

[5-1015-C] Postharvest/Food Technology and Process Engineering (5)

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[5-1015-C-03] Effects of Pre-drying treatment and Drying-air Temperature on Moisture Ratio and Effective Moisture Diffusivity of Tomato (Nigerian Local and Foreign Varieties)

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Keywords: Hausa, Tiwantiwa, Honey and Sugar, Tomato

Tomato is a crop that is highly perishable and there are huge postharvest losses incurred annually in Nigeria. Drying of the fruit is important and suitable for developing economies. However, the heat employed during drying of tomato can influence its quality adversely, as a result it is important to use pre-drying treatments prior to drying operation. Therefore, the aim of this research was focussed on studying the effects of pre-drying treatment and drying-air temperature on moisture ratio (MR) and effective moisture diffusivity of tomato. Three varieties (Hausa, Tiwantiwa and Roma VFN) of fresh tomato were obtained from local farmers in Ilorin province, Kwara state of Nigeria. The samples were sorted and cleaned under running water, and were sliced at different thicknesses (5 mm, 7.5 mm and 10 mm), deseeded and blanched in hot distilled water at 90oC. The samples were further pre-treated using different chemical and osmotic solutions (2% ethyl acetate, 1% MgCl₂ .6H₂O and 0.5% Na₂S₂O₅, 0.5% NaCl and 40oBx of honey and sugar) and Control (Non-pretreated). Samples were drained for 10 minutes after pre-drying treatment and were dried at different temperatures (45, 55 and 65oC) in an automated forced convection cabinet dryer (FCCD) instrumented for the purpose of this experiment. Weight loss of the samples were recorded at different intervals (15 - 60 min) on the trays per stage with the aid of a weight reduction sensing mechanism attached through the rear of the dryer. The drying process was stopped (through a computer system connected to the dryer) when the samples had reached their final moisture content <5% (db). The data obtained from the drying process were used to compute the samples moisture ratio and effective moisture diffusivity and were analyzed using regression and analysis of variance (ANOVA) with Design expert v. 6.0.6 statistical tool at p <0.05. The results obtained show that samples lowest MR were obtained under these conditions; processed Hausa variety, 10 mm thickness, ethyl acetate pre-drying treatment and dried at 55oC while highest effective moisture diffusivity were obtained under these conditions processed Hausa variety, 5 mm thickness, honey and sugar pre-drying treatment and dried at 65oC in a FCCD. It was therefore concluded that processed Hausa variety was more preferable to other varieties used as it promotes low MR and high effective moisture diffusivity during the drying process. This will help reduce energy consumption associated with drying process.

Effects of Pre-drying Treatment and Drying-air Temperature on Moisture Ratio and Effective Moisture Diffusivity of Tomato (Nigerian Local and Foreign Varieties)

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ABSTRACT

Tomato is a crop that is highly perishable and there are huge postharvest losses incurred annually in Nigeria. Drying of the fruit is important and suitable for developing economies. However, the heat employed during drying of tomato can influence its quality adversely, as a result it is important to use pretreatments prior to drying operation. Therefore, the aim of this research was focused on studying the effects of pretreatment and drying-air temperature on moisture ratio (MR) and effective moisture diffusivity of tomato. Three varieties (*Hausa*, *Tiwantiwa* and *Roma VFN*) of fresh tomato were obtained from local farmers in Ilorin province, Kwara state of Nigeria, the samples were sorted and cleaned under running water, and were sliced at different thicknesses (5 mm, 7.5 mm and 10 mm), deseeded and blanched in hot distilled water at 90°C. The samples were further pretreated using different chemical and osmotic solutions (2% Ethyl acetate, 1% $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ and 0.5% $\text{Na}_2\text{S}_2\text{O}_5$, 0.5% NaCl and 40°Bx of Honey and Sugar) and Control (Non-pretreated). Samples were drained for 10 minutes after pre-drying treatment and were dried at different temperatures (45, 55 and 65°C) in an automated forced convection cabinet dryer (FCCD) designed for the purpose of this experiment. Moisture loss of the samples were recorded at different intervals (15 - 60 min) on the trays per stage with the aid of a weight loss sensing mechanism attached through the rear of the dryer. The drying process was stopped (through a computer system connected to the dryer) when the samples had reached their final moisture content < 5% (db). The data obtained from the drying process were used to compute the samples moisture ratio and effective moisture diffusivity and were analyzed using regression and analysis of variance (ANOVA) with Design Expert V 6.0.6 statistical tool at $p < 0.05$. The results obtained show that samples lowest MR were obtained under these conditions; processed *Hausa* variety, 10 mm thickness, Ethyl acetate pre-drying treatment and dried at 55°C while highest effective moisture diffusivity were obtained under these conditions processed *Hausa* variety, 5 mm thickness, Honey and Sugar pre-drying treatment and dried at 65°C in a FCCD. It was therefore concluded that processed *Hausa* variety is more preferable to other varieties used as it promotes low MR and high effective moisture diffusivity during the drying process. This will help reduce energy consumption associated with drying process.

Keywords: Honey and Sugar Hausa Tiwantiwa Slice thickness Tomato

1. INTRODUCTION

Tomato is one of the major vegetable crops cultivated in Nigeria and has been known to be highly perishable (Onifade et al., 2013; Idah and Obajemihi, 2014). Drying of fruits and vegetables such as tomato is gaining popularity in Nigeria, where post-harvest loss of farm produce is on increase on yearly basis, due to poor post-harvest handling techniques; as a result, Nigerians have spent a whooping sum of \$1bn annually on imported tomato products (UNEP, 2016). Drying is a heat and mass transfer phenomenon and has saved more than 20% of crops that are perishable in the world; by extending their shelf lives and ensuring food security (Sohail et al., 2011). Drying is important and most times indispensable in the formulation of functional food products (Trivedi et al., 2011). Drying

of tomato products usually occur in the falling rate period as the moisture content tends to decrease with time.

It is important to study and understand mass transport mechanisms such as moisture ratio (MR) and effective moisture diffusivity (D_{eff}) responsible for drying of tomato and what to be done during pre-drying and drying processes to favour them. Moisture ratio is the ratio of the instantaneous moisture content to that of the fruit's initial moisture content. Effective moisture diffusivity is an internal transport phenomena and it is the rate at which moisture is moved from the center of the fruit to its surface where it will be evaporated (Onwude et al., 2016). D_{eff} is a function of drying-air temperature and samples' MR and was seen as an important mass transport mechanism when it comes to studying drying processes involving fruit and vegetable (Onwude et al., 2016). Zogzas et al. (1996), stated that increase in temperature brings about increase in effective diffusivity but changes with respect to moisture content. When the temperature of food is high, the water molecules in it are bounded loosely to food matrix than at low temperature, therefore more energy is required to remove moisture at lower temperatures compared with high temperatures. Also food structure and void fraction present can significantly affect moisture diffusivity and hence reported that at low porosity, value of effective diffusivity of moisture is majorly by liquid diffusion which is different from that obtainable for granular or porous material, moisture movement is mainly by vapour diffusion through the void or empty spaces. D_{eff} and velocity of moisture movement within the material are relatively related while drying rate is the rate at which moisture vaporizes to the surrounding air or a change of moisture to vapour by evaporation which depends largely on the pressure difference existing between the food material and surrounding air as a result of temperature difference (So'bah et al., 2017).

Pre-drying treatment of fruits and vegetables has been known to favour or disfavour their drying rates which is a function of both internal mass transport mechanisms and external heat (Mauro et al., 2005). It helps retain food sensory and nutritional qualities; as previous researches have shown that the effects of drying-air conditions, most especially drying-air temperature have adversely affected the quality attributes of tomato if not properly controlled.

Therefore, it becomes imperative to investigate the effects of pre-drying treatment and drying-air temperature on moisture ratio and effective moisture diffusivity of tomato.

2. MATERIALS AND METHODS

2.1 Raw Material

Fresh tomato samples of three different varieties were obtained from local growers in Oteh area, a suburb of Ilorin Kwara State of Nigeria. The samples were sorted visually according to their ripeness, firmness and size. Samples were thoroughly washed under tap water, sliced using a stainless steel knife, deseeded with a needle and blanched in hot water for 1 min at 90°C to minimize browning and enzymatic reaction during drying process.

2.2 Pre-drying treatment Process

Sliced samples were divided into five parts and were subjected to further pre-drying treatments following the mechanical and thermal pre-drying treatments used on them initially. These other methods include treatment in osmotic and chemical solutions. The first, second, third and fourth parts were treated in a mixture of honey and sugar solution at 40°Bx concentration (honey: sugar: water ratio 2: 1: 1.9) for 10 min which was prepared using a refractometer (Model: M10481, by ABBE MARK II, USA), 2% ethyl acetate solution for 1 min, 0.5g/100ml NaCl solution for 10 min and 1% $MgCl_2 \cdot 6H_2O$ and 0.5% $Na_2S_2O_5$ for 10 min respectively. And the fifth part served as the control sample which was immersed in distilled water at room temperature for 10 min. Each sample weighed 250 g with an electronic balance (Model: WH-B06, sensitivity $\pm 0.01g$ by WEIHENG, China) before pre-drying treatment. After pre-drying treatment samples were drained and bloated with absorbent paper.

2.3 Drying Procedure

After pre-drying treatments of the samples they were dried in an automated forced convection cabinet dryer (FCCD) designed for the purpose of this research at different drying-air temperatures (45, 55 and 65°C), the dryer was run to attain the desired temperature before loading the samples on its labelled

trays. The trays were rested on load cells which were linked to a microcontroller which was in turn connected to a computer system which has a software with Arduino programme used in monitoring and controlling the dryer. The dryer was also equipped with a thermo-hygrometer sensor used in sensing the drying-air temperature and humidity and three (3) solid state relays which were used for switching on and off the two (2) heaters (3.6 kW) and a centrifugal fan (2m/s). The dryer was pre-selected to take record of every 5 min as the drying experiment progressed. The measurements recorded were the instantaneous weight on each of the four (4) trays, the drying-air temperature and humidity. This dryer totally eliminates the drudgery, time and energy wastages associated with previous drying experiments when samples were brought out to measure. The FCCD is shown in Figure 1.

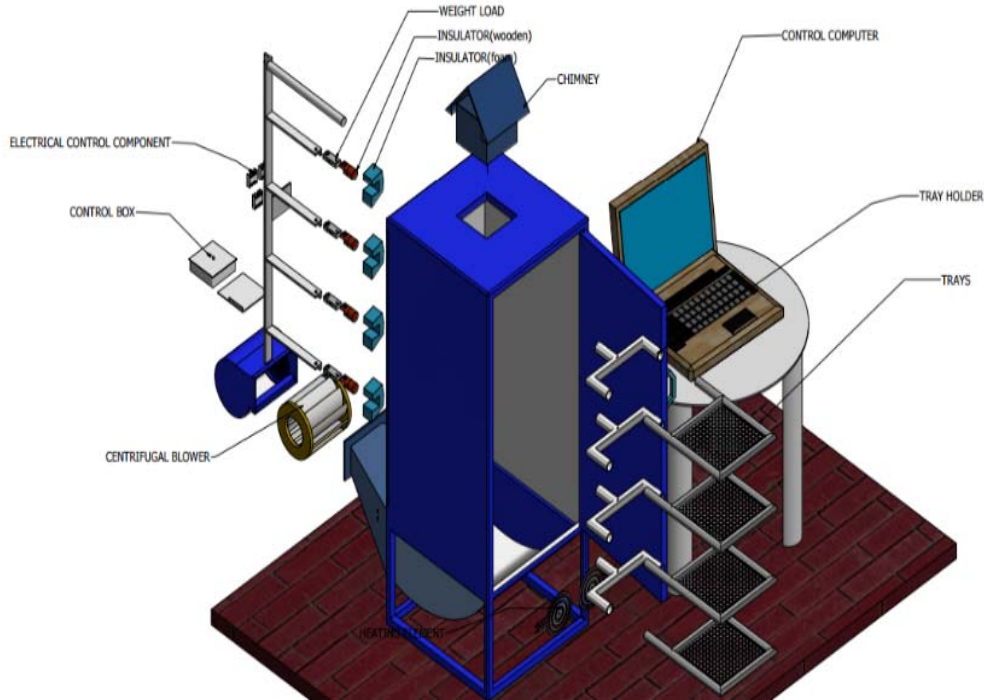


Figure 1. 3D View of the Automated FCCD

2.4 Determination of output Parameters

2.4.1 Instantaneous Moisture Content (M_t)

The instantaneous moisture content (M_t) of tomato at any given time (t) during the drying experiment was estimated using Equation 1;

$$M_t = \frac{(M_o + 1) - W_t - 1}{W_o} \quad (1)$$

where;

M_t = Instantaneous m.c. (% wb)

M_o = Initial m. c. (% wb)

W_t = Weight of product at any time, t during drying (g)

W_o = Initial weight of the sample (g)

2.4.2 Moisture Ratio (MR)

Moisture ratio was calculated as expressed in Equation 2;

$$MR = \frac{M_t - M_e}{M_o - M_e} \quad (2)$$

where;

M_t = m.c. of the tomato samples at any time t (% db)

M_e = Equilibrium m.c. of the tomato samples (% db)

M_o = Initial m.c. of the samples before drying (% db)

2.4.3 Effective Moisture Diffusivity

The effective moisture diffusivity (D_{eff}) was estimated using the “simplified mathematical Fick’s second diffusion model”. The solution of Fick’s second law in slab geometry, having the following assumptions; that moisture migration is strictly dependent on diffusion, shrinkage is negligible, diffusion coefficients are constant and temperature which was the diffusion model was simplified to linear equation by Crank (1975) as it is expressed in Equation 3.

$$MR = \frac{M}{M_o} = \frac{8}{\pi^2} \sum_{n=1}^{\infty} \frac{1}{(2n-1)^2} \exp \left[\frac{-(2n-1)^2 \pi^2 D_t}{4L^2} \right] \quad (3)$$

where,

MR = Moisture Ratio

M = Moisture content at any time (kg water/kg dry matter)

M_o = Initial moisture content (kg water/kg dry matter)

$n = 1, 2, 3, \dots$ the number of terms taken into consideration

t = time of drying in seconds

D_t = Effective moisture diffusivity (m^2/s)

L = thickness of the slice (m)

Equation 4 was used since the drying process involved a long term drying due to high moisture content present in tomato

$$MR = \frac{8}{\pi^2} \exp \left[\frac{\pi^2 D_t}{4L^2} \right] \quad (4)$$

The slope (K_o) of the graph was estimated by plotting $\ln (MR)$ against time (t) as presented in Equation 5;

$$K_o = \frac{\pi^2 D}{4L^2} \quad (5)$$

2.5 Design of Experiment

The experiment was designed using the Box-behnken design (BBD) of response surface framework of Design Expert Software V 6.0.6 (US, Stat-Ease Inc.) resulting in 68 runs. The experimental input parameters were sample variety (*Hausa*, *Tiwantiwa* and *Roma VFN*), slice thickness (5.0 mm, 7.5 mm and 10 mm), pre-drying treatment (Ethyl acetate, $MgCl_2 \cdot 6H_2O$ and $Na_2S_2O_5$, NaCl and Honey and Sugar) and drying-air temperature (45, 55 and 65°C).

2.56 Statistical Analysis

In this experiment statistical analysis of responses were done using quadratic model interface of the Design Expert software with alpha to exit 0.050 and regression coefficients were obtained.

3. RESULTS AND DISCUSSION

3.1 Effects of Input Parameters on Moisture Ratio and Effective Moisture Diffusivity

3.1.1 Effect of Drying-air Temperature, Slice Thickness, Variety and Pre-drying Treatments on Moisture Ratio

The effect of drying-air temperature on the moisture ratio (MR) of tomato samples is shown in Figure 2 a, it shows that samples subjected to 65°C had average MR of 70.19%, 55°C had 69.13%, while those subjected to 45°C had the highest average MR of 77.54%. This result agrees with the findings of Yousefi et al. (2013) on the drying of papaya slices at 40, 50 and 60°C. The highest MR in samples dried at 45°C can be attributed to the slowest rate at which

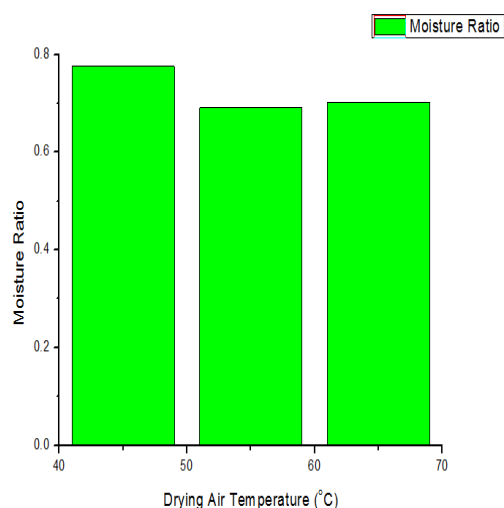


Figure 2 a: Effect of Air-temp. on Moisture Ratio

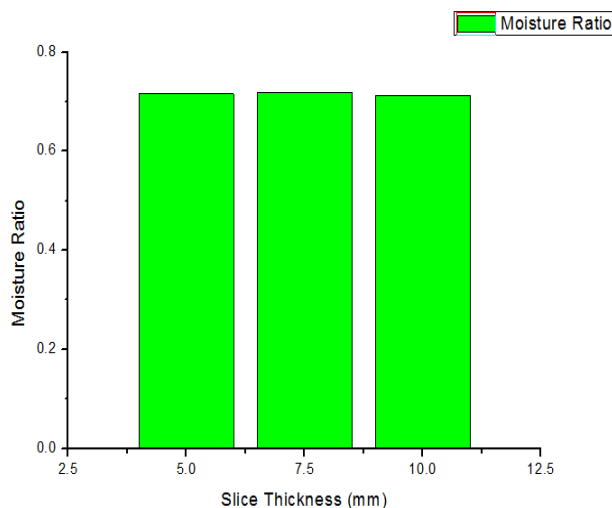


Figure 2 b: Effect of Slice Thickness on Moisture Ratio

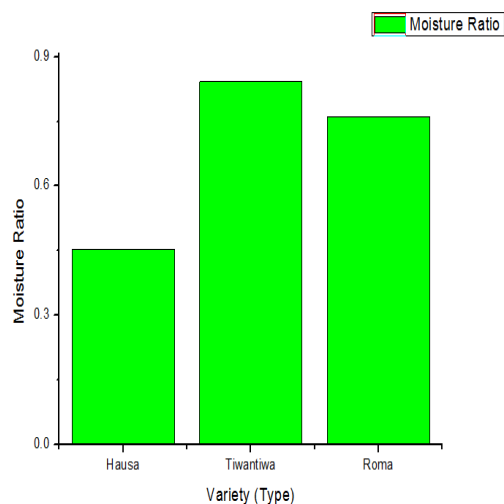


Figure 2 c: Effect of Variety on Moisture Ratio

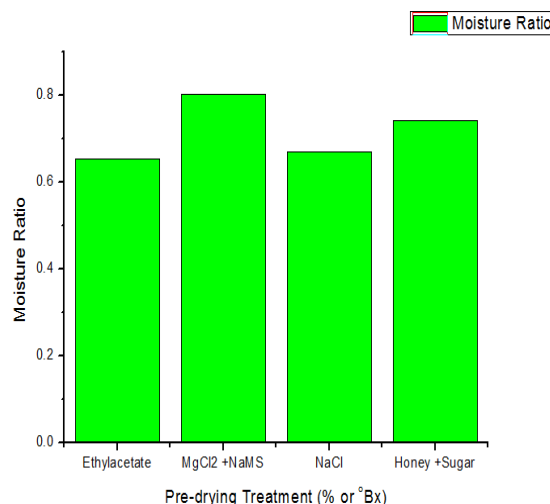


Figure 2 d: Effect of Pre-drying Treatment on Moisture Ratio

Table 1: Analysis of Variance for Moisture Ratio of Tomato Slices

Source	Sum of Squares	DF	Mean Square	F Value	Prob > F	
Model	2.32	21	0.11	11.95	< 0.0001	<i>Sig.</i>
A	0.061	1	0.061	6.60	0.0137	
B	2.979E-005	1	2.979E-005	3.217E-003	0.9550	
C	0.90	1	0.90	97.05	< 0.0001	
D	0.21	3	0.071	7.63	0.0003	
A ²	9.739E-003	1	9.739E-003	1.05	0.3107	
B ²	2.642E-003	1	2.642E-003	0.29	0.5959	
C ²	0.93	1	0.93	100.38	< 0.0001	
AB	3.169E-004	1	3.169E-004	0.034	0.8541	
AC	0.034	1	0.034	3.69	0.0611	
AD	0.057	3	0.019	2.07	0.1184	
BC	5.621E-003	1	5.621E-003	0.61	0.4401	
BD	6.219E-003	3	2.073E-003	0.22	0.8793	
CD	0.11	3	0.035	3.83	0.0160	
Residual	0.41	44	9.260E-003			
LOF	0.40	28	0.014	25.55	0.0001	
Pure Error	8.914E-003	16	5.571E-004			
Cor Total	2.73	65				

LOF-Lack of Fit; Significance Level ($p \geq 0.05$)

moisture was diffusing out of the samples in which more moisture was retained in the samples compared with those dried at 55°C and 65°C. Moisture gets more excited at higher drying-air temperature and diffuses. ANOVA Table 1, revealed that the effect of drying-air temperature (D) was significant on the MR of samples at significance level of $p \leq 0.05$.

The effect of slice thickness on MR is shown in Figure 2 b. It is seen that the MR of samples sliced at 5.0 mm, 7.5 mm and 10 mm were 71.59 %, 71.89% and 71.29% respectively. This values were seen to be very close and the ANOVA Table 2 shows that the effect of slice thickness (B) was not statistically significant ($p \leq 0.05$) on the MR.

The effect of samples' variety on the MR of tomato is shown in Figure 2 c, it was found that *Hausa* variety had an average MR of 45.27%, *Tiwantiwa* variety had 84.25% and *Roma VFN* variety had 76.03%, these show that *Tiwantiwa* variety has the highest MR and *Hausa* variety has the lowest. This can be attributed to the high initial m.c. of *Tiwantiwa* variety which was 95.82% and low moisture content of *Hausa* variety which was 85.03%. While that of *Roma VFN* variety had initial moisture content of 93.76%. The difference in MR of the samples might be attributed to the microstructural characteristics of the tomato varieties as the cells of *Tiwantiwa* variety might be less porous and able to retain more moisture compared with others. The ANOVA Table 1 further reveals it that statistically the individual effect of tomato variety (C), its quadratic effect (C^2) and the interactive effect CD between variety and pre-drying treatment were highly significant statistically at $p \leq 0.05$ on the MR.

The effect of samples' pre-drying treatment on MR of treated tomato samples is shown in Figure 2 d samples pre-treated with ethyl acetate solution had 65.34% MR, those with $MgCl_2 \cdot 6H_2O$ and $Na_2S_2O_5$ solution had 80.21%, while those with NaCl solution had 66.95%, those pre-treated with mixture of honey and sugar solution had 74.11% and control samples had an average MR of 74.09%. This

observation would result from the hydrophilic property of $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ which makes it highly hygroscopic in nature and therefore samples pre-treated in it has the highest MR. Ethyl acetate easily vaporizes into the air and not hygroscopic in nature and therefore was seen to have the least MR among others. As further shown by the ANOVA Table 1 statistically the effect of pre-drying treatment was significant on the MR of treated samples ($p \leq 0.05$).

3.1.2 Effects of Drying-air Temperature, Slice Thickness, Variety and Pre-drying Treatments on Effective Moisture Diffusivity

The effect of drying-air temperature on the effective moisture diffusivity (D_{eff}) of tomato samples is shown in Figure 3 a, it was seen that samples subjected to 65°C had highest D_{eff} of $1.69 \times 10^{-8} \text{ m}^2/\text{s}$, 55°C had $1.20 \times 10^{-8} \text{ m}^2/\text{s}$, while those subjected to 45°C had the lowest D_{eff} of $5.99 \times 10^{-9} \text{ m}^2/\text{s}$, this agrees with the findings of Yilmaz et al. (2017), that increase in air temperature led to increase in D_{eff} . Results with this trend had been reported earlier by Jaiyeoba and Raji (2012) who had worked on the estimation of D_{eff} of Tomato and found that D_{eff} increases with increase in air temperature and also found that the D_{eff} of tomato was within $10^{-8} \text{ m}^2/\text{s}$. The highest D_{eff} observed in samples dried at 65°C can be attributed to the high level of drying-air temperature used which contains more heat energy required to activate the movement of water from the internal part of the products to their surface for drying to occur. As reported by Mewa et al. (2018), that water activity increases with increase in temperature which results in increase in D_{eff} of beef during drying. Analysis of Variance (ANOVA) Table 2, shows that the effect of drying-air temperature was highly significant on the D_{eff} of samples at $p \leq 0.05$, therefore the findings of Yilmaz et al. (2017) was replicated that effect of drying-air temperature was significant on the D_{eff} of pomegranate fruit leather.

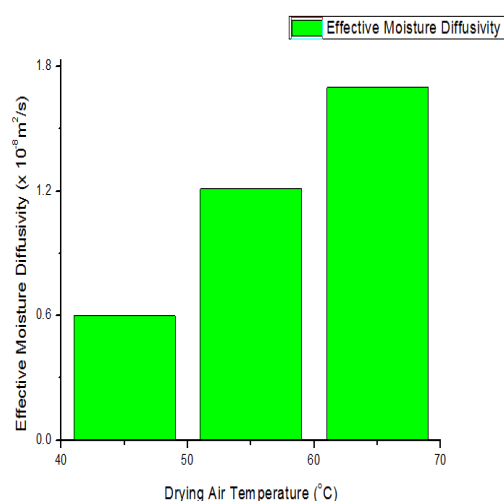


Figure 3 a: Effect of Air-temp. on Effective Moisture Diffusivity

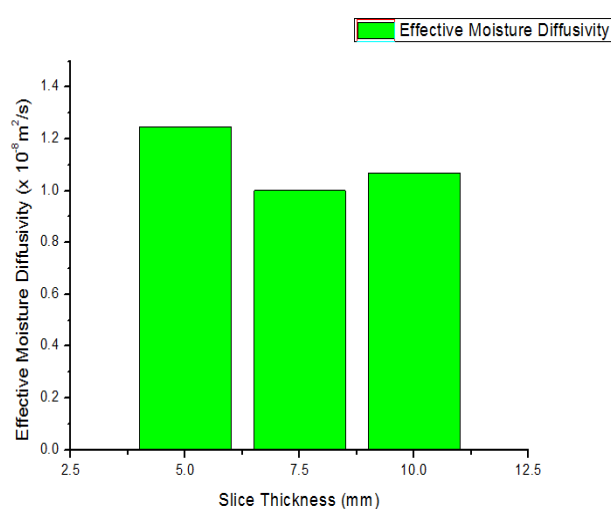


Figure 3 b: Effect of Slice Thickness on Eff. Moisture Diffusivity

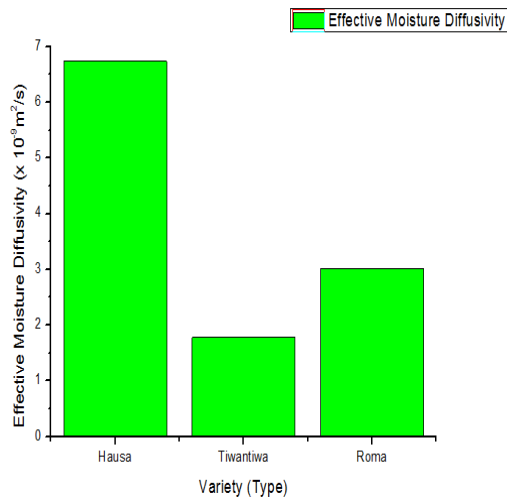


Figure 3 c: Effect of Variety on Eff. Moisture Diffusivity

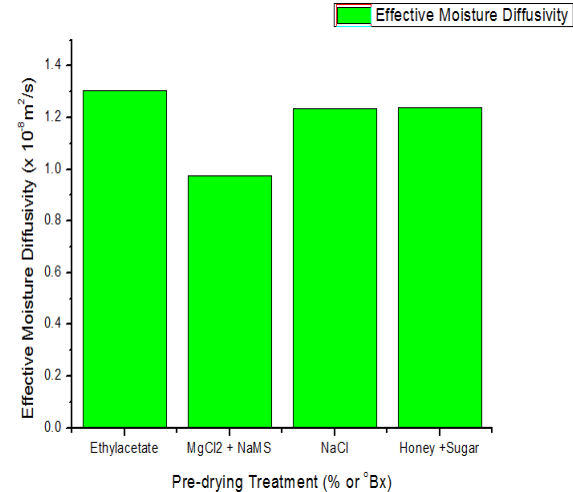


Figure 3 d: Effect of Pre-drying Treatment on Eff. Moisture Diffusivity

Table 2: Analysis of Variance for Effective Moisture Diffusivity of Tomato Slices

Source	Sum of Squares	DF	Mean Square	F Value	Prob.>F
Model	4.107E-015	21	1.956E-016	4.81	< 0.0001 Sig.
A	1.043E-015	1	1.043E-015	25.63	< 0.0001
B	1.575E-017	1	1.575E-017	0.39	0.5369
C	1.574E-016	1	1.574E-016	4.36	0.0408
D	1.040E-016	3	3.465E-017	0.85	0.4728
A ²	9.811E-018	1	9.811E-018	0.24	0.6257
B ²	1.433E-017	1	1.433E-017	0.35	0.5557
C ²	2.492E-015	1	2.492E-015	61.26	< 0.0001
AB	1.699E-019	1	1.699E-019	4.177E-003	0.9488
AC	6.786E-019	1	6.786E-019	0.017	0.8978
AD	2.452E-016	3	8.175E-017	2.01	0.1257
BC	6.958E-020	1	6.958E-020	1.711E-003	0.9672
BD	2.275E-017	3	7.582E-018	0.19	0.9051
CD	2.528E-017	3	8.428E-018	0.21	0.8909
Residual	1.871E-015	46	4.068E-017		
LOF	1.231E-015	30	4.103E-017	1.03	0.4949
Pure Error	6.400E-016	16	4.000E-017		
Cor Total	5.978E-015	67			

LOF-Lack of Fit; Significance level ($p \geq 0.05$)

Effect of slice thickness on D_{eff} is found in Figure 3 b. The D_{eff} of tomato samples sliced at 5 mm, 7.5 mm and 10 mm were 1.25, 1.00 and $1.07 \times 10^{-8} \text{ m}^2/\text{s}$ respectively. These values were seen to be quite close and the ANOVA Table 2 shows that the effect of slice thickness was not significant statistically at $p \leq 0.05$ on the D_{eff} . However, this is not in agreement to the report by Yilmaz et al. (2017) that increase in slice thickness results in increase in effective moisture diffusivity and states that slice thickness was statically significant on D_{eff} .

The effect of samples' variety on the D_{eff} of tomato is shown in Figure 3 c, it was found that *Hausa* variety had an average D_{eff} of $6.73 \times 10^{-9} \text{ m}^2/\text{s}$, *Tiwantiwa* variety had $1.78 \times 10^{-9} \text{ m}^2/\text{s}$ and *Roma VFN*

variety had $3.02 \times 10^{-9} \text{ m}^2/\text{s}$, these show that *Hausa* variety had the highest D_{eff} and *Tiwantiwa* variety had the lowest. These show that the samples with the highest moisture content tend to have lower effective moisture diffusivity than those with the lowest moisture content which have higher effective moisture diffusivity. *Tiwantiwa* variety had the highest initial moisture content of 95.82% and MR while *Hausa* variety had lowest initial moisture content of 85.03% and lowest MR. Roma VFN variety has initial moisture content of 93.76% and average MR. This was in agreement with the findings Sharma and Prasad (2004) in which it was found that D_{eff} is a function of samples' m.c. which increases gradually with decrease in m.c. The reason for this was that as m.c. decreased vapour phase diffusivity increased provided the pores were kept opened. The ANOVA Table 2 further reveals it that statically the individual effect of tomato variety (C) and its quadratic effect (C^2) were highly significant ($p \leq 0.05$) on the D_{eff} .

The effect of samples' pre-drying treatment on D_{eff} of treated tomato samples is shown in Figure 3 d, samples pre-treated with ethyl acetate solution had $1.31 \times 10^{-8} \text{ m}^2/\text{s}$ D_{eff} , those with $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ and $\text{Na}_2\text{S}_2\text{O}_5$ solution had $9.76 \times 10^{-9} \text{ m}^2/\text{s}$, while those with NaCl solution had $1.23 \times 10^{-8} \text{ m}^2/\text{s}$, those pre-treated with mixture of honey and sugar solution had $1.24 \times 10^{-8} \text{ m}^2/\text{s}$ and control had $8.425 \times 10^{-9} \text{ m}^2/\text{s}$. Samples pre-treated with ethyl acetate solution had the highest effective moisture diffusivity while those pre-treated in $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ and $\text{Na}_2\text{S}_2\text{O}_5$ solution had the lowest. From Figure 2 d it can be seen that samples pre-treated in ethyl acetate had the lowest MR while those pre-treated in $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ and $\text{Na}_2\text{S}_2\text{O}_5$ solution had the highest MR. Therefore, the higher the MR the lower the effective moisture diffusivity and vice versa. This claim had also been found by Sharma and Prasad (2004) and Darvishi et al. (2016). As further shown by the ANOVA Table 2 statistically the effect of samples' pre-drying treatment was not significant on the D_{eff} of treated samples ($p \leq 0.05$).

4. CONCLUSION

1. Moisture ratio of tomato at any stage during the drying process reduces with increase in drying-air temperature but effective moisture diffusivity increases with increase in drying-air temperature
2. The moisture ratio of tomato was dependent on its variety which can be linked to its initial moisture content, also Pre-drying treatment of samples had strong influence on samples' MR and effective moisture diffusivity which can either increase or decrease it.
3. Samples' lowest MR were obtained under these conditions; processed *Hausa* variety, 10 mm thickness, Ethyl acetate pre-drying treatment and dried at 55°C while highest effective moisture diffusivity was obtained under these conditions processed *Hausa* variety, 5 mm thickness, Honey and Sugar pre-drying treatment and dried at 65°C in a FCCD.
4. Processed *Hausa* variety is more preferable to other varieties of tomato used; as it promotes low MR and high effective moisture diffusivity during the drying process. This will help reduced energy consumed during drying of tomato and will save processing time.

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