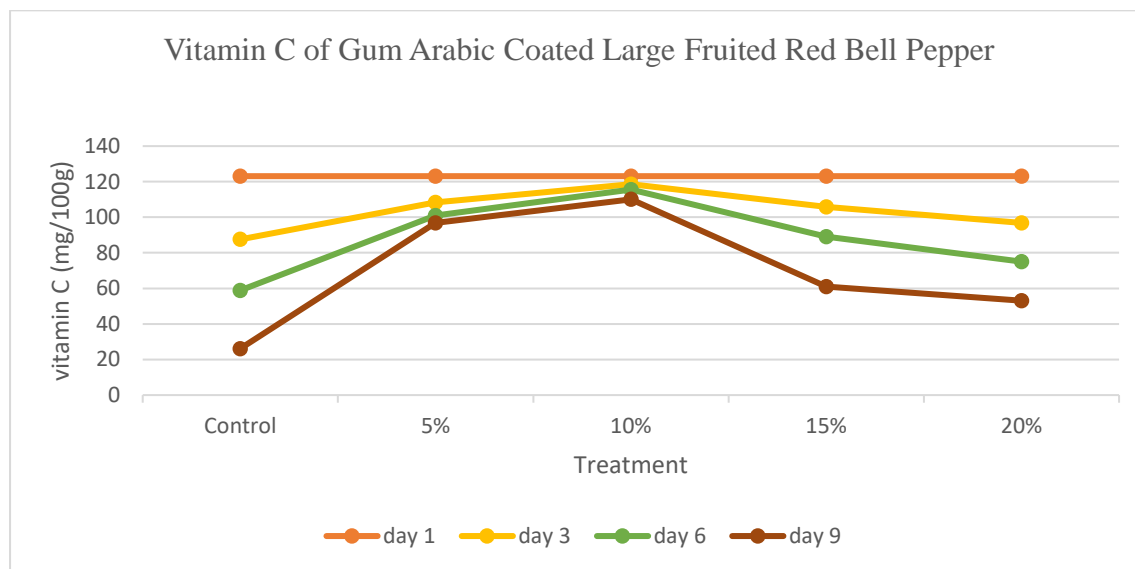
Values are means ± SD of three replications. Values in same row with different superscripts are significantly (P<0.05) different.

### Ascorbic Acid

Figure 1 shows how gum Arabic coating affect the level of ascorbic acid (Vitamin C) as a water-soluble vitamin in red bell pepper. There was a significant decline from the initial 120.09mg/100g ascorbic acid content in the control and treated samples. However, coating with Gum Arabic at different concentration led to retention of more ascorbic acids than what was observed with the uncoated red bell pepper, where the least ascorbic acid value retained after storage time was 53.04% using 200,000ppm, whereas the uncoated red bell pepper was having 26.17% ascorbic acid retention. The highest ascorbic acid retentions (96.75% and 110.06%) were observed in 50,000ppm and 100,000ppm respectively. Ascorbic acid as a water-soluble vitamin often declines under thermal effect and in storage as reported by of Wilson *et al.* (2017) on thermal and storage stability of vitamin C in tomato. The relative decrease in ascorbic acids were in consonance with decrease in other parameters owing to the fact that mature already ripened bell pepper was used and the storage condition was the prevailing room temperature of 28 ±5°C. and 19% relative humidity. In fruits and vegetables such as bell pepper, ascorbic acid content increases with maturity and stage of ripening (Mathooko, 2013), however once fruit reach the full ripe stage, the ascorbic acid content starts to decline. The slow decline in ascorbic acid in coated fruit suggests that the coating slowed



down the degradation of ascorbic acids during storage times. Reports on ascorbic acid decline was also observed in the work of Nasrin *et al.*, (2018) where chitosan and aloe vera gel were utilized as coating materials.



**Figure 1.** Effects of Gum Arabic Coating on Ascorbic Acid Content of Red Bell Pepper during Storage.

### Total Soluble Solids, Titratable Acidity and pH

Table 2 showed result on some chemical changes as influenced by gum arabic coating of red bell pepper stored in ambient conditions. There was a gradual increase in total soluble solids (TSS) during the entire storage period. The TSS was significantly ( $P \leq 0.05$ ) higher in control compared to coated samples and the reduction in TSS in coated red bell pepper was directly proportional to the concentration of the coating. The lowest TSS at the end of the storage period was recorded in fruit coated with 100,000 ppm. This showed that the coatings provided an excellent semi-permeable film around the fruit, modifying the internal atmosphere by reducing oxygen or elevating carbon (IV) oxide and thus, suppressing ethylene build ups. Similar evidence of lower TSS in edible coatings have been reported by many researchers (Mona and Noura, 2023, Asgar, *et al.*, 2010, Yaman and Bayoindirli, 2022 amongst others).

Meanwhile there was decrease in titratable acidity (TA) values of coated and control samples during storage times (Table 2) and the value was significantly ( $P \leq 0.05$ ) more in 100,000ppm compared to control. The increase in TA was directly proportional to the GA concentration. The low level of TA in control fruit compared to coated fruit suggests that the gum arabic coating delayed ripening by providing a semi-permeable film around the fruit. Since organic acids, such as malic or citric acid, are primary substrates for respiration, a reduction in acidity is expected in highly respiring fruit (Nguyen *et al.*, 2019). It is also considered that coatings reduced the rate of respiration and may therefore delay the utilization of organic acids (Yaman and Bayoindirli, 2002). Retention of titratable acidity has been reported previously for various fruits treated with edible coatings and films (Nguyen, *et al.*, 2019, Asgar, *et al.*, 2010).

Although, there was significant ( $P \leq 0.05$ ) increase in pH with storage time for the control sample and that of the highest concentration, however, only about 2% increase in pH was recorded for the 200,000ppm GA coated bell pepper relative to the control which was about 31% rise after the 9th day of storage. The results suggest that coating provided semi-

permeable barrier that reduced respiration as well as other metabolic reactions that would have raise the pH (Mona and Noura, 2023).

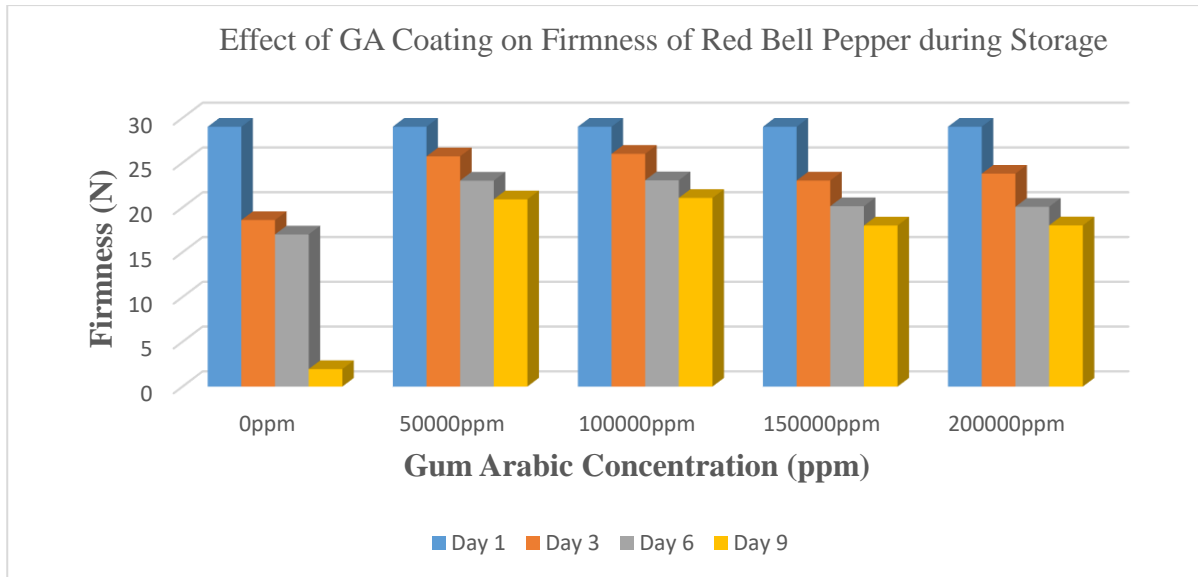
**Table 2:** Effects of Gum Arabic Coating on Changes in Some Chemical Properties of Red Bell Pepper during Storage

Parameters	Days after Storage	Concentration(ppm)				
		0.00	50,000	100,000	150,000	200,000
<b>TSS (°Brix)</b>	0	7.50±0.15 <sup>a</sup>	7.50±0.15 <sup>a</sup>	7.50±0.15 <sup>a</sup>	7.50±0.15 <sup>a</sup>	7.50±0.15 <sup>a</sup>
	3	7.90±0.05 <sup>a</sup>	7.58±0.01 <sup>b</sup>	7.58±0.50 <sup>c</sup>	7.53±0.03 <sup>d</sup>	7.53±1.00 <sup>e</sup>
	9	8.50±0.11 <sup>f</sup>	7.69±0.11 <sup>e</sup>	7.60±0.11 <sup>a</sup>	7.71±0.10 <sup>d</sup>	7.80±0.55 <sup>b</sup>
<b>TA (g Citric Acid/L)</b>	0	0.39±0.01 <sup>b</sup>	0.39±0.01 <sup>b</sup>	0.39±0.01 <sup>b</sup>	0.39±0.01 <sup>b</sup>	0.39±0.01 <sup>b</sup>
	3	0.22±0.00 <sup>c</sup>	0.26±0.00 <sup>d</sup>	0.29±0.00 <sup>e</sup>	0.29±0.10 <sup>f</sup>	0.23±0.00 <sup>g</sup>
	9	0.15±0.00 <sup>a</sup>	0.20±0.01 <sup>e</sup>	0.25±0.00 <sup>f</sup>	0.23±0.01 <sup>e</sup>	0.21±0.00 <sup>g</sup>
<b>pH</b>	0	4.04±0.01 <sup>c</sup>	4.04±0.01 <sup>c</sup>	4.04±0.01 <sup>c</sup>	4.04±0.01 <sup>c</sup>	4.04±0.01 <sup>c</sup>
	3	4.94±0.01 <sup>d</sup>	4.00±0.10 <sup>e</sup>	3.96±0.10 <sup>f</sup>	4.03±0.10 <sup>g</sup>	4.08±0.50 <sup>h</sup>
	9	5.86±0.01 <sup>g</sup>	3.92±0.10 <sup>e</sup>	3.80±0.10 <sup>a</sup>	3.62±0.10 <sup>c</sup>	4.12±0.55 <sup>h</sup>

GA= Gum Arabic, TSS= Total Soluble Solids, TA= Titratable Acidity. Data are means ± SD of three replications. Values in same row with different superscripts are significantly ( $p<0.05$ ) different.

### Firmness

Firmness of fruits generally is a critical quality attribute for consumer acceptability. Figure 2 elucidates how shelf life of red bell pepper was influenced by gum arabic coating at different concentrations. There was significant ( $P\leq0.05$ ) decreased in firmness during the period of storage for both coated and uncoated red bell pepper. At the end of storage, the uncoated samples recorded the least of firmness. There was about 73% firmness retention in the 100000ppm GA coated red bell pepper after nine days as against a 93.3% loss in firmness. The significant firmness recorded with the coated samples were in the reverse order of GA concentration. This could be attributed to the after dry-cracks of coated films of the higher concentrations. Firmness in fruits had always been reported in similar findings to be on the decline (Koh and Melton, 2022, Asgar *et al.*, 2010, Nguyen *et al.*, 2019). Decline in fruits firmness is often associated with degradation of the middle lamella of cortical parenchyma cells, resulting in the hydrolysis of pectin and starch by cell wall hydrolases (Koh and Melton, 2016). The relative firmness conserved in the coated red bell pepper could be due to low oxygen and relatively higher carbon dioxide permeability.



GA= Gum Arabic

**Figure 2.** Effect of Gum Arabic Coating on Firmness of Red Bell Pepper during Storage

### Surface Colour

Surface colour remains a decisive factor of quality and consumer acceptability for fruits and vegetables (Aked, 2015). The colour attributes of the red bell pepper coated with different concentrations and stored in ambient conditions is presented in Table 3. With CIE Lab coordinates of  $L^*$ ,  $a^*$  and  $b^*$ , the brightness or luminosity of fruit ( $L^*$ ) gradually decreased during storage in both coated and uncoated fruits. The highest decrease in brightness was observed in the 0.00ppm (uncoated) red bell pepper, while redness ranges from  $11.56 \pm 56$  to  $26.88 \pm 0.11$  for the uncoated and the  $10 \times 10^3$  ppm GA coated red bell pepper. Significant ( $P \leq 0.05$ ) changes were found in the values of chroma ( $C$ ) and hue angle ( $h^\circ$ ) with about 75.96% and 19.05% before and after coating/storage. Hung *et al.* 2014 demonstrated that  $a^* \times L^*$  characterized the colour of pepper where  $a^* \times L^*$  is greater than 700, denotes brilliant red. The results in Table 3 therefore implies that coating effectively (irrespective of the concentration) confined more redness whereas a value less than 700 is obtained for the uncoated, thus no redness at the end of ambient storage for 9 days. This could be attributed to shielding effect from gaseous exchanges between the experimental samples and the environment that prevented the reddish (more of carotene) degradation. This is in line with the results observed in the work of Park *et al.* (2014) on corn-zein film coating on tomato stored at  $21^\circ\text{C}$  were in congruence to those of this current research.

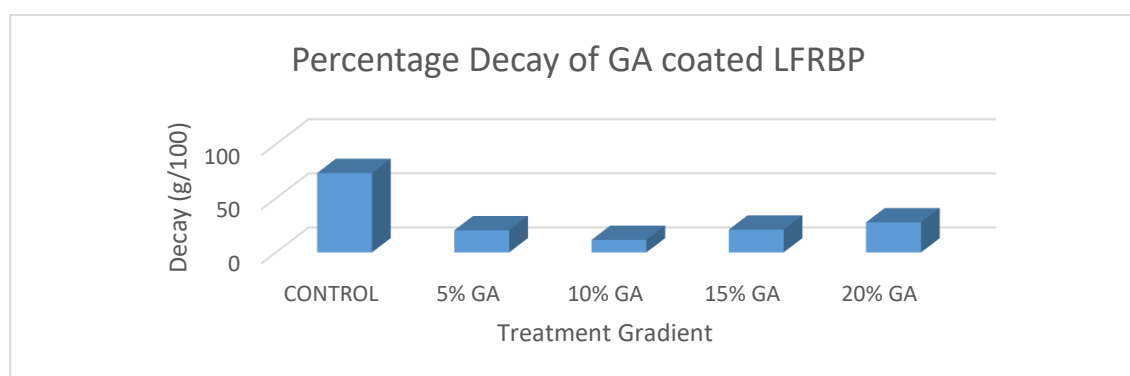
**Table 3:** Effect of Gum Arabic Coating on the External Colour of Red Bell Pepper in Storage

Concentration (ppm)	Days after Storage									
	Before Storage (Day 0)					After storage (Day 9)				
	L*	a*	b*	C	h°	L*	a*	b*	C	h°
50000	58.16 ±0.75 <sup>a</sup>	41.23 ±0.75 <sup>b</sup>	50.20 ±0.75 <sup>c</sup>	63.69 ±0.75 <sup>d</sup>	50.61 ±0.75 <sup>e</sup>	25.07 ±0.75 <sup>b</sup>	26.09 ±0.75 <sup>e</sup>	33.78 ±0.75 <sup>h</sup>	42.68 ±0.75 <sup>a</sup>	52.32 ±0.75 <sup>b</sup>
100000	58.16 ±0.93 <sup>a</sup>	41.23 ±0.93 <sup>b</sup>	50.20 ±0.93 <sup>c</sup>	63.69 ±0.93 <sup>d</sup>	50.61 ±0.93 <sup>e</sup>	33.99 ±0.93 <sup>e</sup>	26.88 ±0.93 <sup>b</sup>	31.05 ±0.93 <sup>e</sup>	41.07 ±0.93 <sup>c</sup>	49.11 ±0.93 <sup>f</sup>
150000	58.16 ±0.75 <sup>a</sup>	41.23 ±0.75 <sup>b</sup>	50.20 ±0.75 <sup>c</sup>	63.69 ±0.75 <sup>d</sup>	50.61 ±0.75 <sup>e</sup>	28.91 ±0.75 <sup>f</sup>	21.98 ±0.75 <sup>c</sup>	26.90 ±0.75 <sup>a</sup>	34.74 ±0.75 <sup>d</sup>	50.75 ±0.75 <sup>d</sup>
200000	58.16 ±0.91 <sup>a</sup>	41.23 ±0.91 <sup>b</sup>	50.20 ±0.91 <sup>c</sup>	63.69 ±0.91 <sup>d</sup>	50.61 ±0.91 <sup>e</sup>	30.75 ±0.91 <sup>d</sup>	24.91 ±0.91 <sup>a</sup>	29.00 ±0.91 <sup>d</sup>	38.23 ±0.91 <sup>f</sup>	49.34 ±0.91 <sup>e</sup>
0.00(uncoated)	58.16 ±0.75 <sup>a</sup>	41.23 ±0.75 <sup>b</sup>	50.20 ±0.75 <sup>c</sup>	63.69 ±0.75 <sup>d</sup>	50.61 ±0.75 <sup>e</sup>	15.09 ±0.75 <sup>a</sup>	11.56 ±0.75 <sup>f</sup>	10.04 ±0.75 <sup>f</sup>	15.31 ±0.75 <sup>e</sup>	40.97 ±0.75 <sup>h</sup>

Values are mean ± SD of three replications. Data with same superscripts in same column after storage are significantly ( $p \leq 0.05$ ) different.

### Percentage Decay

There was significant difference in the overall decay percentage between the coated and uncoated red bell pepper during storage, although, no physically observed decay until the sixth day for the coated and fourth day for the control. An implication is that, coatings significantly ( $P \leq 0.05$ ) reduced decay. Coating effect delayed cellular or tissue death, which could make fruits prone to pathogenic invasions as manifested by rotten (Mona and Noura, 2023). Figure 3 depicted an almost all (over 70% decay) in the uncoated while the highest decay (<30%) in the coated sample was observed in the  $20 \times 10^3$  ppm GA coated red bell pepper. The  $20 \times 10^3$  ppm gum arabic concentration proved to delay decay (<12%) the most at the end of the ninth day of ambient storage.



**Figure 3.** Effect of Gum Arabic Coating on decay percentage of Red Bell Pepper (RBP) in Storage.

### CONCLUSION AND RECOMMENDATION

The coating efficiency of gum arabic was manifested in the shelf-life extension of red bell pepper stored under ambient condition. The coatings in their respective concentrations portends a relative delay in the rate of losses of weight, firmness, titratable acidity, soluble solids, ascorbic acid, decay and colour during ambient storage compared to the uncoated samples. A further study is recommended for sensory evaluations, microbial assays for red bell pepper and for other cliacteric fruits and vegetables with emphasis on ambient storage.





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