Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.8, No.11, 2018

The Effects Packaging Materials on Post Harvest Quality of Tomato (Solanum Lycopersium)

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Abstract
This experiment was conducted during the year 2016 at Debre Markos University to evaluating the effect of packaging material on the post-harvest quality of tomato fruit. through packaging treatments. Treatments consisted of Dried straw, Carton, High perforated plastic film, low perforated plastic film and wooden basket(control) and one storage conditions (ambient condition using completely randomized design with three replications. From a local cultivar tomato fruits were evaluated for their shelf life and quality attributes over a storage period of 9 days. packaging in all days significantly improved postharvest quality parameters of tomato fruits tested as a result of reduction of mean temperature by 2.01^{o}C and increase of relative humidity by 5.25 % in the ambient storage conditions. Packaging also reduced weight and maintained fruit quality characters. there was no significant difference among treatments on TSS and pH for all entries. The highest percentage of tomato color account around 26.7 % of red and light red whereas the lowest percentage were record 5 % for those green and turning color. fruit firmness was exhibited from hard to soft ranges. almost 45 % of tomato tuber exhibited moderate firmness whereas only 5 % from the total tomato fruit exhibited extremely hard and hard texture. This study showed that importance of packaging for considerable number of traits studied and the possibility of selecting appropriate packaging material for tomato fruit for further testing for different post-harvest technologies objectives.
Keywords: Total soluble solid, pH and refractometer

INTRODUCTION

Ethiopia has potential to produce vegetable and fruits. Although the great potential for production of tomato in Ethiopia, the vegetable industry has not been contributing much to the economy of the country. according to Emana and Gebremedhin, (2007)., the production and the consumption of vegetables is relatively lower in developing countries Postharvest technologies have not been developed for most of major vegetable and fruit crops. Marketing of vegetable and fruits in Ethiopia is complicated by high post harvest lost which are estimated to be as high as 25-30% (Taddesse, 1991). It has also been estimated by FAO (2005) that the post harvest loser of perishable commodities in Ethiopia is a high 50%. This high loss has been attributed to several factors among which lack of packaging and storage facilitator and poor means of transportation are the major ones (kebede, 1991; Wolde, 1991). Reduction of the loss in a systematic way requires knowledge of postharvest physiology, its applied technical aspect, handling and appreciation of its biological limitation represented as a storage potential (Naka Sone and paull 1991). Modified atmosphere packaging for storage and transportation of fruits and vegetable is commonly achieved by packaging them in plastic films. Storage in plastic films with different kinds of combinations of materials, perforations, and inclusions of chemicals and individual seal packaging are type of modified atmosphere storage (Burdon 2001; Irtwange 2006).

The nutritional value of tomato make it widely accepted vegetable by consumers, fruits are rich in calcium, phosphors, magnesium, iron, foliate, vitamin A, B6, Vitamin E, Vitamin B2, Vitamin C, iron and carbohydrate (Wamache., 2005). Furthermore the fruit has medicinal value as a gentle for kidneys, and washing of toxin that contaminate the body system it improves the status of dietary antioxidants (lycopene, Ascorbic acid and phenols) in diet (George *et al*.., 2004). Tomato juice is known to be effective for intestinal and lever disorders (Wamache.., 2005).

Now a day in Ethiopia, there are various problem related with shellfire of tomato, postharvest loss due to inappropriate use of packaging materials took a lion share. Therefore, this study was helpful for smallholder consumer, sellers, and farmers to have the knowledge about the uses of packaging materials for tomato postharvest quality, and choose the better option by comparing the selected and preferred packaging material and storage environment with control condition on quality of tomato. Due to its importance the request and demand on tomatoes is rising day after day. However, its production and quality affected by many factors, such as packaging materials, storage environmental conditions. These are environmental stresses, which influences negatively a post-harvest quality and reduction of marketability value of tomatoes. As proved by few findings the user of improper packaging materials and storage environment can shorten the shelf life and quality of tomato crops. It is very important to evaluate the packaging material hence; this study was initiated with the objective of evaluating the effect of packaging material on the post-harvest quality of tomato fruit.

MATERIALS AND METHODS

3.1Description of the Study Area

The study was carried out at Debre Markos university college of Agriculture and Natural resource post-harvest laboratory. In the year of 2016/17 in the laboratory condition.

Experimental Procedures

Materials Preparation

Mature fruit (green-yellowish color) of Melkasalsa tomato fruit was obtained from certified tomato supplier. The fruits were immediately transported to the postharvest laboratory of Debre Markos University. Transportation was done during early in the morning to avoid light and heat damage.

Fruits were selected for uniformity of color, size, shape and freedom from defects. Immediately after selection, unblemished uniform fruits were subjected to cold chain to reduce the field heat and soil particles. Then fruits were washed with water and air dried.

Treatments and experimental design

Treatments consisted five packaging materials (perforated high-density polyethylene (HDPE) film, perforated low density polyethylene (LDPE) film, dried straw (DS), carton and control(Wooden Box) and one storage conditions. The treatments were laid in a completely randomized design with three replications. Thus, the overall experimental units were 15. The washed tomato fruits were divided into 15 groups of 30 fruits each and, the treated fruit were subjected to each treatment and at the ambient environment for nine days for the assessment of physiological weight loss every three-day interval. The physicochemical analysis of the fruits was taken in the laboratory having average temperature of 22^{o}C during the experimental period.

Data Collection

Every three days of storage, 15 fruits were taken randomly from each replication for determination of physical and quality analysis. Datum for all treatments were taken on 0, 3, 6 and 9 days of storage. Physical, chemical and subjective data were taken from sampled fruits during the storage period as follows:

Temperature and relative humidity measurement: Temperature and relative humidity was measured throughout the experimental period using Termo-hygrometer (Hygro-Haar-synth. Germany). The readings were taken at every six-hour interval every day. The average temperature difference between the six termo-hygrometers was calculated using the average of instrument every six hours interval:

Weight loss: The physiological weight loss (WL) was determined using the methods described by Mohammed *et al*. (1999). Weight loss of fruits was calculated from the initial weight of fruits per treatment and at each storage interval during the 9 days storage period. It was determined using sensitive balance (type JD2000-2). The formula given below was used to calculate cumulative weight loss expressed as percentage for the respective treatments.

$$\mathrm{WL}\ (\%) = \frac{\mathrm{Wi-Wf}}{\mathrm{Wi}}\ \mathrm{x}100$$

Where: WL = percentage weight loss,
Wi = initial fruit weight in gram,
Wf = final fruit weight in gram

Fruit firmness: The fruit pulp firmness of fruit was measured manually using a fruit pressure by hand.. Each fruit was placed on a table and pressed in the two opposite sides independently. the average were recorded for pulp firmness determination (from level 10-1).

Total soluble solids (TSS): The TSS was determined following the procedures described by Waskar *et al.* (1999). An aliquot of juice was extracted using a juice extractor. A hand refractometer (WAY-2s Abb'e,0-20 Brix^{o}) was used to determine TSS by placing 1 to 2 drops of clear juice on the prism. Between samples the prism of the refractormeter was washed with distilled water and dried with tissue paper before reuse. The referactrometer was standardized against distilled water (0 percent TSS) and adjusted with temperature.

pH and titratable acidity (TA): An aliquot of juice was extracted from the sample fruits and the pH value of the juice was measured with a pH meter (UB-10 pH/mV meter ultra basic).

Tomato fruit skin color: the predominant color of tomato fruit of each treatment were determined using freshly of tomato. The predominant colors which were used for evaluation are Green, 2=Breaker, 3=Turning, 4=Pink, 5= Light Red, 6= Red and 7 = Deep Red (IPGRI,1991).

Statistical Data Analysis

Significance tests were made by analysis of variance (ANOVA) in randomized complete design with SAS software (statistical analysis system, version 9.2). Comparisons of the treatment means were done using Least Significant Difference (LSD/CD) test at P = 5%.

RESULT AND DISCUSSION

4.1. Temperature and Relative Humidity

During the 9 days of storage period, the day time ambient temperature varied between 20..3°c and 25.6°c with the average being 22.2°c. (Fig.1). The relative humidity ranged between 29% and 68 % under the ambient conditions, with the average being 55% (Fig.2). In the present study, the day time average difference in temperature between different time of the day was 2.01°C and that of relative humidity was 5.25%. The minimum differences in temperature (0.09°C) were found at 6:00 hr, where as the maximum (4.44°C) difference was recorded at 11:30 hr (Fig.1). Similarly, the minimum (3.11%) difference in relative humidity was recorded at 6:00 hr, while the maximum (6.99%) was obtained at 11:30 hr (Fig.2).

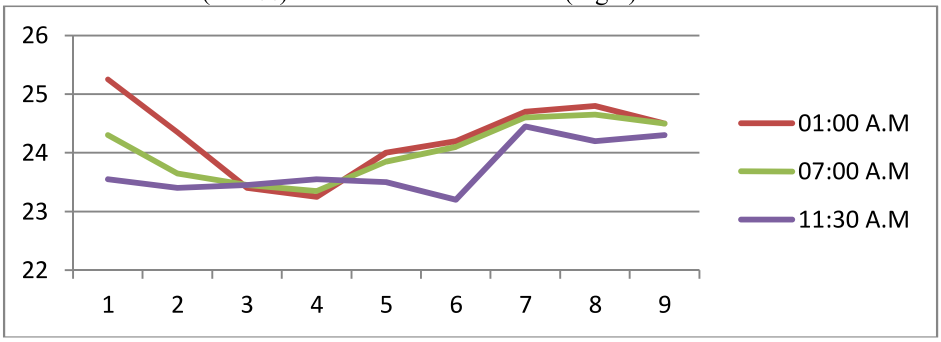


Fig 1.Average day temperature during the nine day storage period

There was little fluctuation in temperature and relative humidity in the ambient environment during the storage period. This is important from point of view of safe and effective storage of perishable commodities (Burdon, 2001). Though, tomato fruits stored under ambient conditions could be exposed to relatively harsh conditions at 7:00 hr because of high temperature and low relative humidity, this leads to a dramatic rise of their climatic respiration. According to Lam (1990), exposure of papaya fruit to excessively hot temperatures during handling results in accelerated depletion of organic acids and sugars due to an increase in the respiration rate, which was normally observed in fruit stored above the optimum temperature.

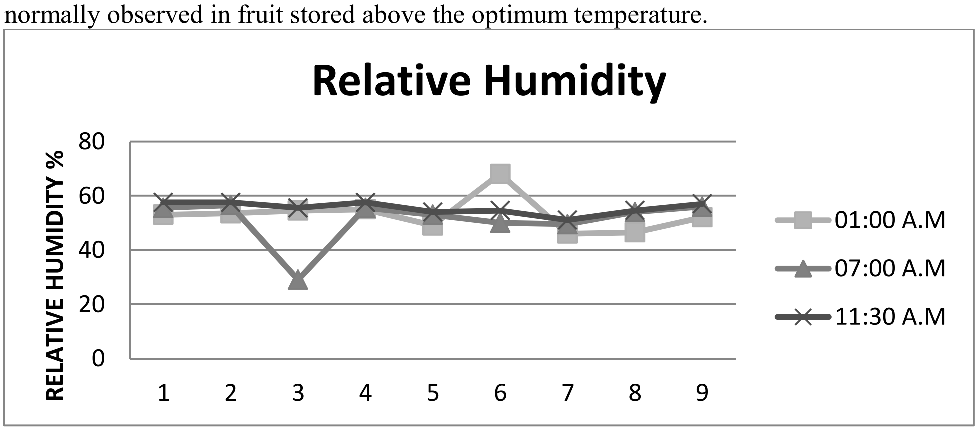


Fig 2. Average Day Relative Humidity During The Nine Day Storage Period

Physiological Weight Loss

Physiological weight loss (%) and rate of respiration. There was highly significant difference between treatments in weight loss progressively increased with packaging days. Due to the interaction effect of packaging and storage environment. However, the weight loss of treatment one (1) (T1) fruit was significantly higher at each packaging day were maximum weight loss was observed, on last (9) day, whereas the lowest record was for fruits packed with low density polythylene (LDPE) films. Rate of respiration was also found to follow similar trend at that of weight loss measurement. The highest weight loss observed in (T1) fruits may be due to the higher respiration rate exercised.

On day 9 of the storage period, weight loss of tomato stored in Straw at ambient condition was 12.668 %, which was higher than the weight loss of tomato fruits subjected to all other treatments (Table 1). The lowest weight loss value (1.268%) on the day 9 was observed in HPPF.

In general, irrespective of packaging and storage conditions, suppressed weight loss compared to fruits that didn't receive plastic film treatment. Similarly, the weight loss was highest during the last date of storage period stored at ambient temperature with respective storage time..

Treatments	Marketable weight loss		
	Storage periods, day		
	3	6	9
Dried Straw	3.616[a]	7.59[d]	12.680[a]
HPPF	2.006[ab]	3.97[c]	6.621[b]
LPPF	1.268[ab]	2.96[ac]	5.044[bc]
Carton	3.780[c]	7.80[ab]	10.168[a]
Control(wooden box)	2.906[d]	6.89[a]	9.966[cd]
CD (5%)	**1.634**	**2.328**	**4.118**
CV (%)	**11.623**	**7..13**	**8.591**

Table 1.mean square of Effect of packaging material on percent weight loss of tomato fruits over a storage period of 9 days

It was reported that high storage temperature leads to accelerated water loss and subsequently to shriveling and softening of fruits (Prolux *et al*., 2005). This might have contributed to the high weight loss of tomato fruits in the later storage condition which is associated with faster metabolism at higher temperature, increased cell wall degradation and higher membrane permeability leading to exposure of cell water for easy evaporation (Lee *et al*., 1995). Moreover, at higher temperature and low relative humidity of ambient condition duration of storage is reduced adding to the detrimental effects of water loss through transpiration (Howard and Hernandez, 1997) and, therefore, a greater loss of water and consequently an increase in weight loss. Willis *et al*. (1998) stated that water loss can be reduced effectively by placing additional physical barriers between the produce and the surrounding air.

Lower weight loss of packaged fruits could be due to slow rate of transpiration and prevention of excessive moisture loss. Similar results were also presented by Gonzalez *et al*. (1990), Lazan *et al*. (1990) and Tilahun and Kebede (2004). The lower water vapor transmission rate of polyethylene sheet may also contribute for the development of relatively higher humidity inside the package (Thompson, 2001; Farber *et al*., 2003; Mathooko, 2003). According to Ben-Yehushua (1985), the main function of packaging is to reduce respiration rate and water loss by transpiration, and injurious atmosphere inside the package, which could affect the fruits metabolism.

In general, the weight loss differences among the treatments in this study appear to be due to differences in temperature and relative humidity among the storage environments and packaging. According to Lam **(**1990), reduced rates of respiration and transpiration at lower temperature and higher relative humidity as well effects of the chemicals in suppressing activity of microorganisms that enhance respiration could be the reason for such a reduced rate of weight loss of fruits under.

pH value and TST

The pH and TSS was measured at day 9 by using pH meter and Refractometer. Table 2 exhibited that there is no significant difference among treatment for both parameters pH and TSS at 5% level of significant.

Treatments	pH and TSS	
	pH	**TSS**
Dried Straw	3.83 [a]	4.69[a]
HPPF	2.83 [a]	4.19 [a]
LPPF	7.00 [a]	3.91 [a]
Carton	2.67 [a]	4.27 [a]
Control(Basket)	3.50 [a]	3.73 [a]
CD (5%)	6.5484 *NS*	1.24 *NS*
CV (%)	17.67	11.45

Table 2. Mean square of Effect of packaging material on pH and TSS of tomato fruits over a storage period of 9 days

The change in pH of tomato fruits subjected to different packaging treatments during 9 days of storage is displayed in Table 2. tomato fruit juice was recorded to be highest in LPPF (pH 7) while the lowest values were obtained in packaged fruits treated with HPPF.

According to Mizrahi *et al.* (1997) during postharvest ripening, carbohydrate and acid metabolism are closely connected, which would thus raise pH of the produce. The tendency of increasing pH value and reduced acidity is observed with longer storage time since the fruit with proceeding of the ripening process is going to diminish its predominant acid (Medlicoot *et al*., 1986). The higher pH of fruits under ambient storage condition could be associated with the utilization of acids for catabolism of sugar at faster rate under ambient condition than in the evaporative cooler. High storage temperature leads to faster respiration rate (Rodriguez *et al*., 2005). Hence, lowering the storage temperature can reduce respiration rate and delay senescence of tomato fruits.

The lower pH values of packaged fruits could be explained by the relatively reduced respiration rate in the package. Reduced O_2 and increased CO_2 which could be created as a result of respiration could delay the rate of respiration in the package (Mathooko, 2003); hence, it may inhibit loss of organic acids (Wang, 1990).

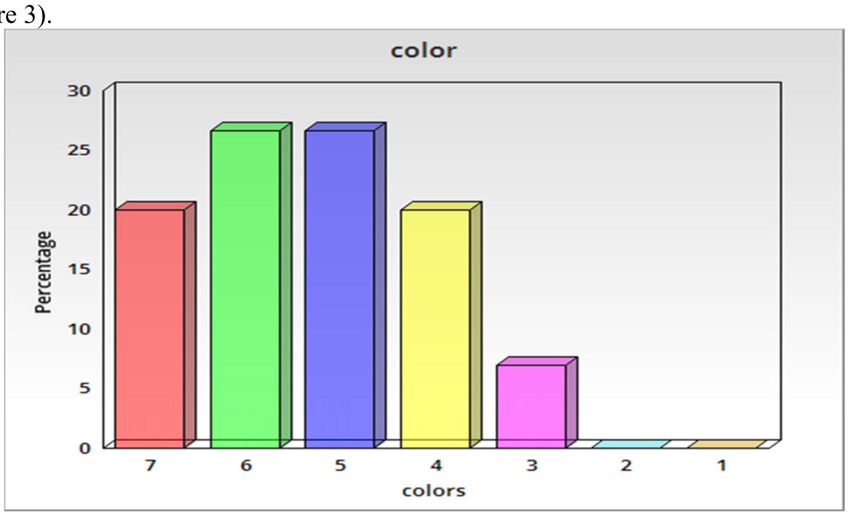
Straw under both storage environments, packaged fruits had higher TSS content (4.5 ^{o}Brix) compared to their respective treatments while the tomato fruit subjected to Carton had small TSS content (1 ^{o}Brix) than other treatments with respect to their storage condition.

The possible atmospheric modification, that is, reduced O_2 and increased CO_2 created in the package, combined with lower temperature might have delayed senescence of the fruits as a result of reduced respiration rate (Mathooko, 2003). Hence, packaged fruits do not rapidly deplete their soluble solids as those tomato subjected to Carton treatment.

Tomato fruit are climacteric fruits, that is, their respiration increase with storage time (Lakshminarayana *et al*., 1979). With storage time, TSS content of fruits could drop due to the use of the sugars as respiration substrate, which could be further aggravated by higher temperature (Lam, 1990; Irtwenge, 2006). High temperature enhances climacteric respiration, which leads to shorter shelf life of fruits (Pinto *et al*., 2004; Irtwenge, 2006.

Tomato Fruit Skin Color

The color chart measurement was taken on 9th day and there were 7 color grades. The grades were (Green-1, breaker-2, Turning-3, pink-4, light red-5, red-6, and deep red-7,) According to those color grades, the changes of the color expressed in percentage. When around 0-5% there were no color changes, meant at green and breaker stage of as the initial or original colors change that in turning color. Majority of skin color of treatment was red and light red which accounts 26.7% each followed by pink and deep red (20 %) each. Variation of skin color was due to storage and packaging material. however, breaker and red account the lowest (5 %) percentage proportion (Figure 3).



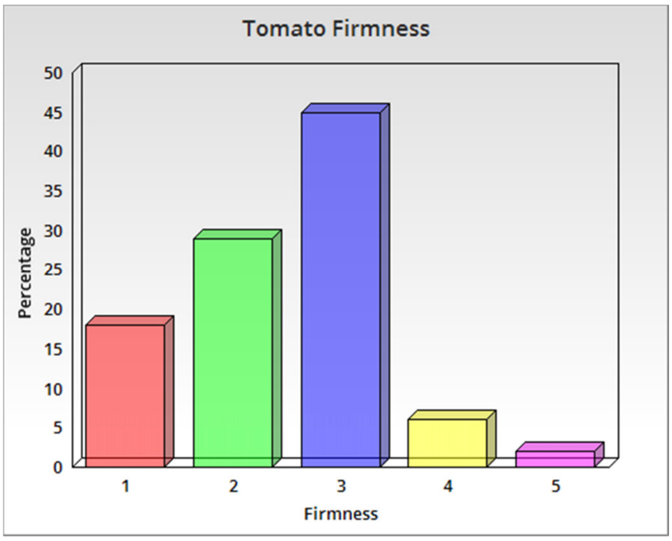
NB1= Green, 2=Breaker, 3=Turning, 4=Pink, 5= Light Red , 6= Red And 7 = Deep Red

Figure 3. Percentage of tomato fruit skin color of 15 entries

Tomato Firmness

The fruit firmness data was taken at 3 days interval that was at 3 days and lasts 9 days. All fruit lost their firmness and become soft after 9 days of storage. There were 5 grade of firmness soft, slightly soft, moderate, hard and extremely hard. According to these grades from 1 to 5.

At the initial there were extremely hard texture (5 %). the highest percentage were moderate (45.5%) followed by 30% of slightly soft and 19% were soft in their firmness.



NB 1=Soft, 2=Slightly Soft, 3= Moderate, 4= Hard And 5= Extremely Hard

Figure 4 average percentage of tomato fruit firmness within nine days

It has previously been reported by Salunkhe and Desai (1984) that controlled atmosphere storage or modified atmosphere packaging with high CO_2 inhibits the breakdown of peptic substances, which retains fruit texture and remains firmer for a longer period. Firmer ripe fruit was considered as one of the benefits of controlled atmosphere storage or modified atmosphere packaging to reduce mechanical damage, avoid fungal infection and increase shelf life of fruits. Mulatua (2008) in banana and Mulualem (2008) in papaya had reported the same result.

Generally, there was softening of fruits as the storage time progressed which could be due to texture modification through degradation of polysaccharides such as pectins, cellulose and hemicellulose that take place during ripening (Irtwange, 2006). It has been well established that texture changes in fruits are consequences of modifications by component polysaccharides that, in turn, give rise to disassembly of primary cell wall and middle lamella structures due to enzyme activity on carbohydrate polymers (Manrique and Lajolo, 2004). Hence, the differences in firmness of tomato fruits in the different treatments could partly be explained by the differences in rate of respiration that affect solubility and depolimerization of pectins (Lazan *et al*., 1995).

SUMMARY AND CONCLUSION

In Ethiopia, huge postharvest losses, especially in horticultural produce, occurs due to lack of packaging, storage facilities, and poor means of transportation. In spite of this fact, the attention given to reduce these postharvest losses has been low in the past. However, in recent years the postharvest handling of horticultural crops is becoming the area of research and there are some considerable work done in this area on different crops. tomato fruit is one of the most common and widely grown fruit crops in Ethiopia. However, information regarding postharvest handling of this crop is scanty. tomato fruit is a delicate and highly perishable fruit and the local production is subject to poor handling and packaging practices. As a result, huge postharvest loss of tomato fruits is incurred at different stages from harvesting to final consumption. Hence, appropriate postharvest handling practice is demanded for better protection and shelf life improvement of the fruit. With this background, the objective of this study was to objective of evaluating the effect of packaging material on the post harvest quality of tomato fruit.

Storage conditions greatly influenced the postharvest quality parameters monitored. The weight loss, firmness, TSS, pH and tomato color were all highly affected by the packaging materials.

There was significant difference among treatment on weight loss on day 3, 6 and 9 of storage period, they showed a general trend of positive effect on all these quality parameters during storage however there was no significant difference among treatment on TSS and pH value for all treatment.

The highest percentage of tomato color account around 26.7 % of red and light red whereas the lowest percentage were record 5 % for those green and turning color.

fruit firmness was exhibited from hard to soft ranges. almost 45 % of tomato tuber exhibited moderate firmness whereas only 5 % from the total tomato fruit exhibited extremely hard and hard texture. generally, the effect of packaging material on ambient atmosphere were showed that direct impact on the shelf life and quality of tomato fruit in all aspects.

Moreover, the current study indicated the need to undertake similar studies in the postharvest handling of tomato fruits with emphasis on:

- a multi storage and packaging pad should be developed in order to reduce the storage temperature

further down and raise the relative humidity up to the maximum potentially attainable especially in arid areas.
- the integrated agro-technology introduced in this study should be investigated under practical conditions on markets and farms.

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