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Effects of Pre-Treatment and Temperature on the Quality and Drying Rate of Tomatoes

The effect of pre-treatment and temperature on the quality and the drying rate of tomatos (Lycopersicon esculentus) were studied. A 3× 5 factorial experiment in a randomized complete block (RCBD) design was used. Firm and fresh ripe tomatoes were washed and sliced to a uniform thickness of 5mm, pre-treatment by boiling for 3 minutes was given to some of the sliced tomatoes while some were blanched by soaking in water at 90^{0}C for 3 minutes and the remaining part was dried raw. 200g each of the sample was dried at temperatures of 50, 55, 60, 65, and 70^{0}C in a cabinet drier until no moisture removal was observed. The moisture removal from the samples in the cabinet was observed and measured on an hourly basis and the vitamin C content of the dried samples was also analyzed. The results obtained for the drying rate and Vitamin C content were statistically analyzed using SPSS software to generate the ANOVA and DNMRT. It was found that samples dried at higher temperatures had higher drying rates irrespective of the pre-treatment. Raw samples and Samples dried at lower temperatures had better quality in terms of vitamin C retention.

Keywords: *tomato, blanching, boiling, drying*

1. Introduction

Tomato belongs to the genus lycopersicon of the family Solanaceae. The tomato is native to South America. According to the online etymology dictionary, the word *tomato* comes from the Nahuatlword*tomato*, literally "the swelling fruit". Tomato is one of the most popular and widely grown vegetable crops in the world (Madhavi and Salunkhe, 1998). Over 20 million metric tonnes of tomatoes are produced each year worldwide.

According to Bencini (1991), tomato is grown in almost all African countries including Nigeria although it is not indigenous to Africa. The first European settlers brought seeds of their favourite vegetables with them. Some of them including tomato have become very important in the African diet.

Generally, vegetables are believed to play an important role in human nutrition in supplying vitamins and other essential nutrients. In addition to this, several studies have shown that vegetables also supply some amount of carbohydrate, protein and energy (Madavi and Salunkhe, 1998; Babalola *et al.*, 2010). Like other vegetables, tomato has been found to contain a substantial amount of vitamins and other essential nutrients. 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 tomato fruit is lycopene which is the pigment that gives tomato its red colour (Darrigues *et al.*, 2008).

Fruits and vegetables are seasonal products and they are highly perishable products because they respire actively (Anghel, 2010; Adegoke and Moyosade, 1987). Similarly, tomato is highly perishable in its natural form. Storage life of this fruit is short and considerable losses are encountered during its handling, transportation and storage (Madavi and Salunkhe, 1998; Bello, 1999). According to FAO (1989), most fresh fruits and vegetables have a storage life of only a few days under even the best environmental conditions. Also, tomato and other fruits are seasonal crops. When they are in season, there is usually a surplus of the product and since they are perishable crops, excess produce go to waste. Hence, there is need to extend the storage life of these crops and make them available even when they are not in season. Therefore it is of utmost importance to find ways of preserving and storing tomato while still retaining its nutrients.

In this study, the effects of temperature and pre-treatment on the drying rate and quality of tomato were investigated. The study focuses on the determination of the effect of drying temperature, boiling and blanching on the drying rate and vitamin C content of dried tomato.

2. Materials and methods

Experimental Equipment and Apparatus

The major equipment used for this study is an electric dryer designed and constructed by Omodara (2011). Other apparatus and materials used include slicer, sensitive weighing balance and chemical reagents.

Experimental Design

In order to achieve the objectives of this study, a 3 × 5 factorial experiment in a randomized complete block design (RCBD) was used. In the design, five (5) levels of temperature (T), and three (3) levels of treatment (t) was used. The temperatures used are 50, 55, 60, 65^{0}C, and 70^{0}C. These temperatures were used based on the findings of Andritosis *et al.* (2003) and Gracia *et al.* (2010) that the best drying temperatures for tomato are low temperatures between 45^0C and 70^0C. Some of the tomatoes were pre-treated by blanching before drying, some cooked/boiled while some were dried in their natural state. According to Talented (2010), blanching brightens the colour, softens the texture and has little effect on nutrient content or flavour of tomato as it is a relatively short process. Each test run was replicated (R) thrice making a total of 45 test runs. The experiment was carried out in Nigeria Stored Product Research Institute (NSPRI), Ilorin.

2.1. Experimental Procedure

Sample Preparation

Fresh, firm and ripe tomato fruits (Figure 1) were bought from Ipata market in Ilorin, kwara State Nigeria. According to Madhavi and Salunkhe (1998), nutritional constituents of tomato are at their peak when the fruit is at its red ripe stage therefore, tomatoes to be used for processing should be fully mature in order to optimize various quality parameters. Roma, a red, round and thick skinned variety was used for the experiment. The tomato fruits were washed and sliced into a uniform slice thickness of 5 mm (Figure 2). Preliminary investigation and the study of Bello, (1999) revealed that drying tomato without deseeding causes discolouration. Hence, the sliced tomato was deseeded as done by Bello (1999). The total sample was divided into three parts. One part was dried in its natural form; one part was boiled before drying while the last part was blanched before drying.

Boiling was achieved by pouring sliced samples in 1000ml of boiling water and was allowed to boil for 3 minutes. The boiled samples were drained on wire gauze for 5minutes. 200 grams of the drained sample was measured and used for the experiment. Blanching was achieved by soaking the samples in water at 90^0C for three (3) minutes as described by Talented (2010). This is expected to minimise enzymatic action which can cause loss of flavour, colour and texture. The blanched samples were then drained on wire gauze for 5minutes. 200g of drained sample was measured and used for the experiment. For a control experiment, 200g of the sliced tomato samples was measured and arranged in the dryer as shown in Figure 3.

Figure 1. Fresh tomatoes.

Figure 2. Sliced tomatoes.

Figure 3. Arrangement of tomatoes on the trays in the dryer

Drying Procedure

The dryer was pre-heated to the desired temperature by means of the temperature regulator while the samples were being prepared to ensure stability of the condition of the drying chamber when the samples will be introduced. The trays were labelled with tags of the different treatments. The samples were weighed at an interval of 1 hour with a weighing balance and the weights were recorded. This was done until there was no more moisture removal from the samples and this was achieved when the average moisture content was 5%. The procedure was repeated for the samples at all temperature levels.

Experimental Measurements and Analysis

The output parameters that were determined are the optimum temperature, optimum drying time for the crop to reach a safe moisture level, and the hourly drying rate in the dryer. Also, the chemical analysis of vitamin C content was carried out.

Quantitative Analysis

(i) Drying Rate

This refers to the rate of moisture removal during the drying process. It was obtained by measuring the weight of samples as drying took place. Drying rate can be expressed mathematically as:

$$DR1 = \frac{W1 - W2}{T}, \quad (1)$$

Where, W_1= weight of product before drying

W_2= weight of product after drying

T= drying time

DR_1= rate of moisture removal (g/hr)

Drying Rate can also be expressed as:

$$DR2 = \frac{M1 - M2}{T}, \quad (2)$$

Where M_1= initial moisture content of product

M_2= final moisture content of product

T= drying time

DR_2= rate of moisture removal (g/hr) (Marcin and Lund, 2003)

Qualitative Analysis

(i) Determination of Vitamin C Content

The vitamin C content of the dried tomatoes was analysed in the chemistry laboratory of the Nigerian Stored Product Research Institute (NSPRI) Ilorin Kwara state Nigeria using the procedure described in the AOAC (1999) manual.

The procedure involved the addition aliquots of 100ml prepared juice to equal volume of HPO_3HOAC solution to a total volume of Vml. Aliquot of prepared solution containing about 2mg of ascorbic acid was pipette into a conical flask. This was titrated against 2,6-dichloroindophenol in the burette to a light but distinct rose pink. Blank determination was made using HPO_3 – HOAC solution and water. The vitamin C content was determined using the calculation below.

$$\text{Mg ascorbic acid/gram or ml} = (T - B) \times \frac{F}{E} \times \frac{V}{Y}, \quad (3)$$

Where,

T=Average titre value for sample

b=Average titre value for blank

F=mg Ascorbic Acid equivalent to 1.0ml indephanol solution
E=Number of g or mg assayed
V=Volume (ml) of initial assay solution
Y=Volume (ml) of sample aliquot titrated

3. Results and discussion

Table1. shows the Statistical analysis of the effect of pre-treatment and drying temperature on drying rate of tomato and it could be observed in Table 2 that only drying temperature is significant on drying rate at 95% confident interval while pre-treatments and their interactions were not significant.

Table 1. Effect of Pre-treatment and Drying Temperature on Drying Rate*

PRE-TREATMENT	Drying temperature (^oC)	Drying rate (g/hr)
Raw	50	17.21±0.05
	55	18.93±0.23
	60	20.96±0.23
	65	20.85±0.06
	70	23.88±0.00
Blanched	50	17.27±0.00
	55	18.97±0.05
	60	20.85±0.06
	65	20.89±0.00
	70	23.88±0.00
Boiled	50	17.36±0.09
	55	18.97±0.05
	60	21.00±0.11
	65	20.90±0.13
	70	23.96±0.07

*Each value is the mean of the three replicates ± standard deviation

Table 2. Analysis of Variance (ANOVA) of the Effect of Pre-Treatment (P) and Drying Temperature (T) on Drying Rates

S.V	D.F	S.S	M.S	F
(P)	2	0.052	0.026	2.350
(T)	4	221.821	55.455	5.016E3*
P x T	8	0.040	0.05	0.447
Error	30	0.332	0.011	
Total	45	18938.43		

*significantly at P≤ 0.05

Effect of Pre-treatment on Drying Rate

Figure 4 shows the effect of pre-treatment on drying rate of tomato at different temperatures. From the figure, it is obvious that drying rate increases as the temperature increases for all the pre-treatment except from 60^0C to 65^0C where drying rate was not significantly different from each other. The figure also reveals that drying rates at the different pre-treatments were not significantly different from one another at all the drying temperatures. The average drying rate for the control, boiled and blanched samples is 17g/hr, 19g/hr, 21g/hr, 21g/hr and 24g/hr at 50^0C, 55^0C, 60^0C, 65^0C and 70^0C respectively.

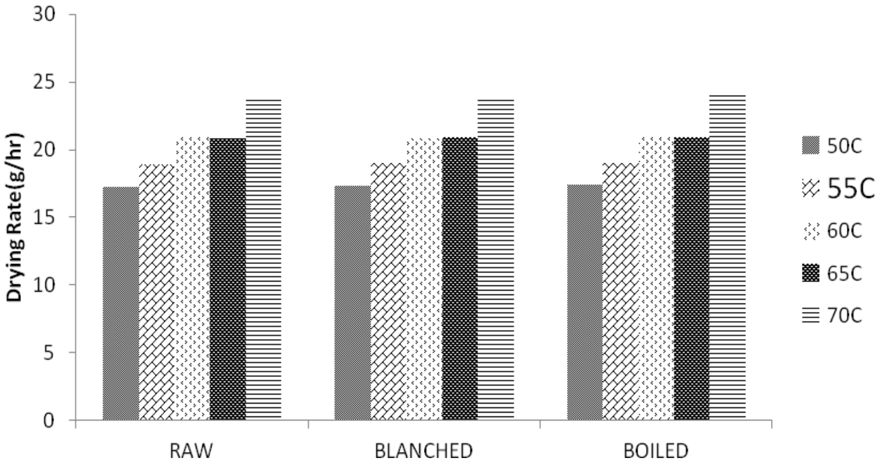

Figure 4. Effect of Pre-Treatment on Drying Rate at different Drying Temperature

Effect of Drying Temperature on Drying Rate

The influence of drying temperature on drying rate at the three levels of pre-treatment is shown in Figure 5. From the figure, it can be observed that drying rate increased progressively from an average of 17g/hr at 50 ^{0}C to an average of 23g/hr at 70 ^{0}C for all treatments. Since the pre-treatments did not have significant effect on drying rate, and the drying rate at all temperatures were almost the same for all the treatments, the graph followed a similar pattern as Figure 4.

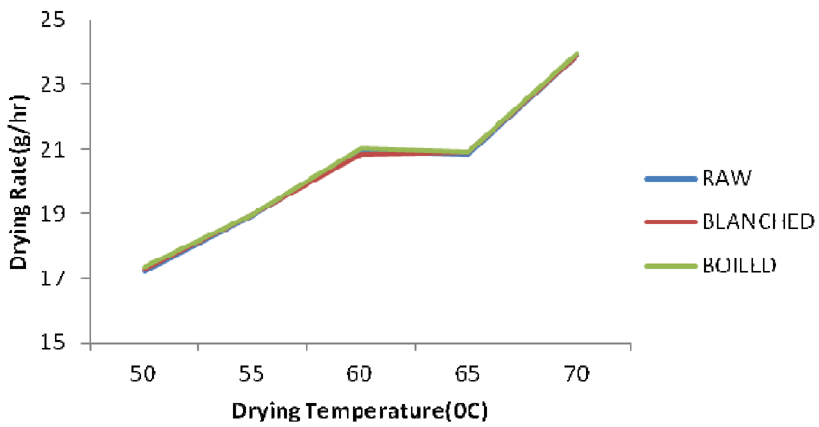

Figure 5. Effect of Pre-treatment on Drying Rate at different Drying Temperature

To further investigate the effect of each level of drying temperature on drying rate, Duncan New Multiple Range Test (DNMRT) shown in Table 3 was used. From the table, it can be seen that drying rates at 60^{0}C and65^{0}c were not significantly different from each other. This was also observed in the drying time as the samples dried at 60^{0}C and 65^{0}C dries to the safe moisture content after 9 hrs. Drying rates at other levels of temperature were significantly different from one another. Mean drying rate at 70^{0}C was highest, while 50^{0}C was the lowest. The result implies that the mean drying rate of samples dried at 60^{0}C and 65^{0}C were significantly the same while the mean drying rate of samples dried at 50^{0}C, 55^{0}C, 60^{0}C and 70^{0}C were significantly different.

Table 3. Duncan Multiple Range Test for the Effect of Drying Temperature on Drying Rate*

Drying Temperature (^{0}C)	Drying Rate (g/hr)
50	17.28^d
55	18.96^c
60	20.94^b
65	20.89^b
70	23.91^a

*Means with the same letters are not significantly different at P ≤ 0.05 using Duncan Multiple Range Test

Vitamin C Content

Table 4 shows the summary of the data obtained for Vitamin C content of the dried tomato. From the ANOVA (Table 5), it can be observed that the effect of the drying temperature and pre-treatment were significant on the Vitamin C content at 95% confidence interval while the interaction between the two factors were not significant on the vitamin C content of the dried tomatoes.

Table 4. Effect of Pre-treatment and Drying Temperature on Vitamin C content*

PRE-TREATMENT	DRYING TEMPERATURE (^{0}C)	VITAMIN C CONTENT (g/100mls)
Raw	50	10.97±1.94
	55	14.29±0.75
	60	18.80±1.13
	65	19.67±3.38
	70	22.87±1.33
Blanched	50	10.97±3.45
	55	12.47±1.44
	60	14.13±1.80
	65	13.96±0.50
	70	15.96±1.33
Boiled	50	9.72±0.94
	55	10.17±2.87
	60	12.94±3.77
	65	12.89±1.04
	70	15.96±0.76

*Each value is the mean of the three replicates ± standard deviation

Table 5. Analysis of Variance (ANOVA) for the Effect of Pre-Treatment (P) and Temperature (T) on Vitamin C Content

S.V	D.F	S.S	M.S	F
Pre-treatment(P)	2	211.665	105.832	25.191*
Temperature (T)	4	295.616	73.904	17.591*
P x T	8	71.328	8.916	2.122
Error	30	126.035	4.201	
Total	44	704.643		

*significant at P≤ 0.05

Effect of Pre-treatment on Vitamin C content

Figure 6 shows the effect of pre-treatment on vitamin C of tomato at different drying temperatures. From the figure, it is obvious that vitamin C content was highest at 50^{0}C and lowest at70^{0}C at all levels of pre-treatments which reflect that the Vitamin C content of dried samples reduces with increase in drying temperature.

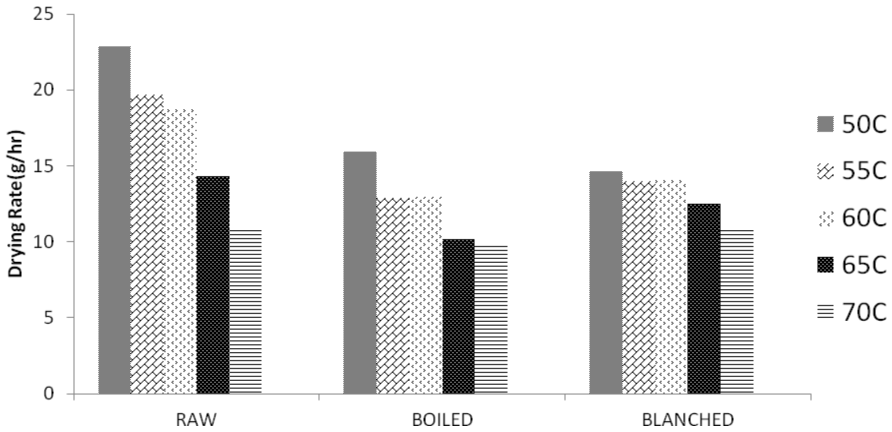

Figure 6. Effect of pre-treatment on Vitamin C Content at Different Drying Temperature

The observations from Figure 6 above were further confirmed using Duncan New Multiple Range Test (shown in Table 6) to compare the means. From the table, it can be seen that the raw sample had the highest vitamin C content followed by the blanched samples and boiled samples in descending order. The table also shows that vitamin C content of boiled samples and blanched samples are not appreciably different from each other. This is similar to the findings of Babalola *et al*. (2007) who discovered that vitamin C content of leafy vegetables is lost due to various processing methods such as blanching and boiling.

Table 6. Duncan Multiple Range Test

PRE-TREATMENT	VITAMIN C CONTENT (mg/100ml)
Boiled	12.3353[b]
Blanched	13.2367[b]
Raw	17.3200[a]

*means with the same letter are not significantly different from each other.

Effect of Drying Temperature on Vitamin C Content

The effect of drying temperature at the three levels of pre-treatment is shown in Figure 7. From the figure, it can be observed that raw samples had the highest vitamin C content at all drying temperature, while the boiled samples had the lowest amount of vitamin C except at 50^0C where blanched samples had slightly lower amount of vitamin C content than raw samples. At a drying temperature of 70^0C, blanched samples and raw samples had the same vitamin C content.

This shows that heat has degrading effect on vitamin C content and this effect becomes increasingly degrading as temperature increases. This finding is in agreement with the claims of Gracia*et al.* (2010), Talented, (2010) and Babalola*et al.*, (2007).

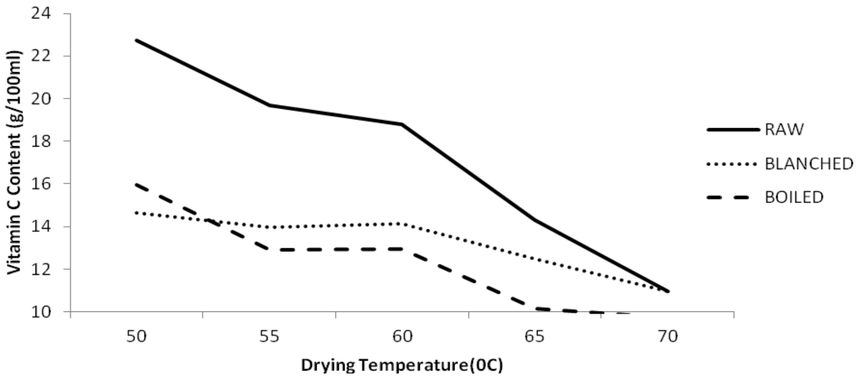

Figure 7. Effect of Drying Temperature on Vitamin C Content at different Pre-treatments

The effect of drying temperature on vitamin C content was further investigated using Duncan New Multiple Range Test (DNMRT). The result of the DNMRT is presented on Table 7 below. From the table it can be seen that vitamin C content of dried samples at 50^0C, 55^0C and 60^0C were not significantly different from one another. Vitamin C content at 65^0C and 70^0C were also not significantly different from each other but were significantly different from that of 50^0C, 55^0C and 60^0C. It can also be seen that vitamin C content was highest at 50^0C and lowest at 70^0C just as it was observed in Figure 7.

Table: 7. Duncan Multiple Range Test for the effect of temperature on vitamin C content

TEMPERATURE (^{0}C)	VITAMIN C CONTENT (mg/100ml)
50	17.8256[a]
55	15.5044[a]
60	15.2922[a]
65	12.3078[b]
70	10.556[c]

*Means with the same letters are not significantly different from each other

4. Conclusion

At the end of the study, it was found that:

- Tomatoes dry faster at higher temperatures than at lower temperatures irrespective of the pre-treatment used.

- The vitamin C content of tomato reduces as the drying temperature increases. This shows that drying tomatoes at high temperature has adverse effect on its nutritive value.
- Drying tomatoes raw preserves more of the vitamin C content than tomatoes pre-treated by blanching and boiling before drying. This shows that pre-treatment is not necessary before drying tomatoes.

The best drying conditions for best quality tomato is a drying temperature of 60^0C.

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