

Evaluation of the Effectiveness of Some Processing Methods in the Preservation of Tomatoes

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Abstract: The effectiveness of hydrocooling, sundrying and evaporation in the preservation of tomatoes (*Lycopersicon esculentum*) were evaluated. The tomato samples were processed and stored for 28 days. The quality characteristics of the stored samples were monitored weekly by analyzing the moisture content, ascorbic acid, total acidity, total solid, protein content, sensory scores and total microbial load. The result showed that the hydrocooled tomato sample significantly retained appreciable moisture content of 93.92% up to the 21st day of storage whereas sundried and evaporated samples had very low moisture contents by the 28th day 16.38 and 36.46%, respectively. Hydrocooled sample also retained higher content of ascorbic acid (14.67%) by the end of the 21st day while the sundried and evaporated samples had barely 5.17 and 6.97%, respectively. In terms of sensory scores, both the hydrocooled and evaporated samples were found to be more acceptable. The hydrocooled tomato sample was found to have significantly higher microbial load (28.33×10^5 cfu g⁻¹) than both evaporated and sundried samples (10.00×10^5 and 10.33×10^5 cfu g⁻¹, respectively) on the 21st day of storage and had completely spoiled by the 28th day. One therefore recommends the use of hydrocooling and evaporation as effective means of extending the shelf life of tomatoes.

Key words: Tomato, hydrocooling, evaporation, sundrying, shelflife, ascorbic acid, pH, moisture content, total solid, microbial load

INTRODUCTION

Post harvest losses in fruits and vegetables especially tomatoes are higher in developing countries like Nigeria where adequate machinery for processing and preservation are not available. Agboola^[1] reported that Nigeria loses about 60% fruits and 40% of vegetables annually. Tomatoes (*Lycopersicon esculentum*) like most fruits and vegetables are classified as perishables because of its tendency to rapidly deteriorate soon after harvesting^[2]. Tomatoes are susceptible to tremendous chemical changes when separated from its parent plant until spoilage finally sets in as a result of attack from bacteria, yeast, mould and viruses^[3].

Arthey and Dennis^[4] in their study, vegetable processing, highlighted the fact that tomatoes commences quality deterioration immediately after harvest. So it is either that the tomato is placed in conditions which will considerably slow the rate of deterioration or processed as soon as possible in order to arrest spoilage. Some of the factors that are responsible for these post harvest

losses are temperature, moisture content of the produce, humidity, biological properties of the produce, insect infestation, rodent attack, micro organisms, socio-economic problems like finance, storage conditions and engineering (structural and mechanical). The consequences of all these are compositional changes, nutritional losses and contamination of the farm produce with dangerous substances like mould, fungi, pest. These losses are evidenced by changes in colour, texture, taste and presence of impurities.

Lack of adequate preservation methods have been the bane of Nigerian agriculture for a long time. Modern methods of preservation such as canning, chemical preservation and refrigeration are expensive, inaccessible and too technical for majority of the people, especially the local farmers who actually produce the crop. A more amenable and feasible alternative becomes necessary, which can be simple, cheap and accessible to the local people. The thrust of this study therefore, is to evaluate the performance of some of these possible processing alternatives such as sundrying, evaporation technique and hydrocooling.

MATERIALS AND METHODS

The test tomato samples of tall variety (*Lycopersicon esculentum*) were purchased from the Umuahia main market as well as the storage materials (earthen ware pots, polyethylene and plastic containers). The research study was conducted at the central service laboratory, National Root Crop Research Institute, Umudike, Nigeria.

SAMPLE PREPARATION

Tomatoes paste: The raw tomatoes were first sorted out, trimmed and washed before blending into a paste using a kitchen blender. The paste was concentrated by straining through a muslin cloth (Muslim sterilized in hot water at 100°C for 15 min). The straining removed about 60% of the moisture. The tomato paste was further concentrated by boiling until most of the water evaporated. The paste was then put into a plastic container and the face covered with a thin layer of groundnut oil.

Dried tomato sample: The firm ripped tomatoes were sorted out, trimmed, washed and cut in halves before steam blanching. They were then sun dried for a week on flat trays. The dried tomato samples were packaged in a jute bag.

Hydrocooled tomato samples: Two different sizes of earthen ware pots (one large sized and one small sized) were employed in the hydrocooling experiment, the small sized pot was put inside the large sized one and the space between them was 15 cm which was filled with river bed sand. The sand was moistened by wetting. The inner pot was then covered with moistened jute sac. The water in the sand and the sac evaporates, drawing the heat of evaporation from the fruits and the inner pot thereby creating, a cooling environment for the fruits

Food analysis

Proximate composition: The protein content and moisture content of the tomato sample were evaluated according^[5].

Determination of vitamin C: Vitamin C content of the tomato sample was determined titrimetrically following extraction with trichloroacetic acid/EDTA solution^[6]. In this method 20 g of the sample was first homogenized and the homogenate filtered through whatman No. 42 filter paper (noting the volume of the homogenate). To 20 mL of the filtrate in a conical flask was added 10 mL of 10% potassium iodide and mixed. The mixture was titrated against 0.01 M CuSO₄ solution using 3 mL of 1% starch solution as indicator. The titration was carried out until black spec was observed on the solution. A blank titration

was also conducted. The vitamin C content was calculated using the relationship: 1 mL of 0.01 mL CuSO₄ = 0.88 mg of vitamin C.

$$\text{Thus vitamin C mg/100 g} = \frac{100}{W} \times 0.88 \times T - B$$

$$X = \frac{Vf}{va}$$

where:

W = Wt. of sample analyzed

T = Titre of the sample

B = Titre of the reagent blank

Vf = Total filtrate volume

Va = Volume of filtrate titrated

Titrateable acidity: This was done by the alkaline titration method of George and Murphy^[7]. A weighed portion of the distilled water and the homogenate was filtered in a filter paper containing activated charcoal. The clear extract was titrated against 0.1 N NaOH solution using 3 drops of phenolphthalein indicator. The titration was done to a faint pink end point along side a reagent blank and the total titrateable acidity calculated using the formula below %

$$\text{TTA} = T - B \times N \times \frac{100}{v}$$

Where:

T = Sample titre

B = Blank titre

N = Normality of the Titrant

Microbial analysis: The method of ICMSF^[8] was used with pour plate method. Nutrient agar was first prepared as follows: 15 g nutrient agar was measured out and made up to 100 mL with water. The mixture was boiled until it dissolved. The mixture was then autoclaved at 121°C (15 psi) for 15 min. This was allowed to cool before pouring into a Petri dish to get set. It was left overnight before inoculating with the sample solution (Tomato). One gram of each sample (Sun dried, evaporated or hydrocooled tomato sample) was dispersed into 9 mL of sterile distilled water and mixed thoroughly. The resulting mixture was diluted serially to the 5th diluent. Into each petri dish, 0.1 mL of a diluent sample was spread under aseptic condition. The three petri dishes were then incubated at 37°C for 24 h. At the end of incubation, the number of colonies of bacteria were counted and multiplied by the dilution factor and recorded as colony forming unit per millilitre (Cfu g⁻¹).

Sensory evaluation: The sensory performance of the tomato samples were evaluated using a 7 point hedonic scale and 20 man panel of judges were used to assess the appearance, taste, colour, aroma and general acceptability of the samples. In the scale, 7 represents like extremely whereas 1 represents dislike extremely. The data generated were analyzed by analysis of variance (ANOVA) and the means separated by Least Significant Difference (LSD) according to Caul^[9].

RESULTS AND DISCUSSION

The results of the changes in moisture content of the tomato samples for a period of 28 days are shown in Table 1. It will be noted from this table that both the control sample and hydrocooled sample had significantly higher moisture content of 93.15% as at the first day of storage whereas the evaporated tomato paste and sun dried samples had lower moisture contents of 30.24 and 15.84%, respectively. As the storage period extended, it could be observed that even though the control sample retained its freshness with minimal changes in moisture content, it could not remain stable beyond the 14th day. Also the hydrocooled sample retained its freshness with little changes in moisture content, however, it spoilt by the 28th day. Sundried sample on the other hand, even though completely lost its freshness remained shelf-stable through out the storage time. The evaporated paste also maintained some degree of stability having 36.42% moisture by the end of the 28th day. The significantly higher moisture contents of the control and hydrocooled samples make them more vulnerable to microbial attack and spoilage^[10], resulting to their complete destruction by the 21st and 28th day, respectively. The sundried and evaporated samples with significantly ($p < 0.05$) lower moisture contents were found to be more shelf-stable.

The impact of the different processing methods on the retention of ascorbic acid of the tomato samples are shown in Table 2. At the beginning of the storage period, it will be observed that the control sample and the hydrocooled sample which were relatively fresh had significantly ($p < 0.05$) higher vitamin C content, 22.37 and 22.73 mg, respectively. On the other hand the evaporated and sun dried samples had significantly lower ascorbic acid as a result of the impact of heat which tend to destroy vitamin C^[11-13] as well as certain level of microbial activities especially for the sundried samples.

As storage progressed, the destruction of ascorbic acid in the control sample became rapid, as a result of microbial activities and fermentation, leaving only 8.07 mg by the 7th day and 4.03 mg by the 14th day. The hydrocooled sample was much more stable in retaining

Table 1: Changes in the moisture content of the tomato samples

Sample	0	7	14	21	28
Control	93.15 ^a	93.88 ^a	94.95 ^a	-	-
Evaporated	30.24 ^b	36.36 ^b	36.28 ^c	36.28 ^b	36.46 ^b
Sundried	15.84 ^c	15.96 ^c	15.96 ^d	16.04 ^c	16.38 ^c
Hydrocooled	93.15 ^a	93.38 ^a	93.72 ^b	93.92 ^a	-

^{abc}.. Mean values in the same row with different superscripts are significantly different ($p < 0.05$)

Table 2: Ascorbic acid content of the tomato samples

Sample	0	7	14	21	28
Control	22.37 ^a	8.07 ^d	4.03 ^d	-	-
Evaporated	10.08 ^b	9.53 ^b	8.80 ^b	6.97 ^b	6.60 ^b
Sundried	8.13 ^b	6.97 ^c	6.60 ^c	5.17 ^c	4.77 ^b
Hydrocooled	22.73 ^a	22.37 ^a	20.17 ^a	14.67 ^a	-

^{abc}.. Mean values in the same row with different superscripts are significantly different ($p < 0.05$)

Table 3: Changes in titratable acidity of the tomato samples

Sample	0	7	14	21	28
Control	0.18 ^a	0.23 ^a	0.30 ^a	-	-
Evaporated	0.17 ^a	0.18 ^a	0.23 ^{ab}	0.27 ^a	0.26 ^a
Sundried	0.17 ^a	0.20 ^a	0.18 ^b	0.23 ^a	0.23 ^a
Hydrocooled	0.18 ^a	0.18 ^a	0.27 ^{ab}	0.07 ^a	-

^{abc}.. Mean values in the same row with different superscripts are significantly different ($p < 0.05$)

Table 4: Total solid of the tomato samples

Sample	0	7	14	21	28
Control	6.85 ^c	6.12 ^c	5.76 ^c	-	-
Evaporated	29.75 ^b	63.64 ^b	63.72 ^b	63.73 ^a	63.58 ^b
Sundried	84.16 ^c	84.04 ^a	84.04 ^a	83.96 ^a	83.62 ^a
Hydrocooled	6.85 ^c	6.85 ^c	6.28 ^c	6.18 ^b	-

^{abc}.. Mean values in the same row with different superscripts are significantly different ($p < 0.05$)

Table 5: Protein content of the tomato samples

Sample	0	7	14	21	28
Control	1.17 ^c	1.46 ^c	1.23 ^c	-	-
Evaporated	2.89 ^b	2.98 ^b	3.27 ^b	3.27 ^b	3.33 ^a
Sundried	6.13 ^a	6.09 ^d	6.30 ^a	6.36 ^a	6.48 ^a
Hydrocooled	1.17 ^c	1.05 ^d	1.29 ^c	1.29 ^d	-

^{abc}.. Mean values in the same row with different superscripts are significantly different ($p < 0.05$)

ascorbic acid than any other method, maintaining as high as 20.17 mg by the 14th day and 14.67 mg by the 21st day. Even though the sundried and evaporated samples had high initial ascorbic acid loses, the subsequent rate of reduction was minimal, each having 4.77 and 6.60 mg by the 28th day, respectively.

It can be noted from the result of the titratable acidity (Table 3) that the highest titratable acidity was given by the control, 0.3% by the 14th day, followed by the hydrocooled sample, 0.27%. The least titratable acidity was observed in the sample dried in the sun, 0.18%, followed by the evaporated sample, 0.23% by the 14th day of storage. The increase in titratable acidity of the control sample and that of hydrocooled sample could be attributed to increased microbial activity as well as fermentation which tend to generate acidic by-products.

Table 6: Sensory evaluation of the tomato samples

Sample	Colour	Taste	Aroma	Appearance	Acceptance
Evaporated	6.55±0.21 ^a	6.25±0.17 ^a	6.00±0.23 ^a	6.20±0.23 ^a	5.75± 0.50 ^a
Sundried	3.95±0.20 ^b	3.95±0.29 ^c	4.25±0.36 ^b	3.85±0.31 ^b	4.00±0.44 ^b
Hydrocooled	5.85±0.34 ^a	5.20±0.25 ^b	5.15±0.33 ^a	5.60±0.37 ^a	5.30±0.47 ^{ab}

^{abc}... Mean values in the same row with different superscripts are significantly different (p<0.05)

Ogunsanya and Akinwomi^[14] reported that the increase in titratable acidity of tomato paste is more likely to be as a result of acids produced by *Bacillus coagulans*, *Clostridium butyricum* and as a result of phenolic compounds produced by *Bacillus coagulans*. Gould^[15] suggested that the increased acidity in the dried samples could be due to the oxidation of alcohol and aldehyde during processing.

Lisiewska and Kmiecik^[16] in a similar work noted a significant increase in total acidity on frozen tomatoes stored for 12 months at -20 to -30°C.

The results of total solids of the tomato samples processed and stored for a month are shown in Table 4. As will be expected, the control and hydrocooled samples generally maintained low total solids when compared with the evaporated and sun dried tomato samples. It is because in both evaporated and sundried samples, reasonable proportion of their water content had been removed thereby increasing their solid component. The higher content of total solid further conveyed some degree of stability to these products explaining why they were storing better than the other two samples.

Similarly the protein contents of the evaporated and sundried tomato samples were found to be significantly higher than those of the control and hydrocooled samples as a result of high reduction in their moisture content. The consistent increase in the protein content of all the samples as storage time increases could be as a result of traces of fermentation which usually increases protein content of foods^[11].

The sensory performance of the stored tomato samples are given in Table 5. As can be noted from this table, the hydrocooled tomato sample was found to score better in all sensory parameters followed by the evaporated tomato samples. The least performance was noted to be the sundried tomato samples. Closely looking at both the hydrocooled and the evaporated samples, it could be discovered that there were no significant differences in terms of colour, aroma, appearance and general acceptability and were in each case significantly better than the sundried tomato samples. The inferior sensory scores of the sundried tomato samples could be attributed to adverse effect of open weather condition under which the drying process was carried out which permits dust and other particles to contaminate the sample^[17].

Table 7: Total microbial load of the tomato samples (×10⁵ cfu g⁻¹)

Sample	0	7	14	21	28
Control	4.67 ^c	24.00 ^a	28.67 ^a	-	-
Evaporated	nd	4.00 ^d	5.00 ^c	10.00 ^b	4.00 ^b
Sundried	7.33 ^a	8.33 ^c	1.033 ^d	10.33 ^b	8.70 ^a
Hydrocooled	5.33 ^b	9.33 ^b	9.67 ^b	28.33 ^a	-

^{abc}... Mean values in the same row with different superscripts are significantly different (p<0.05)

It can be noted from Table 7 that both the control and hydrocooled samples had significantly higher microbial load (more unstable) than either evaporated or sundried tomato samples. By the 14th day the control sample had as high as 28.67×10⁵ cfu g⁻¹ while the hydrocooled sample had 9.67×10⁵ cfu g⁻¹. The evaporated and sundried samples had barely 5.00×10⁵ cfu g⁻¹ and 1.03×10⁵ cfu g⁻¹. The more stability of both the evaporated and sundried samples could be attributed to the impact of heat involved in their processing and reduced water activity. The evaporation process and sundrying may have killed some of the microorganisms and the reduced water activity may have also eliminated some microorganisms that may not survive under lower water activity level. As can also be noted, the control sample completely spoiled by the 21st day of storage while the hydrocooled sample spoiled by the 28th day.

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