Storage Stability of Tomato Paste Packaged in Plastic Bottle and Polythene Stored in Ambient Temperature

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Abstract

Packaging plays an important role in achieving the objectives of safety and waste prevention. This study investigated the effect of using plastic bottles and polythene tube as packaging materials for tomato paste. Paste was produced by concentrating tomato pulp, preservatives were added and packaged with plastic bottles and polythene. Physicochemical analyses were carried out to determine pH, total solids, protein content, ascorbic acid, ash content, brix and titratable acidity. Microbial analyses were also carried out. Results indicated that all samples showed a significant increase in pH with decrease in titratable acidity during storage. While protein content, vitamin C, total solids of all the samples decreased during storage, brix values remained constant and ash content increased. Tomato paste packaged in bottle retained higher amount of vitamin C at the end of the storage period than the one in polythene. Regression analysis showed that bottled samples will retain about 95% of its protein till week ten while polythene samples will retain about 89%. Generally, samples in bottles retained their nutrients more than those in polythene and can be stored for ten weeks while polythene samples can only be stored for seven weeks.

Keywords: *Packaging materials, plastic bottle, polyethylene, tomato paste, storage period*

Introduction

Food packaging is an integral and essential part of modern food processing. It is defined as a coordinated, industrial and marketing system for enclosing products in a container to meet the following needs: containment, protection, preservation, distribution, identification, communication and convenience (Paine and Paine,1992). Efficient packaging is a necessity for every kind of food, ether fresh or processed. It is an essential link between the food producer and the consumer and unless it is performed correctly, the good standing of the product suffers and the consumer goodwill is lost. All the skill, quality and reliability built into the product during development and production is wasted unless care is taken to see that the consumer gets it in prime condition (Guine *et al*., 2007).

Tomato (*Lycopersicon esculentum*, commonly referred to as vegetable is grown throughout the tropical and temperate regions of the world (Okorie *et al*., 2004). Tomato is an important herbaceous perrenial vegetable grown for its edible fruit and as an annual vegetable in temperate regions. This fruit vegetable has the ability to raise the standard quality and acceptance of other diets and are consumed both as raw and/or processed products. Fresh tomatoes are the fifth most popular vegetable consumed in the United States (16.6 pounds per capita) (USDA, 2000). They are a reasonably good source of vitamins and minerals. . It is also very high in moisture and cellulose but low in protein, most of which is in the seed. Although tomato production in Nigeria has more than double in the last decade with the production in 2001 alone reaching 879,000 metric tonnes (FAO, 2002), and presently up to 1million tonnes (FAO, 2007), the market continues to decline because of problems which bother on substantial losses during post harvest transit of this perishable fruit (Olorunda and Tung, 1985).

Tomato paste has been in existence for long. It was produced by crushing ripe tomatoes and concentrating it till the pulp becomes very thick (paste). In addition, salt was added to prolong its stability for use when fresh tomato is not available. The most common method for preservation among the working class house wives is by blending the fruit and storing for weeks in the freezer at frozen temperature. Under the industrial process, tomatoes are made into puree, ketchup, and often canned (Hallowell and Woltrich, 1999; Bourdhrioua *et al*., 2008). Storage and preservation of tomato is very important, and so, any method of storage and preservation that will allow the quality to remain unaffected for a long time and encourage the use of cheap and locally available materials should be utilized.

Polyethylene is one of the most important packaging materials of the present time. Polyethylenes are also widely used in laminations, where they provide the inner layer requiring good heat seal ability. Polyethylenes are strong but flexible, tough, chemically inert, have high clarity and are inexpensive. Generally, polyethylenes are characterized by having a low permeability to water vapour, a high permeability to oxygen, carbon dioxide and other gases. They are good heat sealers forming a strong seal almost instantly.

This study is therefore very important in order to solve the critical problem of post harvest losses by concentrating the product into paste and also find an acceptable, available and affordable package for the paste to enhance its use and storage domestically.

Materials and Methods

Preparation of Sample

Wholesome and fresh ripe tomato fruits were obtained from King's market, Akure, Ondo State. They were sorted and washed to reduce microbial population, dirts and dusts. They were blanched at 90^0C for 2 minutes for easy skin removal. The skins were removed manually. The pulp was milled in an attrition mill. It was then concentrated with Federal University of Technology, Akure (FUTA) Concentrator into paste at 104 ^{0}C. The paste was allowed to cool and divided into three portions of 1 kg each. 5 g of Sodium benzoate was added to one portion, 5 g of sodium metabisulphite was added to the second portion while 2.5 g of sodium benzoate and 2.5 g of sodium metabisulphite was added to the third portion. Each of the paste samples was packaged in plastic bottles and 0.5 mm thick low density polythene and stored at room temperature.

Proximate Analysis

The total solids, protein and ash contents of the samples were determined on weekly basis following the procedures of AOAC (2000) method.

Determination of Physicochemical Properties

pH: The pH values of the samples were measured weekly and directly using a pH meter (pHS 25). Five grams (5g) of each sample was first dissolved in 50 cm^3 distilled water in a beaker and thoroughly shaken. The pH meter was standardized using buffer solutions pH 4 and 7. The values were taken (Ibitoye, 2005).

Titratable Acidity: Titrable acidity was determined by the method described by AOAC (2000) Ten grams(10g) of the sample was weighed in a clean beaker; 25cm^3 of distilled water was added to it and the content shaken together. The solution was then filtered using Whatman filter paper № 1. 10 ml of the filterate was pipetted into a conical flask and two drops of phenolphthalein indicator added. 0.1M NaOH was added dropwise and the solution shaken thoroughly until a pink colour was obtained. Titratable acidity was expressed as percentage citric acid.

$$\% \text{ T.A.} = V \times M \times F$$

Where V = volume of 0.1M NaOH used,
M = molarity of NaOH and F = factor of citric acid (0.007005).

Brix: The glass slide of the refractometer (Atago hand refractometer N_1 0-32%) was cleaned with water and wiped dry with a clean napkin. A smear of the sample was made on the slide of the refractometer and the lid replaced. The reading was taken at the graduated mark. This reading indicates the total soluble solids value of the sample and was recorded in degree brix (^{0}brix) (Owoso, *et* al, 2000).

Ascorbic Acid Content:
5ml of standard solution of ascorbic acid was pipetted into 100ml conical flask. 10ml of oxalic acid was added and the solution titrated against the dye (V_1 ml) until a pink colour persisted for 15 seconds.

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 100ml. The solution was filtered. 10ml 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 (V_2 ml) (Ibitoye, 2005).

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

Where W = sample weight.

Statistical Analysis

Determinations were done in triplicates and all data were subjected to analysis of variance (ANOVA) and the mean separated using Duncan's multiple range test (DMRT) using (SPSS) version 10.0. Regression analytical technique was also used to determine the impact of the packaging materials and preservatives used on the shelf life of the tomato paste produced.

Results and Discussion

Table 1 show that there is no significant difference in the protein contents of all the samples for the first two weeks. As from the third week the protein content of samples in polythene packages had started to be significantly different from those in plastics. Until the sixth week, there was no significant difference in the protein contents of the plastic samples to that of fresh sample except that preserved with sodium metabisulphite. All the polythene samples have shown significant difference since the fourth week. In both plastic and polythene, sodium metabisulphite samples retained the protein content least. According to Paine and Paine (1992), this was possible because of temperature changes in the storage environment. Protein is often denatured by temperature and bottles offer increased stability to heat when compared with polythene (Ngoddy and Ihekoronye, 1995). Regression analysis showed that bottled samples will retain about 95% of its protein till week 10 while polythene samples will retain about 89% (Table 11). S_1 and S_3 showed no significant difference in ash content up to week 4 when compared with the control. Also S_5 showed no significant difference up to week 3. S_2, S_4 and S_6 retained their original ash content for the first two weeks after which there was significant increase ($p>0.05$) in their percentage ash content as storage continued (Table 2). The samples in polythene had higher numerical ash content after 6 weeks than those in bottles. This was brought about by some microorganisms discovered to be present. The higher rate in polythene was because of the high permeability to 0_2, $C0_2$ and other gases which aid the growth of microorganisms that caused the increase (Smith and Hull, 2004). The ash content is estimated to be 7.9% higher in bottled samples in week 10 while it was 15% higher in polythene samples.

Total solid content is a measure of the solid particles after concentration. No significant difference was observed in the total solid content of S_3 and S_5 up to week five when compared with the control. S_1, S_2, S_4, and S_6 also showed no significant difference in the first three weeks (Table 3). After this, there was a significant drop in the total solid content and this continued up to the last week of storage. This reduction was observed to be more in polythene – packed samples than in bottled samples. This implies that the moisture content of S_1, S_2, S_4, and S_6 slightly increased after week 3 and that of S_3, and S_5 increased after week 5. This was possible because both packaging materials permit the diffusion of gases, vapors and volatile flavour though; the permeability of plastic is lower (Smith and Hull, 2004; Paine and Paine, 1992). The microorganisms observed in the samples could have affected the breakdown of solid components present in the samples (Adams and Blundstone, 1974).

Table 4 showed that there was no significant change in the vitamin C content of S_1 and S_5 throughout the six – week storage period. S_3 also experienced no significant change until after week four. S_2 and S_6 had significantly lower Vitamin C content after the third storage week. It was however observed that the slight reduction in Vitamin C content was lower in bottled samples than in polythene samples due to the increased stability of the former to heat and temperature changes which occurs in the storage atmosphere. According to Nawrott *et al* (1999), and Smith and Hull, (2004), increased temperatures normally results in high percentage loss of ascorbic acid.

Also, the lower permeability of plastic bottles compared with polythene helped reduce the microbial population that could cause alteration in nutritive values. (Okorie *et al*, 2004; Guine *et al*., 2007). Vitamin C importance includes prevention of disease, such as scurvy and participation in the regulation of body processes. From regression analysis, 19 – 21mg (90 – 95%) of Vitamin will be retained till week ten in bottled samples while about 80% will be retained in polythene samples (Tong-un *et al*., 2010).

Soluble solid, a measure of the refractive index of the paste, depends on the concentration and temperature of the solutes in solution. . It was observed that measured brix values of all samples remained constant throughout the storage period (Table 5). This showed that the soluble sugar present in the sample was not affected in any way by the packaging materials used within the storage period.

There was a significant increase in pH values of S_2, S_3, S_4, S_5, and S_6, after week 3 while S_1, showed no significant difference from the control until after week five (Table 6). At the point of significant difference in pH, there was also a slight significant decrease in titratable acidity of the samples (Table 7).

Lycopene content in the sixth week was discovered to be significantly lower than that in the control sample (Table 8). This might be due to oxidation as the main cause of lycopene degradation is oxidation which depends on temperature, moisture, etc (Trifiro *et al.*, 1998). The significant increase in the moisture content could have caused oxidation of lycopene. Lycopene content of the control sample was also low and this could be due to the variety of the tomato fruits used and the growing conditions. According to Smith and Hull (2004), the final lycopene concentration depends on the variety and the growing conditions.

Some tomato varieties have been bred to be very high in lycopene. Also, during growth, light level and temperature affect lycopene content. Lycopene loss is also accelerated by high processing temperature. During hot break, the hotter the break temperature, the greater the loss of lycopene, even when operating under a vacuum (Trifiro *et al.*, 1998, Toor and Savage, 2006). Since the tomato paste was concentrated at a high temperature, degradation of lycopene might have occurred; resulting in the low amount of lycopene. It has been reported that heat concentration of tomato pulp can result in up to 57% loss of lycopene (Tamburini *et al.*,1999; Smith and Hull, 2004) .

Table 9 shows that the microbial population does not contain fungi (yeast/mould) but some bacteria were present. Bottled sample had lower number of colony forming units per gram of sample than samples in polythene as a result of the higher permeability of polythene to O_2 and CO_2 than bottles.

Regression analysis showed that all the samples will still retain an appreciable amount of nutrient up till the 10^{th} week (Table 10). However, it is not recommended that S_2, S_4, S_5 and S_6 be stored over seven weeks because of its low acidity and increasing pH as storage progresses (average pH at week 7 = 4.6). Since its high acidity makes it resistant to microbial spoilage, decrease in acidity as storage progresses makes it liable to microbial spoilage (Smith and Hull, 2004). S_1 and S_3 can be stored for 10 weeks.

The peak in all the samples occurred at 490nm. This means that the observed colour was red according to Bauer (1978). This remained the same throughout the storage period. According to Smith and Hull (2004), the colour of tomato paste does not change during storage if the product is kept at room temperature or below. He further reported that no difference in colour was observed after 300 days at 20^0C.

Conclusion

With the actualization of this study based on the effect of two different packaging materials on tomato paste, it can be concluded that tomato paste can also be packaged in plastic bottles and polythene. However, the use of plastic bottles is better because it retained more of the nutrients in the paste than polythene. Therefore, the plastic bottle is better used for packaging and storing of tomato paste.

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Table 1: Protein Content of Tomato Paste Over Six Weeks (%)

Sample/ Weeks	W_0	W1	W2	W3	W4	W5	W6
S1	1.93^{a}	1.93^{a}	1.92^{a}	1.92^{a}	1.90^{ab}	1.90^{ab}	1.89^{ab}
S2	1.93^{a}	1.92^{a}	1.92^{a}	1.91^{ab}	1.82^{b}	1.80^{b}	1.80^{c}
S3	1.92^{a}	1.92^{a}	1.92^{a}	1.91a	1.91^{a}	1.90^{a}	1.83^{b}
S4	1.92^{a}	1.92^{a}	1.92^{a}	1.89^{b}	1.87^{b}	1.83^{b}	1.79^{bc}
S5	1.93^{a}	1.93^{a}	1.92^{a}	1.92^{a}	1.91^{ab}	1.89^{ab}	1.89^{ab}
S6	1.92^{a}	1.93^{a}	1.90^{a}	1.89^{b}	1.87^{b}	1.84^{c}	1.81^{c}

Mean values with different superscripts are significantly different ($P<0.05$)

KEY

S_1 - Plastic bottle with Sodium benzoate
S_2 - Polythene with Sodium benzoate
S_3 - Plastic bottle with Sodium metabisulphite
S_4 - Polythene with Sodium metabisulphite
S_5 - Plastic bottle with Sodium benzoate + Sodium metabisulphite
S_6 – Polythene with Sodium benzoate + Sodium metabisulphite
W – Weeks

TABLE 2: Ash Content of Tomato Paste Over Six Weeks (%)

Sample/ Weeks	Control	W1	W2	W3	W4	W5	W6
S1	1.63^{b}	1.63^{b}	1.61^{b}	1.65^{b}	1.65^{b}	1.75^{a}	1.75^{a}
S2	1.63^{c}	1.64^{c}	1.65^{c}	1.68^{b}	1.72^{b}	1.78^{a}	1.80^{a}
S3	1.62^{b}	1.62^{b}	1.63^{b}	1.63^{b}	1.63^{b}	1.68^{a}	1.71^{a}
S4	1.63^{c}	1.67^{bc}	1.70^{bc}	1.72^{b}	1.73^{b}	1.73^{b}	1.80^{a}
S5	1.63^{c}	1.63^{c}	1.64b	1.65^{b}	1.67^{a}	1.68^{a}	1.72^{a}
S6	1.63^{c}	1.63^{c}	1.64^{c}	1.70^{b}	1.72^{ab}	1.74^{ab}	1.79^{a}

Mean values with different superscripts are significantly different (P<0.05)

Table 3: Total Solid Content of Tomato Paste Over Six Weeks (%)

Sample/ Weeks	Control	W1	W2	W3	W4	W5	W6
S1	20.87^{a}	20.84^{a}	20.74^{a}	20.67^{a}	19.89^{b}	19.73^{b}	19.18^{bc}
S2	20.28^{a}	20.25^{a}	20.19^{ab}	19.97^{ab}	19.70^{b}	19.20^{bc}	18.83^{c}
S3	20.46^{a}	20.45^{a}	20.38^{a}	20.36^{a}	20.34^{a}	20.16^{a}	19.64^{b}
S4	20.42^{a}	20.41^{a}	20.39^{a}	20.36^{a}	20.15^{b}	19.48^{c}	19.15^{d}
S5	21.36^{a}	21.35^{a}	21.35^{a}	21.33^{a}	21.33^{a}	20.70^{ab}	20.40^{b}
S6	20.58^{a}	20.57^{a}	20.50^{a}	20.47^{a}	19.74^{b}	19.29^{b}	19.07^{bc}

Mean values with different superscripts are significantly different (P<0.05)

Table 4: Ascorbic Acid Content of Tomato Paste Over Six Weeks (Mg/100g)

Sample/ Weeks	Control	W1	W2	W3	W4	W5	W6
S1	20.97^{a}	20.96^{a}	20.93^{a}	20.93^{a}	20.89^{a}	20.86^{ab}	20.85^{ab}
S2	20.92^{a}	20.90^{a}	20.90^{a}	20.75^{a}	19.65^{b}	19.21^{b}	17.46^{c}
S3	20.96^{a}	20.95^{a}	20.94^{a}	20.94^{a}	20.94^{a}	19.74^{b}	19.73^{b}
S4	20.94^{a}	20.93^{a}	20.89^{a}	20.88^{a}	20.72^{a}	18.25^{c}	17.64^{c}
S5	20.94^{a}	20.94^{a}	20.93^{a}	20.92a	20.91^{ab}	20.89^{ab}	20.87^{ab}
S6	20.93^{a}	20.92^{a}	20.89^{a}	20.88^{a}	19.69^{b}	18.99^{c}	18.32^{c}

Mean values with different superscripts are significantly different (P<0.05)

Table 5: Brix Values of Tomato Paste Over Six Weeks (^{0}b)

Sample/ Weeks	Control	W1	W2	W3	W4	W5	W6
S1	13	13	13	13	13	13	13
S2	13	13	13	13	13	13	13
S3	13	13	13	13	13	13	13
S4	13	13	13	13	13	13	13
S5	13	13	13	13	13	13	13
S6	13	13	13	13	13	13	13

Table 6: Ph Values of Tomato Paste Over Six Weeks

Sample/ Weeks	Control	W1	W2	W3	W4	W5	W6
S1	3.98^{b}	3.98^{b}	3.99^{b}	3.99^{b}	3.99^{b}	4.21^{a}	4.22^{a}
S2	3.97^{c}	3.98^{bc}	4.03^{b}	4.19^{b}	4.32^{a}	4.38^{a}	4.40^{a}
S3	3.98^{c}	3.98^{c}	3.99^{c}	3.99^{c}	4.02^{b}	4.04^{b}	4.21^{a}
S4	3.80^{c}	3.81^{c}	4.02^{bc}	4.16^{b}	4.24^{b}	4.28^{ab}	4.30^{a}
S5	3.96^{c}	3.96^{c}	3.96^{c}	3.98^{c}	4.07^{b}	4.09^{a}	4.22^{a}
S6	3.76^{c}	3.76^{c}	3.78^{c}	3.79^{c}	4.24^{b}	4.34^{a}	4.43^{a}

Mean values with different superscripts are significantly different (P<0.05)

Table 7: Titratable Acidity of Tomato Paste Over Six Weeks (%)

Sample/ Weeks	Control	W1	W2	W3	W4	W5	W6
S1	0.08^{a}	0.08^{a}	0.08^{a}	0.07^{a}	0.06^{ab}	0.04^{b}	0.01^{c}
S2	0.08^{a}	0.07^{a}	0.06^{a}	0.05^{b}	0.05^{b}	0.05^{c}	0.03^{c}
S3	0.08^{a}	0.08^{a}	0.08^{a}	0.07^{a}	0.06^{b}	0.05^{c}	0.02^{d}
S4	0.07^{a}	0.07^{a}	0.06^{a}	0.06^{a}	0.04^{c}	0.04^{c}	0.03^{c}
S5	0.08^{a}	0.08^{a}	0.07^{a}	0.07^{a}	0.06^{ab}	0.03^{b}	0.01^{c}
S6	0.08^{a}	0.07^{a}	0.06^{ab}	0.06^{b}	0.05^{c}	0.05^{c}	0.03^{d}

Mean values with different superscripts are significantly different (P<0.05)

Table 8: Lycopene Content of Tomato Paste

Sample/ Weeks	Control	W6
S1	0.15[a]	0.14[a]
S2	0.15[a]	0.13[b]
S3	0.15[a]	0.13[b]
S4	0.15[a]	0.13[b]
S5	0.15[a]	0.14[b]
S6	0.15[a]	0.12[b]

Table 9: Microbial Population of SAMPLES

Sample/ weeks	Control	Total count 10^{-3} cfu/g	Yeast/mould 10^{-3} cfu/g
S1	0	3	0
S2	0	10	0
S3	0	5	0
S4	0	12	0
S5	0	5	0
S6	0	11	0

Table 10: Estimated Chemical Values for Week 10 (Regression Analysis)

Samples/	Protein	Vitamin C	Ash	pH	Acidity
S_1	1.87	21.25	1.76	4.36	0.01
S_2	1.70	16.11	1.88	5.59	0.03
S_3	1.86	19.29	1.72	4.54	0.02
S_4	1.71	16.73	1.88	5.38	0.03
S_5	1.87	20.85	1.74	4.75	0.01
S_6	1.85	17.33	1.85	5.03	0.03