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Effect of *Aframomum danielli* Extract on some Chemical and Antioxidant Components of Roma Tomato Variety during Storage

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ABSTRACT

Postharvest treatment of tomato (*Lycopersicon esculentum* Mill) fruits with synthetic fungicide is receiving major criticism due to its health risk and negative ecological inputs. This work was designed to evaluate the effect of *Aframomum danielli* aqueous extract on some chemical and antioxidant components of tomato fruits. Two hundred grams of fresh tomato fruits were dipped differently in 1, 2, 3, 4 and 5% (w/v) *A. danielli* extract for 30 min. Each treatment was packed in 30 μm thickness low-density polyethylene bags. Another batch of 200 g of tomato fruits were treated with sodium bicarbonate and untreated 200 g tomato fruits served as control. The fruits were evaluated at interval of 5 days for changes in pH, brix, reducing sugars, lycopene, ascorbic acid and phenolic contents. A significant higher pH (4.1-4.6) than untreated samples (3.71) was obtained. Treated tomato samples showed significantly ($p<0.05$) higher value (1.17-2.83 °brix) of TSS as compared with control samples (1.00-2.30°brix). Lycopene contents reduced significantly with lower values obtained from sodium bicarbonate-treated and untreated samples. Ascorbic acid differed significantly ($p<0.05$) in all treatments over the storage period in both storage conditions. Samples treated with 5% *A. danielli* had significantly higher values (10.40-20.17 mg 100 g^{-1}) than their control counter parts (9.96-18.17 mg 100 g^{-1}). The results indicate that postharvest treatment with *A. danielli* extract extended the shelf life of tomato and retained significant amount of TSS, lycopene, ascorbic acid of tomato fruits, when compared with untreated samples.

Key words: Tomato, *Aframomum danielli*, low density polyethylene, antioxidant, post-harvest

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) is widely grown in most countries because of its nutritional, anti-oxidant and culinary benefits (Da Silva *et al*., 2008). Despite their many benefits, tomato fruits are highly perishable due to post harvest losses caused by respiration, transpiration and microbial attack (Babalola *et al*., 2008). Efforts made so far in reducing post-harvest losses of tomato include controlled and modified atmosphere packaging (Batu and Thompson, 1998), edible coatings for shelf life extension (Cha and Chinnan, 2004), chemical control of fruit diseases, heat treatment (Ali *et al*., 2004) and storage at low temperature. The use of Modified Atmosphere Packaging (MAP) has been employed in slowing down some postharvest activities that occur during storage. The preservative effect of MAP is based on reduction in oxygen and increase in carbon dioxide composition around the packaged fruits (Ali *et al*., 2004; Lee *et al*., 1995) reported that low concentration of oxygen within the packs can reduce the rate of respiration and increase shelf life

of fruits and vegetables. However, when oxygen is too low in the packs it can encourage the growth of anaerobes responsible for fruit decay. It is therefore important to treat fresh produce with chemicals that have antimicrobial properties.

The use of synthetic chemicals for the control of plant diseases is an age long practice. Joseph and Aworh (1992) showed that treatment of wild mangoes in 0.1% benomyl and 0.5% sodium dehydroacetate followed by waxing and packaging, delayed ripening, controlled decay, minimized weight loss and extended the shelf life of the fruits. Although some of these chemicals are effective in controlling post harvest losses of some fresh produce, alternative control methods are needed because of the health risk associated with their applications (Plotto *et al*., 2003). Some fungal pathogens had developed resistant to fungicides. The use of organic products such as spices with antioxidant and antimicrobial properties can serve as alternative control methods. Examples of such spices include ginger (*Zingiber officinale*), garlic (*Allium sativum*), black pepper (*Xylopia aethiopica*), cloves (*Eugenia aromatica*) and alligator pepper (*Aframomum danielli*). Essential oil of *A. danielli* contains cineole, pinene and terpinene as major constituents (Adegoke *et al*., 2000). The crude oil extracts of *A. danielli* have been found to have antioxidant activity in oil during processing (Adegoke and Krishna, 1998; Fasoyiro *et al*., 2001). *A. danielli* seeds had been reported to possess anti-inflammatory activity (Odukoya *et al*., 1999). *A. danielli* used as a spice is generally regarded as safe because of its low toxicity and eco-friendliness. This work was therefore designed to investigate the effect of aqueous extract of *Aframomum danielli* on some chemical and antioxidant components of tomato fruits at post harvest level.

MATERIALS AND METHODS

Experimental materials: Freshly harvested Roma tomato fruits were obtained from a commercial farm in Iresaadu, Ogbomoso, Nigeria and were harvested at advanced stage of ripeness and maturity. Average fruit diameters were between 50-60 mm. The seeds of *Aframomum danielli* were obtained from a Research Institute in Ibadan, Nigeria. Analytical grade sodium bicarbonate was obtained from Department of Food Science and Engineering, Ladoke Akintola University of Technology (LAUTECH), Ogbomoso. Low density polyethylene (30 μm thick) bags were obtained from a private company in Lagos, Nigeria.

Experimental setup and treatments: The dried seeds of *A. danielli* were winnowed and pulverized into fine powder using a hammer mill. Concentrations of 1, 2, 3, 4 and 5 % (w/v) of *A. danielli* were prepared by weighing 1, 2, 3, 4 and 5 grams crude powder of the spices in 100 mL of distilled water. The suspensions were kept in the refrigerator for 5 days followed by centrifugation as described by Adegoke *et al*. (2000). Tomato fruits were harvested, sorted and divided into batches prior to treatment. Two hundred grams each of the fruits were weighed and dipped in different solutions of *A. danielli* for 30 min. Another 200 g of tomato fruit was separately dipped into 3% sodium bicarbonate and distilled water as control. All samples were packaged in low density polyethylene bags (200×150 mm, 30 μm thickness). The packed samples were prepared in two batches such that a batch was stored at ambient (26±2°C; 80±5 RH) and the other stored at refrigeration (13±2°C; 85±5 RH) conditions. Samples were taken for analyses at 5 days intervals till the treated tomato samples became unfit for consumption.

Laboratory analyses

pH: Tomato fruits (50 g) were blended, homogenized and strained. Five milliliters of the juice was measured on a pH meter EDT instrument model BA 350 after the pH meter had been calibrated with buffers at 4.0 and 7.0 (AOAC, 1990).

Total soluble solids: Total soluble solids were determined using a refractometer (Tech-Jam International Inc. Tokyo, Japan) and expressed as degree Brix according to the method described by Akbudak and Akbudak (2007).

Reducing sugars: Reducing sugars were determined as presented by Tadesse *et al.* (2012). Ten milliliters of tomato juice was added to 15 mL of 80% ethanol, mixed and heated in a boiling water bath for 30 min. Mixture of saturated lead acetate (1 mL) and sodium phosphate (1.5 mL) were gently added. The mixture was filtered and made up to 50 mL with distilled water. An aliquot of 1 mL extract was added with 1 mL copper reagent in a test tube and heated for 20 min in a boiling water bath. After heating, the contents were cooled under running tap water without shaking. Arsenomolybdate colour reagent (1 mL) was added, mixed, made up to 10 mL with distilled water and left for about 10 min to allow colour development, after which the absorbance was determined by a spectrophotometer at 540 nm in a Jenway model 6100 spectrophotometer.

Ascorbic acid: Ascorbic acid content in tomato fruits was estimated by macerating the sample with 20% metaphosphoric acid as described by Kirk and Sawyer (1991). Titration method using 2, 6, dichlorophenol indophenols dye was used in estimating the amount of ascorbic acid in 10 mL of juice obtained from tomato fruits. Standard ascorbic acid was prepared from 0.05 g of pure ascorbic acid which was dissolved in 60 mL of 20% metaphosphoric acid diluted with water to exactly 250 mL in a volumetric flask. The mixture was titrated with 2, 6, dichlorophenol indophenols solution until a faint pink colour persists for 15 sec:

$$\text{Vitamin C in mg } 100\ \text{g}^{-1} = \frac{(\text{Titre value} \times 0.212 \times 100)}{\text{wt. of sample}}$$

Total phenols: The method of Zielinski and Kozlowska (2000) was used in estimating phenolic compounds in tomato samples. Tomato juice was added to methanol and 1% HCl (8:2) and was vigorously mixed. The 0.5 mL of Folin-Ciocalteau reagent was added to the mixture and vortexed. Standard was prepared by dissolving 10 mg of gallic acid in 100 mL of de-ionized water. The absorbance of the colour obtained was measured at 725 nm. Total phenols were determined as gallic acid equivalents (mg gallic acid g^{-1} in fruits) and the values are presented as means of three replicates.

Lycopene: Tomato fruits were weighed and extracted with hexane, methanol and acetone in ratio 2:1:1 into a flask containing 2.5% BHT (butylated hydroxy toluene). It was centrifuged at 14000 rpm for 20 min at 4°C. The extraction continued till the residue became colourless. It was purified using 1 M NaCl and 10% aqueous potassium carbonate. Sodium sulphate was used to remove the moisture content. Optical density of the hexane extract was measured spectrophotometrically at 502 nm against a hexane blank. Concentration of lycopene was calculated using the extinction coefficient (E%) of 3150. All analyses were done in triplicate (Perkins-Veazie *et al.*, 2001).

Data analysis: Data were subjected to analysis of variance using SPSS (2006) package 15 and means were separated using Duncan multiple range test at 5% probability level.

RESULTS

pH: pH values decreased from 5.37 in all treatments on day zero to 3.73 (Fig. 1) after 30 days of storage at refrigerated condition. The pH of treated tomato fruits was significantly higher (4.1-4.6) than pH of control samples (3.71) when stored at refrigeration conditions (Fig. 1). In the samples stored at room temperature (Fig. 1), there was a decline in pH (5.3-4.5) of all samples till day 10 and this later increased till day 15. Samples treated with 5% *A. danielli* had significantly highest values on day 15 but there was no record for sodium bicarbonate and untreated control samples due to spoilage of fruits.

Total soluble solids (TSS): The TSS of tomato fruit before storage was 3.37° brix (Table 1). The total soluble solids of all samples reduced significantly throughout the storage period at 13°C. On day 5, the degree brix ranged from 2.13 in sodium bicarbonate treated fruits to 2.83 in 5% *A. danielli* treated samples. Similar trends were observed till day 15 and 30 at both storage conditions. The maximum value among the treated fruit was observed in 5% treated sample (2.23-2.83) throughout the storage at refrigeration conditions. All samples showed significantly higher value (1.17-2.83) of TSS when compared to th e control samples (1.00-2.30) from day 0 to 30 except for sample treated with 1% *A. danielli* that had 0.96°brix on day 30. At room temperature, the values of TSS reduced from 3.40 to (0.23-0.30) in all samples. Significant higher value (1.50) was observed in 5% *A. danielli* treated fruits than control (1.10). The concentration of *A. danielli* had significant effect on TSS. The values reduced drastically at room temperature on day 15. At the end of the storage period, tomato samples treated with 4 and 5% *A. danielli* had the highest TSS values at refrigerated and room temperature, respectively (Table 1 and 2).

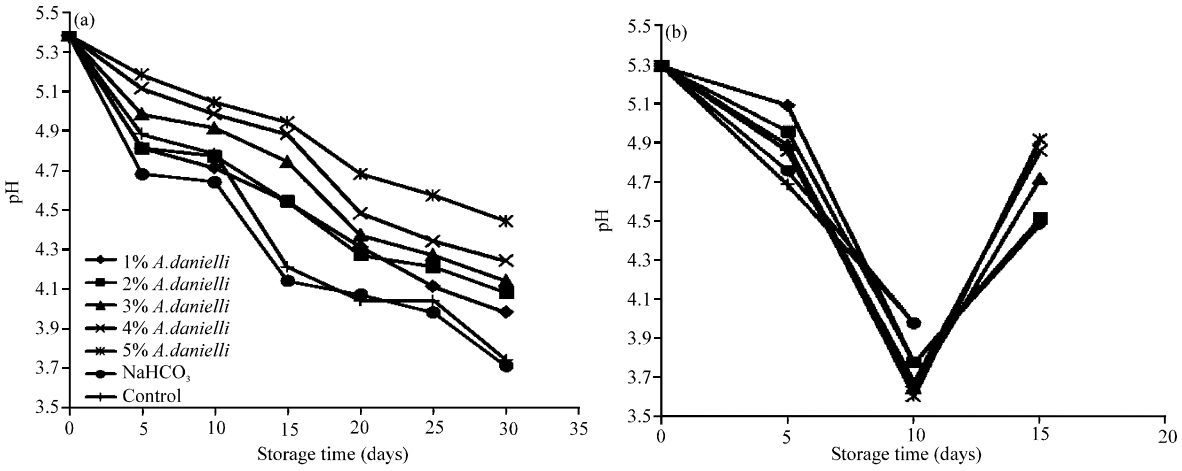

Fig. 1(a-b): Effect of *Aframomum danielli* aqueous extracts on pH of tomato fruits stored at refrigeration and ambient conditions, (a): Refrigeration condition (13±2°C; 85±5 RH), (b): Ambient condition (26±2°C; 80±5 RH)

Table 1: Impact of *Aframomum danielli* aqueous extract on total soluble solids (°Brix) of tomato stored at 13±2°C

	Storage period (days)						
Treatment	0	5	10	15	20	25	30
1%	3.37±0.13^{a}	2.33±0.06^{b}	1.70±0.01^{a}	1.33±0.06^{a}	1.13±0.06^{a}	1.03±0.06^{a}	0.96±0.06^{a}
2%	3.37±0.13^{a}	2.50±0.06^{c}	1.73±0.06^{a}	1.33±0.06^{a}	1.23±0.06^{a}	1.13±0.06^{a}	1.17±0.06^{b}
3%	3.37±0.13^{a}	2.67±0.16^{d}	1.83±0.06^{b}	1.53±0.06^{b}	1.37±0.10^{b}	1.20±0.10^{b}	1.20±0.06^{b}
4%	3.37±0.13^{a}	2.73±0.06^{d}	1.87±0.06^{b}	1.57±0.06^{b}	1.40±0.10^{b}	1.23±0.06^{b}	1.13±0.06^{b}
5%	3.37±0.13^{a}	2.83±0.06^{d}	2.03±0.06^{c}	1.70±0.10^{c}	1.47±0.06^{b}	1.33±0.06^{c}	1.23±0.06^{b}
$NaHCO_3$	3.37±0.13^{a}	2.13±0.06^{a}	1.63±0.06^{a}	1.27±0.06^{a}	1.13±0.06^{a}	1.03±0.06^{a}	1.00±0.29^{a}
Control	3.37±0.13^{a}	2.30±0.01^{b}	1.70±0.10^{a}	1.30±0.00^{a}	1.17±0.06^{a}	1.07±0.06^{a}	1.00±0.00^{a}

Means with different letters are significantly ($p<0.05$) different using Duncan multiple range test. Data are means of three replicates ±SD

Table 2: Impact of *Aframomum danielli* aqueous extract on total soluble solids (°Brix) of tomato stored at 26±2°C

	Storage time (days)			
Treatment	0	5	10	15
1%	3.40±0.06^{a}	2.93±0.06^{b}	1.37±0.12^{b}	0.37±0.00^{b}
2%	3.40±0.06^{a}	2.93±0.06^{b}	1.47±0.12^{b}	0.23±0.06^{a}
3%	3.40±0.06^{a}	2.97±0.06^{b}	1.47±0.06^{b}	0.20±0.00^{a}
4%	3.40±0.06^{a}	2.93±0.06^{b}	1.40±0.10^{b}	0.27±0.12^{ab}
5%	3.40±0.06^{a}	2.93±0.06^{b}	1.50±0.10^{b}	0.23±0.12^{a}
$NaHCO_3$	3.40±0.06^{a}	2.30±0.59^{a}	1.03±0.00^{a}	-
Control	3.40±0.06^{a}	2.30±0.55^{a}	1.10±0.00^{a}	-

Means with different letters are significantly ($p<0.05$) different using Duncan multiple range test. Data are means of three replicates ±SD

Reducing sugars: The reducing sugar value recorded on day zero was 1.20% (Fig. 2). There was significant reduction in *A. danielli*-treated, sodium bicarbonate-treated and untreated samples till day 15 for tomato stored at refrigeration condition but no significant difference was observed on day 25 and 30. There was general decrease in the trend of reducing sugars during storage. On day 10, significant higher value (0.6%) was recorded in samples treated with 5% *A. danielli* at refrigeration condition when compared with control (0.1%). On day 30 of refrigeration storage, there was no significant difference in all concentrations, although higher value was recorded in 5% treated sample. At ambient condition, a significant ($p<0.05$) decrease in reducing sugar was observed and higher values (0.8-0.9%) were recorded in treated samples than control (0.7%). After day 10, the control samples had spoilt and no data was presented on day 15.

Lycopene content: Lycopene contents reduced significantly in all samples during storage at refrigeration conditions (Fig. 3). On day 25, lycopene content was significantly ($p<0.05$) higher (1.5 mg 100 g^{-1}) in treated samples. However, sodium bicarbonate and untreated packed samples recorded significantly lower (1.10 mg 100 g^{-1}) lycopene content. At the end of the storage period, lycopene losses were higher in the untreated sample. At ambient condition, higher values (2.1-2.5 mg 100 g^{-1}) were recorded in samples treated with 2-5% *A. danielli* on day 5 than control (1.05 mg 100 g^{-1}) samples and similar trend was observed till day 15.

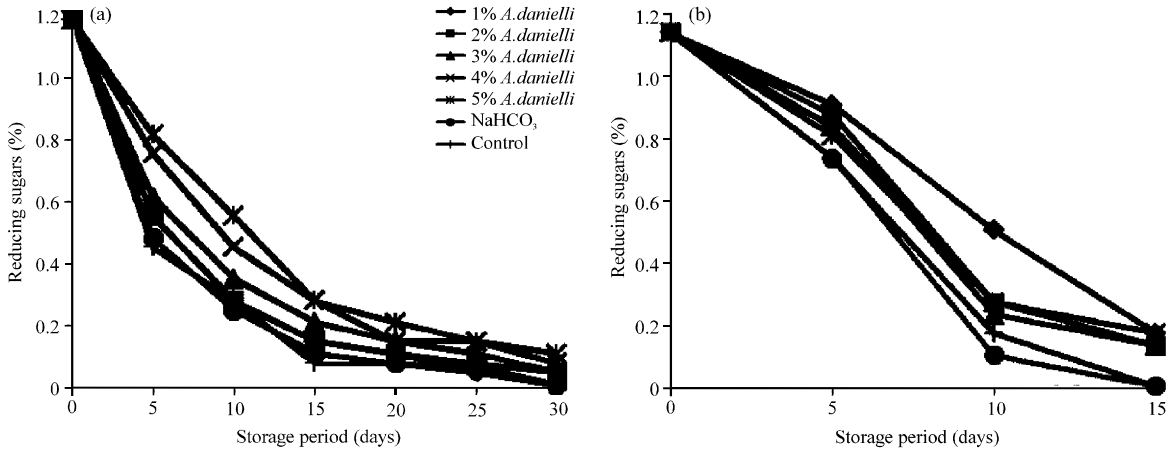

Fig. 2(a-b): Effect of Aframomum danielli aqueous extracts on reducing sugar of tomato fruits stored at refrigeration and ambient conditions, (a) Refrigeration condition (13±2°C; 85±5 RH) and (b) Ambient condition (26±2°C; 80±5 RH)

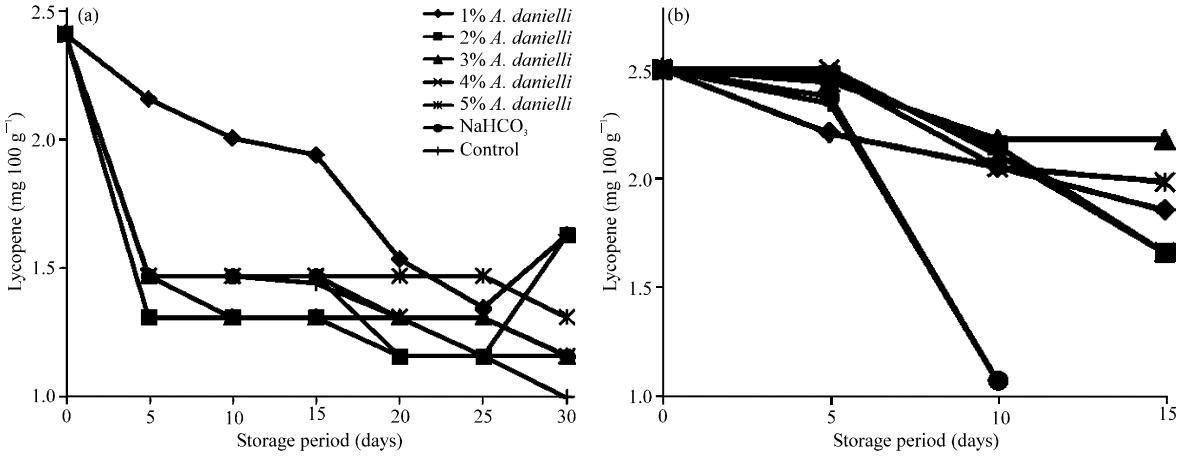

Fig. 3(a-b): Effect of Aframomum danielli aqueous extracts on lycopene of tomato fruits stored at refrigeration and ambient conditions (a) Refrigeration condition (13±2°C; 85±5 RH) and (b) Ambient condition (26±2°C; 80±5 RH)

Ascorbic acid: The ascorbic acid content of freshly harvested tomato was 22.00 mg 100 g^{-1} (Table 3). Ascorbic acid content reduced over storage time. Significant higher values (21.00-21.80 mg 100 g^{-1}) were observed in treated samples than control (18.17 mg 100 g^{-1}) sample on the fifth day. Ascorbic acid content differed significantly among treatments and storage conditions (Table 3). Highest values of 12.00-12.20 mg 100 g^{-1} were recorded in 4 and 5% *A. danielli* samples while control samples had 10.07 mg 100 g^{-1} at the end of storage at refrigeration condition. On the other hand, samples stored at ambient temperature recorded significant higher value in 5% treated sample as compared with control (9.63) fruits on day 10 (Table 4). Ascorbic acid was best retained in samples treated with 4-5% *A. danielli* at both storage conditions. Comparing the storage conditions, treated samples stored at lower temperature had better retention of ascorbic acid compared with those stored at higher temperature.

Table 3: Impact of *Aframomum danielli* aqueous extract on ascorbic acid (mg 100 g^{-1}) of tomato stored at 13±2°C

	Storage period (days)						
Treatment	0	5	10	15	20	25	30
1%	22.00±0.00^{a}	21.00±0.00^{b}	17.00±0.00^{a}	12.70±0.26^{b}	12.26±0.12^{b}	10.87±0.06^{b}	10.40±0.10^{b}
2%	22.00±0.00^{a}	21.23±0.06^{b}	18.00±0.00^{c}	14.53±0.06^{c}	12.67±0.06^{b}	11.30±0.10^{c}	10.53±0.06^{b}
3%	22.00±0.00^{a}	21.33±0.06^{b}	18.80±0.17^{c}	14.83±0.06^{c}	12.96±0.06^{c}	11.96±0.06^{d}	11.30±0.10^{c}
4%	22.00±0.00^{a}	21.50±0.00^{c}	19.40±0.17^{d}	15.47±0.06^{d}	13.43±0.12^{d}	12.67±0.06^{e}	12.00±0.00^{d}
5%	22.00±0.00^{a}	21.80±0.00^{c}	19.5±0.20d	15.83±0.06^{d}	13.96±0.15^{d}	13.03±0.06^{e}	12.20±0.10^{d}
$NaHCO_3$	22.00±0.00^{a}	18.17±0.29^{a}	17.33±0.15^{b}	12.07±0.15^{a}	11.40±0.10^{a}	10.23±0.12^{a}	9.96±0.15^{a}
Control	22.00±0.00^{a}	18.17±0.29^{a}	17.27±0.06^{b}	12.10±0.10^{a}	11.20±0.17^{a}	10.40±0.10^{a}	10.07±0.06^{a}

Means with different letters are significantly ($p<0.05$) different using Duncan multiple range test. Data are means of three replicates ±SD

Table 4: Impact of *Aframomum danielli* aqueous extract on ascorbic acid (mg 100 g^{-1}) of tomato stored at 26±2°C

	Storage period (days)			
Treatment	0	5	10	15
1%	25.17±1.04^{a}	20.33±0.58^{b}	12.50±0.00^{c}	5.37±0.06^{b}
2%	25.17±1.04^{a}	20.67±0.58^{b}	14.33±0.57^{e}	5.27±0.06^{ab}
3%	25.17±1.04^{a}	20.67±0.58^{b}	14.17±0.29^{e}	5.17±0.06^{a}
4%	25.17±1.04^{a}	20.50±0.50^{b}	13.67±0.00^{d}	5.13±0.05^{a}
5%	25.17±1.04^{a}	20.17±0.29^{b}	13.33±0.00^{d}	6.00±0.00^{c}
$NaHCO_3$	25.17±1.04^{a}	20.17±3.86^{b}	9.00±0.00^{a}	-
Control	25.17±1.04^{a}	20.00±3.69^{a}	9.63±0.00^{b}	-

Means with similar letters are not significantly ($p>0.05$) different using Duncan multiple range test. Data are means of three replicates ±SD

Table 5: Impact of *Aframomum danielli* aqueous extracts treatment on phenolic contents (mg GAE g^{-1}) of tomato during storage at 13±2°C

	Storage period (days)						
Treatment	0	5	10	15	20	25	30
1%	1.50±0.00^{a}	1.50±0.00^{b}	1.33±0.00^{b}	1.33±0.00^{b}	1.10±0.00^{a}	1.10±0.29^{a}	1.10±0.29^{a}
2%	1.50±0.00^{a}	1.17±0.29^{a}	1.00±0.00^{a}	1.17±0.29^{a}	1.00±0.00^{a}	1.00±0.00^{a}	1.00±0.00^{a}
3%	1.50±0.00^{a}	1.17±0.29^{a}	1.17±0.29^{a}	1.17±0.29^{a}	1.17±0.29^{a}	1.17±0.29^{a}	1.00±0.00^{a}
4%	1.50±0.00^{a}	1.33±0.29^{b}	1.17±0.29^{a}	1.17±0.29^{a}	1.17±0.29^{a}	1.00±0.00^{a}	1.00±0.00^{a}
5%	1.50±0.00^{a}	1.50±0.00^{b}	1.17±0.29^{a}	1.17±0.29^{a}	1.17±0.29^{a}	1.17±0.29^{a}	1.17±0.29^{a}
$NaHCO_3$	1.50±0.00^{a}	1.17±0.29^{a}	1.00±0.00^{a}	1.00±0.00^{a}	1.00±0.00^{a}	1.00±0.00^{a}	1.00±0.00^{a}
Control	1.50±0.00^{a}	1.17±0.00^{a}	1.00±0.00^{a}	1.00±0.00^{a}	1.00±0.00^{a}	1.00±0.00^{a}	1.00±0.00^{a}

Means with similar letters are not significantly ($p>0.05$) different using Duncan multiple range test. Data are means of three replicates ±SD

Effects on phenolic contents: The phenolic content of tomato fruits before storage was 1.50 mg GAE g^{-1}. The phenolic contents reduced in all samples over storage at refrigerated condition (Table 5). The treatment did not affect the phenolic content significantly although a higher value was recorded in 5% *A. danielli* treated sample on day 5. Reduction of phenolic contents during storage at 13±2°C in *A. danielli* refrigerated treated samples was gradual.

There was significant difference in total phenolic contents of 4 and 5% *A. danielli*-treated samples on day 5. Higher phenolic content was recorded in sample treated with 5% *A. danielli* on

Table 6: Impact of *Aframomum danielli* aqueous extracts treatment on phenolic contents (mg GAE g^{-1}) of tomato during storage at 26±2°C

	Storage days (mg GAE g^{-1})			
Treatment	0	5	10	15
1%	2.17±0.29^{a}	2.00±0.00^{a}	1.87±0.12^{a}	1.50±0.00^{a}
2%	2.17±0.29^{a}	2.00±0.00^{a}	2.00±0.00^{ab}	1.83±0.29^{b}
3%	2.17±0.29^{a}	2.00±0.00^{a}	2.00±0.00^{ab}	2.00±0.00^{b}
4%	2.17±0.29^{a}	2.10±0.00^{a}	2.00±0.00^{ab}	2.00±0.00^{b}
5%	2.17±0.29^{a}	2.00±0.00^{a}	2.00±0.00^{ab}	2.00±0.00^{b}
$NaHCO_3$	2.17±0.29^{a}	2.17±0.20^{b}	2.17±0.00^{b}	-
control	2.17±0.29^{a}	2.00±0.00^{a}	2.00±0.00^{ab}	-

Means with similar letters are not significantly ($p>0.05$) different using Duncan multiple range test (n = 3)

day 30. In samples stored at room temperature, there was no significant difference in the values of phenolic compounds but on day 15, 3-5% of *A. danielli* had significantly higher values of 2.00 mg GAE g^{-1} than samples treated with 1% *A. danielli*. Control samples reduced from 1.50 to 1.00 mg GAE g^{-1} on day 10 (Table 6) and the values were constant till the end of the storage period.

DISCUSSION

A significant reduction in pH of all the samples was observed over storage at refrigerated condition. At room temperature, the pH of all samples reduced till day 10 and later increased on day 15. Babitha (2006) also reported higher pH in tomato fruits stored at room temperature than at 13°C. The increase recorded after day 10 in samples stored at room temperature could be as a result of increase in metabolic and ripening rate. Gomez (2002) reported similar trend with initial reduction and consequent increase in pH of tomato during storage. Lowest value (3.7) was observed in control sample and this can encourage the growth of acidophilic organisms (Zagory, 1995).

The effect of spice extracts on TSS was concentration and storage period-dependent. Samples treated with 4 and 5% *A. danielli* had significantly higher values than samples treated with lower concentrations at refrigeration condition. Nasrin *et al.* (2008) reported reduction in brix of tomato during storage. Gaur and Bajpai (1982) also reported a decline in TSS during storage of red ripe tomato. Storage time and temperature had significant effect on TSS of tomato fruits. Higher reduction of TSS was observed in tomato stored at ambient condition. Vinha *et al.* (2013) observed reduction in sugar accumulation of Redondo tomato cultivar when stored at 12°C. The extent of reduction of TSS can be associated with respiratory breakdown of sugars.

There was a steady decrease in reducing sugars of all the samples during storage. Akbudak and Akbudak (2007) reported a decline in reducing sugar during the first 7 days when tomato was stored in modified atmosphere package. The trend of reduction observed in tomato samples was similar to the report of Nasrin *et al.* (2008). The author reported that, reducing sugar of tomato fruit reduced from 2.9-0.95% after 14 days of storage. Since reducing sugar is a substrate of respiration, values retained could be linked to extent of respiration.

The lycopene contents of tomato fruits progressively decreased at both storage conditions. The reduction in lycopene contents during storage showed that spice extracts both inhibited lycopene degradation during storage. At room temperature, the concentrations of the spice did not have significant ($p>0.05$) effect on lycopene contents for all treatment. However, treated tomato fruit was significantly ($p<0.05$) different from control samples (Fig. 3). Shi *et al.* (1999) reported that extreme

pH and degrading enzymes can lead to oxidation and isomerisation of lycopene. This could be responsible for the lower values obtained in control samples. Rapid degradation of lycopene was minimal in treated samples than in control untreated samples.

Ascorbic acid was best retained in *A. danielli* treated samples and this confirmed the potential of *A. danielli* in preventing loss of ascorbic acid (Adegoke and Krishna, 1998). In a research conducted by Nasrin *et al.* (2008), 12.3 mg 100 g^{-1} ascorbic acid was recorded in chlorine-treated tomato before storage. This value reduced significantly to 4.1 and 5.3 mg 100 g^{-1} in both control and samples treated with hypochlorite. The value recorded for ascorbic acid content of tomato by Akbudak and Akbudak (2007) was 28.1 mg 100 g^{-1}. This value was higher than the one reported in this study. The results obtained for ascorbic acid was similar to the report of Babarinde and Adegoke (2013). The authors reported higher significant values in *Xylopia aethiopica* treated tomato fruits compared with control. Reductions were also observed in ascorbic acid values during storage of tomato treated with hot water and packaged in 100 μ polyethylene (Akbudak and Akbudak 2007).

Phenolic losses were higher in samples stored at refrigeration condition than at room temperature. Dewanto *et al.* (2002) reported stability of total phenolic and carotenoids at higher temperature. This could be responsible for values obtained at room temperature. The result showed that both the treatment and storage temperature had effect on phenolic compounds. Phenolic compounds are essential components of fruit cells because they help in retaining ascorbic acid of fruits (Pila *et al.*, 2010).

CONCLUSION

The result obtained showed the efficacy of *A. danielli* in minimizing loss of valuable attributes of tomato. The botanical effect was more pronounced in the retention of ascorbic acid a major nutritional component of most fruits and vegetables. The spice can be used in extending the shelf life of tomato fruits even at advanced stage of ripeness.

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