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Effect of Pre-treatment Methods on The Quality Attributes of Tomato Powder

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Abstract

Pretreatment of tomatoes into powder reduces spoilage and postharvest loses; however, maintaining the nutritional quality of the powder poses a challenge. Thus, a quantitative approach was employed to measure the effect of some pretreatment methods of making tomato powder, where fresh tomatoes were blanched and exposed to different pre-drying treatments (untreated, treatment with 2% NaCl, 2% CaCl and 0.25% $Na_2S_2O_2$). These samples were then oven dried at 60°C for 8 h before blending to the various powders. The proximate parameters (ash, fibre, protein, CHO, fats, moisture), physic chemical, antioxidants, colour and microbial parameter of the powder samples were then determined over a duration of 3 months. Results of the study showed that oven drying and chemical pretreatment significantly increased the nutrient component of the tomato powder and decreased cfu/g of bacteria, which could enhance the shelf life of the product. The antioxidants properties such as lycopene, B carotene, Vitamin C, and colour were significantly retained with chemical pretreatment. All pretreated samples retained more nutrients and reduced microbial load of tomato powder. That of $\mathbf{Na_2S_2O_5}$ retained more nutrients while $CaCl_2$ retained more antioxidant properties. The NaCl treated powdered samples retained more ash and total fiber. Similar observations were made for antioxidants properties. L*a*b values of colour were higher at month 0 and lowest at month 3, this implies that at month 3, traces of undesired colour change began and as such, storage beyond this time may be unhealthy. Also, at month 0, $\mathbf{Na_2S_2O_5}$ retained higher values of colour (L*a*b) whereas $\boldsymbol{CaCl_2}$ retained more at month 3. There was a gradual increase in the bacteria and fungi load as the storage period increased. The pre-drying treatments adopted showed potentials to enhance the quality and shelf life of tomato powder although may not be encouraged beyond 3 months of storage.

Keywords: Tomato, chemical pretreatment, oven drying, powder, proximate, antioxidants, shelf life.

Introduction

Tomato (Lycopersicon esculentum Mill) belongs to the family "Solanaceae" and it is a vital agricultural commodity worldwide. Tomato is the first in industrialized volume and in terms of area, it is the second horticultural product cultivated, Camargo and Mazzei, (1996). Tomato is a climacteric fruit, having a short shelf life under ambient storage conditions. It is difficult market fresh tomato for a prolong time because of its short post-harvest life, which leads to high post-harvest losses (Jayathunge *et al.*, 2012). Short postharvest life and inadequate processing facilities result in heavy revenue loss. Therefore, it is advantageous to develop a preservation method for tomatoes. Drying is the most suitable method to fulfill the above requirements. Dried tomato products are used as important ingredients for popular foods like pizza, sauce for many purposes, local soups. There has been increasing interest in the antioxidant activity of lycopene as the most abundant carotenoid in tomatoes. The presence of lycopene has promoted research activities on fresh tomatoes and tomato products (Zanoni *et al.*, 1999). Drying of food materials helps to extend shelf life, decrease of product volume significantly, increase of product diversity, increase of food process applications and improve the product quality. However, drying can accelerate some reactions that can adversely affect the product quality. Some of these effects are shrinkage during drying, decreasing of porosity, damage on the natural tissue of product, loss of nutritional value and changes in physical properties such as texture and colour (Atares *et al.*, 2009). Handling from harvest to retail is a major influencer of post-harvest losses in horticultural fruit crops. Losses are caused by mechanical injuries, inadequate storage, unsuitable handling and transport and on display time in the retail market (Ferreira *et al.*, 2005). The major step towards achieving a greater level of food increase and security therefore is to prevent food losses between harvest and consumption.

Processing of tomatoes using sun drying of sliced, drying of whole tomatoes, spray drying and convection drying using solar or mechanical systems has been used for many years (Baloch *et al.*, 2006). Traditional sun drying is a slow process compared with other drying methods and quality losses may result from high moisture content, color degradation by browning and microbial growth (Lewicki, *et al.*, 2002). Consumer demands have increased for processed products that keep more of their sensory properties and their nutritional value, so that it has become necessary to optimize drying conditions in order to achieve certain characteristics related to colour, texture, water content, etc. (Heredia *et al.*, 2002). Tomatoes can be processed into different forms and preserved for longer periods. However, these products require high-cost technology for development of good quality products. The development of low cost and community adaptable preservation methods which include the use of some chemicals to pretreat these food material show prospects to farmers and consumers (Shi 2000). The use of common or table salt (NaCl) as a pretreatment of foods for storage is common. The use of similar chemicals to common salt for this purpose is thus researchable concern for more options available. This research was aimed at studying the effects of pre-treatments using $Na_2S_2O_2$, $CaCl_2$, NaCl for drying tomato into powder and comparing them with quality attributes of oven drying non pre-treated tomato powdered samples.

Materials and Methods

All materials that were employed in this work were standard laboratory equipment and the reagents as mentioned in the methods were analar grade reagents which were acquired commercially. All other non-standard laboratory materials used were also stated. Standard laboratory procedures were employed in the preparation of solutions used, stated in the methods further on.

Preparation of Samples

Fresh and ripe tomato fruits were harvested from a farm in Makurdi, Benue state, Nigeria. These fruits were sorted and washed and dried. They were then subjected to hot steam blanching for 5-10 min, cooled, and sliced into smaller pieces (1 cm in length) using sharp sterilized stainless steel knives.

Pre-drying treatments of tomato slices
The tomato slices were divided into three (3) with each treated by dipping in 2% $CaCl_2$ for 5 min, 0.25% $Na_2S_2O_5$ for 5 min, 7g/100g NaCl at 80 °C for 5 min respectively in an equal mass of solution. A fourth slice underwent no treatment (control) (Aderibigbe et al,. 2018).

Dehydration/drying of Tomato Slices
The tomato slices were spread on perforated stainless-steel trays (50 x 34 x 5 cm) and oven dried at 60 °C for 8 h (Aderibigbe et al,. 2018).

Preparation of tomato powder
The dried tomato slices were collected and milled using a clean household electric grinder and stored in sealed high-Density polyethylene (HDPE) prior to further analysis.

Physicochemical Analyses
pH
The pH of the tomato samples was determined using a pH meter (Eijkelkamp). The pH meter was standardized in buffers 4 and 7 solution at 25 °C as described by Gaithersburg *et al*., (2005).

Titratable acidity
These samples were titrated with 0.1 M NaOH using phenolphthalein indicator. The estimate titratable acidity was calculated as percentage of citric acid monohydrate (g 100 g-1) using the formula stated in (1) (Gaithersburg *et al*., 2005).

$$\text{Titratable acidity (\%acid)} = \frac{[ml\ NaOH\ used] \times [0.1\ NaOH] \times [\ milliequivalent\ factor]}{gram\ of\ sample} \times 100 \ldots.(1)$$

Colour
Colour measurements (L*, a*, b*) were made using a hand-held color meter (FRU WR-10 Shenzhen wave optoelectronics technology). This colour assessment system is based on the Hunter L*, a*- and b* coordinates. L* represented lightness and darkness, + a* redness, -a* greenness, + b* yellowness and - b* blueness, (Gaithersburg *et al*., 2005).

Vitamin A and Lycopene determination
The concentrations of vitamin A and lycopene in the respective samples was determined by the method of *Aderibigbe et al., (2018)* and Adebisi *et al*, (2014) employing a UV-Vis spectrophotometer. Calculations were carried out using (2) and (3)

$$\text{Vitamin A } \left(\frac{\mu g}{100g}\right) = \frac{(\text{Absorbance of sample} \times \text{Dilution Factor})}{(\text{Weight of sample (g)})} \ldots (2)$$

$$\text{Lycopene (mg/100)} = \frac{(\text{Absorbance of sample} \times \text{Gradient factor} \times \text{Dilution Factor})}{(\text{Weight of sample (g)})} \ldots (3)$$

Vitamin C
This was determined using the 2, 6-Dichloroindophenol Titrimetric method and the results reported as mg/100 g of tomato fruit, (AOAC, 1995).

Determination of total carotenes
About 0.2 -0.3 g of chopped and homogenous samples were extracted with cold acetone which was later partitioned with petroleum ether. The ether phase was passed through Neutral Alumina (activity III) packed column. The column was eluted with petroleum ether and the band was collected into a 25 mL volumetric ûask. The extract was read at 450 mm and total carotenoid content calculated are as follows;

$$C\ (\mu g/g) = A \times \text{Volume (ml)} \times 104A1\% \times 1cm \times \text{sample weight (g)} \ldots. (4)$$

Where A = Absorbance, A1 % = absorption coefficient of –carotene in PE (2592) Rodriguez-Amaya and Kimura (2004)

Determination of Phenolic Acid
Phenolic acid was determined using the method described by Krishnaiah *et al*., 2017.

Proximate Analysis
Moisture content
A known weight of the sample was dried to constant at 105 °C. The percentage moisture content was then calculated as follows (Onwuka, 2005).

$$\% \text{ moisture} = \frac{(W2-W3)}{(W2-W1)} \times 100 \quad (5)$$

Where, W_1 initial weight of empty porcelain crucible, W_2 weight of porcelain crucible + sample before drying, W_3 final weight of dish + sample after drying.

Ash content

This was carried out as described by (Onwuka 2005) where the sample was weighed into previously a weighed W_1 porcelain crucible and reweighed (W_2). The crucibles containing the samples was transferred into a furnace at 550 °C for 4 h. They were then removed and allowed to cool in the desiccators then finally weighed (W_3). The % ash content was calculated as follows;

$$\% \text{ Ash (dry basis)} = \frac{(W3-W1)}{(W2-W1)} \times 100\% \ldots.(6)$$

Nitrogen and crude protein determination by Kjeldahl method

This method by AOAC, 1995 was adopted for this determination. Percentage Nitrogen was calculated using the formula;

$$\% N = \frac{(T \times N \times D \times 14)}{(W \times 1000)} \times 100 \quad (7)$$

Where T: Titre value, N: Normality, D: Dilution factor, 14 Molar mass of Nitrogen, W: Weight of sample, 1000 Conversion from g to mg

$$\% \text{ Crude Protein} = \% N \times 6.25 \quad (8)$$

6.25 = Conversion factor

Crude fat

Crude fat was determined using the procedure described by Gaithersburg, (2005)

Crude fiber content

Crude fibre content was determined using the procedure described by Gaithersburg, (2005)

Carbohydrate

Carbohydrate as nitrogen free extract (NFE) was calculated by difference as:

NFE = 100 − (crude protein + crude fibre + moisture + ash + crude fat)[13, 20].

Microbial Analysis

Total bacterial, yeast and fungi count was determined using the pour plate method (Adegoke 2000). The sample (1g) is transferred to each test tube containing 10 mL of distilled water. Serial dilutions were made by transferring 1 mL of the first dilution into another test tube containing 9 mL of distilled water. This was repeated up to six times (10^{-6}). From each dilution, 1 mL was transferred to the Petri dish in duplicate. About 15 mL of the molten nutrient agar at 45 °C was poured in each of the Petri dishes. The plates were allowed to set, then inverted and incubated at 30±2 °C. For yeast and fungi growth, potato dextrose agar with 10% tartaric acid was used. For bacteria and coliform, the plate was incubated for 24 h while the fungi plates were incubated for 48 h. The microbial load was calculated as number of colonies multiplied by dilution factor and was reported as colony forming unit per gram (cfu/g).

Statistical Analyses

The result of the analysis carried out was expressed as mean ± standard deviation and SPSS Statistical Package version 22.0 was used to analyze the variances using one-way analysis variance (ANOVA) with Duncan Multiple range test at p d" 0.05

Results and Discussion

Table 1 presents the result of the proximate analysis of samples of pre-treated tomato powders oven dried for 0 – 3 months and the control while table 2 presents the results of the physic chemical properties of the pre-treated tomato powders oven dried for 0 – 3 months and the control

Table 1: Proximate analysis of Tomato Powder during Three (3) months of Storage

	SAMPLE	MONTH 0	MONTH 1	MONTH 2	MONTH 3
MOISTURE	A	8.575±0.176^{a}	8.875±0.063^{a}	9.450±0.155^{ab}	10.3250±0.176^{a}
	B	8.625±0.134^{a}	8.945±0.049^{a}	9.465±0.134^{ab}	10.3600±0.509^{a}
	C	8.560±0.084^{a}	8.525±0.247^{a}	9.125±0.176^{a}	10.4900±0.098^{a}
	D	8.195±0.049^{b}	9.150±0.494^{a}	9.680±0.056^{b}	10.6600±0.070^{a}
	ANOVA	0.070	0.298	0.067	0.646
PROTEIN	A	24.090±0.169^{c}	18.740±0.127^{ab}	15.020±0.424^{b}	10.910±0.523^{a}
	B	24.930±0.091^{c}	20.830±0.438^{c}	16.960±0.049^{c}	10.805±0.417^{a}
	C	21.960±0.374^{b}	19.820±0.395^{bc}	13.540±0.417^{a}	9.270±0.212^{b}
	D	20.530±0.452^{a}	17.170±1.180^{a}	13.130±0.834^{a}	8.850±0.353^{b}
	ANOVA	0.001	0.021	0.006	0.013
FAT	A	1.825±0.035^{d}	1.270±0.014^{a}	0.875±0.035^{a}	0.565±0.021^{b}
	B	1.715±0.021^{c}	1.255±0.077^{a}	0.835±0.021^{a}	0.710±0.014^{c}
	C	1.570±0.028^{b}	1.125±0.035^{a}	0.715±0.007^{b}	0.515±0.007^{a}
	D	1.065±0.021^{a}	1.245±0.205^{a}	0.725±0.035^{b}	0.725±0.021^{c}
	ANOVA	0.001	0.592	0.010	0.001
ASH	A	46.945±0.091^{a}	49.075±0.374^{a}	54.480±1.301^{a}	57.010±1.781^{ab}
	B	47.275±0.190^{a}	51.175±1.166^{ab}	54.250±2.757^{a}	58.330±1.385^{ab}
	C	48.205±0.544^{a}	52.320±1.527^{b}	57.550±0.707^{a}	60.605±0.558^{b}
	D	47.295±0.855^{a}	49.725±1.096^{ab}	54.200±0.070^{a}	56.175±1.605^{a}
	ANOVA	0.233	0.125	0.237	0.117
CRUDE FIBRE	A	0.240±0.056^{a}	2.025±0.728^{a}	4.950±0.240^{b}	7.4950±0.134^{a}
	B	0.240±0.042^{a}	2.175±0.247^{a}	4.850±0.212^{ab}	7.7400±0.367^{a}
	C	0.310±0.056^{a}	2.410±0.000^{a}	4.590±0.127^{ab}	8.0750±0.954^{a}
	D	0.235±0.035^{a}	2.595±0.572^{a}	4.225±0.304^{a}	7.1400±0.197^{a}
	ANOVA	0.449	0.674	0.108	0.437
CHO	A	18.295±0.388^{a}	18.170±1.004^{ab}	15.225±0.445^{a}	14.0600±2.064^{ab}
	B	21.710±0.410^{b}	15.340±0.933^{a}	19.300±0.014^{b}	23.1300±0.707^{c}
	C	23.130±0.707^{b}	21.535±1.548^{b}	18.155±0.318^{b}	16.4200±1.315^{b}
	D	19.800±0.721^{a}	15.775±1.704^{a}	14.235±1.053^{a}	12.4400±0.777^{a}
	ANOVA	0.004	0.030	0.003	0.005

Values are Mean ± Standard deviation of three determinationsValues with same superscript are not statistically significant (Duncan Multiple range test) at p d" 0.05

Sample A – samples treated with $CaCl_2$
Sample B – samples treated with $Na_2S_2O_5$
Sample C – samples treated with NaCl
Sample D – Untreated sample

Moisture

The moisture content of tomato powder under different pre-treatments ranged between 8.2 - 10.67% after three months of storage. Following the trend with no significant difference at (<0.05) across the months, Sample A (treated with $CaCl_2$) had least moisture retention; followed by sample B then sample C whereas D (untreated) had more moisture retention at month 3. The high moisture content in fresh tomato slices predisposes it to microbial attack and eventual spoilage. Oven drying was effective in reducing the moisture content of tomato powders significantly ($p<0.05$) to 10% at month 3 of storage. The increased nutrient in tomato powder compared to fresh tomato suggests that drying does not only extend the shelf life of tomatoes but also concentrate

the nutrient contents (*Aderibigbe et al., (2018)*. In this study tomato powder exposed to pre-treatment methods, reduced the moisture and also retained the nutrients compared to the tomato powder not exposed to treatment.

Protein

The Analysis of variance the protein content were significant at (P<0.05). The trend showed a general decrease in the protein content across the month with the control having the least value of protein 8.850±0.353 as compared to those pretreated with **$Na_2S_2O_5$**, **$CaCl_2$** and **NaCl** (protein =10.805±0.417, 10.910±0.523, 9.270±0.212 respectively) at the third month. This implies that while the control (untreated sample) had the propensity to lose more protein over the storage duration, the treated could retain within an acceptable range. The protein values of the samples at month 0 ranged from (20.530±0.452 - 24.090±169), does not agree with the studies on effects of pre drying chemical treatments on quality of cabinet dried tomato powder, which had protein values ranged from (12.6% - 13.9%) (*Mozumder et al*., 2012). However, a steady decrease across the month 2 and 3, ranged (15.020±0.424 - 8.850±0.353) may confirm a similar decrease (14.3% - 8.9%) in the studies on storage of tomato powder in different package material (Woodwall *et al*., 1997). Changes in protein content might be related to reactions. i.e., non-enzymatic browning which was found to be more in the untreated sample and less in $Na_2S_2O_5$ and $CaCl_2$ treatment (*Narsing, et al., 2006)*. This could be an indication that the presence of the chemicals employed for the pretreatment inhibited the depletion of the nutrients.

Fats

Fats content for the pretreated tomato powder samples were observed to follow a similar trend as those of the protein where at month 0 was in the order **$CaCl_2$ > $Na_2S_2O_5$ > NaCl > untreated sample** (1.825> 1.715> 1.715> 1.065 respectively), there was a decrease in the trend as the month progressed, except for the noticeable deviation of the untreated sample at month 3 (0.725) was higher than that of pretreated samples A, B, and C. The fat content at month 0 ranged from 1.06 -1.8%, with a significance diûerence at (p<0.05) partially agrees with (1.7- 2.0%) in a previous research (*Olaniyi et al., 2017)*.

Ash

The Ash content of the pretreated tomato powder increased with incresing storage duration. For instance, for Sample A, the ash content ranged 46.945 - 57.010 between months 0 – 3 respectively. This was the same trend for all the other samples, including the untreated one. This trend was a reverse of the previously studied nutrients of protein and fats, where both the treated and the untreated samples had lowest values at month 3. This trend should ordinarily be expected as drying will normally do away with organics and expose more of the inorganics. Consistent with increase in ash content of tomato powder, other researchers have reported similar observations (Sarker *et al.,* 2014). However, Narsing *et al,* (2008) have strangely reported a reverse trend.

Crude fibre

The crude fibre trend was as well observed to be similar with that of the ash content where there were increases in the crude fibre content of the samples from month 0 - 3. For instance, for samples A and B, the values for crude fibre were 0.240 - 7.4950 and 0.240 - 7.7400 respectively. This also showed no significant different at (P > 0.05) for all the samples across the months. Fibre content would naturally increase with increased treatment of samples, most especially with temperature as fibre would resist the action of temperature more that proteins and fats. Similar to ash which are inorganics that withstand more temperature than the other parameters that are organics. The increase in fibre can reduce circulating cholesterol and increase glucose tolerant level. Fibre is useful for maintaining bulk, motility and increasing intestinal tract. It is also necessary for healthy condition, curing of nutritional

disorders and food digestion (Uwaegbute 1989).

Carbohydrate

Generally, the treated samples had higher carbohydrate content in them over the study duration than the untreated one. Carbohydrate content was highest in the tomatoes pretreated with **NaCl** and lowest in the untreated tomato powder (CHO = 23.130 and 16.420) (CHO = 19.800 and 12.440) between month 0 and 3, respectively. Though the trend showed an unsteady decrease in the CHO content across the months with a significance difference at ($p<0.05$). Also, a spike in the CHO content of the $Na_2S_2O_5$ treated sample at month 3 which was not consistent could not be explained as it beats all scientific imaginations. The CHO content is expected to be reduced at higher level of treatments with time but this was not the case in this particular result.

Our overall observation showed that, at month 3 the Tomato powder that was not exposed to any pre-drying treatment had lower nutrients (protein=8.850, CHO=12.4400 ash=56.175 and fiber=7.14 than those exposed to pretreatment except for fat content, which was highest in untreated (fat=0.725) and lowest in the one pretreated with NaCl (fat=0.515). Vegetables in their fresh state have been noted to be poor sources of carbohydrate, but the carbohydrate content increases after drying of vegetables (Kolawole *et al* 2011). Low carbohydrate content of fresh vegetables show that they supply little or no energy when consumed except when supplanted with other foods (Rossello *et al.,* 2000).

Table 2: Physiochemical and antioxidant properties of Tomato

	SAMPLE	Month 0	Month 1	Month 2	Month 3
pH	A	3.905±0.007^{ab}	4.080±0.113^{a}	4.220±0.028^{a}	4.5100±0.014^{a}
	B	4.050±0.070^{b}	4.180±0.113^{a}	4.215±0.007^{a}	4.3850±0.106^{a}
	C	3.875±0.091^{a}	4.215±0.007^{a}	4.305±0.007^{b}	4.5050±0.007^{a}
	D	4.235±0.007^{c}	4.485±0.035^{b}	4.515±0.021^{c}	4.7250±0.035^{b}
	ANOVA	0.011	0.030	0.001	0.017
TTA	A	8.056±0.071^{b}	7.215±0.262^{c}	7.810±0.084^{c}	7.0950±0.091^{c}
	B	7.980±0.028^{b}	7.000±0.014^{bc}	7.325±0.134^{b}	6.2400±0.084^{b}
	C	7.911±0.014^{ab}	6.710±0.098^{b}	7.060±0.098^{b}	6.0450±0.063^{ab}
	D	7.750±0.141^{a}	5.970±0.056^{a}	6.160±0.212^{a}	5.9200±0.098^{a}
	ANOVA	0.072	0.004	0.001	0.001
Vitamin C	A	63.500±0.028^{c}	54.425±0.586^{b}	50.190±0.127^{b}	46.030±0.395^{c}
	B	62.700±0.636^{c}	53.030±1.117^{b}	49.415±0.091^{b}	41.505±0.629^{b}
	C	55.500±0.636^{b}	48.490±0.636^{a}	44.275±0.883^{a}	39.450±0.622^{a}
	D	51.450±0.763^{a}	47.440±0.579^{a}	44.525±0.021^{a}	38.685±0.247^{a}
	ANOVA	0.001	0.002	0.001	0.001
Lycopene	A	7.940±0.056^{c}	7.410±0.014^{c}	7.050±0.000^{c}	6.915±0.007^{a}
	B	6.015±0.007^{b}	5.865±0.077^{b}	5.790±0.070^{b}	5.420±0.140^{a}
	C	5.290±0.000^{a}	5.025±0.106^{a}	4.910±0.070^{a}	4.400±0.113^{a}
	D	5.375±0.077^{a}	5.165±0.021^{a}	5.065±0.063^{a}	4.820±0.098^{a}
	ANOVA	0.001	0.001	0.001	0.479
B Carotene	A	4.600±0.014^{b}	4.520±0.014^{b}	4.525±0.007^{b}	4.0500±0.070^{b}
	B	5.395±0.007^{c}	5.065±0.091^{c}	4.540±0.622^{b}	4.7750±0.077^{c}
	C	4.560±0.070^{b}	4.475±0.035^{b}	4.325±0.035^{b}	4.1300±0.042^{b}
	D	3.140±0.042^{a}	3.020±0.028^{a}	2.750±0.000^{a}	2.5400±0.000^{a}
	ANOVA	0.001	0.001	0.012	0.001
Phenol	A	2019.26±0.00^{c}	2002.48±0.00^{c}	1986.51±0.01^{b}	1966.91±0.01^{c}
	B	2150.11±0.00^{d}	2090.53±0.04^{d}	2048.55±0.07^{b}	2012.45±0.04^{d}
	C	1894.12±0.00^{b}	1872.02±0.00^{b}	1858.91±0.01^{a}	1842.34±0.00^{b}
	D	1825.06±0.34^{a}	1832.44±2.89^{a}	1843.62±0.50^{a}	1788.53±0.00^{a}
	ANOVA	0.001	0.001	0.003	0.001

Values are Mean ± Standard deviation of three determinations

Values with same superscript are not statistically significant (Duncan Multiple range test) at p dH 0.05

Sample A – samples treated with $CaCl_2$
Sample B – samples treated with $Na_2S_2O_5$
Sample C – samples treated with NaCl
Sample D – Untreated sample

Physico-chemical properties and Antioxidant properties of tomato powder.

pH

pH and titratable acidity are interrelated in terms of acidity, but have different impacts on food quality. While titratable acidity influences more on the ûavour and taste quality of products pH gives a measure of the strength of the acid in food. (Underhil, 1989). Lower pH confers more protection against microbial growth; Increase in titratable acidity may be due to concentration of organic acids in tomato during drying (Sadler and Murphy, 2010). The pH value of the tomato powder ranged (3.875 - 4.725). This trend shows an increase in pH as the months progressed, with the control retaining higher value of pH for month 0 (4.235) and month 3 (4.7250±0.035) of storage, while those treated with $\mathbf{Na_2S_2O_5}$ had least pH values 4.385 at month 3 The samples A, B, C and D were significantly different at ($P<0.05$).

Titaratable Acidity

The trend however showed a decrease in acidity across the months of storage with a significant difference at ($p<0.05$). TA at initial month ranged (7.750 - 8.056g/100g) slightly higher than the range of (5.18-6.05g/100g) as established in the study of effects of pretreatment and dehydration method on quality characteristics of tomato powder and its storage stability (Reihaneh and Mehdi 2009). The values TA in the tomato powders decreased across the month with samples of $\mathbf{CaCl_2}$ (A) and $\mathbf{Na_2S_2O_5}$ (B) retaining a higher values (7.095 and 6.240 g/100g) respectively at month 3, and the control (sample D) having the least value (5.92g/100g) of acidity. This implies that organic acid concentrate more with tomato powder pretreated before drying (Sarker *et al.,* 2014).

Vitamin C

This showed a decrease across the months with significance change at ($p<0.05$). At month 3 the values were; (46.030, 41.505, 39.450 and 38.685) for $CaCl_2$, $\mathbf{Na_2S_2O_5}$, $NaCl_2$ and the control respectively. This was expected because of the sensitivity to oxidation of ascorbic acid over storage conditions and temperature also implying that Vitamin C content is affected by pretreatments. However, this result does not agree with the values in a study obtained for open sun dried tomatoes which ranged 17.04 - 5.60 mg/100g, solar dried ranged 23.73-13.37mg/100gand hybridphotovoltaic dried tomato that ranged 29.20 - 24.82 mg/100g (Tigist *et al.,* 2013).Vitamin C content of tomato is important because of its ant oxidative characteristics. Ascorbic acid is one of the most thermo labile components of food products (Tigist *et al.,* 2013).

Lycopene

Lycopene content of tomato powder under different pretreatment at month 0 were (7.940 mg/100g, 6.0150 mg/100g, and 5.290 mg/100g and 5.375 mg/100g for $\mathbf{CaCl_2}$, $\mathbf{Na_2S_2O_5}$, $\mathbf{NaCl_2}$ and control respectively). The trend showed a decrease in content of lycopene at significant difference ($p=0.001$,) for month 0, 1 and 2 of the storage time. The values at month 3 were (6.915, 5.450, 4.400 and 4.820) with no significant difference at ($p>0.05$). The $\mathbf{CaCl_2}$ pretreated sample retained higher content of lycopene as compared to the other pretreated tomato powder. Pretreatment methods provide a protective effect for lycopene pigments against heat damage during drying. Similar protective effect has been reported for lycopene in tunnel-dried tomato pretreated with potassium metabisulphite (93.0 mg/100g) and calcium chloride (91.0 mg/100g) (*Aderibigbe et al., 2018)*. Lycopene has been reported to be affected by blanching tomatoes prior to drying. (Ferrer *et al.,* 1989).The main role of bisulphite in dehydration of food products is to inactivate the enzymes that cause enzymatic browning in food products, this depletes lycopene content of a food. A Bisulphites reacts with the o-quinones

forming colourless complex compounds; additionally, bisulphites act as competitive inhibitors by binding a sulphydryl group at the active site of the enzyme; thus, the polyphenoloxidase is irreversibly inhibited (Piaocaro *et al.,* 1993). This phenomenon, which is known as non-enzymatic browning or Millard reaction produces dark pigments and destroys the natural colour of products (Ferrer *et al.,* 1989).

B-carotene

After a period of three months, the highest value of ²-carotene from a range (5.395-2.5400) was 4.77 mg/100g sample treated with $\mathbf{Na_2S_2O_5}$ and the lowest was the control 2.54 mg/100g. This is similar to the values obtained for sun-dried tomatoes ranged from 4.12 - 3.72 mg/100 g, solar dried ranged from 4.94 - 4.25 mg/100g and hybrid dried ranged from 4.98 - 4.65 mg/100g in a previous study *Aderibigbe et al (2018)*. It is also reported that, ²-carotene content of dried sample depends on temperature, storage period and storage condition (Sarker *et al.,* 2014), confirming the observation in this present studies.

Total phenolic

The initial TPC in the four (4) tomato powder under study was significantly different (p = .001) and occurred in the range of (2019.26 ± 0.00 – 1825.06± 0.34 mg) pretreatments relative to the control. At variant with a range (672 ± 24.30 – 764.28 ± 18.94 mg) established in other literature (Mwende *et al.,* 2018). The higher minimization of phenolic degradation of pretreatment as compared to the control may be attributed to the ability of $\mathbf{Na_2S_2O_5}$ and $\mathbf{CaCl_2}$ to retard oxidative reactions and tissue damage that may cause irreversible changes in the quality of dried tomato.

Colour analysis of tomato powder during three months of storage

The results (Table 3) show that all color parameters (L*, a* and b*) changed significantly across the months, at ($p<0.05$) level of confidence. At month 0, B= $Na_2S_2O_5$ had the highest value of L (measure of degree of lightness to darkness) closely followed by sample A ($\mathbf{CaCl_2}$) and control, with sample C $\mathbf{(NaCl_2)}$ having the least value. The same trend was observed for the value of a (which measure the degree of redness to greenness) whereas a slight change was noticed for b value (which is measure of degree of yellowness to greenness). With B= $Na_2S_2O_5$ having a higher value, followed by sample D, Samples A and C, retaining the least value for b. The interactions between parameters (L*, a* and b*) for the four samples across the months also show an unsteady decrease. However, the (L*, a* and b*) values of tomato powder treated with $\mathbf{CaCl_2}$ was highest at the 3rd month compared to those treated with $\mathbf{Na_2S_2O_5}$, control and with $\mathbf{NaCl_2}$ respectively. *Undesirable changes in the colour may lead to decrease in quality and marketing value of dried tomato powder. Therefore, the surface colour of the dried tomato is an important criterion. Loss of redness colour was cause by degradation of lycopene. The darkening may be due to auto oxidation of carotenoids, the stability of the Carotenoids during storage depend on pre-treatments and packaging materials with the rate of deterioration increasing as the storage period increases (*Gonçalves *et al.,2010). Also, d*uring dehydration and subsequent storage, the typical red colour characteristic of tomato gradually changes to brick red and then to brown (visual appreciation).

Table 3: Colour analysis of Tomato Powder during three months of Storage

	SAMPLE	Month 0	Month 1	Month 2	Month 3
Colour L	A	61.280±0.000^{c}	64.080±0.000^{d}	62.250±0.707^{c}	60.840±0.000^{d}
	B	62.215±0.021^{d}	60.270±0.000^{b}	60.040±0.000^{b}	58.470±0.084^{c}
	C	59.590±0.014^{a}	59.820±0.070^{a}	58.910±0.014^{a}	56.850±0.000^{a}
	D	60.205±0.007^{b}	60.535±0.021^{c}	60.000±0.014^{b}	57.910±0.014^{b}
	ANOVA	0.001	0.001	0.003	0.001
Colour A	A	12.020±0.000^{b}	15.125±0.035^{d}	4.690±0.212^{a}	12.4750±0.035^{d}
	B	12.810±0.014^{c}	12.170±0.014^{c}	11.055±0.021^{d}	9.7300±0.000^{c}
	C	11.215±0.007^{a}	9.220±0.014^{a}	9.200±0.000^{b}	8.4500±0.155^{b}
	D	12.905±0.007^{d}	11.620±0.141^{b}	10.440±0.056^{c}	9.3950±0.007^{a}
	ANOVA	0.001	0.001	0.003	0.001
Colour B	A	8.310±0.000^{b}	9.410±0.014^{c}	8.350±0.014^{c}	9.240±0.056^{c}
	B	9.050±0.000^{d}	8.125±0.035^{b}	7.900±0.070^{b}	8.390±0.056^{b}
	C	8.185±0.007^{a}	6.530±0.070^{a}	7.590±0.000^{a}	7.895±0.077^{a}
	D	8.915±0.021^{b}	8.050±0.000^{b}	7.910±0.028^{b}	8.320±0.014^{b}
	ANOVA	0.001	0.001	0.001	0.001

Values are Mean ± Standard deviation of three determinations
Values with same superscript are not statistically significant (Duncan Multiple range test) at $p \leq 0.05$

Sample A – samples treated with $CaCl_2$
Sample B – samples treated with $Na_2S_2O_5$
Sample C – samples treated with NaCl
Sample D – Untreated sample

Microbial count of tomato powder during the months of storage

From observations on table 4, there was an increase in the bacteria and fungi load as the storage period progressed i.e. from month 0 to month 3. The increase was not drastic but gradual. This shows that the micro-climate of the samples was not all that conducive to the microorganisms. Sample B and D had higher bacteria load but had lower fungi load. The high bacteria load suppressed the growth of fungi, thereby reducing their population in the samples. Microbiological quality is a common criterion used to determine the acceptability and shelf life of dehydrated plant based products. Pre-treatments reduced microbial (fungi, bacteria) growth in tomato powder. The reduction in moisture content after drying was also observed to have reduced microbial activity and consequently increased storage stability of dried products, this has also been reported elsewhere (Jayathunge *et al.*,2012). Sample D which is the control had the highest bacteria load followed by sample B treated with $Na_2S_2O_5$. This implies that, the control (sample D) is more susceptible to spoilage as compared to other pretreated samples. In this work $Na_2S_2O_5$ does not prevent the growth of bacteria effectively as much as $CaCl_2$ and **NaCl**. Sample treated with **NaCl** had the lowest bacteria load but high fungi load. The microbial load (bacteria and fungi) after three months of storage were below the safe level of 10^5 as prescribed by International Commission on Microbiological Specifications for Foods (ICMSF. 1978). Generally, chemical pretreatment is expected to reduce microbial activity as observed in the trend of these results.

Table 4: Total microbial count of tomato powder during three months of storage (TOTAL VIABLE COUNT (TVC) x10² cfu/ml)

SAMPLE	MONTH 0	MONTH 1	MONTH 2	MONTH 3
A	1.133±0.306[a]	2.000±0.200[a]	2.633±0.153[a]	3.533±0.152[a]
B	15.000±2.000[b]	20.000±2.000[b]	23.340±1.519[b]	26.433±1.504[b]
C	1.000±0.200[a]	1.267±0.252[a]	1.766±0.153[a]	2.367±0.153[a]
Ds	44.067±3.579[c]	52.400±4.059[c]	58.123±5.762[c]	66.500±0.500[c]
ANOVA	0.001	0.001	0.001	0.001

Values are Mean ± Standard deviation
Values with same superscript are not statistically significant (Duncan Multiple range test) at $p \leq 0.05$

(TOTAL FUNGI COUNT (TFC) x10² cfu/ml)

SAMPLE	MONTH 0	MONTH 1	MONTH 2	MONTH 3
A	1.067±0.115[a]	2.067±0.115[b]	4.467±0.115[c]	4.967±0.158[b]
B	0.333±0.577[a]	1.200±0.200[a]	1.700±0.100[a]	2.600±0.100[a]
C	1.000±0.000[a]	1.233±0.057[a]	4.067±0.115[b]	4.900±0.100[b]
D	0.667±0.577[a]	1.200±0.200[a]	1.800±0.200[a]	2.767±0.058[a]
ANOVA	0.191	0.001	0.001	0.001

Values are Mean ± Standard deviation
Values with same superscript are not statistically significant (Duncan Multiple range test) at $p \leq 0.05$

Sample A – samples treated with $CaCl_2$
Sample B – samples treated with $Na_2S_2O_5$
Sample C – samples treated with NaCl
Sample D – Untreated sample

Conclusion

The study has revealed that oven drying and chemical pretreatment significantly increased the nutrient component of dehydrated tomato powder and decreased cfu/g of bacteria, which could enhance the shelf life quality of the products. The antioxidants properties such lycopene, B carotene, Vitamin C, and colour were retained in acceptable range due to pre-treatments before drying. In this present study all pretreated samples retained more nutrients, colour and reducing microbial load of tomato powder. That of $Na_2S_2O_5$ retained more nutrients while that of $CaCl_2$ retained more antioxidant properties. The **NaCl** treated powdered samples retained more ash and fiber. Proximate parameters of pre-treated samples showed a steady decrease across the storage period. The values of the proximate parameters were lowest/poorest at the third month of storage indicating that tomato powder storage for more than three months may not be healthy for consumption. Similar observations were made for antioxidants properties expect that the change for the proximate parameters were more drastic as compared to that of antioxidants properties. *L*a*b values of colour were higher at month 0 and lowest at month 3, this implies that at month 3 traces of undesired colour change began and as storage beyond this time may be unhealthy. At month 0,* $Na_2S_2O_5$ *retained higher values of colour (L*a*b) whereas* $CaCl_2$ retained more at month 3. There was an increase in the bacteria and fungi load as the storage period progressed i.e. from month 0 - 3. The increase was not drastic but gradual. This shows that the micro-climate of the samples was not all that conducive to the microorganisms but an increase of microorganism may increase with storage time. Thus, storage of tomato powder for more than three months may not be encouraged.

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