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EFFECT OF POSTHARVEST PACKAGING ON QUALITY AND SHELF LIFE OF TOMATO FRUITS (*Solanum lycopersicum* (L.) IN KURA, KANO STATE, NIGERIA

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ABSTRACT

Nigeria is the second largest producer of tomatoes in Africa and 13th in the world but the estimated postharvest loss is about 60% which translates to huge economic loss. This loss prompted the search of simple and effective methods to reduce the postharvest losses. Technology like dips, packaging and improved storage conditions can greatly reduce losses and improve quality. The study was a 3x3x3 factorial comprising of dip, packaging and storage condition replicated three times. The paper investigates the effect of various packaging materials on quality and shelf life of tomatoes. Fruits were hand harvested and conveyed to site in the morning. They were sorted, divided into 3 kg lots and given the postharvest treatments and packaged using different materials (P₁ = packaging in kraft paper bag, P₂ = perforated polyethylene bag, P₃ = packaging in sealed polyethylene bag). Physico-chemical parameters of the fruits were analyzed every three days for a period of 24 days. Data generated were analyzed using GLM and SAS and means separated using LSD. Results revealed that packaging in low density polyethylene bag had significant effect on tomato quality because lower weight loss and rot were recorded; and fruits maintained fair change in measured parameters. Therefore, low density polyethylene is the best packaging material for tomato fruits in Kura, Kano State and is here by recommended particularly at retail outlets to preserved the quality and extend the storage life of tomato fruits.

INTRODUCTION

Tomato (*Solanum lycopersicum* (L.) Mill.) is an herbaceous annual plant belonging to the family Solanaceae. Tomato is believed to have originated from coastal highlands of Central

and South America where it grows in the wild in Ecuador, Peru and Bolivia. The word tomato is a modification of the word 'tomati' which literally means 'the swelling fruit'.

The Spanish explorers were credited with the introduction of tomatoes to Africa in 1500's from where it spread to other colonies (Wikipedia, 2016).

In Nigeria, tomato fruits are consumed in fresh and many other processed forms. Yusuf and Okusanya (2007) reported that tomato alone accounted for 18 % of the total vegetable intake in Nigeria. Ihekoronye and Ngoddy (1985) reported that tomato fruit contains 93 % water, 1.1 % protein and 0.3 % Fat. They further reported micronutrients per 100 g as Calcium 11 mg, Iron 0.6 mg, Riboflavin 0.04 mg, Niacin 0.5 mg, Ascorbic acid 0.5 mg and Vitamin A 700 IU. Tomato fruits also contain high amounts of lycopene, a carotenoid with anti oxidant properties beneficial in reducing incidence of diseases like cancer (Basu and Imrhan, 2007) and cardiovascular disorders (Freeman and Reimers, 2010). The lycopene content of tomato fruit has been reported by various workers and it varies from one variety to another and also with environment. Brandt *et al.* (2003) reported a range of 60 -160 mg/kg in cherry tomatoes, Liana *et al.* (2009) reported lycopene content of fresh tomatoes as 12 mg/ 100 g. The peel of fresh tomato was found to contain on average 3.5-3.75 times more lycopene (on fresh weight basis) than the pulp (Markovic *et al.*, 2010).

Nigeria is the second largest producer of tomato in Africa and 13th in the world and produces 6 million tonnes annually (FAOSTAT, 2014) but the estimated total postharvest loss of tomato fruits in Nigeria is about 60% according to Kutama *et al.* (2014) which translates to huge economic loss. The huge loss prompted the search for simple, effective and economical methods to control pre and postharvest diseases and other losses in tomato value chain. Postharvest technologies like chemical dips, packaging and storage can greatly reduce the losses and improve the quality of the produce (Srividya *et al.*, 2014). This study was therefore, aimed at evaluating the effect of packaging materials on quality and shelf life of tomato fruits in Kura, Kano State of Nigeria.

MATERIALS AND METHODS

The study was conducted between 25th March to 18th April, 2013 at Kofar yamma in Kura town of Kura local government area of Kano State

located between latitude 11° 46' N and longitude 8° 25' E. The analyses were conducted in the laboratories of the Department of Food Science and Technology, Kano University of Science and Technology Wudil and Kano Area laboratory of Abuja Commodity Exchange. The fruits (UC 82B grown in Kura) of fairly uniform size were carefully hand harvested at green mature stage and free of any visible defect. The design was a 3x3x3 factorial consisting of three treatments laid out in Randomized Complete Block Design with three replications. There were three factors postharvest treatments, packaging, and storage. Postharvest treatments consisted of three levels which were:

- i. freshly harvested tomato fruits dipped in tap water for 5 minutes (D₁)
 - ii. freshly harvested tomato fruits dipped in 200 ppm Sodium hypochlorite for 5 minutes and later dipped in 1% w/v Calcium chloride for 5 minutes (D₂).
 - iii. freshly harvested tomato fruits dipped in 200 ppm Sodium hypochlorite for 5 minutes and later dipped in 3% Potassium sorbate for 1 minute (D₃).
- i. Packaging of fresh tomato fruits in kraft paper (P₁).
 - ii. Packaging of fresh tomato fruits in perforated low density polyethylene bags (P₂).
 - iii. Packaging of fresh tomato fruits in sealed low density polyethylene bags (P₃).

The storage conditions consisted also of three levels which were:

- i. Storage of fresh tomato fruits at ambient room temperature (S₁) [32°C and 29% RH]
- ii. Storage of fresh tomato fruits at refrigerated chamber (S₂) [11°C and 90-95% RH]
- iii. Storage of fresh tomato fruits in "zero energy" cool chamber (S₃) [24°C and 71% RH]

Each treatment consisted of 3 kg of sound, unblemished mature green tomato fruits of fairly uniform size which were dipped in the various dips and subjected to various forms of packaging and stored in the various storage structures.

Analyses were conducted on the various physicochemical parameters on day one and thereafter every three days. Data were analyzed using generalised linear model (GLM) procedure of statistic analysis system (SAS) and means separated using least significant difference (LSD).

Fruit firmness

The firmness of tomato fruits were measured with the aid of HP-FFF analog fruit firmness tester (Qualitest International Inc. Canada) using 0.25 cm² test anvil (specifically for tomato fruits). To test the firmness the tester was placed on two different points of the fruit (opposite each other and free of blemishes) with a constant press. The degree of firmness of the fruit was calculated as a quotient of the number directly displayed on the instrument.

Percentage weight loss

The percentage weight loss of the stored tomato fruits was determined as a percentage of the total weight stored. This was done every three days for the period of storage of the tomato fruits

$$\% \text{ Weight loss in Tomato} = \frac{\text{Initial weight stored} - \text{Final weight}}{\text{Total weight stored}} \times 100$$

Percentage decay

For the determination of % Decay, rotted fruits were isolated and the percentage decay calculated as a percentage of the total amount of tomato fruits stored.

$$\% \text{ Decay in Tomato} = \frac{\text{Initial weight stored} - \text{Weight of decayed fruits}}{\text{Total weight stored}} \times 100$$

Ascorbic acid content

The ascorbic acid content of the tomato fruits was determined by the indophenol method as reported by Onwuka (2005). The fruit was pulped using domestic juice extractor (Master Chef Model MC-J2101). Two grams of the blended pulp was weighed and 100 ml of distilled water added to it in a volumetric flask. The solution was filtered using a filter paper to get a clear solution. Fifty milliliters of unconcentrated juice was then pipetted into 100 ml volumetric flask in triplicate. Twenty five milliliters of 20% Metaphosphoric acid was added as a stabilising agent and diluted to 100 ml volume. About 10 ml of the solution was

then pipetted into small flask and 2.5 ml of acetone added. The solution was titrated with 2,6 - Dichlorophenol indophenol to a faint pink colour which persisted for roughly 15 seconds. The amount of ascorbic acid in the tomato fruit was calculated as follows:

$$\text{Vitamin C (mg / 100 g)} = 20 \times V \times c$$

Where V= ml indophenol solution in titration and c= mg vitamin C /ml indophenol

Lycopene content

Fresh tomato fruits were squeezed using potable juice extractor (Master chef Model MC-J2101) to obtain pure tomato juice. The freshly squeezed sample was drawn into a 100 µl micro pipette and outside glass bore was wiped clean using tissue paper. The pipette was allowed to stand to display air bubbles from the pipette. The sample was then dispensed into 50 ml separating funnel and closed tightly. Blank sample using 100 µl of water instead of tomato juice was prepared. Eight millimeter of hexane: ethanol: acetone in ratio 2:1:1 was carefully added immediately and kept out of bright light. After about 10 minutes 1 ml of water was also carefully added and vortex again. The sample was allowed to stand for another 10 minutes to allow phases to separate and all air bubbles disappear. The cuvette of the spectrophotometer was rinsed clean with upper layer from one of the blanks. The liquid was discarded and another fresh blank was used to zero the spectrophotometer (Jenway Model 752) at 503 nm. The absorption of the upper layers of the sample was then determined using spectrometer at 503 nm. Lycopene content was then calculated using the following relationship:

$$\text{Lycopene (mg/kg fresh weight)} = (A_{503} \times 137.4) \quad (\text{Onwuka, 2005})$$

RESULTS AND DISCUSSION

Effect of packaging on firmness

The results of the effect of packaging on tomato fruit firmness are presented in Figure 1. Highly significant differences ($P \leq 0.01$) in firmness were observed from days 6 to 24. There was no significant difference observed on day 3 of the experiment.

Highest firmness values of 0.036 kgf was observed in fruits packed in kraft paper bag on days 6 and 9 while the other treatments were not statistically different. The lowest firmness was observed in fruit packaged in sealed low density polyethylene bags on day 21 of the experiment.

Firmness ranged from 0.0263 – 0.0364 kgf. The values were slightly lower than 0.049 kg reported by Ranatunga *et al.* (2009) in their work on effect of measurement of non destructive methods. The results were contrary to the finding of Shahnawaz *et al.* (2012) who reported that tomatoes wrapped in polyethylene bags showed highest firmness scores followed by the one wrapped in newspapers and finally grease free paper. It is also contrary to the findings of Talukder *et al.* (2003), Nasrin *et al.* (2006) who both reported that tomatoes in perforated package were firmer than the control sample. Hour *et al.* (2015) also reported that low density polyethylene packaging stored was found good in retaining the firmness and lightness of tomato fruits. The type of packaging material has an influence on the rate of respiration and subsequent degradation of polysaccharides. Kraft paper is a thick packaging material which even though allows respiration of the tomato fruits but at a slower rate than perforated polyethylene. The brown color of the paper may possibly be a factor in lowering respiration rate. Rahman *et al.* (2010) opined that the colour of packaging material has a significant effect on measured parameters and subsequently the shelf life of the fruits.

Effect of packaging on weight loss

The results of the effect of packaging on tomato fruit weight loss are presented on Figure 2. There were significant differences ($P < 0.01$) in fruit weight loss from different packaging materials on days 3, 18, 21 and 24. No significant difference was however observed in fruit weight loss on the other days. Highest percentage weight loss was observed in fruits packaged in kraft paper bag. On the other hand, the least percentage weight loss was recorded in fruits packaged in perforated polyethylene bag.

On day 18 of the experiment, highest percentage weight loss was recorded in fruits

packaged in sealed polyethylene bag. The least percentage moisture loss was recorded in fruit packed in kraft paper bag.

On day 21 and 24, the trend observed in day 3 was that fruits packaged in kraft paper bag recorded highest percentage moisture loss and least percentage moisture loss was recorded in fruits packaged in polyethylene bag.

Packaging of fresh horticultural produce is carried out to prevent kinds of degradation that might render it unsuitable for consumption (Sibomana *et al.*, 2015). Different effects of packaging materials on tomato fruit weight loss were observed for packaging in kraft paper bag, packaging in mildly perforated polyethylene bag and packaging in sealed polyethylene bag. Packaging in both types of polyethylene bags had a similar trend from day 15 after storage but packaging in mildly perforated polyethylene bag seemed to be the best by maintaining a fair decrease in weight loss, a fair increase at 18 days of storage and another decrease thereafter. Sammi and Masud (2007) reported that packaging significantly reduced tomato fruit weight loss. Hour *et al.* (2015) also reported lowest weight loss in tomatoes packaged in low density polyethylene bag at 15°C. Results also agreed with the report of Rahaman *et al.* (2010) who recorded lowest weight loss and higher shelf life in black perforated polyethylene bag. According to Shahnawaz *et al.* (2012) the weight loss of fresh tomatoes was primarily due to transpiration and respiration.

Transpiration is a mechanism in which water is lost due to differences in vapour pressure of water in atmosphere and the transpiring surface. Sparsely perforated polyethylene bag retained moderately significant moisture during storage when compared with kraft paper and sealed polyethylene and as tomatoes packaged in it showed less weight loss.

Effect of packaging on fruit rot

Figure 3 presents the results of the effect of packaging on percentage rot of tomato fruits. Results showed significant difference ($P \leq 0.01$) on 12, 15 and 18 days; and at $P \leq 0.05$ on 21 and 24 days of storage.

The highest percentage rot on day 12 of the experiment was in fruits packaged in sealed polyethylene bag but it was statistically not different from fruits packaged polyethylene bag. On day 15 of the experiment, there was no significant difference ($P \leq 0.01$) between fruits packaged in sealed and perforated polyethylene bags. The highest percentage rot was in fruits packaged in perforated polyethylene bag while the least rot was recorded in kraft paper packaged fruits.

On 18 day of the experiment, no significant difference was observed between fruits packaged in sealed and in perforated polyethylene bags. The highest rot was in perforated polyethylene bag while the least was in fruit packaged in kraft paper bag. The same trend of no significant difference between sealed and perforated polyethylene bag in terms of rot was also observed in 21 and 24 days of the experiment. The highest rot was recorded in perforated polyethylene bag while the least was recorded in kraft paper packaged fruits.

The same trend of initial increase (at 15 days) and gradual decrease thereafter in all the treatments was observed. Packaging in kraft paper bags was the best for maintaining lowest percentage rot throughout the storage period followed by packaging in mildly perforated polyethylene bag even through it recorded highest percentage rot of 24.82 on 15th day.

The high rot recorded in sealed polyethylene could probably be due to faster rate of deterioration in sealed polyethylene compared to other packaging materials. Proper packaging in sealed package creates a modified atmosphere by allowing respiration and gas permeation through the packaging material (Sammi and Masud, 2007). The result agreed with the report of Talukder *et al.* (2003) in their work on pre-packaging, storage losses and physiological changes in fresh tomato as influenced by post harvest treatments. They concluded that perforated polyethylene and kraft paper bag showed better physical appearance than all other treatments.

Effect of packaging on Ascorbic acid content

The results of the effect of packaging on ascorbic acid content of tomato fruits are

presented in Table 1. Significant differences were observed ($P \leq 0.05$) on days 3, 21, and 24. The highest ascorbic acid content (28.97 mg/100g) was recorded in fruits packaged in sealed polyethylene bag on 21st and 24th days of the experiment. The other treatments were not statistically different. The least ascorbic acid content (15.48 mg/100g) was recorded in fruits packaged in sealed polyethylene bag on 3 day of the experiment.

Results of study indicated a progressive increase in Ascorbic acid content of the tomato fruits in all the packaging materials. The values reported in this study were higher than the range (9.29 – 15.08 mg/100g) reported by Tigist *et al.* (2013) but within the range (7.65 – 31.29 mg/100g) reported by Shahnawaz *et al.* (2012). Many investigators have reported increase synthesis of Ascorbic acid in tomatoes stored in different packaging materials. Sood *et al.* (2015) reported that modified atmosphere packaging of tomatoes significantly maintain a higher Ascorbic acid content over period. Shahnawaz *et al.* (2012) also reported an increase in Ascorbic acid. The high Ascorbic acid content could be attributed to the maintenance of higher CO₂ level and reduced O₂ concentration within the modified atmosphere storage. Sammi and Masud (2007) also stated that an increase in Ascorbic acid is an indication that the fruit is still in ripening stage. The higher Ascorbic acid value reported was in agreement with the report of Shahnawaz *et al.* (2012) who reported similar values.

Effect of packaging on lycopene

Figure 4 presents the results of the effect of packaging on the tomato fruit lycopene. Results indicated significant differences between the various treatments on days 3, 15, 21 and 24 of the experiment. The other days of the experiment did not show significant differences among the packaging materials. The highest lycopene of 317.18 mg/kg was obtained in fruits packaged in sealed polyethylene bags on 21st and 24th days of the experiment while the least amount of 75.47 mg/kg lycopene was obtained in fruits packaged in perforated polyethylene bags.

The significant effect of packaging on the lycopene content of stored tomato fruits can be seen in the results.

There is a gradual increase in lycopene contents of tomato fruits packaged in kraft paper bag and also in those packaged in sealed polyethylene bag where the value were higher than the range (60 – 160 mg/kg) reported by Brandt *et al.* (2003). The highest lycopene content (317.18 mg/kg) was recorded in fruits packaged in sealed polyethylene bag. This is contrary to the report of Alsadon *et al.* (2014) in their work on effect of plastic and paper packaging on tomato fruits stored at different temperature and relative humidity. They reported that high and low density polyethylene resulted in slowing down the color development.

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CONCLUSION

Results of various packaging materials used in postharvest packaging of harvested tomato fruits during the study revealed that packaging in low density polyethylene bag without perforation had significant effect on the quality parameters of tomato fruits. It recorded lower weight loss and lower rot. Fruits packaged in polyethylene maintained a fair change in the measured parameters. Therefore, the best packaging material to preserve the quality and extend the storage life of tomato fruits particularly at retail outlets in Kura, Kano State is low density polyethylene bag (LDPE) because it creates a modified atmosphere packaging (MAP) which allows for limited exchange of respiratory gases.

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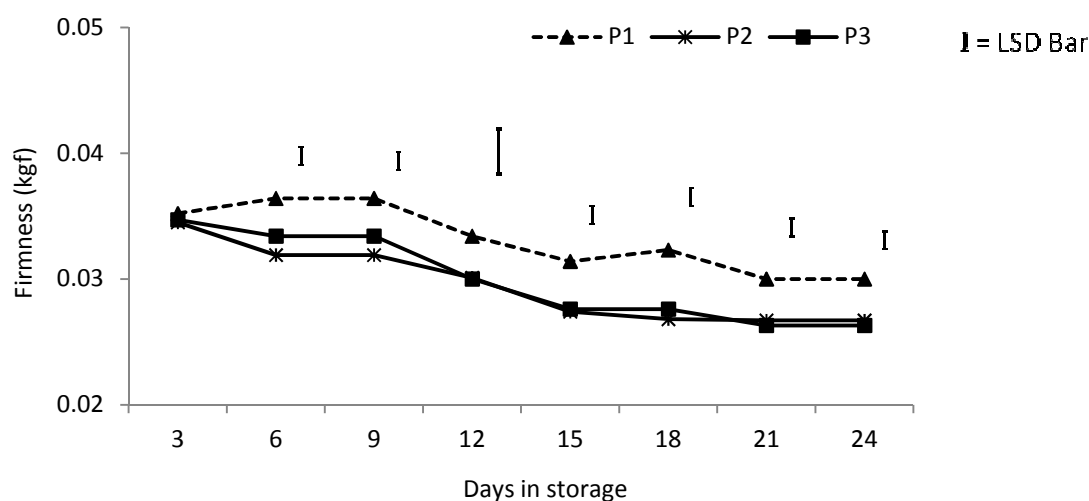


Fig. 1: Effect of Packaging on Tomato Fruit Firmness (kgf)

Key:

P₁: Packaging fruit in kraft paper bags

P₂: Packaging fruits in sparsely perforated low density polyethylene bags

P₃: Packaging fruit in sealed low density low density polyethylene bags

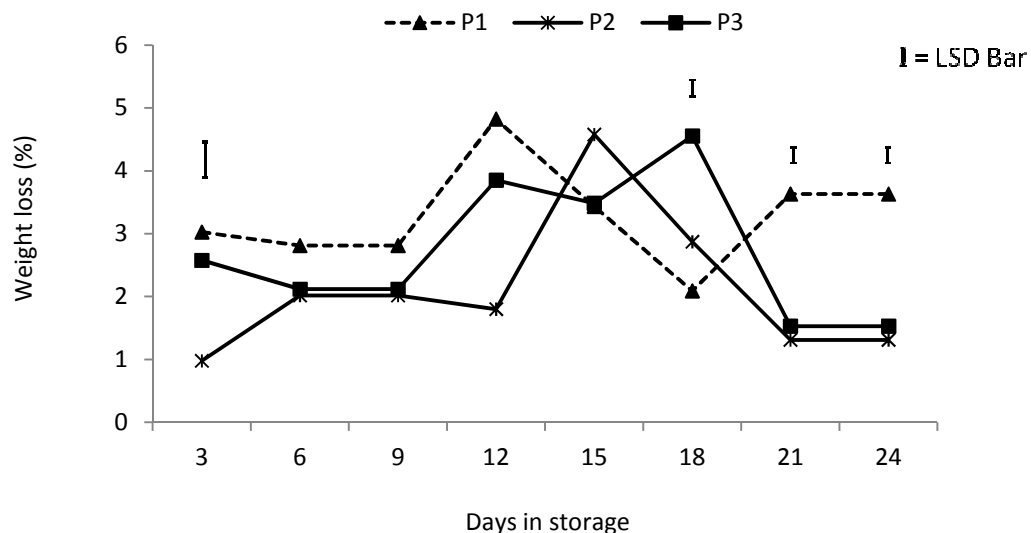


Fig. 2: Effect of Packaging on Tomato Fruit Weight loss (%)

Key:

P₁: Packaging fruit in kraft paper bags

P₂: Packaging fruits in sparsely perforated low density polyethylene bags

P₃: Packaging fruit in sealed low density low density polyethylene bags

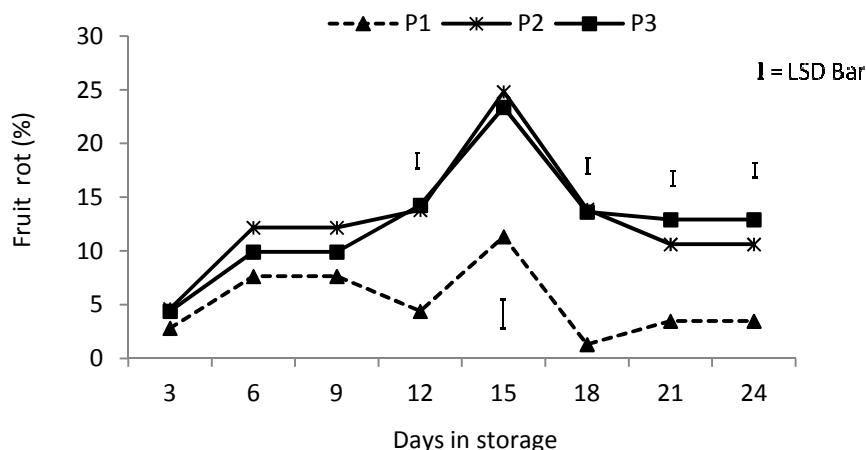


Fig. 3: Effect of Packaging on Tomato Fruit Rot (%)

Key:

P₁: Packaging fruit in kraft paper bags

P₂: Packaging fruits in sparsely perforated low density polyethylene bags

P₃: Packaging fruit in sealed low density low density polyethylene bags

Table 1: Effect of Packaging on Tomato Fruit Ascorbic acid Content (mg/100g)

Packaging	Days in storage							
	03	06	09	12	15	18	21	24
P ₁	21.081	23.315	23.315	28.423	26.200	30.360	24.404	24.404
P ₂	19.033	26.277	26.277	23.548	28.612	20.570	24.008	24.008
P ₃	15.481	29.672	29.672	22.005	28.348	19.000	28.967	28.967
Mean	18.570	26.421	26.421	24.764	27.657	24.206	25.400	25.400
LSD	4.544	ns	ns	ns	ns	ns	4.124	4.124
P≤F	0.0480	0.142	0.142	0.284	0.384	0.452	0.0462	0.0462

Key:

P₁: Packaging fruits in kraft paper bags

P₂: Packaging fruits in sparsely perforated low density polyethylene bags

P₃: Packaging fruits in sealed low density low density polyethylene bags

ns: not significant

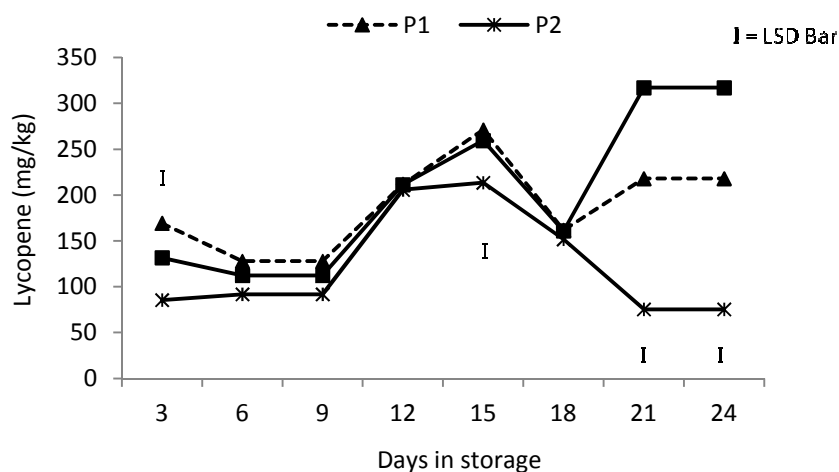


Fig. 4: Effect of Packaging on Tomato Fruit Lycopene Content (mg/kg)

Key:

P₁: Packaging fruit in kraft paper bags

P₂: Packaging fruits in sparsely perforated low density polyethylene bags

P₃: Packaging fruit in sealed low density low density polyethylene bags