Effects of Osmotic Pre-Drying Treatments, Duration and Drying Temperature on Some Nutritional Values of Tomato Fruit

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ABSTRACT

Tomato (Lycopersiconesculentum) is a highly perishable crop widely grown in most parts of the tropical region of the world. It is rich in vitamin A, C and E, soluble solids, ash and protein and also a good source of lycopene. Drying is one of the most widely used methods of preserving tomato for a longer period. This research was carried out to study the effect that osmotic pre-drying treatment has on the nutritional qualities of the processed tomato product. Fresh Roma tomato samples were sliced to a thickness of 5 mm and the seeds were removed. Weight of 300 g was measured for each of the three replicates and immersed in a hypertonic solution of sucrose of different concentrations 40 and 60 ^{O}Bx each held for osmotic duration of 1 and 2 hr, drained for 10 min and then dried at 50, 60, and 70 ^{O}C in a mechanical dryer. Control samples were also weighed 300 g per replicate and dried at 50, 60, and 70 ^{O}C without pre- drying treatment. Moisture loss of each sample was monitored and recorded hourly until the product has reached the desired final moisture content (≤7%).Colour and nutritional content which include vitamin C, soluble solids, ash and crude protein were analysed for each sample. Statistical analysis was carried out to know the level of significance difference of individual treatment and their interaction at p≤0.05 using ANOVA, DNMRT and Independent samples T-Test. The results show that control samples have the highest content of vitamin C, ash and protein contents with average values of 37.97 mg/100 g, 4.941% and 20.39% respectively. Samples pre-treated with 60 ^{O}Bxconcentrations have the highest value of soluble solids with an average value of 30.78% than those with 40 ^{O}Bxconcentration and the control having 30.54% and 21.94% respectively. The best colour grade 3.5 was obtained for samples pre-treated with 60 ^{O}Bxconcentrations at 2 hr osmotic duration and dried at 50°C. Therefore it was concluded that drying temperature of 50 ^{O}C, pre- drying concentration of 60 ^{O}Bx and 2 hr osmotic duration have great influence on the colour of dried tomato fruit which is one of the most visible quality attributes used by consumers for accepting or rejecting processed vegetables.

Keywords: Tomato, Osmotic Time, Brix Concentration, Drying temperature, Nutritional compositions

INTRODUCTION

Tomato is a relatively short duration crop and gives a high yield, it is economically attractive and the area under cultivation is increasing daily (Naika*et al*., 2005). Tomatoes contribute to a healthy, well-balanced diet because they are rich in minerals, vitamins, essential amino acids, sugars and dietary fibres. Tomato also contains high values of vitamin B and C, iron and phosphorus. They are used to produce economically important processed products (Naika*et al*., 2005). It has been found from various studies that tomato contains between 90% and 95% moisture content and ascorbic acid of about 25mg/100g edible portion (Bencini, 1991; Bello, 1999; Igwe, 1999). Bencini (1991) also reported that tomato contains 1% protein, 0.2% fat, 4.8% carbohydrate, 0.6% fibre, 0.5% ash. Another important constituent of

ISSN: 2223-9944, eISSN: 2223-9553
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tomato fruit is lycopene which is the pigment that gives tomato its red colour (Darrigues*et al.,* 2008). The main antioxidants in tomatoes are the carotenoids, ascorbic acid and phenolic compounds (Giovanelli*et al*., 1999). Tomato's lycopene pigment reduces the risk of cardiovascular disease and can also reduced incidence of cancers, heart diseases and in addition it is an excellent blood cleanser (Gracia*et al*., 2010).

One major problem is that this vital product deteriorates very fast after harvest leading to heavy postharvest losses. Since tomato fruits are termed to be short duration fruits that can easily deteriorate immediately after harvest if not handled with care, there are postharvest problems associated with the fruits as soon as they ARE harvested from the farm. Morris *et al.* (2004) identified various causes of postharvest losses namely: physical spoilage, physiological ageing of fruits, insect or rodent attack, and mechanical damage during transportation, microbial infection, chemical and enzymatic spoilage.

In order to prolong the shelf-life of tomato fruit; the fresh products had to be processed. It was discovered that fresh tomato fruits are well preserved by the application of different preservation techniques which include: Freezing technique, application of heat, chemical method, physical method and drying (Morris *et al*., 2004).

Drying of fresh tomato fruits is one method being used by many local processors of tomato fruit and the consumption of dried tomato fruit is becoming more popular in developing countries including Nigeria, but most of these dried products have poor quality especially the physical appearance such as colour. Apart from the physical appearance, the nutrients are also affected by the drying processes. It is in view of this that certain osmotic pre-treatment would be carried out prior to drying to actually improve on these quality parameters. Studies have shown that heat processing has adverse effect on food if not properly controlled and also colour of foods is an important sensory attribute for product acceptance (Sousa, 2008). Therefore osmotic pre drying treatment of tomato can help protect against loss of flavour, colour, texture, and also the nutritional qualities of fruits such as the vitamins and mineral composition of the fruits most especially vitamin A and C during drying process.

Pre drying treatment is noted for good sensory qualities such as colour and flavour. Osmotic dehydration is one of the most important pre drying treatment of fruit and it involves partial removal of water from fruit by means of an osmotic agent (usually sugar or salt solution) which retains the initial food qualities such as colour, aroma, flavour and nutritional constituents (Sunjka and Raghavan, 2004).Carmargo*et. al* (2004) found that the use of antioxidants such as sodium metabisulphite and isoascorbic acid together with osmotic dehydration lead to higher vitamin C and lycopene content of tomato.

The research is aimed at determining the effects of osmotic pre-drying brix concentration, drying temperature and osmotic duration on proximate composition of dried tomato fruit with the view to derive the best and desired product quality.

MATERIALS AND METHODS

Raw Material

Roma tomato fruits that were ripe, fresh and firm were bought from a farmer in a local farm in Ilorin metropolis. The tomatoes were selected in order to obtain fruits of uniform size, shape and ripening degree based on the external appearance of the skin and the soluble solids content of samples. Tomato fruits used had 94% initial moisture content (wet basis). The tomato fruits were washed and sliced into a uniform slice thickness of 5 mm. The seeds of the sliced tomato were removed to prevent immediate spoilage of the fresh samples due to microbial action on the seeds.

ISSN: 2223-9944, eISSN: 2223-9553

Brix Preparation and Pre-Drying Treatment

Osmotic pre drying brix concentration of 40 °Bx was prepared from a sucrose solute of 453 g and 60 °Bx was prepared from a sucrose solute of 680 g both dissolved in 925 ml of distilled water at room temperature for duration of 10 min with rigorous stirring. The concentration was monitored on a refractometer scale.

The total sample was divided into five (5) parts, each part weighing 300 g. The first part was treated with 40 °Bx at 1 h Osmotic time; Second part with 40 °Bx at 2 h osmotic time; the third part was 60 ^{o}Bx at 1h osmotic time; the fourth part was 60 °Bx at 2 h osmotic time and the fifth part was left untreated as the control and thereafter all the samples was dried on labelled trays.

Drying Procedure

After pre drying treatment, the treated samples were drained for about 10 min before they are arranged into the dryer. Drying was stopped when the products have reached their calculated final mass and this gave their targeted final moisture content of about 7% (wb). The products were withdrawn from the dryer spread on a net for 10 min to cool before being packaged and transferred to the laboratory for analysis.

Determination of Nutritional Contents

Analysis of the nutritional contents of the dried fruits was done, after converting them to powdery form. The analysis was carried out to assess the quality of tomato samples after drying and was done in accordance with the AOAC (1990) standards to determine the total soluble solids content, protein content, vitamin C content and Ash content.

Colour Measurement

The use of Colorimetric method helped in the determination of the colour index. This was done by the use of a laboratory colorimeter and the procedures are stated below;

Dried Samples was soaked in 10 ml of chilled water for 3 minutes. It was ground carefully to avoid de-colouration. The colorimetric curvette was filled with the samples. The colour red and blue graphical display shown on the computer monitor and the reading was taken.

Experimental Design and Analysis

A factorial experiment under a randomized complete block design (RCBD) resulting into 45 runs altogether was used. Each experiment was replicated thrice. A Statistical Package for Social Science (SPSS) for Windows version 16.0 was used to analyse the data and the level of significance of individual treatment and their interaction were determined at $p \leq 0.05$ using Analysis of Variance (ANOVA), Duncan New Multiple Range Test (DNMRT) and Independent samples T-Test.

RESULTS AND DISCUSSION

The results of the nutritional contents and colour grade of the dried tomato fruit are presented in Table 1. Table 2 shows Duncan New Multiple Range Test for the effect of pre-drying treatment on nutritional content of tomato fruit while Table 3 shows the level of significance of the effects of drying temperature on the nutritional content of tomato. In Table 1, it was observed that for all the samples the nutritional contents and colour grade decreases as the temperature increases which occur due to the samples been denatured at higher temperatures. This was further subjected to DNMRT (Table 2) to establish if there is any significant difference at different drying temperatures employed in drying the samples. The results show that the average values of the nutritional contents of samples dried at drying temperature of

50, 60 and 70^{o}C differed significantly from one another except ash content in which there is no significant difference between samples dried at 60^{o}C and 70^{o}C but were significantly different($p \leq 0.05$) from those dried at 50^{o}C. Table 1 also shows the effects of osmotic pre drying brix concentration and time on the nutrients and colour of the end products and those of the control samples.

Soluble Solids Content

It can be seen (Table 2) that samples dried at 50^{o}C, 60^{o}C and 70^{o}C have average soluble solids content of 31.650%, 30.558% and 29.833% respectively. The results showed that drying at higher temperatures reduces the soluble solids content of the end product. Table 3 shows that the values of soluble solids were higher at 40 ^{o}Bx and 60 ^{o}Bx (30.588 and 30.772% respectively) compared to the control (21.944%). The soluble solids content of samples pre-treated with 60 ^{o}Bx is higher than those pre-treated with 40 ^{o}Bx because it had been shown from earlier studies that increase in sugar solution concentration can lead to increase in sugar content Jain *et al*. (1998). These values obtained from the pre-treated samples were significantly higher ($p \leq 0.05$) than the control samples confirming the fact that the treatment actually influenced the value of the total soluble solids.

Regarding the time the samples were held in the brix solution, it can be seen from the results (Table 1) that the soluble solids contents were higher for samples held for 1 h osmotic time than those pre-treated for 2 h. These findings are in agreement with the findings of Jain *et al.* (1998) on osmotic dehydration of papaya cubes in sugar syrup.

Vitamin C Content

Drying temperature has an adverse effect on vitamin C content of the dried samples as shown in Table 2. Samples dried at 70^{o}C were badly affected recoding an average value of 22.162 mg/100g of vitamin C compared to those dried at 50^{o}C and 60^{o}C with average values of 24.887 mg/100g and 23.618 mg/100g respectively. Similar observation was made by Idah*et al.*(2010) that high temperatures have adverse effect on vitamin C content of dried tomato samples.

It can be observed from the results (Table 3) that pre-drying brix concentration also affects vitamin C content. Samples pre-treated at 60 ^{O}Bx have the least values of vitamin C content with 22.712mg/100g, those at 40 ^{O}Bx have 24.398mg/100g while the control (untreated) samples have 37.974mg/100g and these were significantly different ($p \leq 0.05$). The use of chemical solution as a means of pre- drying treatment of chilli pepper was carried out by Wiriya*et al*. (2009) and it was discovered that the control samples have better content of vitamin C compared with the pre-treated samples except those pre-treated in ascorbic acid solution.

The effect of the duration of osmotic dehydration in sugar solution on vitamin C content of the dried showed that the samples pre-treated for 1hr osmotic time have higher content of vitamin C than those pre-treated for 2 hrs (Table 1).

Protein Content

It can be seen from the results (Table 1) that samples pre-treated for 2 hrs osmotic time has better protein content than those for 1 hr osmotic time. The value of protein contents at different drying temperatures showed that as the drying temperatures increased from 50^{o}C to 70^{o}C , the protein contents of the samples decreased from 14.677% to 13.967% (Table 2). The results (Table 3) further revealed that the control samples have higher percentage of protein content (20.391%) compared to those pre-treated with 40 ^{o}Bx and 60 ^{o}Bx (14.300 and 14.328% respectively). The protein content of the samples pre-treated with 40 ^{o}Bx and 60

ISSN: 2223-9944, eISSN: 2223-9553

^{o}Bx are not significantly different ($p \leq 0.05$) but differed significantly from those of the control. It has been shown (Adeboye, 2012) that control samples of plantain have higher percentage of protein than the pre-treated ones.

Ash Content

The results (Table 1) showed that samples pre-treated with 60 ^{o}Bx for 2 hrs have higher percentage of ash content irrespective of the drying temperatures than those pre-treated with 60 ^{o}Bx for 1h. This is an indication that ash content of dried tomato samples pre-treated for 2 hrs osmotic time are higher than those pre-treated for 1 hr. The results in Table 2 also show that ash content decreases with increase in drying temperatures. This could be attributed to the denaturing of the samples at higher temperatures. Samples with the best ash content of 2.793% were those dried at 50^{o}C drying temperature.

The results (Table 3) revealed that there were no significant differences ($p \leq 0.05$) between the average values of ash contents of the samples pre-treated with 40 ^{o}Bx and 60 ^{o}Bx but these values were significantly different ($p \leq 0.05$) from the values of the control samples which have the highest value of ash content (4.946%).

Colour Grade

Colour grade of finished agricultural products is one of the most important attributes that usually determine whether such products will be accepted or rejected by the consumers. The results from this study showed that drying temperature of 50^{o}C and pre-drying brix treatment of tomato samples with 40 ^{o}Bx and 60 ^{o}Bx in sucrose solution has great influence on preserving the colour of the dried product (Table 1).

Table 1. Mean Values of the Nutritional and Colour Parameters of Tomato Fruit

Treatments	*Soluble Solids (%)*	*Vitamin C (mg/100g)*	*Protein (%)*	*Ash (%)*	*Colour Grade (Red)*
40 ^{o}Bx 1 h 50^{o}C	31.80	27.96	14.70	3.08	2.57
60^{o}C	30.57	25.39	14.40	2.35	0.23
70^{o}C	30.13	23.56	14.07	2.39	0.10
40 ^{o}Bx 2 h 50^{o}C	31.43	24.59	14.40	2.69	3.83
60^{o}C	29.93	23.16	14.24	2.53	0.17
70^{o}C	29.67	21.73	13.98	2.35	0.17
60 ^{o}Bx 1 h 50^{o}C	32.53	25.24	14.91	2.51	3.21
60^{o}C	31.63	24.98	14.30	2.38	0.43
70^{o}C	29.57	22.52	14.01	2.34	0.17
60 ^{o}Bx 2 h 50^{o}C	30.83	21.75	14.69	2.89	3.77
60^{o}C	30.10	20.95	14.25	2.53	1.37
70^{o}C	29.97	20.83	13.80	2.42	0.10
Control 50^{o}C	22.60	39.63	21.27	5.35	0.67
60^{o}C	21.83	37.99	20.73	4.89	0.10
70^{o}C	21.40	36.31	19.18	4.59	0.00

ISSN: 2223-9944, eISSN: 2223-9553
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The results in Table 2 revealed that the colour grade of the samples dried at the three temperatures were significantly different (p≤ 0.05). Samples that were dried at 50°C have the best colour grade of 3.075 compared with those dried at 60°C and 70°C with colour grade of 0.550 and 0.133 respectively. Similar observations on tomato colour after drying had been made by Sahin*et al*.(2011).

The samples pre-treated at 40 °Bx has colour grade of 1.178 while those pre-treated at 60 °Bx has 1.328 colour grade and these were significantly different (p≤ 0.05), but these values were significantly different from the colour grade of the control samples (0.258). The results (Table 1) revealed that the samples pre-treated for 2 hrs osmotic time have better colour grade than those pre-treated for 1 h osmotic time. This could be attributed to the fact that there were more accumulation of sucrose from the solution by the samples pre-treated with 60 °Bx for 2 hrs. Sucrose is capable of minimizing the adverse effects of drying temperature and helps in enhancing the colour grade of tomato samples. These findings agreed with Wiriya*et al*. (2009) on chilli pepper that pre-treatment of fruits in chemical solution produced dried products with better colour attributes.

Table 2. Duncan New Multiple Range Test for the Effect of Drying Temperature on Nutritional Content of Tomato Fruit

Temperature	*Soluble Solids (%)*	*Vit.C (mg)*	*Protein (%)*	*Ash (%)*	*Colour Grade (red)*
50 OC	31.650a	24.887a	14.677a	2.793a	3.075a
60 OC	30.558b	23.618b	14.299b	2.448b	0.550b
70 OC	29.833c	22.162c	13.967c	2.377b	0.133c

*Means in the same column with different letters are significantly different at p ≤ 0.05

Table 3. Duncan New Multiple Range Test for the Effect of Pre-drying brix concentration on Nutritional Content of Tomato Fruit

Treatment	*Soluble Solids (%)*	*Vit.C (mg)*	*Protein (%)*	*Ash (%)*	*Colour Grade (red)*
40 OBx	30.588a	24.398a	14.300a	2.513a	1.178a
60 OC	30.772a	22.712b	14.328a	2.654a	1.328a
Control	21.944b	37.974c	20.391c	4.946b	0.256b

*Means in the same column with different letters are significantly different at p ≤ 0.05

CONCLUSIONS

The effects of pre-drying treatment of fresh tomato fruits, duration of pre-treatment and drying temperature had been investigated in this study and the following conclusions can be drawn. The nutritional contents and colour of the dried tomato samples were preserved better at low drying temperature of 50°C than at higher temperatures. For the pre-treated samples those pre-treated with brix concentration of 60 °Bx resulted in better nutritional contents and colour compared to those pre-treated with 40 °Bx. Some nutritional contents of tomato fruit such as vitamin C, protein and ash were preserved better by drying control samples than the treated samples. The nutritional contents and colour of samples pre-treated for 2 hrs osmotic time were better than those treated for 1 hr. Drying of samples pre-treated with 60 °Bx for 2 hrs at a drying temperature of 50°C gave the best colour of dried tomato which is a major criterion either accepting or rejecting processed products by consumers.

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ISSN: 2223-9944, eISSN: 2223-9553