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The Effect of Moringa Seeds Oil and Shea Butter Oil Waxing On the Post-Harvest Life of Tomato Fruit (*Solanum lycopersicum*)

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ABSTRACT: *Tomato belongs to the family, Solanaceae and the genus Lycopersicon, is considered as one of the best healthy foods in the world due to its rich source of vitamin B and phyto-nutrients and abundant in carotenoids and lycopene. There has not been alternative means of preservation asides refrigeration as fast ripening disorder sets in and reduce its shelf life as the level of its calcium and potassium reduces during these processes. Post-harvest waxing has proved to be the alternative means of extending its shelf life. Standard analytical methods were used to test for colour, hardness, ash content, moisture content, total solid, brix, pH and total titrable acidity for two single and eight composite waxing (shea butter and moringa) of tomato fruits from day one to seven respectively. Waxing helps to delay the effect of divalent cations, which played an essential role in pectin metabolism and result to tissue softening in the pericarp of tomato fruit during ripening. The result obtained indicated that single oil waxing at 100%MOT (100% moringa oil) yielded good result up to five days while composite oil waxing at 10:90MST (10%moringa and 90%shea butter) could retard the effect of divalent cations for ripening for four days than the rest of waxing in single and composite oil waxing respectively.*

KEY WORDS: Moringa oil, Shea butter oil, Shelf life, Tomato, Waxing

INTRODUCTION

Tomato (*Solanum lycopersicum.*) has been a major horticultural crop with projected global production of over 129 million metric tons (F.A.O., 2008a). It is one of the most widely consumed vegetables in the globe (Chapagain and Wiesman, 2004). It has proved to be a crop of high economic importance in many countries due to its relatively short duration from planting to harvesting with high yield (Obeng-Ofori, *et al.*, 2007). It is economically attractive to west African continent because of the favorable climatic conditions and the area under cultivation is increasing daily (F.A.O., 2008b).

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The fruit is consumed in diverse ways, which includes raw, as a major constituent in many dishes and sauces and in drinks. The tomato fruit is classified as a prominent "protective food" (Alam *et al.*, 2007). Tomatoes and tomato-based foods have been a expedient medium by which nutrients and other health-related food nutients are supplied to the body. Tomato forms a very important component of food consumed in Africa and this is obvious that many African dishes have tomatoes as a constituent ingredient (Tambo and Gbemu, 2010).

Tomato is a good source of vitamin B and phyto nutrients, the most prominent compounds in tomatoes are carotenoids, lycopene. Beta-carotene and gamma-carotene are also present as well as several minor carotenoids (Beecher, 1998).Lycopene is a good antioxidant that purportedly fights the free radicals that interfere with normal cell development and its activity in the body. These free radicals, according to Filippone (2006), has been reported for its potential cancer development, heart disease and premature aging in man. Apart from environmental factors, Handling of the fruits after harvesting affect their quality and appearance and may affect the shelf life, which is defined as the period in which a product should maintain a predetermined level of quality under specified storage conditions (Ball, 1997).

Water loss during storage is equally an important factor that affects the quality of most fruits and vegetables, and this depends on the temperature and relative humidity conditions inside and outside the store (Perez *et al.*, 2003). Consumers and buyers judge the quality and value of fresh tomatoes by their firmness, color and taste, which correlated to their ripeness and shelf life. The majority of the losses incurred in the quality and quantity of fresh vegetable and their products occur between harvest and consumption period (Brooks *et al.*, 2008). Also, the effect of storage temperature affects the physiochemical quality and quantity changes in tomatoes and varies with cultivars. Generally, fruits are highly perishable as they contain 80–90% water by weight and there is loss of quality between harvest and consumption especially when there is need for transportation and distribution over long distances from the farm. This has been a major problem faced by the marketers before it gets to the consumers. One of the most effective methods of prolonging the post-harvest life of fresh fruits is low temperature or cold storage. These methods have proved to reduce the quality losses of the fruits. Chien *et al*., 2008 reported that a temperature of 5°C is effective in maintaining the shelf life of mandarin oranges (*Citrus reticulata*) compared to those stored at room temperature. The perishability of tomatoes requires the development of technologies that will reduce the post-harvest deterioration and extend its shelf life (Gonzalez- Aguilar *et al.,* 2009). The use of double coatings or waxing appears to be a good approach to lessen these circumstances and preserve the freshness of tomatoes (Gonzalez-Aguilar *et al.*, 2010).

1.1. Botany of Tomato

According to botanist, tomato belongs to the family of *Solanaceae* and the genus *Lycopersicon*. (Cox, 2000) has reported that, there are six species of tomatoes, two of these are edible, namely; *Lycopersicon esculentum* Mill, a common tomato and *Lycopersicon pimpinellifolium* Mill, currant tomato. The plant grows to height of 1–3 metres (3–10 ft) with weak stem that frequently sprawls over the ground and creeps over other plants. The plant is perennial to its native habitat, though frequently grown outdoors in temperate climates as an annual crop (Cox, 2000).

1.2 Nutritional Value of Tomatoes

Tomatoes are considered one of the best health foods in the world. They abound with essential nutrients such as vitamins and minerals. One cup of cherry tomatoes for example contains approximately 31 calories, 7 grams of carbohydrates, and only 0.5 grams of fat (Bradley, 2003). Tomatoes are also noted to have a variety of nutrients including fiber and potassium according to the USDA National Nutrient Database (2010). The nutrient value changes based upon the type of tomato.

1.3. Antioxidant Properties and Other Health Benefits of Tomatoes

Antioxidants are naturally occurring chemicals in many foods, especially fruits and vegetables. Foods rich in antioxidants help protect humans from disease attack and they slow the aging process (Sun *et al*., 2009). According to Keith (1999), over the last 20 years, scientists have been able to demonstrate a common link among the various chronic diseases that currently plague the American people. For example, conditions such as cancer, Alzheimer's disease, rheumatoid arthritis, cardiovascular disease, and cataracts as well as the actual aging process itself may all be, in part, caused by a phenomenon known as oxidative or free radical damage. The term oxidative is used because oxygen is frequently involved (Keith, 1999).

Lycopene has also been shown to be the most potent antioxidant produced by the carotenoid’s pathway (Cox, 2001). Consumption of fruits and vegetables is linked to lower incidence and lower mortality rates of several types of cancer. These positive effects on human health are attributed in large part to the antioxidant compounds found in high quantities in fruits and vegetables (Cox, 2001). According to Giovannucci (2002), of the 14 carotenoids found in human serum, tomato and tomato products contribute to nine and are the predominant source of about one-half, including lycopene.

According to Cox (2001), a University of California Davis survey ranked the tomato as the single most important fruit or vegetable of Western diets in terms of overall source of vitamins and minerals. Tomatoes are also an excellent source of flavonoids and polyphenols, which are also associated with lower cancer risk (Campbell *et al*., 2004). Cooked tomatoes according Knekt *et al.*, (2002) contain significant amounts of absorbable naringenin and chlorogenic acid. Lycopene works synergistically with the other phytochemicals in whole tomatoes to provide a wide range of health benefits. New evidence shows that the protective effects of tomatoes against cancer and cardiovascular disease are due to a combination of lycopene and the other phytonutrients naturally present in the fruit and skin of the tomato. In other words, you will not obtain all the nutrients if you skin the tomatoes (Heber and Lu, 2002). Italian researchers Riso *et al.* (2006) at the University of Milan reported that a daily glass of a commercial tomato juice could lower one of the primary markers of inflammation by almost 35% in less than one month. In addition, in a recent study at the University of the Negev in Beer Sheva, Israel, Engelhard *et* *al.* (2006) evaluated the effect of a tomato extract containing lycopene on systolic and diastolic blood pressure in patients with hypertension, as well as the serum lipoproteins, plasma homocysteine and oxidative stress markers.

1.4 Postharvest Losses of Tomatoes

Losses of horticultural produce are a major problem in the post-harvest chain. They can be caused by a wide variety of factors, ranging from growing conditions to handling at retail level. Not only are losses clearly a waste of food, but they also represent a similar waste of human effort, farm inputs, livelihoods, investments and scarce resources such as water. Post-harvest losses for horticultural produce are, however, difficult to measure. In some cases everything harvested by a farmer may end up being sold to consumers. In others, losses or waste may be considerable (Mrema and Rolle, 2002).

i) Primary Causes of Postharvest Loss in Tomato

Primary causes are those that directly affect the tomato. They may be classified into the following groups:

a) Microbiological: Microorganisms such as fungi and bacteria, usually directly consume small amounts of the food but they damage the food to the point that it becomes unacceptable because of rotting or other defects. Toxic substances elaborated by moulds (known as mycotoxins), cause some food to be discarded hence lost (Cornelius and Obeng-Ofori, 2008)

.*b) Biological*: Consumption of food by rodents, birds and other large animals causes direct disappearance of food. Sometimes the level of contamination of food by their excreta, hair, feathers of animals and birds is so high that the food is condemned for human consumption. Insects cause both weight losses through consumption of the food and quality losses because of their frass, webbing, excreta, heating, and unpleasant odour that impart to the fruit which makes it unpleasant for human consumption (Cornelius and Obeng-Ofori, 2008).

c) Physical: Excessive or insufficient heat or cold can spoil foods. Improper atmosphere in closely confined storage containers at times causes losses.

d) Physiological: Natural respiratory loss that occurs in all living organisms account for a significant level of weight loss and the process generates heat. Changes which occur during ripening, senescence, including wilting, and termination of dormancy may increase the susceptibility of the commodity to mechanical damage or infection by pathogens.

e) Mechanical. Bruising, cutting, excessive peeling or trimming of horticultural products are causes of loss (Cornelius and Obeng-Ofori, 2008).

ii. Secondary Causes of Postharvest Loss in Tomato

These losses lead to conditions that encourage a primary cause of loss. They are usually the result of inadequate or nonexistent of capital expenditures, technology and quality control. Some examples are:

a) Inadequate Harvesting, Packaging and Handling Skills: **-** Improper harvesting of tomato can result in mechanical injury, which predisposes the fruit to pathogens thereby reducing the quality of the produce. Time of harvesting also contributes to high losses; late harvesting exposes the produce to pests, rodents and microorganisms. Inappropriate packaging containers

such as wooden creates with rough edges, splinters; protruding nail or staple causes mechanical injury to the produce (Cornelius and Obeng-Ofori, 2008).
b) Lack of tomato preservation techniques and processing methods in the production centers contributes to high losses.: - After harvesting, bruised or damage produce that have been rejected by wholesalers and retailers needs to be processed into canned tomato paste, but because there is no preservation techniques and processing system in the production centers the fruits rot (Cornelius and Obeng-Ofori, 2008).
c) Inadequacy of transportation to move the food to market before it spoils: - Bumper harvest can overload the post-harvest handling system or exceed the consumption need and cause excessive wastage (Cornelius and Obeng-Ofori, 2008).

The objectives of this research work were to examine the effect of waxing on the storability of tomato fruits with different composite waxed from Moringa and Shea butter oils at 10/90, 20/80, 30/70, 50/50, 70/30, 80/20 and 90/10 respectively. Tomato fruit is a perishable fruit due to high percentages of its water content and it is very significant in human nutrition due to its nutritive values, most especially the presence of vitamin like carotenoid that aided vision. Reduced Shelf life makes it unavailable throughout the season. Moringa and shea butter are recognized oil with high antimicrobial activity and less toxic. Identifying the best composite oil mixed to preserve the fruit will thereby contribute to the existing literature on the effect of waxing on tomato fruits with other convectional oils that are more toxic, denature or reduce the nutritional composition of the fruit and reduce the post-harvest deterioration and extend its shelf life.

2.0 MATERIAL AND METHODS

2.1 Materials

The tomato fruit, Moringa seed and Shea butter were purchased from Shasha market, along Owo/Akure expressed road, Akure, Ondo State and were taken to the Food processing laboratory of the Department of Food Science and Technology, Rufus Giwa Polytechnic for processing and sample preparation. All chemicals used for analysis were of analytical grade and obtained from Delson Pascal Scientific Laboratory chemicals and Equipment in Alagbaka, Akure, Ondo State, Nigeria.

2.2 Preparation of samples

Firm tomatoes (Fig1), were sorted and washed to remove dirt and sand. *Moringa oleifera* seeds were de-husked and roasted. Production of the Moringa seed oil was achieved by mechanical pressing method (hydraulic press) in the processing laboratory. The oil was kept in an airtight bottle until when needed to avoid adulteration while the shea butter was bought directly from local producers (Fig.2). These were waxed with different composition of Moringa oil and Shea butter (Fig3) and the waxing tomatoes were placed in baskets and stored for eight days. The samples were picked and blended into slurry each day for an*alysis* (Fig3).

Fig1: Firm Tomatoes from Shasha market in Akure North L.G.A, Ondo State

Fig2: Single oil (Moringa and shea butter oil).

Fig3: Composite oil (moringa and Sea butter oil mix).

Fig4: Tomato paste for chemical and physical Characterization at Different Single and Mixed Oil Waxing

2.3 Physical properties

Texture, color development, total soluble solid, brix and hardness as described by Association of Official Analytical Chemist (AOAC,2005).

2.4 Chemical composition

The chemical composition observed were moisture content, ash, titrable acidity and pH as described by the standard method of Association of Official Analytical Chemist (AOAC, 2005).

3.0 RESULTS AND DISCUSSION

Table 1: Physicochemical Properties of Waxed Tomato Stored for Day One and Two

	Composite Waxing	Colour	Hardness Kg/cm^3	Ash Content g/100g	Moisture Content g/100 g	Total Solid g/100g	Brix	PH	Titrable A. g/dm^3
Day 1	FRT	Light Red	2.600	0.400	94.460	5.540	5.300	3.950	58.214
Day 2	FRT	Red	2.310	1.180	94.460	5.540	5.000	4.600	40.346
	100%SOT	Light Red	2.450	1.150	94.640	5.360	5.000	4.800	44.346
	100%MOT	Red	2.500	1.750	92.320	7.680	5.000	4.300	46.109
	80:20 MST	Red	2.320	1.800	95.000	5.000	4.000	4.400	43.228
	20:80MST	Red	2.350	1.800	95.000	5.000	4.000	4.400	43.228
	50:50 MST	Red	2.200	1.180	94.180	5.820	5.000	4.400	40.346
	90:10MST	Red	2.410	1.750	94.140	5.860	5.000	4.300	40.346
`	10:90MST	Light-red	2.300	0.580	94.100	5.900	5.000	4.400	40.346
	30:70MST	Red	2.200	1.150	95.440	4.560	5.000	4.400	40.346
	70:30MST	Red	2.300	1.400	94.520	5.480	5.000	4.400	40.346

Keys

1. FRT - **Fr**esh **T**omatoes
2. 100%SOT - 100% **S**hea butter **O**il for **T**omato
3. 100%MOT - 100% **M**oringa **O**il for **T**omato
4. 80:20MST - 80% **M**oringa oil & 20% **S**hea butter oil for **T**omato
5. 20:80 MST - 20% **M**oringa oil & 80% **S**hea butter oil for **T**omato
6. 50:50 MST - 50% **M**oringa oil & 50% **S**hea butter oil for **T**omato
7. 90:10MST - 90% **M**oringa oil & 10% **S**hea butter oil for **T**omato
8. 10:90MST - 10% **M**oringa oil & 90% **S**hea butter oil for **T**omato
9. 30:70MST - 30% **M**oringa oil & 70% **S**hea butter oil for **T**omato
10. 70:30MST - 70% **M**oringa oil & 30% **S**hea butter oil for **T**omato

Tomato is considered as an excellent model system for studying fruit development and climacteric fruit ripening (Giovannoni, 2004; Klee, 2004; Inaba, 2007; Ezura, 2009). Table 1 shows the results of colour, hardness, ash content, moisture content, total solid, brix pH and total titrable acidity of single and composite waxing of tomato fruits in day 1 and 2 respectively. There were no changes in colour of tomatoes from day 1 to day 2 in non-waxing samples. Lycopene is responsible for the red colour of tomatoes and is important for human health due to its antioxidant activity. Chlorophyll in green fruit is replaced in ripe tomatoes by oxygenated carotenes and xanthophylls, the most abundant of which are lycopene (red) and its precursor phytoene (colourless). Tomato is a typical climacteric fruit where ripening is associated with an increase in respiration and ethylene production along with the gradual change in the colour. The Hardness results also showed that the hardness value of all tomatoes samples is best quality in day 1 (2.600) and started decrease in value (2.310) in non-waxing, but at 100%MOT, close value of 2.500 was observed. Ash content increased significantly from 0.400 in FRT to 1.800 in 80:20 MST and 20:80MST respectively. Total titrable acidity decreased from 58.31 in day one, close value was observed in100%MOT with value of 46.109. These showed decrease in acidity within the twenty-four hours of waxing and there is no significant different in other parameters of composite waxing

Table 2: Physicochemical Properties of Waxed Tomato Stored for Day Three

	Composite Waxing	Colour	Hardness Kg/cm^3	Ash Content g/100g	Moisture Content g/100 g	Total Solid g/100g	Brix	pH	Titrable A. g/dm^3
Day 3	FRT	Deep Red	2.000	0.400	94.450	5.050	5.100	4.300	28.819
	100%SOT	Red	2.300	0.300	94.980	5.020	5.000	4.400	34.580
	100%MOT	Light Red	2.400	0.130	94.140	5.860	5.100	4.500	34.819
	80:20MST	Red	2.200	0.230	94.520	5.480	5.000	4.500	28.819
	20:8MST	Red	2.200	0.200	94.440	5.560	5.000	4.400	34.582
	50:50MST	Red	2.200	0.350	94.760	5.240	5.000	4.600	32.346
	90:10MST	Red	2.300	0.230	94.640	5.560	5.000	4.500	34.582
	10:90MST	Light Red	2.200	0.400	94.260	5.740	5.000	4.400	28.819
	70:30MST	Deep Red	2.100	0.350	95.520	5.080	5.000	4.400	29.587
	30:70MST	Red	2.200	0.250	94.460	5.540	5.000	4.500	32.819

Table 2 showed the results of the colour, hardness, ash content, moisture content, total solid, brix pH and total titrable acidity for single and composite waxing of tomato fruits in day3. Deep colour observation in the FRT (non-waxing tomato) indicated that more ripening has set in which may eventually result to rotten unlike other single and composite waxing tomato samples. Hardness reduced significantly in FRT (2.000) and 70:30%MST Deep Red (2.100) than other parameters in single and composite waxing with highest in 100% MOT (2.400). The ash content showed the mineral composition of the sample. This was higher in FRT (0.400),100%SOT (0.400),10:90 MST (0.400) and least in 100%MST (0.130). Nutritional composition increases with ripening. There is no significant different in moisture content except70:30MST (95.520). The highest total solid was observed in100% MOT (5.860) while there no significant different in brix (5.00±0.10) and pH (4-4.5) respectively. Acidity decreases with ripening; the best result was observed with 100% MOT with value of 34.580. A noticeable result was obtained from100% MOT in day 3 than the rest of single and composite waxing tomato fruit samples.

Table 3: Physicochemical Properties of Waxed Tomato Stored for Day Four

	Composite Waxing	Colour	Hardness Kg/cm^3	Ash Content g/100g	Moisture Content g/100 g	Total Solid g/100g	Brix	pH	Titrable A. g/dm^3
Day 4	FRT	Deep Red	1.200	0.530	94.620	5.380	6.100	4.600	24.582
	100%SOT	Deep Red	2.300	0.630	94.100	5.900	6.000	4.800	28.819
	100%MOT	Red	2.300	0.200	92.920	5.080	5.500	4.500	30.555
	80:20MST	Red	2.200	0.230	94.600	5.400	5.900	4.500	28.819
	20:80MST	Deep-Red	2.100	0.380	94.520	5.480	5.900	4.500	28.819
	50:50MST	Deep -Red	2.100	0.280	95.000	5.000	5.500	4.600	23.055
	90:10MST	Deep-red	2.300	0.430	94.100	5.900	6.000	4.200	28.819
	10:90MST	Red	2.200	0.450	94.920	5.080	5.800	4.700	25.580
	70:30MST	Deep -Red	2.200	0.410	93.300	5.700	5.600	4.500	28.819
	30:70MST	Deep-Red	2.100	0.300	94.640	5.360	6.000	4.700	30.082

Table 3 showed the results of the colour, hardness, ash content, moisture content, total solid, brix pH and total titrable acidity for single and composite waxing of tomato fruits in day4. Deep red colour for ripening were more pronounced in FRT, 100% SOT, 20:80MST, 50:50MST,90:10MST, 70:30MST and 30:70MST. Hardness was reduced in FRT (1.200) than all the single and composite waxing. The ash content that indicated the mineral composition increased with ripening and the least of these were found in100%MOT (2.00). Moisture content was considerably higher in all the values, but lesser in100%MOT (92.920). The significant different were equally observed in total solid, brix (5.500), pH (4.500) and triable acidity (30.555) in 100%MOT. Higher acidity and low pH indicated non-ripening and acidic activity of o fruit.

Table 4: Physicochemical Properties of Waxed Tomato Stored for Day Five

	Composite Waxing	Colour	Hardness Kg/cm^3	Ash Content g/100g	Moisture Content g/100 g	Total Solid g/100g	Brix	pH	Titrable A. g/dm^3
Day 5	FRT	Deep Red	1.000	1.250	95.159	4.841	6.200	5.000	24.159
	100%SOT	Deep-Red	2.000	1.430	95.819	4.181	6.000	4.900	28.819
	100%MOT	Red	2.100	0.450	94.819	5.181	5.700	4.600	29.510
	80:20%MST	Red	2.200	0.600	94.700	5.300	5.900	4.600	25.700
	20:80%MST	Deep Red	2.000	0.550	95.119	4.881	6.000	4.700	28.819
	50:50%MST	Deep-Red	2.000	0.580	95.119	4.881	6.100	4.800	28.819
	90:10MST	Pale-red	1.800	0.650	95.360	4.640	5.000	4.700	25.936
	10:90MST	Deep-Red	2.000	0.750	94.819	5.181	6.100	4.600	28.819
	70:30%MST	Deep-Red	2.000	0.530	94.582	5.418	6.000	4.900	24.582
	30:70%MST	Deep Red	2.000	0.650	95.137	4.863	6.100	4.900	25.937

Table 4 showed the results of the colour, hardness, ash content, moisture content, total solid, brix pH and total titrable acidity for single and composite waxing of tomato fruits in day5 respectively. Ripening progress from light-yellow to deep and pale red in most of the single and composite oil waxing except100%MOT (Red) and 80:20%MST (Red). Production of

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lycopene in the tomato fruits is subject to the concentration of potassium(K) in the cytoplasm and vacuole as explained by Dumas *et al., (*2002); Zdravkovic *et al., (*2007). By Studying the effect of K on the pigments of tomato fruit, Trudel and Ozbun (1971) discovered that the level of carotenoids at any stage of ripening of potassium-deficient fruits would be lesser than the potassium-sufficient fruits. Hardness also reduced as ripening increased except100%MOT (2.100) and 80:20%MST (2.200) respectively. Moisture content, total solid, brix, pH and titrable acidity had a stable feature with day4 except the ash content increased in FRT (1.250) and 100%SOT (1.430).

Table 5: Physicochemical Properties of Waxed Tomato Stored for Day Six

	Composite Waxing	Colour	Hardness Kg/cm^3	Ash Content g/100g	Moisture Content g/100 g	Total Solid g/100g	Brix	pH	Titrable A. g/dm^3
Day 6	FRT	Pale-red	0.800	1.550	95.180	4.820	6.300	5.200	34.582
	100%SOT	Pale-red	1.700	1.530	96.170	4.830	6.100	5.000	27.666
	100%MOT	Deep-red	1.800	1.250	95.180	4.820	5.800	4.800	25.937
	80:20MST	Deep-Red	1.500	1.230	95.290	4.710	5.800	4.900	23.429
	20:80MST	Pale-red	1.800	2.400	95.020	4.980	5.900	4.700	28.006
	50:50MST	Pale-red	1.500	0.700	95.700	4.300	6.000	4.900	28.006
	90:10MST	Pale-red	1.800	0.750	95.360	4.640	5.000	4.700	25.936
	10:90MST	Pale-red	1.700	0.770	95.180	4.820	5.900	5.000	23.429
	30:70MST	Deep-red	1.800	0.760	94.190	5.810	6.000	5.000	25.348
	70:30MST	Deep-red	1.600	1.750	95.240	4.760	5.900	5.000	27.819

Table 5 showed the results of the colour, hardness, ash content, moisture content, total solid, brix pH and total titrable acidity for single and composite waxing of tomato fruits in day6. Ripening to pale-red and deep-red colour were prominent in all the single and composite wax samples. Hardness ranged from 0.800 to1.800 in which100%MOT was in the range. Ash content, which is the measure if mineral composition has prominent increase in 100%MOT (1.250). Moisture content are within the same range (94.00-96.175), brix indicated the sugar content in ripening fruit with least in 90:10MST (5.00) in contradiction to increase in day5 90:10MST (5.181). Also, 5.800 was observed in 100%MOT (5.800). low value in pH means higher acid concentration. Acidity in terms of the pH is higher in 10:90MST (4.7) and100%MOT (4.800), equally reflected in the triable acidity in 10:90MST (23.492) and100% MOT (25.937) respectively.

Table 6: Physicochemical Properties of Waxed Tomato Stored for Day Seven

	Composite Waxing	Colour	Hardness Kg/cm^3	Ash Content g/100g	Moisture Content g/100 g	Total Solid g/100g	Brix	pH	Titrable A. g/dm^3
Day7	FRT	Rotten Red	0.600	1.700	96.760	3.240	6.400	5.400	35.158
	100%SOT	Rotten Red	0.600	1.600	95.080	4.920	6.100	4.900	34.006
	100%MOT	Deep-red	1.500	1.500	96.060	3.940	6.300	5.100	26.513
	80:20MST	Deep-red	1.200	1.730	95.080	4.920	6.100	5.000	31.700
	20:80MST	Pale-red	1.000	0.730	94.440	5.560	6100	4.800	34.582
	50:50MST	Rotten Pale Red	0.500	0.780	96.540	3.460	6.000	4.900	29.971
	90:10MST	Pale-red	1.000	0.700	95.500	4.500	5.100	4.900	31.700
	10:90MST	Pale-red	1.200	1.400	95.620	4.380	6.100	5.000	27.700
	70:30MST	Rotten Pale Red	0.700	0.780	95.090	4.910	6.300	5.100	28.819
	30:70MST	Rotten Pale-Red	0.500	1.450	92.740	7.260	6.000	5.000	34.006

Table 6 showed the results of the colour, hardness, ash content, moisture content, total solid, brix pH and total titrable acidity for single and composite waxing of tomato fruits in day7 when the analysis terminated at rotten stage. Rotten occurred in most of the samples from deep to pale red except in 100%MOT and 80:20MST with deep-red. Ripening disorders in tomato have also been affiliated increased with high nutrition composition of potassium and Calsium (Fontes *et al;* 2000). In tomato fruits, the occurrence of ripening disorder usually called 'greenback' increases with inadequate supply of K (Fontes *et al;* 2000). Proper waxing composition reduced the ripening disorder and prolong its shelf life as indicated in 100%MOT and 10:09MST with least titrable acidity and firm structures as recorded in their hardness values than other values obtained in single and composite waxing.

3.1 Conclusion: Increase of disorders during the postharvest ripening and storage of fruit is subject to on a range of preharvest features such as fruit's maturity at the harvest, fruiting position on the tree, environmental temperature of the fruit and mineral- nutrients contents and its distribution in the fruit (Ferguson *et al.,* 1999). Many ripening disorders in fruits and vegetables are associated with unbalanced content of mineral nutrients. The results from table1 to 6 revealed the physico-chemical analysis of the preservative measures taken to know the effect of waxing on the shelf life of five samples of tomato fruits using fresh, shea butter and moringa oil waxing at different composition for seven days.

Divalent cations have played crucial role in pectin metabolism and coursing tissue softening in pericarp of tomato fruit during ripening (Burns and Pressey,1987). It was discovered that single oil waxing at 100%MOT (100% moringa oil) yield good result, followed by composite oil waxing at 10:90MST (10%moringa and 90%shea butter) could retard the effect of divalent cations than the rest of waxing in single and composite oil wax.

3.2 Recommendation: It is recommended that waxing at 100%MOT Should be encouraged for shelf life up to eight days while that of 10:90MST could be up to six or seven days before consumption.

AUTHOR CONTRIBUTIONS

O.A. Ajala sought for the study authorization from the relevant government institutions. O.A. Ajala, G. Aladekoyi and O. A. Shakpo developed the study methodology that also comprised preparing a checklist that was used in data collection. G. Aladekoyi and. O. A. Shakpo analysed the samples and interpreted the data. O.A. Ajala, G. Aladekoyi undertook the literature review that included the introductory background information and the theoretical context. All authors edited the paper to ensure completeness and consistency with the journal's formatting guidelines.

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CONFLICT OF INTREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript. In addition, the ethical issues; including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy has been completely observed by the authors.

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