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RESEARCH ARTICLE

# Effect of Film Packaging on the Quality of Tomato Fruits under Ambient Conditions

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## Abstract

Polyethylene bags of different permeabilities were tested to extend the life of tomatoes (*Lycopersicon esculentum*) under ambient conditions. Tomato fruits at breaker stage of ripening were packed in low density polyethylene bags (thickness 0.0046 mm) with four different types of perforation, i.e. without pinholes, bag with 10, 15 and 20 pinholes. All bags were stored for 21 days at 28ºC and 74% relative humidity. Fruits were evaluated for changes in colour, physical appearance, firmness and weight loss. Soluble solids content was determined at the end of storage. All unwrapped tomato fruits were red ripe 6 days after storage and after 21 days of storage fruits were soft, appeared deep red, shriveled and dusty. Fruits sealed in bags delayed red colour development, appeared glossy after 21 days of storage. Fruits sealed in polyethylene bags were significantly ($p<0.05$) firmer and had low weight loss than fruits stored unwrapped. Fruits sealed within polyethylene bag with 20 pinholes had the highest soluble solids content after 21 days. This study shows that storage of tomatoes in polyethylene bag under ambient condition is a promising alternative to refrigeration to reduce wastage and consequently increase the marketable life of harvested tomatoes in tropical countries.

Keywords: tomatoes, storage, low density polyethylene bags, ambient conditions

## Introduction

Tomato is one of the leading vegetables in Ghana. It is cultivated in large scale and brings income to farmers, transporters, wholesalers and retailers along the value chain. Tomato is a highly perishable vegetable decaying within few days after harvest leading to huge economic losses for farmers, retailers and consumers. It is estimated that postharvest losses of tomatoes in Ghana are up to 25% (WFLO Report, 2010). Poor harvesting and postharvest handling practices have contributed to the high postharvest losses. Fresh tomato quality is determined by appearance, flavour, colour, firmness; the latter two quality attributes being major factors in consumer preference of tomatoes (Thorne and Alvarez, 1982). The shelf life of tomato can be extended using postharvest treatment such as low temperature storage i.e. refrigeration which is a major economic cost for farmers, retailers and consumers particularly in rural Ghana. Therefore there is the need to develop a simple and cheap method of extending the marketable life at room temperature. One option is the use of modified atmosphere packaging (MAP). MAP refers to the technique of sealing actively respiring produce in a polymeric film to alter the oxygen and carbon dioxide levels within the package atmosphere (Kader, 1986). If a film of correct permeability is selected, a desirable equilibrium modified atmosphere can be established when the rate of oxygen and carbon dioxide diffusion through the package equals the products' respiration rate (Day, 1993). MAP diminishes respiration rate, slow ripening and softening of fruits, decrease water loss and shrinkage during storage (Batu and Thompson, 1998). The objective of this study was to determine the effect of polyethylene bags of different permeability on the marketable life and quality of tomatoes at ambient temperature.

### Materials and Methods

*Sample Preparation*

Tomato 'Power' fruits at the breaker stage (first appearance of external pink red or tannish yellow colour) of maturity were harvested from a commercial farm at Techiman in Brong Ahafo Region of Ghana. One mini crate of wooden box (52 kg) of fruits was transported to the Department of Crop Science, University of Ghana. The fruits (about 48 hours after harvesting) were selected for uniformity in size and absence of defects. They were washed with tap water and then later with sodium hypochlorite solution (150 ppm) for two minutes to reduce the microbial load. One hundred and twenty (120) fruits were used in the experiment. Six fruits of average weight 62 g were packed in each of low density polyethylene (LDPE) bags (21cm × 18cm - Zipper type) with different permeability: (no pinhole), (10 pinholes), (15 pinholes) and (20 pinholes) to constitute a treatment (Table 1). The polyethylene bags were perforated using a safety pin of 0.56 mm in diameter. The control was unwrapped. There were four replications for each treatment which were arranged on laboratory bench in a completely randomized design layout. The temperature of the laboratory ranged between 25-31ºC and relative humidity of 54.0-87.5% during the experimental period. Fruits were held in this condition for 21 days.

Table 1. Description of treatments

| Treatment | Level of permeability |
|---|---|
| Control | Without packaging |
| PE +0 | PE bags with no perforation |
| PE +10 | PE bags with 10 perforations |
| PE +15 | PE bags with 15 perforations |
| PE +20 | PE bags with 20 perforations |

**Data Collection and Analysis**

Weight and firmness of fruits were assessed before treatment (time 0) and at weekly intervals. Total soluble solids content was determined at the end of experiment using handheld refractometer (RB 32 Hanna Instruments). Firmness was measured non-destructively using an Intertest Benelux Penetrometer (Netherlands). Fruit colours were evaluated using tomato fruit colour chart from Cantwell (2013) with criteria as follows:

- Green means the tomato surface is completely green with the shade vary from light to dark green
- Breaker means there is a definite break of color from green to bruised fruit, tannish-yellow, pink or red or 10% or less of the tomato surface.
- Turning means tannish-yellow, pink or red color shows on over 10% but not more than 30% of the tomato surface.
- Pink means pink or red color shows on over 30% but not more than 90% of the tomato surface; light red means light red pinkish to red color shows on over 60% but red color covers not more than 90% of the tomato surface.
- Red means that more than 90% of the tomato surface, in aggregate, is red.

Data collected were subjected to analysis of variance (ANOVA) using GENTATS release 3.22 (VSN International, UK) and means were compared using least significant difference (LSD) at 5%.

## Results and Discussion

*Fruit Colour and Physical Appearance*

The colour change and physical appearance of tomato fruits is shown in Table 2. After six days of storage the control fruits were red ripe, PE+0 was turning while PE+15 was pink (Figure 1a, 1b, and 1c respectively). Control fruits which were not stored in polyethylene film ripened 6 days (Figure 1a) after storage and at the end of 21 days appeared deep red, shriveled and dusty. However fruits stored in PE +10, PE+15 and PE+P20 bags developed red colour slowly over the storage period and at the end of 21 days, fruits were red and appeared glossy. Interestingly fruits stored in bag without pinhole (PE+0) appeared turning on the sixth day and remained pink and glossy from the $12^{th}$ to the $21^{st}$ day of storage.

Table 2. Colour changes and physical appearance of tomato fruits sealed in polyethylene bags of different permeability and stored at 28ºC and 74% relative humidity**

| | Days after Storage | | | | |
|---|---|---|---|---|---|
| Treatment | 0 | 6 | 12 | 18 | 21 |
| Control (unpacked) | Breaker | Red | Red, shriveled | Red, shriveled | Deep red, shriveled dusty |
| PE+0 | Breaker | Turning | Pink | Pink, glossy | Pink, glossy |
| PE+10 | Breaker | Pink | Light red | Red glossy | Red glossy |
| PE+15 | Breaker | Pink | Light red | Red glossy | Red glossy |
| PE+20 | Breaker | Pink | Red | Red glossy | Red glossy |

Note: ** Tomato maturing and ripening stage criteria from Cantwell (2013).




Figure 1. Tomato fruits at six days after storage. Left: control fruits (unwrapped); middle: wrapped in polyethylene bag without pinholes; right: wrapped in polyethylene bag with 15 pinholes.

*Fruit Weight Loss*

Fruit weight losses in all the treatments increased during storage with losses in packed fruits being linear throughout the storage period (Figure 2). Weight losses in film packed fruits (PE+0, PE +10, PE +1 and PE +20) were significantly lower (p<0.05) than the unpacked fruits. However, there were no significant differences in weight loss among film packed fruits. Weight loss was considerably reduced (less than 2%) in the film packed fruits than the control (12%) (Figure 2).

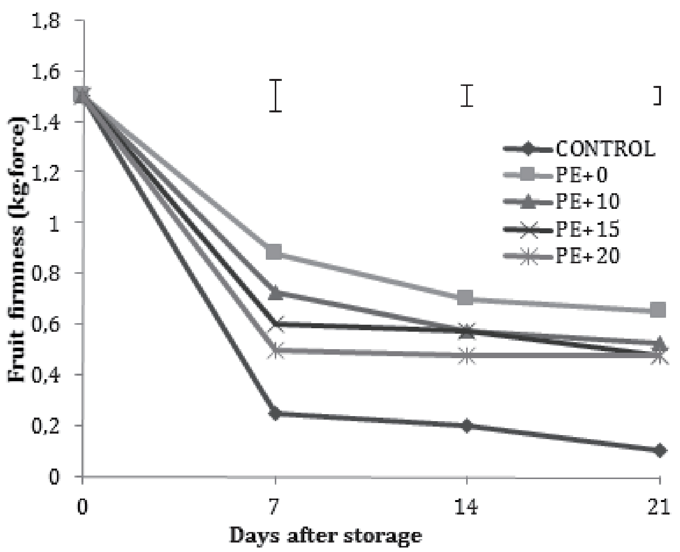


Figure 3. Firmness of tomato fruits sealed in polyethylene bags of different permeabilities and stored for 21 days at 28ºC and 74% relative humidity. Vertical bars represent LSD (0.05).

*Soluble Solids*

Soluble solids content in fruits packed in film with 20 pinholes (PE+20) was significantly higher (p<0.05) than fruits in all other treatments, however no significant differences were observed among the control, PE+0, PE+10 and PE+15 (Figure 4).

The loss of moisture results in reduction in the fresh weight of harvested produce which when sold on a weight basis is translated into loss in value. Generally the loss of 5-10% moisture renders a wide range of products including tomatoes unsellable (Kays, 1991). Weight loss was therefore considerably reduced (less than 2%) in the film packed fruits.

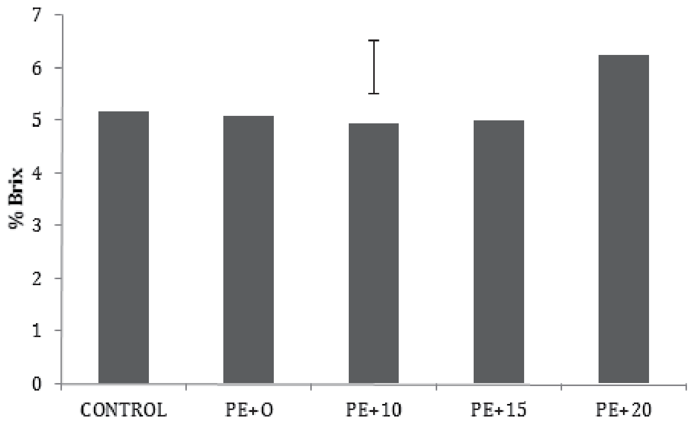


Figure 4. Soluble solids (% Brix) content of tomato fruits packed in polyethylene bags of different permeability and stored for 21 days at 28ºC and 74% relative humidity. Vertical bars represent LSD (0.05).

Red colour development (associated with ripening) in tomatoes is triggered by ethylene activity in the presence of oxygen leading to the synthesis of the pigment lycopene which is responsible for the red colour. Low oxygen levels coupled with high carbon dioxide concentration reduce ethylene activity. This may explain why ripening was delayed in the polyethylene bag packed fruits. Buescher, 1979, observed that high $CO_2$ levels affected colour development of tomatoes by restraint of ethylene production. The failure of the fruits in polyethylene bag without pinhole (PE+0) to completely ripen has been observed by Kelly and Saltveit (1988) and Nakhasi *et al.* (1991) that storage of tomatoes under extremely low oxygen or anaerobic conditions results in accumulation of ethanol in the tissues which halts or slows down the ripening process even after exposure to high oxygen environment.

Weight loss in fresh produce such as tomatoes is associated with moisture loss which is primarily due to transpiration and respiration. However the reduced weight loss observed in the packed fruits is most likely due to the high relative humidity maintained inside the bags. The mechanism by which water is lost is due to differences in vapour pressure in the package atmosphere and the tomato surface (Batu and Thompson, 1998). This has also been observed by Bhowmik and Pan (1992) that high relative humidity under controlled atmosphere considerably reduced weight loss in tomato fruits.

Fruit firmness decreased with prolonged storage as had earlier been shown by Batu and Thompson (1998). Fruit softening (firmness decline) has been found to be associated with pectin degradation in the middle lamella of the tomato cell wall (Themmen et al., 1982) as the tomato fruit ripens. However, packaging reduced the rate of firmness loss compared to non-packed fruits. Reduced respiration rate in the packed fruits might have reduced the rate of pectin degradation and by extension slow down softening of the fruits.

Mathooko (2003) observed that tomato storage under modified atmosphere (polyethylene bag) at warm temperatures had no significant effect on soluble solid content. Javanmardi and Kubota (2006) have also shown that storage of tomato at room temperature had no effects on soluble solids.

However, the differences observed in film with 20 pinholes and all the other treatments cannot be explained. The soluble solid content of tomato fruit is made up of free sugars (glucose, fructose, and sucrose), organic acids and soluble pectins (Garner et al., 2003). These components play a very significant role in the development of taste and flavour in the fruit.

## Conclusion

Tomato fruits packed in polyethylene bags developed red colour less rapidly, had reduced firmness loss and decreased weight loss than the fruits kept unwrapped. Generally fruits in polyethylene bags had an extended life and appeared glossy, fresh and acceptable after 21 days of storage at room temperature. This study shows that tomato fruit storage in suitable polyethylene bag under ambient conditions is a promising alternative to refrigeration to reduce wastage and consequently increase the marketable life of harvested tomatoes in tropical countries.

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