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Original Article

Improvement of Quality and Shelf Life of Banana with Edible Coating Surface of Carboxy-Methyl Cellulose

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ABSTRACT

The recent study was undertaken to illustrate the impact of edible coating surface of banana by applying three different concentrations of carboxymethyl cellulose (CMC) (0.5, 1.0 and 1.5%) on physiochemical properties and storability at 14±1 °C for 20 days with 5-day intervals. Fourier-transform infrared spectroscopy (FTIT) was used to identify functional groups of CMC, subsequently, Scanning electron microscopy (SEM) was utilized to appear images of particles and structures of CMC. Consequently physiochemical properties analyzed (Weight loss, Pulp/Peel, Total soluble solids (TSS), Titratable acidity (TA) and TSS/TA as well as speed respiration rate and total carotene in pulp and peel of banana, finally measures of color indexes changes (a,b,c,L,H and Wight index (WI). The results demonstrated significant improvements in edible coating surface of banana by applying CMC matched to uncoated ones. Non-significant differences among the percentage of weight loss of banana uncoated and coated as a CMC-mean values. Statistical analysis for CMC-Mean values of pulp/peel ratios, titratable acidity (TA) and TSS/TA) in most banana samples had significantly been realized when treated with various concentration of CMC as an edible coating and storage period. Additionally, there are significant differences between CMC-Mean values of respiration rate in coated banana by all concentration (0.5, 1.0 and 1.5%) compared to the control (Uncoated) sample. Moreover, effect of CMC to slow down increase of carotenes in pulp and peel as a CMC-Mean values. Otherwise, there were a significant difference between storage-Mean values of most parameters, except weight loss, and some of color indexes before and after coating. Finally, the slower and faster peel color changes of banana due to synthesis or and degradation of pigments, the banana peel gradually improved from dark green indexes to light green and then to yellow during the ripening process and coating by high concentrate of CMC in this study.

Keywords: Banana, Quality, shelf life, Carboxy-Methyl Cellulose.

1 Introduction

Bananas (*Musa spp*.) fruits are widely consumed globally, especially in tropical and subtropical regions. It belongs to the Musaceae family, and it is the largest herbaceous flowering plant[1] . The genus Musa consists of approximately fourty species. Based on the total value of yield, bananas rank as the fourth most important food commodity worldwide, following grains such as wheat, rice, and maize. Furthermore, bioactive compounds in fruits, which are essential for human health, including antioxidants like vitamins C, E, and other vital to human well-being. Despite their numerous health benefits, bananas have faced challenges in terms of postharvest preservation due to their intrinsic and extrinsic perishability. [2]

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Explained that the demand for freshness in fruits and vegetables is increasing day by day. These fruits possess a high moisture content (94%) and are susceptible to postharvest physical, chemical property conversion, green color deterioration, and microbial activity [3].

Kurdistan Regain/ Iraq is an agricultural region known for cultivating and producing most deciduous fruit trees, but the climate in some places are unsuitable for bananas. Bananas are a popular fruits and imported in large quantities annually, stored, and then artificially ripened. It is known that the storage period for bananas after ripening is short.

Several researchers, [4-6] described the properties of Carboxymethyl cellulose (CMC), which is considered a polymer has a swelling capacity, tasteless, odorless, non-toxicity, biodegradability, unique reactivation, hydrophilicity as well as having affordable and soluble in both hot and cold water has great potential to form a transparent and flexible layer and adhere to the surface of the treated product. The major challenge handled by the industry inducing produce marketability is considered the perishability of fruits in post-harvest management. Authors, [7] reported that several factors are influence to shrinkage the quality of banana due to biological degradation through ethylene production, speed respiration rate, physiological change and high enzyme activity. Previously, many studies have shown that different techniques for controlling the ripening of climacteric fruits have been utilized, such as modified atmosphere [8]. Controlled atmosphere storage, and low-temperature storage [9]. Recently, edible coatings have been used to maintain the quality and extend the shelf life of some fresh fruits and vegetables, such as citrus fruits, bananas, apples, peppers, and cucumbers [10]. The edible coating works as a barrier to control moisture loss and gas exchange (CO2 and O2) between the fruit and their surrounding environment, thereby slowing down the respiration rate, delaying the physiological ripening process, and preventing the loss of natural volatile flavor compounds [11]. The application of edible coatings to fruits appears to be a suitable decision for prolonging the shelf life of fruits and vegetables. In this regard, coating the surface of bananas has developed as a particularly promising technique because it effectively prolongs the shelf life of products and maintains bioactive compounds when compared to untreated products. [10, 12 & 13].

Other researchers, [14] reported that the edible coating dropping respiration process, thus slowing the rate of degeneration due to senescence. Several parameters such as Weight loss, total soluble solids (Brix), pH, titratable acidity (%) and disease severity values as compared to control samples were favorable due to treatment of banana samples by chitosan, as well as the ability to increase storage periods of banana up to more than two weeks. According to our knowledge, there is a no research on CMC as an edible coating to maintain the quality and extending the shelf life of banana.

The main goal of this work is to investigate the various concentration of carboxymethyl cellulose (CMC) used for coating surface bananas to elongate the storage periods of bananas with maintaining their physiochemical properties.

2. Materials and Methodology

2. 1 Experimental materials

Banana (*Musa spp)* (type of Ecuador), treated by ethylene from cold room (15 ℃) for 48 hrs, with absence of physical damage and fungal infection in Erbil city (Elwa) was used in this study.

2. 2 Edible coating with carboxy-methyl Cellulose (CMC)

Bananas were divided into two groups, first one without any treatment will be taken as the control set, and the second one will be coated with different concentrations of CMC (BDH, England) (0.5, 1.0, and 1.5%) . To preparation 4 liters of each concentrate, dissolve 20, 40 and 60gm, CMC separately, in distilled water, in order to obtain a suitable quantity of solution for the experimental. Banana immersed in the coating solution for 1:30 (one minutes and thirty seconds). Then all samples were stored at 14 ℃±1 for 20 days (0, 5, 10, 15, and 20 days). The physicochemical properties were determined every 5 days to confirm the safety and quality of the final product.

2. 3 Confirm and characterization of Carboxymethyl cellulose (CMC)

2. 3. 1 Scanning electron microscopy (SEM)

The morphology of the CMC powders was examined using a scanning electron microscope (Quanta 450, USA). Before imaging, the samples were dried at 60C overnight and gently ground in an agate mortar to break up soft agglomerates. A small amount of powder was then sprinkled onto aluminum SEM stubs covered with double-sided conductive carbon tape and the loose excess was removed with a gentle air stream to obtain a thin, well-dispersed layer. To minimize surface charging, the mounted powders were coated with a thin conductive film by magnetron sputtering (Ag target) to a thickness of approximately 200 A. The coated samples were observed in high-vacuum mode at an accelerating voltage of 20–30 kV using the secondary-electron detector. Several regions were imaged for each sample to ensure that the observed morphology was representative.

2. 3. 2 Fourier-transform infrared spectroscopy (FTIR) Analysis

To identify of functional groups of CMC that act and stability was tested using Fourier-transform infrared spectroscopy (FTIR, Shimatzo-IRSpirit Model). CMC with potassium bromide (KBr) used to create pellet, and the spectra was measured in the wavenumbers of 500-4000 cm-1 [15].

2. 4 Physicochemical parameters for banana

The methods of studying the aforementioned parameters were analyzed and discussed.

2. 4. 1 Determination of percentage of total weight loss (%)

The physiological loss of mass was calculated according to the procedure described by [16]. Weight loss of banana was measured by the fresh weight as an initial weight by using a balance with an accuracy of 0.0001 g., and then weight it after storage for each, 05, 10, 15 and 20 days. Finally, using the following formula to find weight loss.

$$\text{Weight loss\%} = Initial\ weight - Final\ weight / Initial\ weight \times 100 \qquad \text{Eq (1)}$$

2. 4. 2. Pulp to Peel Ratio (%)

In order to determine the effect of coating substances on pulp to peel ratio, the weight of pulp is divided by peel weight [17].

2. 4. 3 Total soluble solids (TSS) (Brix) , Titrable Acidity (TA%) and TSS/TA (%)

Centrifuged at 10,000×g for 20 minutes of 5g flesh of banana before and after coating. The supernatant was utilized to measure the TSS using a digital refractometer. The TA was assessed according to a method described in previous research with slight modifications [18]. Due to distilled water, 10 grams of flesh banana was diluted to complete the quantity of 100 ml. 0.4 g of kaolin was added to each gram of sample. Then, blender was used to homogenized and filtered. The aqueous was transferred into a 250 ml beaker and placed over a magnetic stirrer. The juice was then titrated using standardized 0.1 mol/L NaOH at the phenolphthalein endpoint (pH = 8.2 ± 0.1). Titrable acidity was calculated by using the following formula.

Titratable acidity (%)= [Vol.NaOH (ml) X (Normality of NaOH) X (0.064)/Pulp Juice (ml)] X 100 Eq.(2)

Finally, calculate the TSS/TA. Three replicates will be performed for each samples.

2. 4. 4 Measurement the Speed of Respiration (mg/Kg/hr)

The speed of respiration can be estimated by CO_2 which measure the amount of CO_2 output of the fruits with closed system. Place100 ml of sodium hydroxide solution NaOH with known molarity (0.1M), then put one kg of the banana before and after coating (leave the fruit in the laboratory until the fruit temperature equal with the temperature of the surrounding air 20-25℃), after that close the desiccator and left it in a room temperature in the dark to prevent photosynthesis for 24 hrs, depending on crop type and the degree of completion growth [19].

$$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$$

Took 10 ml of NaOH solution and added 2-3 drops of phenolphthalein pigment, then titrated with HCl (0.1N) until change the color of solution.

CO2 mg / Kg / hr. = 1/ hr X 1/Weight of sample X eq. wt. of CO2 X Volume of NaOH X Volume of HCl Eq. (3)

Equivalent weight of CO2 = 22.

2. 4. 5 Total Carotenoids (mg/100g)

By using 2 ml of fruit juice mixed with 20 ml of acetone 80% to extract the pigments. Also 0.1 gm of sodium bicarbonate placed to the mixture to prevent oxidation of carotene pigment. Then the ending was filtered and the optical density of the samples was read by a spectrophotometer at a wavelength of 480nm [20]. The total carotenoids were calculated a cording to the following equation

$$X= \frac{EY}{e \times 100} \times 1000 \qquad \text{Eq. (4)}$$

X *is total carotenoids content,* ***E*** *is absorbance at 480nm,* ***Y*** *is dilution factor,* ***e*** *is extinction coefficient*

2. 5 Measurement of colors

Calibrated the Precision colorimeters due to a standard reference object (White and color objects), and then, the measurement function of the colorimeter, place the probe of the colorimeter on the peel of banana to be measured, and record the measurement results. The Colorimeter JENWAY, CR- 300, Osa) was utilized to measure the color of peel of banana before and after coating with differente concentration of CMC. The whiteness index (WI) (Equation 5 values were determined using the equations of [21], as shown below).

$$\text{Whiteness index, WI} = 100 - \sqrt{\left\{(100 - L*)^2 + a*^2 + b*^2\right\}} \qquad \text{Eq. (5)}$$

2. 6 Statistical Evaluation

All experiments were carried out in triplicates and presented and using (SAS, 2002-2003), which used the Completely Randomized Design factorial (CRD) and then Duncan's multiple range tests for comparisons among all treatments and control at level of 0.05 were utilized to statistical analysis of data.

3. Results and Discussions

3. 1 Identification of Functional Groups of banana coated peel substances using (FTIR)

This equipment plays a crucial role in outcome and functional groups in most of compounds of substances. FTIR spectrum of carboxymethyl-cellulose (CMC), conduction pattern investigated between 4000 cm−1 to 500 cm−1 (Fig 1)

A strong band in (Fig 1) is observed in zones 3292.48cm^{-1} matches to stretching of OH groups, as well as a spectral broad absorption at 2883.07cm^{-1} this stretching vibration was due to C–H groups. Furthermore, due to a another absorption band at zone 2365.93cm^{-1}, leads to illustrate the stretching vibration of carboxyl groups (COO). Besides that, the absorption bands centered at about 1986.69, 1590.21, 1413.52 and 1048.65cm-1, the bands within the frequency range of 2000–1000 cm^{-1} are widely recognized. This result was slightly different with researchers [22]**.** Which they are found that However, the vibrations of –OH bending and C–O–C stretching are recognized to bands between 1021.36 to 567.4 cm−1, as well as the exposure of 1,4-glycoside of cellulose was completed of 420.90 cm−1.

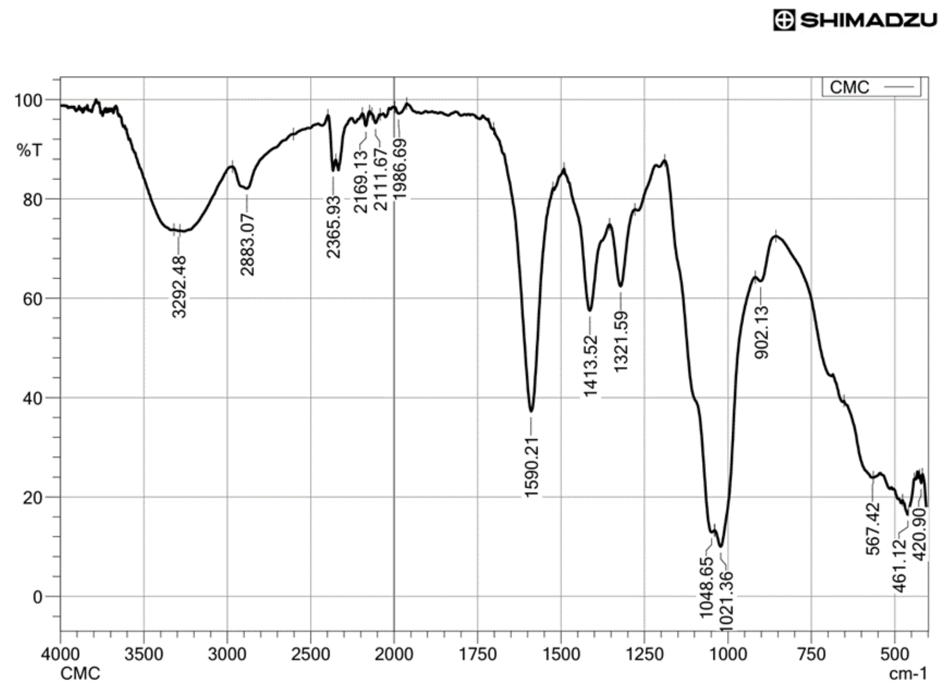


Figure 1: Characterization of Carboxy Methyl Cellules (CMC) by Fourier transform infrared spectroscopy.

3. 2 Scanning electron microscopy (SEM)

In this study, SEM utilized to illustrate the morphological (images) carboxy-methyl cellulose (CMC). The results in Fig. 2 observed that the morphology of CMC appear as tenuous properties and the distance between molecules compounds of CMC far from each other. Researchers [22] reported that CMC contents was gradually insignificant and had a big space between molcules due to methylated due to carboxymethyl groups substituted on.

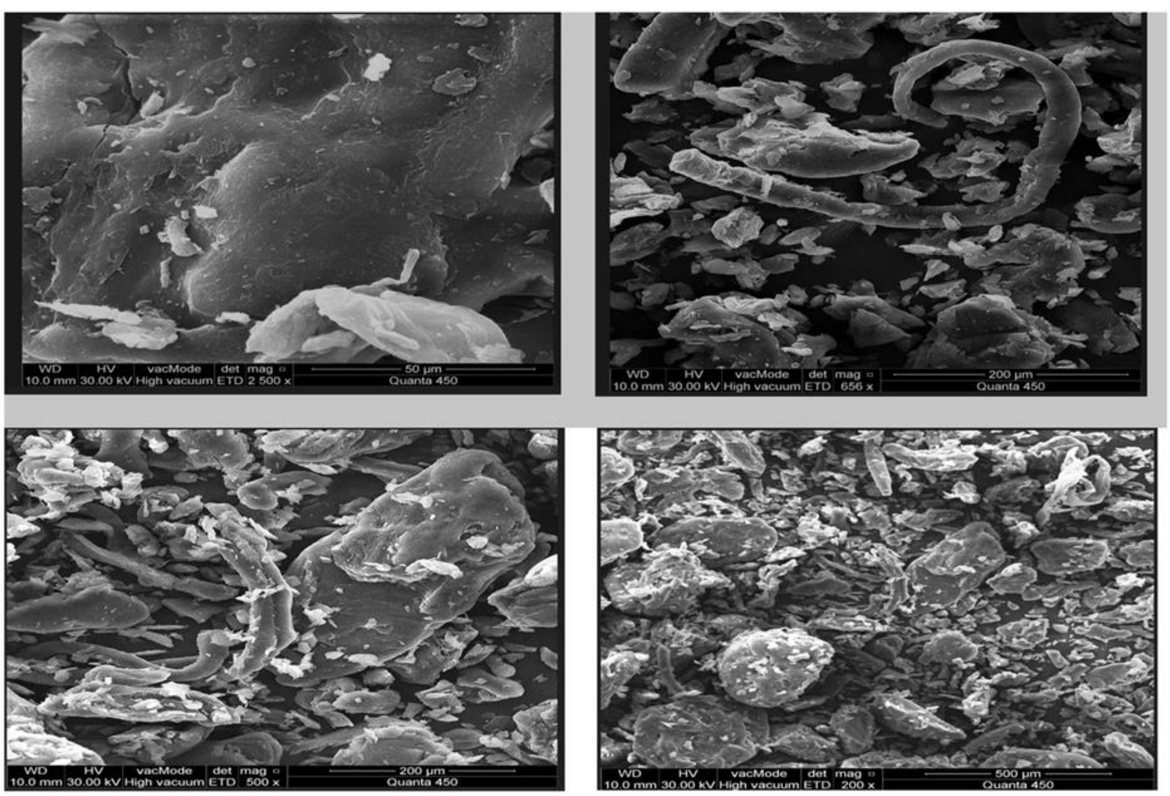


Figure 2: Morphological of Carboxymethyl Cellulose (CMC) by Scanning Electron Microscopy (SEM).

3. 3 Weight loss (%)

One of the essential elements of banana characteristics during elongated storage time and to increase shelf life of banana is weight loss. The results in Table 1. Generally, observed that non-significant of Weight loss%, at the same time, slightly accelerated during storage in all samples of banana coated by CMC compared to the banana uncoated. However, statistically no significant variation of storage-Mean among all banana coated and control from the zero day to the last day of storage (20 days). In addition, the highest and lowest total average weight loss values were observed (Control) (0.72 and 0.54 %) in banana uncoated and banana coated with C3 (1.5%). This results are similar to the previous researches [17] who was reported that slightly increase the weight loss of banana before and after coated for some samples and during storage periods. On the other hand, This results are in contrast with all researchers [23,24 and 1], whose they found significant variation among samples before and after treatments. This is due to banana over fifteen days of kept at 22 °C, as well as differences of samples, stages of ripening and types and concentration of substance for coating as well as related to the storage conditions. The High value weight loss more than twenty days of the storage period in all samples before and after treatments due to maximum transpiration through holes cells of commodities. The degree of transpiration is associated to the temperature, this phenomenon is similar to [23].

Table 1: Effect of coating with various CMC concentrations for a storage period and their interactions on weight loss (%).

Storage (days)	Concentration of CMC				Storage-Mean
	C0 (Control)	C1 (0.5%)	C2 (1.0%)	C3 (1.5%)	
0	.0	.0	.0	.0	0
5	1.44 ± 0.23 a	1.22 ± 0.27 a	1.13 ± 0.36 a	0.96 ± 0.24 a	1.19 ± 0.13 a
10	0.2 ± 0.11a	0.38 ± 0.17 a	0.47 ± 0.25 a	0.45 ± 0.47 a	0.38 ± 0.13 a
15	0.67 ± 1.19 a	0.73 ± 0.48 a	0.72 ± 0.2 a	0.65 ± 0.96 a	0.69 ± 0.34 a
20	0.59 ± 1.34 a	0.52 ± 1.44 a	0.24 ± 1.07 a	0.11 ± 0.38 a	0.37± 0.49 a
CMC-Mean	0.72 ± 0.37 a	0.71 ± 0.31 a	0.64 ± 0.24 a	0.54 ± 0.24 a	

The same letter on the means of each factor and their interactions are not significantly different from each other according to Duncan's Multiple Range Test at 5% and standard Error (SE).

3. 4 Pulp to Peel ratio (%)

Weight pulp and peel individually and considered as pulp/peel ratio. This parameter is considered essential element to the post-harvest losses during ripening stages of fruits. Statistical analysis are investigated that the CMC-Mean and storage-Mean of pulp/peel significant values between bananas coated and control (Table 2). The impact of various concentration of CMC (1.5, 1.0 and 0.5%) coating on pulp to peel ratio of banana fruits recorded between 1.32 to 1.60, 1.31 to 1.66, 1.29 to 1.68 (%) respectively, which they were less increased percentage of pulp/peel as compared uncoated banana (Control) 1.29 to 2.12% from 0 day to the final days of storage periods. The maximum and minimum values of total average pulp/peel of banana observed 1.65 and 1.42 in uncoated samples and banana coated with highest concentration (1.5%), respectively. [9] explained that, due to evaporate water contents from peel to pulp and into around, after that increased the total soluble solids (TSS) in pulp. This factor leads to increase the amount of pulp to peel ratio by speed up osmotic pressure transfer within the pulp. Furthermore, due to coating surface of banana by different concentration of CMC, leads to slow down the respiration and oxidation responses as well as keep the pulp/peel in fruits by improving their properties after collection. These findings concur with those of [17] who found that less increase in pulp/peel of banana coated with AgNPs that was 1.4–1.6% at day seventh and 1.9–2.4% at day thirty two. Compared to the control samples. In addition, the results similar to previous, researchers'[25] noted that the coated banana fruits demonstrated less increase in pulp to peel ratio than uncoated banana.

Table 2: Pulp to peel ratio (%) in banana before and after edible coating of CMC and storage periods.

Storage (days)	Concentration of CMC				Storage-Mean
	C0 (Control)	C1 (0.5%)	C2 (1.0%)	C3 (1.5%)	
0	1.29 ± 0.04 g	1.29 ± 0.03 g	1.31 ± 0.02 g	1.32 ± 0.02 g	1.3 ± 0.01 e
5	1.45 ± 0.04 g	1.36 ± 0.02 fg	1.32 ± 0.03 g	1.3 ± 0.02 g	1.36 ± 0.02 d
10	1.57 ± 0.02 d	1.44 ± 0.03 ef	1.39 ± 0.01 fg	1.37 ± 0.04 fg	1.44 ± 0.03 c
15	1.83 ± 0.02 b	1.59 ± 0.03 cd	1.54 ± 0.02 d	1.53 ± 0.06 ed	1.62 ± 0.04 b
20	2.12 ± 0.02 a	1.68 ± 0.03 c	1.66 ± 0 c	1.6 ± 0.05 cd	1.77 ± 0.06 a
CMC-Mean	1.65 ± 0.08 a	1.47 ± 0.04 b	1.45 ± 0.04 bc	1.42 ± 0.04 c	

The same letter on the means of each factor and their interactions are not significantly different from each other according to Duncan's Multiple Range Test at 5% and standard Error (SE).

3. 5 Total soluble solids (TSS) (Brix)

Authors [12] described the total soluble solids (TSS), which majority components of Total soluble solids (TSS) are included glucose, sucrose and fructose in banana pulp. This parameter is an essential indicator of commodities maturity. Table 3 represents the influence of various concentration of carboxy methylcellulose on the (TSS) of banana fruits for a period from zero to twenty days. The results investigated that TSS quantity in the control treatment between 4.33 Brix and 22.77 Brix from 0 day and twenty days respectively. Moreover, there was significant differences of CMC, and storage–Means of TSS in Banana coated and control as well as the interaction between treatments and storage time. The highest and lowest values were recorded in sample without treatment (22.77%) (Brix), at 20 days, and (4.33 %) at 0 day, respectively.

Table 3: Total soluble solid (TSS) (Brix) in banana before and after coating by different concentration of CMC for storage periods.

Storage (days)	**Concentration of CMC**				**Storage-Mean**
	C0 (Control)	**C1 (0.5%)**	**C2 (1.0%)**	**C3 (1.5%)**	
0	4.33 ± 0.12j	4.4 ± 0.15j	4.4 ± 0j	4.37 ± 0.19j	4.38 ± 0.06 e
5	6.73 ± 0.23h	5.77 ± 0.19hi	5.33 ± 0.33ji	5.5 ± 0.29ji	5.83 ± 0.2 d
10	11.03 ± 0.58f	9.47 ± 0.07g	8.97 ± 0.29g	9 ± 0g	9.62 ± 0.29 c
15	16.4 ± 0.66c	14.83 ± 0.13d	12.33 ± 0.44e	12.33 ± 0.67e	13.98 ± 0.57 b
20	22.77 ± 0.64a	20.1 ± 0.35b	19.67 ± 0.17b	20 ± 0.5b	20.63 ± 0.42 a
CMC-Mean	12.25 ± 1.79 a	10.91 ± 1.56 b	10.14 ± 1.48 c	10.24 ± 1.51 c	

The same letter on the means of each factor and their interactions are not significantly different from each other according to Duncan's Multiple Range Test at 5% and standard Error (SE).

The more increase in TSS in banana without treatment was due to the loss of water contents through evaporation and change of organic solutes into sugar substances, as described multiple study by [26,27 and17].The results also showed that the TSS was increased with increasing the storage time. This increase due to breakdown of starch into total sugar [15 , 28-29]. The current outcomes are in line with those [30,31].

3. 6 Titratable acidity (TA %) and ratio of TSS/TA (%)

The influence of various coating of CMC on the titratable acidity and TSS/TA are presented in Table 4 and 5. Change in TA linked with amount of TSS, due to increase in TSS decrease in TA. Statistical analysis for this parameter in most banana samples had significantly been realized when treated with various concentration of CMC as an edible coating and storage period. On the other hand, no significant variation among several samples. These results are in line with researcher [32]. Who reported no significant differences between Ramutan coated and control of the TA. Otherwise, significant differences of CMC-Mean and storage-Mean values of TA in all samples coated and control. This result was consistent with[33], who described there was significant differences between bananas coated and control. However the outcomes exposed that the minimum value of TA obtained from sample without treatment (0.23%) at the final storage period, while the highest value was recorded from all samples before and after treatments (0.83%) at the first day of storage. In addition, the decrease titratable acidity in samples from first day to the end were higher than the decrease of TA in coating samples by different concentration of CMC, this phenomenon are related to the influence of coating by various concentration of CMC. It was perceived that the coated banana revealed drop in TA production banana. This results agree with researchers [34,35]**.**

On the other hand, (TSS/TA) was details in table (5). The TSS/TA ratio is considered a maturity index of fruits. This property in banana was changed from 0 day to the final days (twenty days). In current study that is meaning in immaturity stage of banana the TSS/TA was lower than in maturity stage. Furthermore, there was significant of CMC-Mean and storage-Mean values of TSS/TA of bananas treatment and without treatment. This results showed similar with previous researchers [36] Who reported that the amount of TSS/TA significant variation among samples before and after coating, this difference might be linked to the changes of sugar content and also due to changes of moisture contents by two factors, exit water contents to out, and osmotic pressure transfer to the pulp.

Table 4: Titratable acidity (TA%) in banana before and after treatments for storage periods.

Storage (days)	**Concentration of CMC**				**Storage-Mean**
	C0 (Control)	**C1 (0.5%)**	**C2 (1.0%)**	**C3 (1.5%)**	
0	0.83 ± 0.01 a	0.83 ± 0.02 a	0.83 ± 0.03 a	0.83 ± 0.02 a	0.83 ± 0.01 a
5	0.75 ± 0.01 b	0.76 ± 0.02 b	0.76 ± 0.01 b	0.78 ± 0.03 ab	0.76 ± 0.01b
10	0.64 ± 0.02 c	0.65 ± 0 c	0.67 ± 0.01 c	0.69 ± 0.04 c	0.66 ± 0.01 c
15	0.49 ± 0.01 e	0.53 ± 0.02 ed	0.55 ± 0.01 d	0.51 ± 0.01 ed	0.52 ± 0.01 d
20	0.23 ± 0.02 g	0.32 ± 0.03 f	0.33 ± 0.02 f	0.36 ± 0 f	0.31 ± 0.02 e
CMC-Mean	0.59 ± 0.06b	0.62 ± 0.05 a	0.63 ± 0.05a	0.63 ± 0.05a	

The same letter on the means of each factor and their interactions are not significantly different from each other according to Duncan's Multiple Range Test at 5% and standard Error (SE).

Table 5: Ratio of Total soluble solid/Titratable acidity (TSS/TA) (%) in banana before and after coating with CMC and storage periods.

Storage (days)	Concentration of Carboxy methyl cellulose CMC (%)				Storage-Mean
	C0 (Control)	C1 (0.5%)	C2 (1.0%)	C3 (1.5%)	
0	5.24 ± 0.18 h	5.3 ± 0.12 h	5.31 ± 0.17 h	5.25 ± 0.33 h	5.28 ± 0.09 d
5	8.94 ± 0.44 gh	7.64 ± 0.42 gh	7 ± 0.5 gh	7.08 ± 0.17 gh	7.66 ± 0.29 d
10	17.23 ± 1.34 efg	14.56 ± 0.1 efgh	13.38 ± 0.26 fgh	13.06 ± 0.71 fgh	14.56 ± 0.59 c
15	33.22 ± 0.74 c	28.27 ± 1.3 dc	22.3 ± 0.67 efd	24.03 ± 1.3 ecd	26.95 ± 1.35b
20	99.91 ± 12.68 a	63.1 ± 5.76 b	60.07 ± 3.75 b	56.07 ± 1.22 b	69.79 ± 6.13 a
CMC-Mean	32.91 ± 9.56a	23.78 ± 5.76b	21.61 ± 5.42b	21.1 ± 5b	

The same letter on the means of each factor and their interactions are not significantly different from each other according to Duncan's Multiple Range Test at 5% and standard Error (SE).

3. 7 Respiration Rate (mg/Kg/hr)

Respiration is a highlighted of storability study of banana after produce. The value of this parameter is related two factors, first one is internal and second one is external factors. Internal factors includes level of organ improvement, the dimensions of the product, growth regulating compounds, and the second one is external factors, which it involves (temperature, ethylene, oxygen, carbon dioxide and nutrients growth regulator [37]. As seen in Table (6). There are significant differences between CMC-mean values of respiration rate in coated banana by all concentration (0.5, 1.0 and 1.5%) compared to the control (Uncoated) sample. It is also it has a significant differences between most of samples from 0 day storage-mean time to the last day of storage time for all samples before and after coated by carboxy-methyl cellulose (CMC). [38] are reported that the maturity stage was affected significantly on the respiration rate. This results are due CMC is worked to slow down respiration rate and barrier of exchange gases between banana's cell with environment. In addition this barrier is helped of banana to delay of ripening process and elongated the storage period of the product. Moreover, greater quantity of respiration rate (50.77 mg/kg/hr) found in uncoated banana in twenty days of storage period, and the lowest value (17.37mg/kg/hr) in coated of banana by highest concentration (1.5%) in the 0 day of storage time.

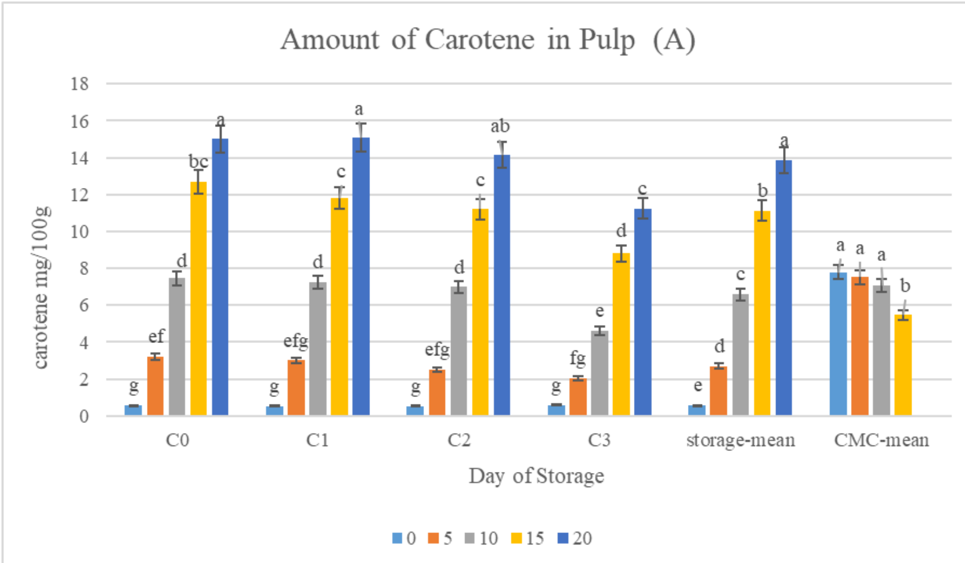
Table 6: Speed respiration rate in banana before and after treatments for storage periods.

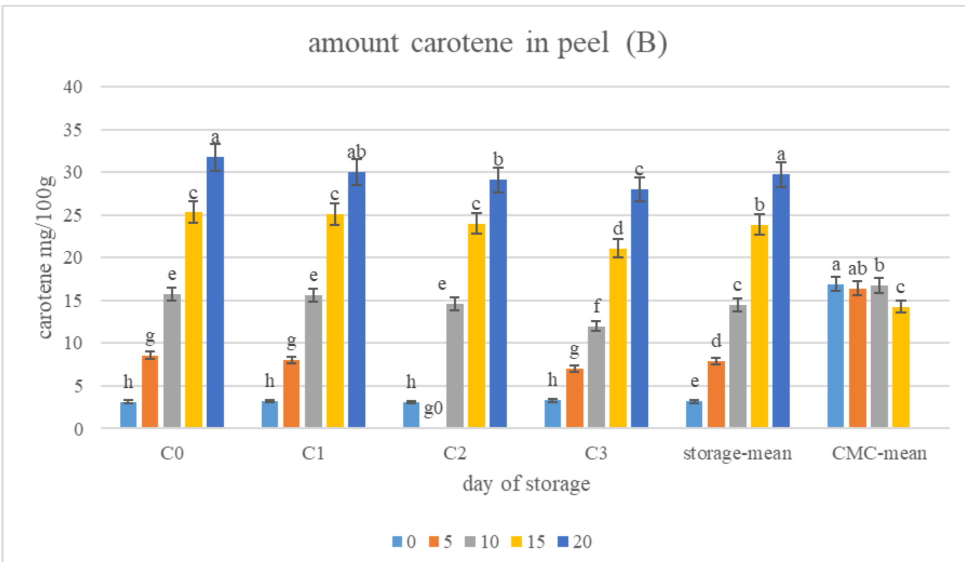
Storage (days)	Concentration of CMC				Storage-Mean
	C0 (Control)	C1 (0.5%)	C2 (1.0%)	C3 (1.5%)	
0	21.64 ± 1.29 ij	20.2 ± 1.14 ij	18.42 ± 0.92 j	17.37 ± 1.8 j	19.41 ± 0.75 e
5	28.54 ± 1.51 g	26.7 ± 0.72 gh	23.56 ± 1.7 hi	21.17 ± 1.73 ij	24.99 ± 1.06 d
10	38.98 ± 1.62 ef	35.61 ± 2.66 f	30.78 ± 0.38 g	28.39 ± 0.93 g	33.44 ± 1.43 c
15	46.1 ± 1.65 bc	44.78 ± 1.35 cd	39.64 ± 0.65 ef	37.2 ± 2.29 ef	41.93 ± 1.29 b
20	50.77 ± 0.79 a	49.23 ± 0.93 ab	44.67 ± 1.42 cd	40.48 ± 0.92 de	46.29 ± 1.3 a
CMC-Mean	37.21 ± 2.94 a	35.3 ± 2.95 b	31.41 ± 2.64 c	28.92 ± 2.46 d	

The same letter on the means of each factor and their interactions are not significantly different from each other according to Duncan's Multiple Range Test at 5% and standard Error (SE).

3. 8 Caroten in Pulp and peel (mg/100g)

Values of total carotene in pulp and peel of banana untreated and treated by three different concentrations of CMC (0.5, 1 and 1.5%) are shown in Fig. 3. (A and B). Generally, the value of total carotene in peel of banana higher than in pulp of banana. This parameter changed and increased with increasing storage time or and with develop of maturity. The range of total carotene of CMC-mean contents in this study close to the earlier research by [39], The results showed that carotenoid ranged from 0.18 to 36.82 µg/gin pulp and 0.9 to 16.2 µg/g in peel. The statistical analysis designated that there was no significant difference among the CMC-mean of carotenes in pulp of the coated samples and untreated samples, except the pulp of banana coated by highest concentration of CMC (1.5%). (Fig 3, B) indicated thet significant difference between the CMC-mean values of carotene in peel of banana coated by the concentration of CMC (1.0 and 1.5)%, compared to control.





The same letter on the means of each factor and their interactions are not significantly different from each other according to Duncan's Multiple Range Test at 5% and standard Error (SE).

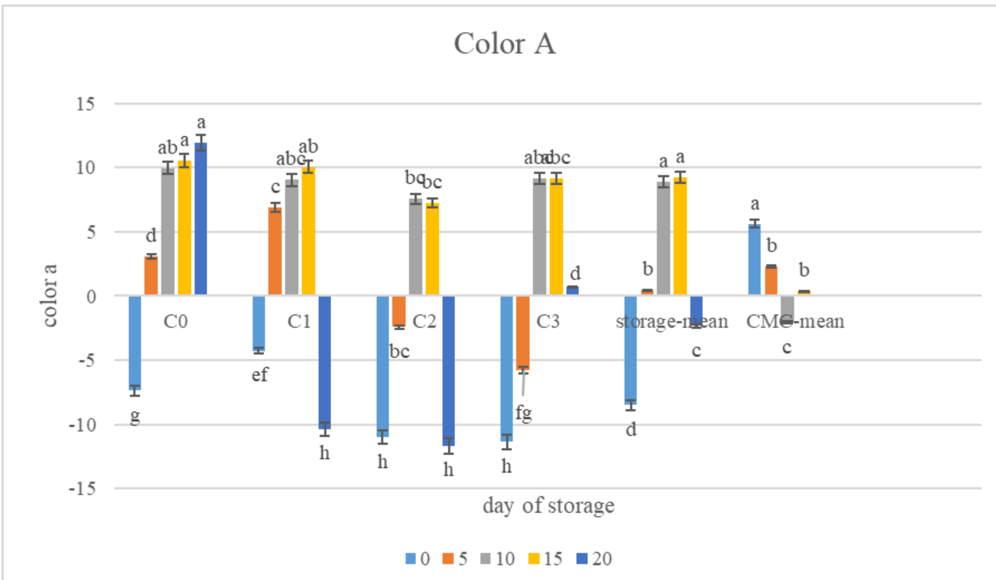
Figure 3: (A and B): Amount of Carotene in Pulp and peel in banana before and after coating by various concentration of CMC at storage periods.

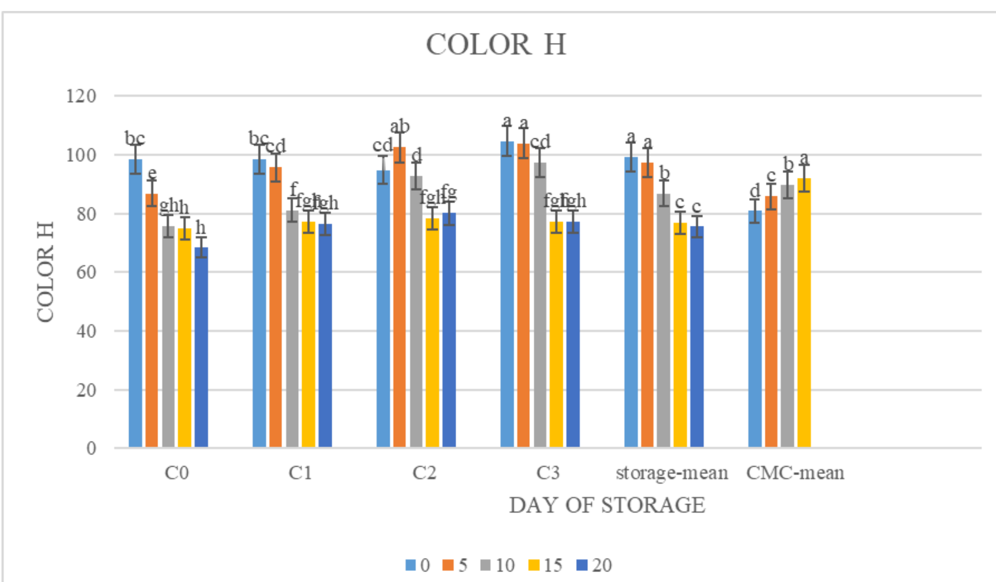
One can roughly conclude that banana untreated would have the highest carotene content (7.79 and 16.9mg/100g), while banana treated by highest concentration of CMC was recorded the least (5.475 and 14.28mg/100g) in pulp and peel of sample respectively. These dilemma are related to the work of CMC as a barrier to produce of carotenes or effect of CMC to slow down increase of carotenes in pulp and peel as a CMC-mean value. Several researchers reports that designated a relaxed rise in TSS of some fruits treated with chitosan [40,33], which might be due to chitosan's effect on reducing speed the ripening, degree of respiration, and metabolism processes of the commodities. Generally, the quantity of carotene in peel higher than the quantity in pulp. On the other hand, from 0 day to the final day of storage, the results of carotene in pulp to peel of banana before and after coating were investigated that the amount of carotene improved during ripening stages. The coated fruits with different concentration (1.5%) of CMC had significant impact on total carotene contents in pulp compared to banana uncoated during 10 to 20 days of storage, while the percentage of CMC 1 and 1.5% had a significant impact on this parameter in peel of banana at 20 days and at 10 to the last day of storage, respectively. This phenomenon is meaning the high concentration of CMC are more active to reduce the change of total carotene from 0 day to the final day or delay the ripening process.

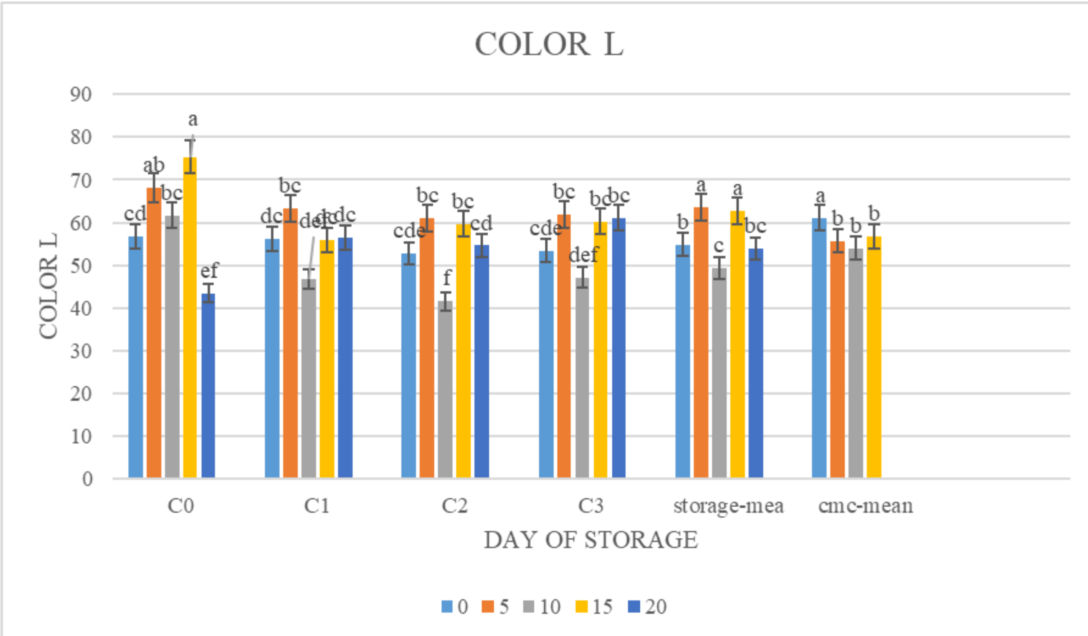
3. 9 Changes in colour of the peel during storage periods

Color is a major key of sensory evaluation to attract consumers. Peel of bananas were tested for luminosity (L*), from 0 (black) to 100 (diffuse white) a*, from green (negative values) to red (positive values) b*, from blue (negative values) to yellow (positive values). Chromaticity (C) and angle Hue (h) values. In addition, detect of white index via equation as we mentioned previously. A study was conducted to compare the impact of various concentrations of CMC coating as an edible coating of banana and uncoated of banana as well as stored for 20 days under 14±1 °C. Retorted ripening of banana due to plays a role of low temperature. The results showed that the slower and faster peel color changes of banana in Figures 2 (a,H,L,b, C and WI). First of all, in Fig 4 A. The dark green was demonstrated in most of banana coated and uncoated at the 0 day of storage due to the negative value of color indexes (a), as well as the highest value were recorded of uncoated samples from 10,15 and 20 days of storage due to positive value of color indexes (a) this results in a line with researchers [41]. In this research, due to synthesis of pigments such as carotenoids and degradation of chlorophylls the banana peel gradually improved from dark green indexes to light green and then to yellow during the ripening process. Moreover, Researchers [42] found that *a value was improved in all samples during the storage period. In addition the pulp became softer and loses of whiteness and brightness as well as converted to yellow color. Finally, over the ripening during storage black spots on the surface of the peel appeared depend on the bananas situation.

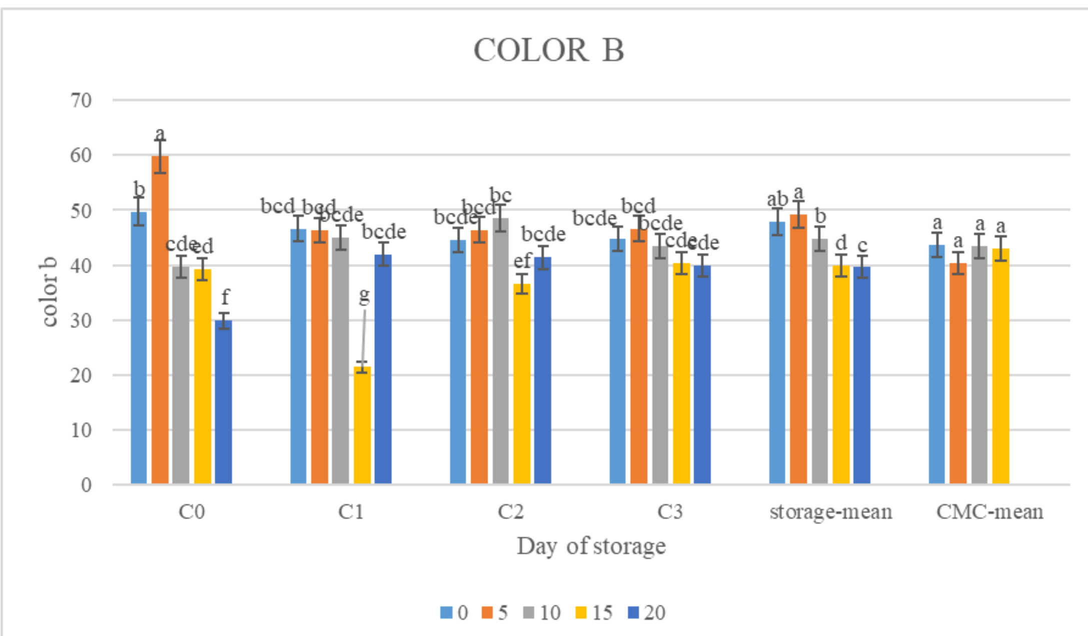
Statistically analysis, the CMC-mean of color changes (a, H and L) the peel of banana after coating compared to control were observed significant values. The higher values for the above color indexes changes were observed in control 5.63, and in Highest concentration coating of banana 92.05 and 61.09 in control), respectively, and the lowest values color changes for the (a, H and L) (-2.06) in banana coated by1% of CMC, 80.81 value in control (uncoated sample) and 53.95 value was observed in banana coated by 1% of CMC.



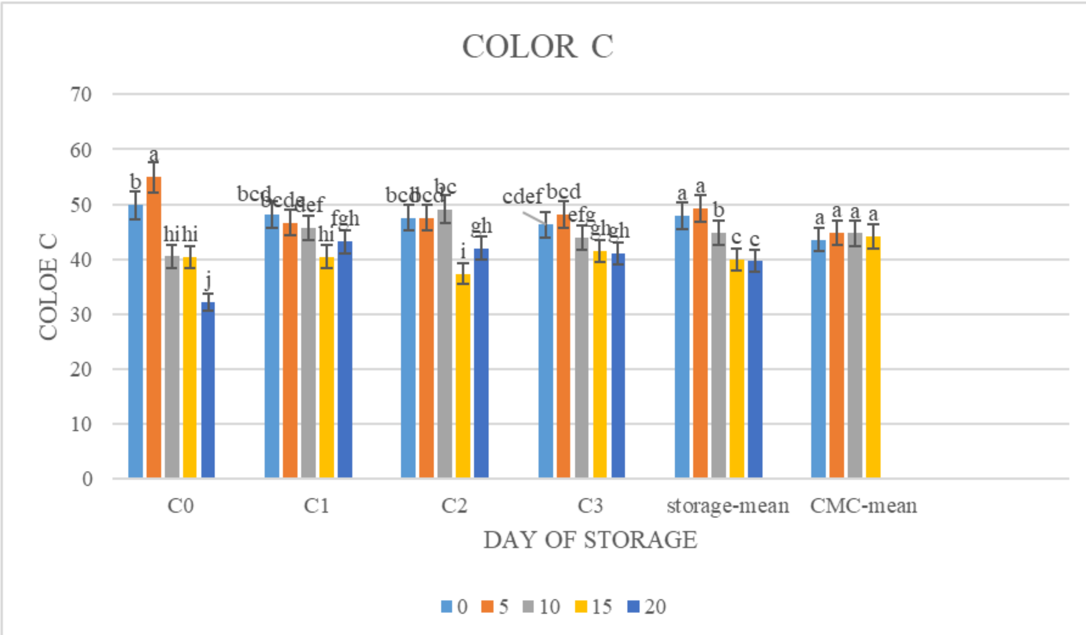


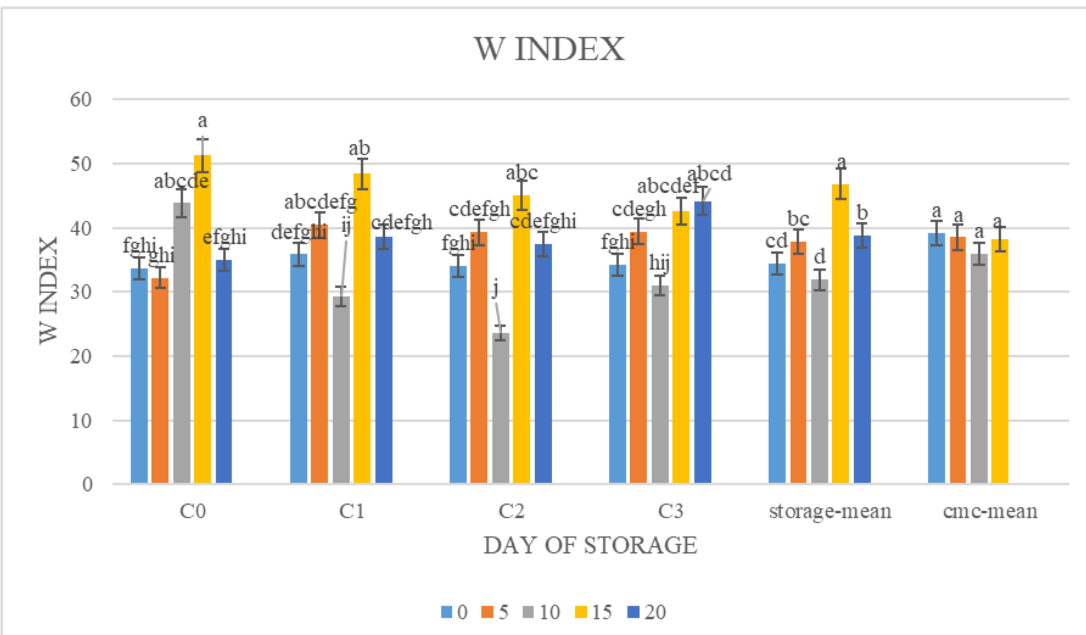


Forever, in contrast for the other indexes of color changes (b, c and WI) the CMC-mean of color changes non-significant values. In this study, most of banana samples from zero day to the final storage period were detected



significant values for most of color indexes. As observed a significant differences in storage-Mean values at zero day compared to 10 to 20 days of storage. This is due to synthesis of pigments such as carotenoids and degradation of chlorophylls, the color will be change it [43].





The same letter on the means of each factor and their interactions are not significantly different from each other according to Duncan's Multiple Range Test at 5% and standard Error (SE).

Figure 4: color change indexes o peel of banana (a,H,L,b,c and WI) during storage.

4. Conclusion

Overall, this work found that the influence of edible coated surface of banana with various concentrations carboxy methyl cellulose to reduce the weight loss, respiration and slow down breakdown of starch and make a sugar (TSS). Thus, Increase TA, as well as delay ripening process or senesces, which there were expressed to prolonging shelf life for some time and maintain the quality of final product such as color, total carotenes in peel and pulps.

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