EFFECT OF FOAMING AGENT, FOAM STABILIZER AND WHIPPING TIME ON DRYING PROCESS OF TOMATO PASTE UNDER DIFFERENT DRYING EQUIPMENT

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ABSTRACT

Laboratory experiments were conducted to determine the effect of foaming agent (egg white, EW), foam stabilizer (carboxyl methyl cellulose, CMC) and whipping time on drying rate and quality of tomato (*Lycopersicon esculentus)* paste dried under air oven, microwave oven and mechanical dryer. A 4^3 factorial experiment in Randomized Complete Block Design (RCBD) was used to study the effect four levels each of foaming agent (5, 10, 15 and 20% EW), foam stabilizer (0.15, 0.30, 0.45 and 0.60% CMC) and whipping time (3, 5, 7 and 9 min) on drying rate and quality of foam-mat dried tomato powder in the three drying equipment. Each trial was performed in triplicates making a total number of 576 samples that were individually tested and measured. 25 g sample of the paste were dried to a moisture content of 7.60 % (wb) for 8 h in mechanical dryer and oven dryer at temperatures of 55 ^{0}C and 50 ^{0}C respectively and 10 min in microwave oven at 540W. Data obtained from the experiments were statistically analyzed using the analysis of variance (ANNOVA) while the Duncan's Multiple Range Test was used to compare the means. Results showed that drying rate increased with increase in foaming agent, foam stabilizer and whipping with minimum values of 9.21 g/h obtained in mechanical dryer, 9.31 g/h in air oven, and 8.05 g/h in microwave oven. Increase in foaming agent, foam stabilizer and whipping time did not cause any adverse effect on vitamin C, ash, protein, fat, carbohydrate, crude fibre contents of the samples. Samples reached a stable moisture content of 7.60 % (wb) in less than 8 h in mechanical dryer and air and less than 10 min in microwave oven. The results of the study showed that egg white, CMC and whipping time influenced the drying rate and quality of foam-mat dried tomato powder.

Keywords: foaming agent, foam-mat drying, foam stabilizer, drying rate, equipment, tomato

1. INTRODUCTION

Tomato (*Lycopersicon esculentus*) is the second most important vegetable in many regions of the world with the production in Nigeria being more than doubled in the last ten years. In 2001 alone, the production was 879,000 metric tonnes (FAO 2002) and these were largely consumed in the fresh state. Large quantities are processed into soups, juices, sauces, puree, paste and canned products. Transportation of tomatoes over long distance, hauls in lorries or trucks or in basket subject the tomatoes to vibration and bruising, hence cause loss of nutrient due to enzymatic actions.

Daily intake of tomatoes provides the body some nutrients such as carotene, vitamin, lycopene which lower the risk of cancer and cardiovascular diseases as recommended by the American Cancer Society (Block, Patterson, and Subar 1992). Tomatoes also have antioxidant components that are medically useful in the area of cataracts, bone metabolism and asthma. About 90 % of the developing nations' (such as Nigeria) food supply are wasted owing to postharvest deterioration each year. Tomato production is seasonal and it is a highly perishable commodity in its natural state after harvest. Thus processing it to a form that can be easily preserved is crucial to minimizing wastage and spoilage during the production season and ensuring that maximum nutritional values of the fruit are retained. Literature and past researches (Sachin, Janghan, and Mujumdar 2011) have shown that drying is one of the best methods of preserving fruits, vegetable and foods.

Various methods of drying fruits, vegetables and food exist; such methods include open sun drying, controlled solar drying, hot-air drying, freeze drying, vacuum drying and more. Idah, Obajemihi, Adeboye, and Olaniyan (2014) studied the assessment of osmotic dehydration-assisted drying of tomato at different drying temperatures under a hot-air dryer. They reported that the osmotic dehydration pretreatments had great influence on the drying kinetics and quality of tomato. The drying characteristic of banana chips and physicochemical changes during drying process were investigated by Itang (2010a, 2010b). Result of the study revealed that a drying temperature and microwave energy of 55 ^{0}C and 2.5 W/g respectively were the most suitable drying parameters while the biggest physicochemical changes were found at the primary drying stage. Olaniyan and Omoleyomi (2013) investigated the drying process of Okra (*Abelmoschus caillei*) under different conditions using a hot-air dryer. Result showed that an optimum drying rate could be achieved by subjecting okra to osmotic dehydration pretreatment prior to drying.

According to Jangan, Law, and Mujumdar (2011), the four major considerations in drying food, vegetables and fruits are speed of operation, energy efficiency, cost of operation and quality of dried products. It is essential that any food drying process should carefully establish these parameters as objective functions. This present study was conducted to investigate some of these parameters in drying tomato paste to tomato powder under different drying equipment: air oven, microwave oven and mechanical dryer. Therefore, the objectives of the study were: (i) to develop mathematical models to estimate the effects of foaming agent (egg white, EW), foam stabilizer (carboxyl methyl cellulose, CMC) and whipping time on drying rate and quality of tomato paste dried under air oven, microwave oven and mechanical dryer; and (ii) to optimize the drying process for maximum drying rate and quality of dried product. It is expected that this will elucidate the problems of drying and enable the establishment of process parameters for optimal drying of tomato paste to tomato powder.

2. MATERIALS AND METHODS

2.1. Experimental Equipment

The following equipment and apparatus were used for the study: (i) a mechanical dryer designed and fabricated by Omodara, Olaniyan, and Oyewole (2011) as shown in Figure 1; (ii) a microwave oven (Model: HTMO- 2890EG); (iii) an air oven (Model: MINO/50-10G039, Genlab Engineers); (iv) an electronic weighing balance; (v) a stainless steel knife; (vi) desiccators; and (vii) a blender (Model: HR-2815).

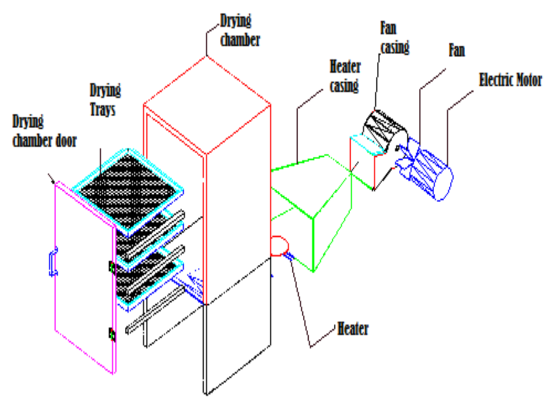

Figure 1: Exploded View of the Mechanical Dryer showing the Component Parts

2.2. Experimental Design

A 4^3 factorial experiment in a randomized complete block design was used in this study. The factors taken into consideration included 3 levels each of foaming agent, foam stabilizer, and whipping time. The range of foaming agent considered was 5, 10, 15 and 20 % EW; foam stabilizer was 0.15, 0.30, 0.45 and 0.60 % CMC while the whipping time was 3, 5, 7. and 9 min. Every trial was carried out in triplicate in the three drying equipment (mechanical dryer, air oven and microwave oven), making total of 576 samples that were individually tested and measured.

2.3. Experimental Procedure

The experiment was carried out in the Department of Chemical Engineering Laboratory, University of Ilorin. The average room temperature was 30 ^{0}C throughout the period of experimentation. Enough quantities of fresh and ripe tomatoes were bought from a local market in Ilorin metropolis. The tomatoes were graded to ensure uniformity of samples to be used for experimentation.

2.3.1. Sample Preparation

The graded tomatoes were washed in clean water, sliced and deseeded with the use of the stainless steel knife on a stainless steel tray and then blended to form tomato concentrate. 100 ml of the concentrate was measured and foamed with 5, 10, 15 and 20 % EW and 0.15, 0.30, 0.45 and 0.60 % CMC. The mixture was then foamed for 3, 5, 7 and 9 min whipping time with the aid of the blender to form a ready-for-drying foamed mixture.

2.3.2. Drying Procedure

The air oven and mechanical dryer were set at temperatures 50 ^{0}C and 55 ^{0}C respectively while the microwave oven was set at power of 540W. 25g of foamed samples prepared as described earlier were spread evenly on the labelled laboratory dishes at a foam thickness of between 2-3 mm and carefully placed inside each of the drying equipment for drying as shown in Figures 2, 3 and 4 below. The weights of the samples were taken every one hour and the drying operation continued until there was no more changes in the weight of the samples. The experiment was performed in triplicate in all the three drying equipment.

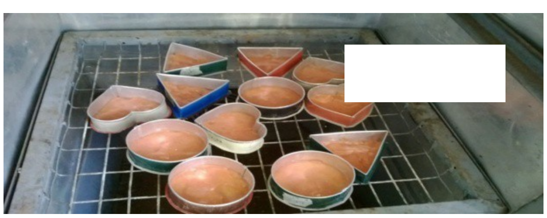

Figure 2: Samples in the Mechanical Dryer during Drying

Figure 3: Sample in the Air Oven during Drying

Figure 4: Samples in the Microwave Oven during Drying

2.4. Output Parameters

2.4.1. Drying Kinetics

In this study, drying rate is the amount of moisture removed from product per unit time during a drying operation. It was determined by the equation used by Olaniyan and Omoleyomi (2013) which is expressed below as:

$$R=\left(\frac{dM}{dt}\right)=\frac{m_i-m_f}{t} \quad (1)$$

where; R is the drying rate in g/h; dM is change in mass of okra in g; dt change in time in h; t is the total time of drying in h; m_i and m_f are the initial and final mass of okra samples respectively in g.

2.4.2. Quality of Dried Product

Proximate analysis of the dried samples were carried out to determined their crude protein, crude fat, vitamin C, ash content, carbohydrate, crude fibre and moisture contents using the standard procedures (AOAC 1990). These together with colour evaluation were used as quality determining criteria in this study.

2.5. Experimental Analysis

Using the SPSS (16.0) computer software package, model equations were developed by employing essential regression analysis. The model equations were used to predict the drying rate and quality of dried product based on foaming agent, foam stabilizer and whipping time. Furthermore, the drying process was optimized for maximum drying rate and maximum post-drying quality considered in the study.

3. RESULTS AND DISCUSSION

3.1. Development of Model Equations

The model was based on a three-factor essential regression model and the factors were foaming agent, foam stabilizer and whipping time. From the regression analysis, the following regression models (Equations 2 – 9) were obtained for drying rate, vitamin C content, ash content, fat content, crude fibre content, carbohydrate content, protein content and moisture content respectively.

3.1.1. Drying Process in Mechanical Dryer

The model developed for the drying process of tomato paste in the mechanical dryer is described by the equations below:

Y_{ddr} =

$10.96-0.232\alpha-5.619\beta+0.01177\alpha^2+1.508\alpha\beta$

; $R^2 = 0.89$ (2)

Y_{dvc}

$-0.453\gamma+1.575\alpha\beta-0.00232\alpha^2{}_2$

; $R^2 = 0.91$ (3)

Y_{das}

$-0.04316\alpha\beta+0.000861\alpha\gamma+0.08476\beta\gamma-{}_2$

; $R^2 = 0.85$ (4)

Y_{dfa} =

$1.637-0.113\gamma-0.000976\alpha^2-0.06560\alpha\beta+0.00651\alpha\gamma+0$

; $R^2 = 0.81$ (5)

Y_{dcf} =

$3.323-0.00547\gamma-0.127\alpha\beta+0.995\beta^2=0.00431\alpha^2\beta$

; $R^2 = 0.85$ (6)

Y_{dca} =

$4.170+0.000591\alpha^2\gamma-0.001\alpha^2\gamma+0.000297\alpha\beta\gamma$,

$R^2 = 0.90$

(7)

Y_{dpr}= 0

$.547-0.03686\alpha-0.08069\gamma+0.00284\alpha\beta^2+0.02757\alpha\beta+0$

$R^2 = 0.91$

(8)

Y_{dmc} =

$87.83-0.00381\alpha^2+0.252\alpha\beta-4.071\beta^2+0.000539\alpha^2\gamma-0.0$

, $R^2 = 0.88$ (9)

where Y_{ddr}, Y_{dvc}, Y_{das}, Y_{dfa}, Y_{dcf}, Y_{dca}, Y_{dpr} and Y_{dmc} are drying rate, vitamin C content, ash content, fat content, crude fibre content, carbohydrate content, protein content and moisture content respectively and α, β and γ are foaming agent, foam stabilizer and whipping time respectively.

3.1.2. Drying Process in Air Oven

The model developed for the drying process of tomato paste in the air oven is described by the equations below:

Y_{adr} =

$= 7.693+24.22\beta-1.159\alpha\beta+0.07100\alpha\gamma-23.53\beta^2$

$-2.352\ \beta\ 43.36-8.527\ \beta$

; R = 0.80 (10)

Y_{avc} =

$=39.17+1.112\alpha\beta+0.03877\alpha\gamma-14.64\beta^2-0.05078\alpha^2\beta$

$+1.124\ 1.252$

; R = 0.90 (11)

Y_{aas} =

$1.235+0.0778\,\alpha-0.00204\,\alpha\gamma-0.00260\,\alpha^2\,\beta+0.\ 0$

; R^2 = 0.89 (12)

Y_{afa} =

$1.524-0.106\,\gamma+0.01515\,\gamma^2-0.0001\,\alpha^2\,\gamma+0.146$

; R^2 = 0.83 (13)

Y_{acf} =

$3.953-0.05952\,\alpha-0.07786\,\gamma-2.237\,\beta^2+0.308$

; R^2 = 0.89 (14)

Y_{aca} =

$4.302+1.593\,\beta-0.08763\,\gamma-0.353\,\alpha\,\beta+0.01306$

; R^2 = 0.91 (15)

Y_{apr} =

$1.843+0.04380\,\alpha+3.393\,\beta-0.288\,\alpha\,\beta-4.824\,\beta^2$

, R^2 = 0.85 (16)

Y_{amc} =

$88.46-12.20\,\beta+0.852\,\alpha\,\beta-0.02793\,\alpha\,\gamma+10.68\,\beta^2$

; R^2 = 0.81 (17)

where Y_{adr}, Y_{avc}, Y_{aas}, Y_{afa}, Y_{acf}, Y_{aca}, Y_{apr} and Y_{amc} are drying rate, vitamin C content, ash content, fat content, crude fibre content, carbohydrate content, protein content and moisture content respectively and **α**, β and γ are foaming agent, foam stabilizer and whipping time respectively.

3.1.3. Drying Process in Microwave Oven

The model developed for the drying process of tomato paste in the microwave oven is described by the equations below:

Y_{mdr} =

$4.383+0.559\,\alpha+2.424\,\alpha^2-0.01861\,\alpha^2-0.155\,\alpha$

; R^2 = 0.85 (18)

$Y_{mvc} = 41.33-0.315\,\alpha+9.552\,\beta+0.122\,\alpha\,\gamma-3.292\,\beta\gamma-0.00849\,\alpha\,\gamma$

, R^2 = 0.90 (19)

Y_{mas}=

$1.248+0.01769\,\alpha-0.392\,\beta-0.000995\,\alpha^2+0.718\,\beta^2+0.0003$

; R^2 = 0.91 (20)

Y_{mfa}=

$1.336-0.07280\,\alpha+0.155\,\gamma+0.00308\,\alpha^2+0.109\,\alpha\,\beta-0.196\,\beta$

; R^2 = 0.88 (21)

Y_{mcf} =

$3.715-4.013\,\beta+0.00132\,\alpha^2-0.01627\,\alpha\,\beta+3.715\,\beta^2+0.768$

; R^2 = 0.85 (22)

Y_{mca} =

$4.257-0.00335\,\gamma^2+0.00220\,\alpha^2\,\beta-0.113\,\alpha\,B^2+0.00869\,\beta\,\gamma^2$

; R = 0.90 (23)

Y_{mpr} =

$2.206+0.000121\,\alpha^2+0.00200\,\gamma^2+0.00346\,\alpha\,\beta\gamma-0.000164\,\alpha$

; R^2 = 0.91 (24)

Y_{mmc} =

$86.51+8.292\,\beta-0.00201\,\alpha^2+0.02645\,\alpha\,\gamma-9.302\,\beta^2-1.364$

$R^2 = 0.88$ (25)

where Y_{mdr}, Y_{mvc}, Y_{mas}, Y_{mfa}, Y_{mcf}, Y_{mca}, Y_{mpr} and Y_{mmc} are drying rate, vitamin C content, ash content, fat content, crude fibre content, carbohydrate content, protein content and moisture content respectively and **α**, β and γ are foaming agent, foam stabilizer and whipping time respectively.

3.2. Model Validation

The measured (observed) outputs of drying rate and post-drying quality attributes of tomato paste were compared with the predicted values from the developed models. The two sets of data were plotted on the same graph to see how favourably compared the two of the curves are and the plots are shown in Figures 5, 6 and 7. From the figure, it is obvious that little or no difference could be noticed in the trend of the paired curves generated. This shows that all the predicted values compared favourably with the observed values. Therefore, the models reliably predicted the drying characteristics of tomato paste very well in terms of these output parameters.

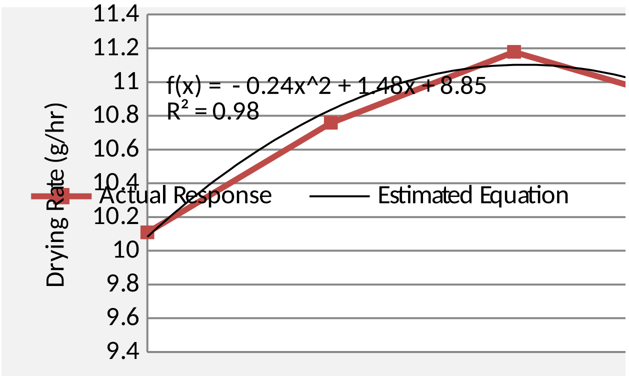

Figure 5: Effect of Foaming Agent on Drying Rate using Mechanical Dryer

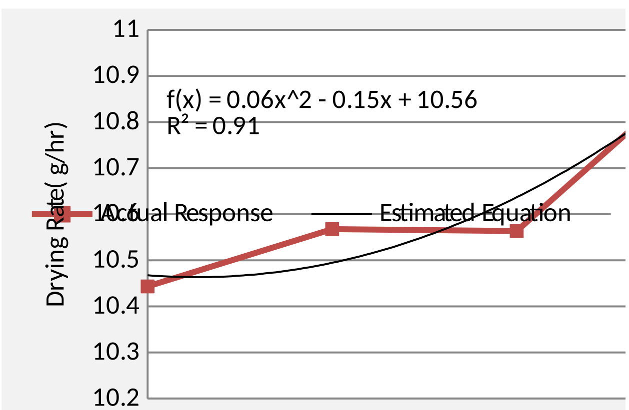

Figure 6: Effect of Foaming Agent on Drying Rate using Air Oven

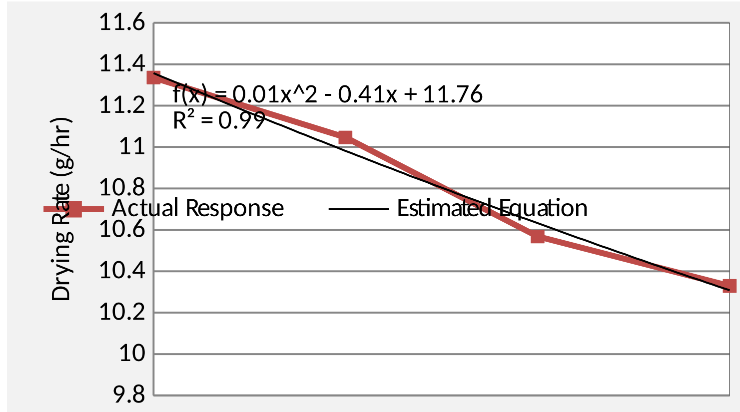

Figure 7: Effect of Foaming Agent on Drying Rate using Microwave Oven

3.3. Process Optimization

The optimum values of the process variables (foaming agent, foam stabilizer and whipping time) and optimized value of process outputs (drying rate and post-drying qualities) are presented in Table 2. The table shows that in order to maximize drying rate of tomato paste in the mechanical dryer, foaming agent, foam stabilizer and whipping time of 14.0 %EW, 0.48 %CMC and 9 min respectively must be combined to give the optimum drying rate of 11.36 g/h. For ash content, a combination 20 %EW foaming agent, 0.6 %CMC foam stabilizer and whipping time of 9 min resulted to the optimum value of 1.3 %.

An optimum value of 43.4 % was obtained for vitamin C at a foaming agent of 8.78 %EW, foam stabilizer of 0.6 %CMC and whipping time of 9 min. The crude fat content of tomato paste has 1.39 % as its optimum value and this corresponds to a combination of 5 %EW foaming agent, 0.15 %CMC foam stabilizer and 3 min whipping time. A foaming agent of 5 %EW, foam stabilizer of 0.15 %CMC and whipping time of 3 min should be selected to give the optimum crude fibre of 3.25 %.

Carbohydrate requires a foaming agent of 20 %EW, foam stabilizer of 0.6 %CMC and whipping time of 3 min to give the optimum value of 4.3 %. An optimum value of 2.5 % was obtained for protein at a foaming agent of 20 %EW, foam stabilizer of 0.15 %CMC and whipping time of 3 min. Ash content of dried tomato powder has 1.18 % as its minimum value and this corresponds to a combination of 20 %EW foaming agent, 0.3 %CMC foam stabilizer and 3 min whipping time.

Table 2: Optimized Values of Process Parameters and Process Outputs

Drying Equipment	Output Parameters	Foaming Agent (%EW)	Foam Stabilizer (%CMC)	Whipping Time (min)	Optimized Value	Nature of Solution
Mechanical Dryer	Drying Rate (g/h)	14.0	0.48	9	11.36	Maximized
		5	0.15	3	10.16	Minimized
	Vitamin C (%)	8.78	0.6	9	43.4	Maximized
		20	0.15	6	40.9	Minimized
	Ash (%)	20	0.6	9	1.3	Maximized
		20	0.3	3	1.18	Minimized
	Fat (%)	5	0.15	3	1.39	Maximized
		13.2	0.6	6.7	1.25	Minimized
	Crude Fibre (%)	5	0.15	3	3.25	Maximized
		14.79	0.47	9	3.0	Minimized
	Carbohydrate (%)	20	0.6	3	4.3	Maximized
		20	0.15	9	4.0	Minimized
	Protein (%)	20	0.15	3	2.5	Maximized
		9.29	0.15	5.87	2.2	Minimized
Air Oven	Moisture Content (%)	20	0.15	9	8.8	Maximized
		20	0.15	3	8.7	Minimized
	Drying Rate (g/h)	20	0.15	6.7	11.57	Maximized
		5	0.6	6.5	9.56	Minimized
	Vitamin C (%)	15.6	0.3	3	42.7	Maximized
		5	0.5	3	39.9	Minimized
	Ash (%)	12	0.6	3	1.3	Maximized
		20	0.4	3.8	1.2	Minimized
	Fat (%)	5	0.6	3	1.39	Maximized
		20	0.4	6.55	1.18	Minimized
	Crude Fibre (%)	5	0.2	3	3.5	Maximized
		17	0.5	9	3.0	Minimized
	Carbohydrate (%)	20	0.15	6.4	4.2	Maximized
		20	0.3	3	3.8	Minimized
	Protein (%)	20	0.15	3	2.4	Maximized
		20	0.3	9	2.2	Minimized
Microwave Oven	Moisture Content (%)	20	0.3	3	8.9	Maximized
		5	0.4	9	8.7	Minimized
	Drying Rate (g/h)	5	0.15	6.26	12.05	Maximized
		13	0.6	3	9.59	Minimized
	Vitamin C	20	0.15	7.3	43.5	Maximized

Drying Equipment	Output Parameters	Foaming Agent (%EW)	Foam Stabilizer (%CMC)	Whipping Time (min)	Optimized Value	Nature of Solution
	(%)	5	0.6	6.5	41	Minimized
	Ash (%)	11.1	0.15	9	1.3	Maximized
		20	0.6	3	1.2	Minimized
	Fat (%)	5	0.15	5.4	1.4	Maximized
		14.5	0.15	3	1.2	Minimized
	Crude Fibre (%)	5	0.16	9	3.5	Maximized
		7.4	0.6	9	2.9	Minimized
	Carbohydrate (%)	20	0.2	3	4.3	Maximized
		15.5	0.6	3	3.95	Minimized
	Protein (%)	20	0.6	9	2.3	Maximized
		5	0.15	3	2.2	Minimized
	Moisture Content (%)	12.9	0.6	6.4	8.8	Maximized
		5	0.15	3.2	8.7	Minimized

EW= Egg white, CMC= Carboxyl Methyl Cellulose, WT= Whipping Time

3.4. Practical Application

Preservation of tomato and quality retention could be best achieved if it is processed to a powdery form immediately after harvest. The process involves drying tomato paste to a powdery form with a shelf-stable moisture content. Since tomato is a food product, pretreatment methods, drying conditions and other process parameters should be carefully controlled in order not to destroy or denature the sensory characteristics such as flavor, aroma and other quality attributes. The result of this research provides useful information for process monitoring, control and observation during the drying of tomato. The model can be used for optimizing the efficiency of commercial food drying process and the performance of commercial food dryers. An important aspect of the research is the microwave drying process which is a new technology for dehydrating fruits, vegetables and food without damaging their nutritive and sensory values. Therefore, a food drying process based on the result of this research would ensure a high process efficiency and appreciable retention of product quality.

4. CONCLUSION

The empirical models developed to relate the drying rate and post-drying qualities of tomato paste to foaming agent, foam stabilizer and whipping time were found to have described the dying characteristics of tomato very well and sufficiently predicted output parameters. Therefore these models can be applied for industrial drying of tomato under different process pretreatments and different drying conditions. Further analysis of the models by optimization showed that an optimum drying rate of 11.36 g/h could be achieved using a mechanical dryer if tomato paste is pretreated with foaming agent, foam stabilizer and whipping time of 14.0 %EW, 0.48 %CMC and 9 min respectively. The vitamins C content of the tomato powder could be maximized to an optimum value of 43.4 % if foaming agent, foam stabilizer and whipping time of 8.78 %EW, 0.6 %CMC and 9 min were used to pretreat tomato paste and then dried in the mechanical dryer. In the same development, tomato powder of water an optimum ash content of 1.3 % could be obtained with a foaming agent of 20 %EW, foam stabilizer of 0.6 %CMC and whipping time of 9 min. It could be inferred from this study that the drying process of tomato paste could be optimized under different pretreatments and drying conditions. Further studies should be carried out on the factors that affect the storability of tomato powder for long-time storage and preservation.

ACKNOWLEDGEMENT

The authors wish to appreciate the efforts of the Head, Department of Chemical Engineering, University of Ilorin, for providing a conducive environment throughout the period of experimentation.

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BIOGRAPHY OF THE AUTHORS

1. **Dr. Adesoji Matthew Olaniyan** graduated with B.Eng, M.Eng and PhD in Agricultural Engineering from University of Ilorin, Nigeria in 1991, 1998 and 2006 respectively. Since 1998, he has been working on techniques, processes and equipment for processing agricultural and bioresources materials to food, fibre and industrial raw materials. Dr. Olaniyan's principal area of research is on Bioproduct Processing and Food Process Engineering, where he has carried out a number of projects and published a number of papers in local and international journals. He joined the service of the University of Ilorin in 1998 as an Assistant Lecturer in the Department of Agricultural and Biosystems Engineering and rose to the position of a Senior Lecturer in 2009. Currently, he is an Associate Professor at the Department of Agricultural and Bio-resources Engineering, Federal University Oye-Ekiti, Nigeria. Dr. Olaniyan has bagged several awards including the Award for the Best Paper (2007) in the Journal of Food Science and Technology, Mysore, India; Chinese Government Sponsorship (2008) for International Training Programme in Protected Agriculture at International Exchange Centre, Yangling, China; Netherlands Fellowship Programme (2009) for International Training Programme in Milk Processing at Practical Training Centre, Onkerk, the Netherlands; and Postdoctoral Fellowship (2011) of the Academy of Sciences of Developing Countries.

2. **Dr. Musliu Olushola Sunmonu** graduated with B.Eng, M.Eng and PhD in Agricultural Engineering from Federal University of Technology, Mina, Nigeria in 2000, 2006 and 2014 respectively. Since 2008, he has been working on postharvest processing and storage of agricultural products. Dr. Sunmonu's principal area of research is on postharvest storage and packaging, where he has carried out a number of projects and published a number of papers in local and international journals. He joined the service of the University of Ilorin in 2008 as an Assistant Lecturer in the Department of Agricultural and Biosystems Engineering and rose to the position of Lecturer I in 2013. Dr. Sunmonu has received some awards including the Netherlands Fellowship Programme (2010) for International Training in Milk Processing at Practical Training Centre, Onkerk, the Netherlands.