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Storage stability of tomato paste as influenced by oil-citric acid and packaging materials

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Tomato pulp was concentrated by boiling at 90°C for 1 h. A mixture of 0.1% citric acid and 25 ml of vegetable oil were added to 100 g of the paste and packaged in aluminum foil (AF), low density polyethylene (LDP), plastic containers (PC) and stored under ambient temperature (30±0.1°C). Chemical analyses were carried out to determine pH, total solids, total acidity and refractive index as well as viscosity. Microbial analyses were also carried out after 8 weeks of storage. Results obtained showed significant ($p<0.05$) decreased in the pH value and increase in the titrable acidity (TTA) with storage time in all the packaging materials and samples treated with oil and citric acid (WOC) and those with no oil and citric acid (NOC). However, the decrease in pH and increase in TTA was more rapid in NOC than WOC. The total solid, vitamin A and C decreased significantly ($p<0.05$) with storage time following the trend as pH. Yeast and total viable count increased significantly ($p<0.05$) as the storage time increased. Tomato paste stored using AF had lower total plate count, ranging from 1.25×10^5 to 4.51×10^5 as compared to LDP (1.21×10^5 - 4.41×10^5) and PC (1.21×10^5 - 6.02×10^5). Generally, tomato paste in AF retained higher quality after 8 weeks of storage as compared to samples stored in LDP and PC. Also, NOC samples were more prone to spoilage than WOC. These findings can be applied for better preservation of tomato paste in rural communities where there is no electricity for cold storage.

Key words: Packaging materials, tomato paste, citric acid, vegetable oil, storage period.

INTRODUCTION

Tomato (*Lycopersicon esculentum*) is one of the most widely consumed fresh vegetable in the world (Thybo et al., 2006). Fresh-market tomatoes are a popular and versatile fruit vegetable, making significant contributions to human nutrition throughout the world (Simonne et al., 2006).

Tomato is rich in water soluble vitamin such as carotenoids, vitamins B and C; it could provide 12.2% recommended daily allowance of vitamin C (Smith and Hull, 2004). It has 20-25 mg ascorbic acid per 100 g (Ahmed and Shivhare, 2001). Tomato is also a rich source of natural lycopene. Tomato

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contains diseases fighting phytochemical (Robert et al., 2002) and antioxidant agent (Ahmed and Shivhare, 2001). The fruit consist of 98.1 g water/100 g, 0.7 protein/100 g, 3.1 g carbohydrate/100 g, 1.3 g dietary fibre/100 g and 0.3 g fat/100 g (Ahmed Shivhare, 2001).

FAO reports indicate that tomato production is on the increase globally (FAO, 2007), leading to rapid development of tomato processing industries with a series of inter-linked activities such as production of salad, soup, juice, puree, paste and powder and extraction of oil from the pulp. The demand for tomato pastes is increasing rapidly both in domestic and in international market (Tyssandie et al., 2004).

Tomato production in Nigeria at present is estimated at about one million tonnes (FAO, 2007). Due to its highly perishable nature, huge wastage and losses occur during the harvesting period. Therefore, the prevention of this losses and wastage is of major interest especially in Nigeria where there is imbalance in supply and demand at the harvesting and offseason (Akanbi et al., 2006). The imbalance is largely due to inability of the large population of Nigerians, especially the rural dwellers, to have access and use readily available and appropriate packaging materials for storage of tomato pastes, rather depending mainly on fresh tomato.

Packaging of the pastes is very important because of protection of the product from contamination by macro or micro-organism, reduction of oxidation (Matsuoka et al., 2002). Appropriate packaging of tomato pastes locally will serve purposes which are essential to extend the shelf life of the product and create a brand that is appealing to the consumers as well as add value to the product (Matsuoka et al., 2002).

Several works have been reported in literature on the use of plastic containers and low density polyethylene in the packaging of tomato paste (Famurewa et al., 2013; Akanbi and Oludemi, 2004); information is lacking on the use of Aluminum foil which are readily available and cheap. This work seeks to investigate the use of Aluminum foil in tomato paste packaging and storage.

Citric acid and oil has being reported to have inhibitory effect on the growth of microorganism especially in canned tomato (USDA, 2009). There is however scanty information on the use of citric acid and oil to extend the shelf life of packaged tomatoes. Thus, oil and citric acid were used in this study to investigate the effect of the pre-treatments on shelf life of packaged tomato pastes.

The objective of this study was to evaluate the effect of three different storage materials on the shelf stability of tomato paste pre-treated with citric acid and vegetable oil.

MATERIALS AND METHODS

Source of materials

The tomatoes used in this study were ripe and free from any form of mechanical injury, visible disease or rot. The fresh tomatoes were purchase from a farm on the bank of River Benue at Wurukum Makurdi, Benue State, Nigeria. Aluminum foil, low density

polyethylene and plastic container were purchased from Modern Market Makurdi.

Sample preparation

Tomato paste was processed by the traditional methods described by (Iwe, 2002) with slight modifications. The ripe and wholesome tomatoes were sorted out, selected and washed thoroughly to remove dirt and contaminants. The fresh tomatoes were blanched in hot water at about 90°C for 3-5 s to inactivate enzymes and easy peeling of the skin. The blanched tomatoes were sprayed with cold water and the skin was peeled off by pulling it back from the blossom end. The seed cavity was removed neatly with a knife and pulped in a blender. The pulp was heated in an open pot at 90°C for 1 h to concentrate the paste.

The paste was divided into three lots of 100 g each and filled into plastic containers, low density polyethylene and aluminium foil respectively, to a head space of about 10 mm in each case. Each lot was divided into two sublots. The headspace of one of the sublots was overlaid with vegetable oil and citric acid, while the sub lots without oil and citric acid act as control. The plastic container, low density polyethylene and aluminium foil were covered with air tight-lid and stored at room temperature $30 \pm 1^\circ\text{C}$. Samples were checked at two weeks intervals for chemical and microbiological changes.

Determination physicochemical analysis

Total acidity

The total acidity was determined according to AOAC (2005) official method by direct titration of 2 g of the puree with 0.1 M sodium hydroxide using phenolphthalein as indicator. The total acidity (as percentage citric acid) was calculated as follows:

$$\text{Citric Acid} = \frac{\text{mole of NaOH} \times \text{volume of base} \times \text{molar mass of acid} \times 100}{\text{Milli equivalent of acid} \times \text{volume of sample}}$$

pH

Twenty grammes of samples were dissolved in water and made up to 100 ml. The pH of the pastes was estimated using the electrode of a portable pH meter. The pH meter was standardized using buffer solution prior to sample analysis.

Vitamin A

This was determined according to the method of James (1995)

Ascorbic acid content

5 ml of standard solution of ascorbic acid was pipetted into 100 ml conical flask. 10 ml of oxalic acid was added and the solution titrated against the dye (V1 ml) until a pink colour persisted for 15 s.

The dye consumed is equivalent to the amount of ascorbic acid. Also, 0.5g of the sample was extracted in 4% oxalic acid and made up to 100 ml. The solution was filtered. 10 ml of oxalic acid was added to 5ml of the filtrate above. The solution was then titrated against the dye solution (2,6-dichlorophenol indophenol). The volume of dye used was recorded as (V2 ml) (Ibitoye, 2005).

$$\text{Ascorbic acid (mg/100 g)} = \frac{0.5 \text{ mg} \times V_2 \times 100 \text{ ml}}{V_1 \times 5 \text{ ml} \times W} \times 100$$

Where W = sample weight.

Table 1. Physicochemical parameters and vitamin content of tomatoes paste stored in aluminum foil (AF) without and with oil/citric acid for varying period of time.

Storage time	PH		Total solid		Viscosity (centipoise)		Total Acidity		Refractive index		Yeast count (cfu/g)		TVC (10 ⁵) (cfu/g)		Vitamin C		Vitamin A	
	NOC	WOC	NOC	WOC	NOC	WOC	NOC	WOC	NOC	WOC	NOC	WOC	NOC	WOC	WOC	NOC	NOC	WOC
0 week	4.51 ^a	4.22 ^a	0.90 ^a	0.90 ^a	91.25 ^a	80.10 ^a	0.006 ^d	0.071 ^c	1.35 ^a	1.33 ^a	0.62 ^d	0.39 ^c	1.81 ^d	1.21 ^e	2.31 ^a	2.31 ^a	1.61 ^a	1.32 ^a
2 weeks	4.48 ^a	4.21 ^a	0.87 ^b	0.90 ^a	90.10 ^a	80.20 ^a	0.05 ^c	0.06 ^d	1.35 ^a	1.33 ^a	0.61 ^d	0.31 ^d	1.51 ^e	1.22 ^d	2.22 ^b	2.12 ^b	1.51 ^b	1.31 ^b
4 weeks	4.41 ^a	4.20 ^a	0.85 ^c	0.87 ^b	90.01 ^a	80.10 ^a	0.05 ^c	0.07 ^c	1.35 ^a	1.35 ^a	0.65 ^c	0.39 ^c	2.92 ^c	1.82 ^c	1.96 ^c	2.11 ^c	1.49 ^c	1.31 ^b
6 weeks	4.35 ^a	4.11 ^a	0.81 ^d	0.85 ^c	85.15 ^b	75.10 ^b	0.01 ^b	0.17 ^b	1.36 ^a	1.34 ^a	1.21 ^b	0.73 ^b	3.41 ^b	2.52 ^b	1.86 ^d	2.06 ^e	1.32 ^d	1.30 ^c
8 weeks	4.05 ^b	3.99 ^b	0.78 ^e	0.81 ^d	80.10 ^c	70.20 ^c	0.12 ^a	0.18 ^a	1.35 ^a	1.34 ^a	2.22 ^a	1.81 ^a	4.52 ^a	3.31 ^a	1.86 ^d	2.07 ^d	1.30 ^e	1.31 ^b
P-Value	0.210		0.001		0.787		0.004		0.224		0.001		0.001		0.004		0.002	

Mean in the same column with different superscripts differ significantly (P<0.05). NOC, Without oil and citric acid; WOC, with oil and citric acid.

Viscosity

The viscosity of the tomato was measured using A Brook field viscometer (Lv – 8 viscometer) with spindle No. 4 at a speed of 6 rpm.

Total solid

This was determined by the use of a refractometer (IHP series Brownel London, Belligham and Stanly Limited). Ten grammes of the paste were mixed with 20g of water and filtered through muslin. The total solid was then determined by a drop of the filtered paste on the splint with the corresponding reading on the refractometer as percentage total solid AOAC (2005).

Refractive index

Ten grammes of the puree was mixed with 20 ml of the water and strained directly through muslin. The refractive index of the drop of the filtrate at 30°C was obtained by taking the corresponding reading on the refractometer (Okanlawon et al., 2002).

Total soluble solids

The total dissolved solids of the various samples were analyzed by weighing 10 g of the sample into 20ml of small Whatman filter paper. The refractive index of a drop of the

filtrate was taking at 20°C (AOAC, 2005).

Microbiological analysis

Preparation of media

Acidified potato dextrose agar for mould count was prepared according to the method of Ogbulie et al. (2001).

Microbial culturing and examination

Methods of standard pour plate technique were used as according to Ogbulie et al. (2001). After autodialing and cooling of the agar media to a temperature of 45°C about 20-25 ml of agar was poured into each dried plate.

1 ml portion of each sample serial dilution was added to the plate and the plate tilted from side to side until the liquid was evenly distributed across the surface of the agar. The culture plates were incubated at 37°C for 24 h for bacteria and mould count respectively prior to counting of colonies.

Statistical analysis

Determination were done in triplicate and all data were subjected to analysis of variance (ANOVA) and the mean separated using Duncan's multiple range test (DMRT) using version 16.0.

RESULTS AND DISCUSSION

Tables 1, 2 and 3 respectively showed that the pH values of samples treated with oil and citric acid (WOC) were generally lower than that with no oil and citric acid (NOC), indicating that WOC samples were more acidic. Addition of citric acid may have increased acidity of WOC samples. Also, the pH of samples stored in aluminum foil (AF) was higher than that stored in low density LDP and PC. The differences could be due to variation in rate of permeability of oxygen in the packaging materials. Aluminium foil has higher resistance to oxygen permeability (Smith and Hull, 2004) and therefore experienced less oxidation, evidenced by low pH values compared with LDP and PC.

There was general decrease in the pH value as the storage time increased for both WOC and NOC samples. pH values decreased from 4.51- 4.05; 4.51-3.95 and 4.51-3.98 for NOC samples stored in AF, LDP and PC respectively within the storage time of 8 weeks. Similarly, WOC samples showed more slow decrease in pH values from 4.22-3.99; 4.44-3.55 and 4.46-3.20 for AF, LDP and PC respectively. Values were not significantly different (p<0.05) from 0-6 weeks but differed significantly (p>0.05) at the 8th week across storage period.

Table 2. Physicochemical parameters and vitamin content of tomatoes paste stored in Low density polyethylene (LDP) without and with oil/citric acid for varying period of time.

Storage time	pH		Total solid		Viscosity (centipoise)		Total Acidity		Refractive index		Yeast count (cfu/g)		TVC (10 ⁵) (cfu/g)		Vitamin C		Vitamin A	
	NOC	WOC	NOC	WOC	NOC	WOC	NOC	WOC	NOC	WOC	NOC	WOC	NOC	WOC	WOC	NOC	NOC	WOC
0 week	4.51 ^a	4.44 ^a	0.90 ^a	0.90 ^a	91.15 ^a	87.00 ^a	0.006 ^d	0.07 ^c	1.34 ^a	1.34 ^a	0.85 ^c	0.14 ^e	1.81 ^e	1.21 ^e	3.21 ^a	2.85 ^a	1.37 ^a	1.31 ^a
2 weeks	4.35 ^a	4.31 ^{ab}	0.88 ^b	0.90 ^a	91.15 ^a	80.10 ^b	0.05 ^a	0.06 ^d	1.36 ^a	1.35 ^a	0.73 ^e	0.56 ^c	2.52 ^d	1.72 ^d	3.21 ^a	2.83 ^b	1.30 ^b	1.31 ^a
4 weeks	4.22 ^b	4.20 ^b	0.87 ^c	0.88 ^b	85.20 ^b	80.20 ^b	0.01 ^c	0.02 ^e	1.36 ^a	1.35 ^a	0.82 ^d	0.43 ^d	4.11 ^c	2.81 ^c	2.96 ^b	1.76 ^d	1.30 ^b	1.31 ^b
6 weeks	4.21 ^b	4.00 ^b	0.83 ^d	0.86 ^c	80.20 ^c	70.25 ^d	0.01 ^c	0.17 ^b	1.37 ^a	1.37 ^a	2.01 ^b	1.61 ^b	4.51 ^b	3.01 ^b	2.72 ^c	1.77 ^c	1.28 ^d	1.24 ^d
8 weeks	3.95 ^c	3.55 ^c	0.70 ^e	0.76 ^d	70.25 ^d	75.15 ^c	0.02 ^b	0.80 ^a	1.37 ^a	1.35 ^a	4.15 ^a	2.62 ^a	4.91 ^a	4.41 ^a	2.72 ^c	1.77 ^c	1.29 ^c	1.25 ^c
P-Value	0.210		0.001		0.787		0.004		0.224		0.001		0.001		0.004		0.002	

Mean in the same column with different superscripts differ significantly (P<0.05). NOC, without oil and citric acid; WOC, with oil and citric acid.

Table 3. Physicochemical parameters and vitamin content of tomatoes paste stored in Paste container (PC) without and with oil/citric acid for varying period of time.

Storage time	pH		Total solid		Viscosity (centipoise)		Total Acidity		Refractive index		Yeast count (cfu/g)		TVC (10 ⁵) (cfu/g)		Vitamin C		Vitamin A	
	NOC	WOC	NOC	WOC	NOC	WOC	NOC	WOC	NOC	WOC	NOC	WOC	NOC	WOC	WOC	NOC	NOC	WOC
0 week	4.51 ^a	4.46 ^a	0.90 ^a	0.93 ^a	91.15 ^a	80.06 ^a	0.006 ^d	0.009 ^e	1.33 ^a	1.34 ^a	0.63 ^e	0.39 ^d	1.81 ^e	1.21 ^e	2.31 ^b	3.03 ^a	1.51 ^a	1.31 ^a
2 weeks	4.46 ^a	4.24 ^b	0.89 ^b	0.91 ^b	91.10 ^a	70.10 ^b	0.006 ^d	0.09 ^c	1.35 ^a	1.34 ^a	1.71 ^d	0.83 ^c	3.31 ^d	1.82 ^d	2.32 ^a	2.83 ^b	1.50 ^a	1.31 ^a
4 weeks	4.31 ^{ab}	4.19 ^b	0.86 ^c	0.90 ^c	91.02 ^a	65.15 ^c	0.07 ^c	0.08 ^d	1.36 ^a	1.34 ^a	1.41 ^c	0.73 ^d	4.21 ^c	3.71 ^c	2.22 ^d	2.79 ^c	1.50 ^a	1.31 ^a
6 weeks	4.21 ^b	3.99 ^b	0.85 ^d	0.88 ^d	90.02 ^b	60.10 ^d	0.16 ^b	0.18 ^b	1.36 ^a	1.34 ^a	2.81 ^b	2.22 ^b	5.71 ^b	4.21 ^b	2.22 ^d	2.66 ^d	1.49 ^b	1.30 ^b
8 weeks	3.98 ^c	3.20 ^c	0.79 ^e	0.84 ^e	88.10 ^c	60.05 ^d	0.17 ^a	0.19 ^a	1.37 ^a	1.34 ^a	4.21 ^a	3.72 ^a	6.81 ^a	6.02 ^a	2.23 ^c	2.52 ^e	1.49 ^b	1.30 ^b
P-Value	0.210		0.001		0.787		0.004		0.224		0.001		0.001		0.004		0.002	

Mean in the same column with different superscripts differ significantly (P<0.05). NOC, without oil and citric acid; WOC, with oil and citric acid.

The decrease in the pH values with storage time may be due to increase in microbial activities with storage time (Giordano et al., 2000). According to Campos et al. (2006), pH is a key element in tomato quality and for tomato paste, pH below 4.5 is appropriate for tomato paste, but above 4.5 is undesirable trait, because it will not halts the proliferation of microorganisms in the final product.

Total solid (TS) content is a measure of the solid

particles after concentration. The results of the total solid as presented in Tables 1, 2 and 3 for samples stored in AF, LDP and PC respectively revealed that WOC samples had higher TS values compared with NOC samples. Similarly, samples stored in PC were higher in TS than those stored in AF while those in LDP had lower in values. Generally, there was significant (p<0.05) decrease in TS as the storage period increased. From Table 1, for samples

packaged in AF, the TS value of NOC decreased significantly (p<0.05) from 0.90 - 0.78 during the period of storage (0-8 weeks). On the other hand, the values for WOC decreased more steadily from 0.90-0.81. Similar trend were also observed for samples stored in LDP and PC (Tables 2 and 3). Smith and Hull (2004) reported that AF, LDP and PC permit the diffusion of gases, vapour and volatile flavour of stored products. Therefore, the

observed trend could be due to differences in the rate of diffusion of gasses through the packaging materials.

According to earlier researchers (Saliba-Colombani et al., 2001), there is a connection between sugar content and total solid in tomato fruit. Soluble solid content measurements may give a fair estimate of the sugar level in tomato fruit, thus, the reduction in TS over storage time may be a function of the degradation of sugar by microorganism which was more noticeable in NOC than WOC samples. This gives indication of the inhibitory effect of citric acid and oil on microbial activities.

The viscosity of tomato products depends on fibre, fat, protein, and total solids (Tamburini et al., 1999). The viscosities of NOC samples stored in AF were higher and decreased more steadily than WOC samples (Tables 1, 2 and 3). Viscosity was observed also to decrease significantly ($p < 0.05$) with storage time especially from the 2nd week of storage. Similar trend was also observed in samples stored in LDP and PC packaging materials, attributable to microbial activity on the stored tomato paste

The total titrable acidity (TTA) increased significantly ($p < 0.05$) with the storage period for both NOC and WOC samples stored in AF, LDP and PC packaging materials. In Tables 1, 2 and 3, the TTA of WOC samples were generally higher than NOC, owing to the presence of citric acid and oil used in the treatment procedure. The TTA of NOC samples stored in PC were higher (0.006-0.17) than LDP (0.006-0.05) and AF (0.006-0.12). On the other hand, TTA of WOC sample was higher in LDP (0.07-0.80) compared to the other packaging materials. This result is in line with the work of Okanlawon et al. (2002). The authors observed that, decrease in acidity is probably due to the effect of organisms responsible for the spoilage, some of which can release basic substances into the samples.

The refractive index of WOC samples were generally lower than NOC, although values were not significantly different ($p < 0.05$) across the packaging materials and storage period (Tables 1, 2 and 3). Refractive index is a measure of the soluble solid (Famurewa et al., 2013), hence the presence of citric acid and oil in WOC samples reduced the breakdown of solids leading to less available soluble solids compared to NOC samples.

Tables 1, 2 and 3 show that the yeast counts in WOC samples were generally lower than NOC in the three packaging materials namely AF, LDP and PC. The yeast count of WOC samples ranged from 0.39-1.81; 0.14-2.62 and 0.39-3.72 for AF, LDP and PC respectively, while that of NOC was higher ranging from 0.63-4.21; 0.85-4.15 and 0.62-2.22. Samples were observed to increase significantly ($p > 0.05$) in yeast count with storage time in all the packaging materials. This trend could be attributed to the effect of the citric acid and oil which inhibited the multiplication of the microorganism in WOC samples. Samples stored in LDP were higher in yeast count than AF and PC for NOC and WOC. This higher population of the microorganisms in LDP may be due to higher permeability of O₂, CO₂ and other gases (Smith and Hull, 2004). The growth of yeast

and mould increased with storage time in accordance with the report of (Mozumber et al., 2012)

Tables 1, 2 and 3 also show that the total viable count (TVC) followed the same trend as the yeast and mould count. Total viable count was higher in NOC samples than WOC across all samples stored in AF, LDP and PC. This is also attributable to the inhibitory action of oil and citric acid.

Values obtained for samples stored in AF, were lower than those stored in LDP and PC, indicating the relative resistance of AF to microbial growth. The total viable count values generally increased significantly ($p < 0.05$) as the storage time increased in accordance with (Mozumber et al., 2012) who reported that microbial growth increases as the storage time prolongs.

The results presented in Tables 1, 2 and 3 show that there was significant difference ($p > 0.05$) in the vitamin C content among the pre-treatments and the storage period.

The vitamin C values of samples treated with oil and citric acid (WOC) were generally higher than samples with no citric acid and oil (NOC). Higher retention of vitamin C in WOC may be as a result of inaction of the endogenous enzymes such as ascorbic acid oxidase, cytochrome oxidase and peroxidase as reported in similar by (Okorie et al., 2004).

The vitamin C of NOC samples was lower than WOC. Vitamin C was higher in LDP compared to the other packaging material. Generally, vitamin C decreased significantly ($p < 0.05$) with storage period owing to the reactive nature of vitamin C, to storage environment (Davey et al., 2000). The result of this work agrees with earlier work by Leonardi et al. (2001) who reported that storage condition has significant impact on the loss of ascorbic acid.

The data obtained for vitamin A showed higher values in NOC than WOC samples. This may be due to the concentration of citric acid used in the pre-treatment procedure of the samples. Vitamin A samples stored in PC degraded more slowly than those stored in LP and AF; this may be as a result of heat generated internally by the PC. Vitamin A values were observed to decrease more gradually, relative to the other parameters as the storage time increased. This may be due to degradation of vitamin A by light and heat in the storage environment.

Conflict of interest

The authors did not declare any conflict of interest.

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