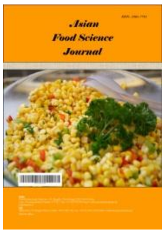

Asian Food Science Journal

20(10): 81-94, 2021; Article no.AFSJ.74264
ISSN: 2581-7752

Effect of Temperature on Drying Characteristics and Quality of Three Nigerian Onion Varieties Using a Fabricated Electrically Powered Dryer

O.O. Oniya[1*], A. B. Fashina[1], A. O. Adeiza[2], O. Ogunkunle[3] and A. O. Adebayo[1]

[1]Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria.
[2]Nigerian Stored Products Research Institute, Km 3 Asa Dam Road, Ilorin, Kwara State, Nigeria.
[3]University of Johannesburg, South Africa.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AFSJ/2021/v20i1030364
Editor(s):
(1) Dr. Nelson Pérez Guerra, University of Vigo, Spain.
Reviewers:
(1) Hendronoto Arnoldus Walewangko Lengkey, Universitas Padjadjaran, Indonesia.
(2) Mohamed Rasheed Roshana, South Eastern University of Sri Lanka, Sri Lanka.
Complete Peer review History: https://www.sdiarticle4.com/review-history/74264

Original Research Article

Received 17 July 2021
Accepted 27 September 2021
Published 28 September 2021

ABSTRACT

The research work is done to evaluate the effect of temperature on drying characteristics and quality of red, cream and white varieties Nigerian onion using a locally fabricated electrically powered dryer. Clean onion samples of 1.5 kg from each of the three varieties were sliced into 3 mm thickness. Fresh samples of the three onion varieties were analyzed to determine the initial values of protein, fat, ash, crude fibre, and moisture content on a dried basis (m.c.d.b.) using recommended AOAC methods.. Vitamin C and microbial loads content were determined before loading into a locally fabricated electrically-powered dryer. The onion samples were dried at varying pre-determined temperatures of 50, 60, and 70 °C. After drying, the proximate compositions, vitamin C and microbial loads were also determined. The protein, fat, ash and crude fibre of the fresh onion samples were 1.5, 0.5, 0.6 and 0.5%, respectively, while m.c.d.b, vitamin C content and microbial loads ranged from 85.1-88.2%, 8.1-8.3 mg/100 gm and 4.45-5.39 mg. Red onion samples were dried for 13:15h, 12:10h and 10:30h; white onion samples for 13:00h, 12:25h and 10:40h; while cream onion samples for 13:10h, 12:35h and 10:15h at 50, 60, and 70 °C, respectively. The protein, fat, ash, crude fibre, m.c.d.b, vitamin C content and microbial loads of the

---

**Corresponding author: Email: oooniya@lautech.edu.ng;*

dried onion samples at all the drying temperatures ranged from 10.110.4, 1.1-1.5, 3.3-3.5, 5.5-5.8, 5.5-6.9%, 3.1-4.9 mg/100 gm, 1.314.17 mg, respectively. The drying temperature had a significant effect (p-value < 0.05) on the quality of all the onion samples. At 70 ºC, protein, fibre, ash, fat and pungency retention were significantly (p< 0.05) high and within acceptable limits while microbial loads were low with the reduction in Vitamin C contents in all the onion varieties. Therefore, onion can best be dried at 70 ºC to achieve the optimum quality and flavour required for its use as a spice.

Keywords: Onions; fabricated; dryer; quality; temperature.

1. INTRODUCTION

Onion is a widely cultivated vegetable and spice crop grown all over the world. A global review of the production area of onion shows that it is grown in 126 countries over an area of 2.3 million hectares producing 40.0 million tonnes of fresh onion [1]. Nigeria is one of the leading countries in Africa producing white, red and cream onion. These crops are largely grown in the northern part of the country twice in the rainy season and once in the dry season. Experience showed that the rain-fed onions are sold at a relatively cheap price and there is always a high percentage of losses due to fungus attacks. This is so because the Nigerian onions are produced by local farmers with little or no idea of adequate post-harvest loss prevention techniques. In Nigeria, losses of over 49% have been reported for onions along the value chain, from farm to the consumers [2]. This report attests to the fact that the only storage system in place is the bagging of onion bulbs and heaping on each other in the stores. From a historical perspective, humans have struggled to develop means to provide protection from the ravages of time and environment for natural and manufactured products [3].

There is little documented research work on the drying of Nigerian onions. Value addition to onion through drying can reduce losses during peak seasons and earn the country foreign exchange through export and also encourage farmers to grow more onions [4,5]. Drying is a unit operation in which water is removed from foodstuff under controlled conditions to halt or slow down the growth of spoilage micro-organisms as well as the occurrence of biochemical-reaction that leads to deterioration and toxicity in food [6]. Onions are dried from the initial moisture content of about 82% or less to 4% sufficient for storage and processing. Faster dehydration that yields a higher quality production is always required to achieve high stability against deteriorative microbial and enzymatic reactions [7]. Some of the common drying methods include cabinet drying, puff drying, kiln drying, drum drying, tray drying, tunnel drying, spray drying, freeze dehydration, osmotic dehydration, extrusion drying and the use of microwaves, radio frequency (RF), refractive window and hurdle technology [8-9]. Electrically powered drying which is a form of cabinet drying was used in this research work because of the capacity to attain the required temperature in a short time and further maintain the temperature for a longer period of drying [10]. Like other vegetables, onions are hygroscopic in nature [11], therefore this method can dry the crop to a safe level of moisture content for storage. Also, this method provides an easy and safe drying process for dried onions, to meet up with an internationally acceptable standard for dried onion products. The aim of this research was to evaluate the effect of drying temperature on the drying characteristics and quality of red, white and cream varieties of Nigerian onions using a locally fabricated electrically powered dryer. This project was designed to achieve safe temperature and conditions at which onion would dry that will guarantee a minimal loss in the food value and flavour degradation.

2. MATERIALS AND METHODS

2.1 Materials

Three varieties of onions; red, white and cream onions were used for the trials. The fresh samples of onion varieties were purchased from the National Institute of Horticultural Research (NIHORT) Kano substation, Nigeria. All the varieties were subjected to the same process. The onion was cleaned by removing the top and bottom along with the outer dry layers and first layer to achieve the consistent composition of onion slices. Cleaned onions were sliced perpendicular to the axis into pieces 3mm thick using a stainless steel knife. The ring onion slices were maintained intact and placed in the electrically powered dryer at a pre-determined temperature of 50, 60, 70 ºC for drying. This experiment was carried out for each variety at different times in triplicates.

2.2 Electrically Powered Dryer (Multi-crop Dryer)

The electric dryer used for this research consist of a drying chamber (95x 65 x 65cm) mounted on top of a combustion chamber which house 2 heating elements. A fan powered by a 1.5kW permanent magnet DC motor (Dayton Electric MnSg.Nites.IL) circulates air in the drying chamber. The heating elements are connected to the electricity via a thermostat through which the temperature of the drying chamber can be regulated. The air velocity for all the drying tests was set at 0.5m/s. The drying chamber housed 5 drying trays with an area (86 x 52cm^2) each. It consisted of a fine mesh galvanized screen stretched across a strip steel frame. An aluminium waveguide rested on top of the drying tray and surrounded the product sample. Prepared samples of onion were spread on the trays in a thin layer with the drying temperature set at 50, 60 and 70 ºC. The front view of the electrical dryer is shown in Plate 1.

2.3 Methods

The weight changes of the drying samples were recorded every two hours until the product weight was constant. After drying, the dried onion samples were cooled and later packaged in transparent airtight bottles. Initial and dry samples of onions were analyzed for protein, fat, ash, crude fibre, moisture and vitamin C contents. The proximate compositions such as protein, fat, crude fibre and moisture content and vitamin C were determined using recommended AOAC [12] methods. The moisture content, pungency, aerobic plate count, yeast and mould populations are measured as described in the following sub-sections. The moisture content was calculated on a dry weight basis. Consumer acceptability and colour changes were monitored and scored on a 1-3 basis with the verdict or test panel drawn from a cross-section of end-users of onion namely; housewives, food vendors and suya sellers using the scale below;

KEY:

Consumer Acceptability Score:
1 = good as a fresh one
2 = almost as good as fresh
3 = not as good as fresh

Colour Change score:
1 = Very bright
2 = almost bright
3 = not bright

2.3.1 Moisture content determination.

Fresh onion samples of 30g from each onion variety were placed in pre-weighed aluminum weighing dishes and dried according to ADOGA, [11, temperature of 70 ºC for 6h at 26.1Hg vacuum in a Thelco 29 vacuum oven (precision scientific, Chicago, IL). Dishes were removed and placed immediately in desiccators to allow temperature to equilibrate before weighing. The weighing balance used for the scale had an accuracy of 0.01g. All moisture measurements for each trial were replicated twice and moisture contents were calculated on dry basis using the following formula developed by ADOGA, [11].

$$\mathrm{MC}(\%\mathrm{db}) = \frac{(\mathrm{Wi-Wf})}{\mathrm{Wf}} \times 100 \text{ (Eqn. 1)}$$

Where:
W_i *= initial weight of the sample*
W_f *= final weight of the sample*

The moisture content of the dried samples was determined using infrared moisture determination balance AD-4714A, (Centurion scientific Ltd). Following the manual recommendation, 5g of each sample was weighed into a clean dried dish. The sample was then place in the infrared moisture determination balance. The temperature was regulated to 105 ºC for 30minutes. The moisture content was indicated automatically by the reading on the machine.

2.3.2 Pungency degradation tests

Forty grammes (40g) of sliced onion samples in each tray were dried in batches. Trays were removed at different times during drying. The times were 10, 20, 30, and 40 minutes for 70ºC experiments; 10, 20, 30, and 40 minutes for 60ºC experiments; and 10, 20, 30 and 40 minutes for 50ºC experiments. After removal of sample weight was measured and corresponding moisture content was calculated. De-ionized water was added to the dried products until the total weight of water plus product was 90grams. Sample were allowed to rehydrate for 5min and then homogenized for 30 sec at 7,000 RPMs followed by another 30sec at 10,000 RPMs using a hand-held Bahmix Bio-Mixer Homogenizer

(Bartlesville, OK). Slurries were allowed to sit for 30min for enzymatic formation of pyruvate.

Pungency was measured using a chemical pyruvic acid assay outlined by Anthon and Barrett [13. Onion slurries were filtered through two layers of cheese cloth and 25µl of the filtrate was added to a 13mm x 100mm test tube using an Eppendorf pipette (Westbury, NY). Then, 1.0cm^3 of de-ionized water and 1.0cm^3 of 0.25g DinitroPhenylhydrazine (DNPH) in 1M HCl were added to the solution. The sample solution was placed in a 37 ^{0}C water bath for 10 min. After removal from the water bath 1.0 ml of 1.5M NaOH was added and the test tube was vortexed for 10sec. Absorbance of the liquid at 515 nanometers (mn) was measured on a Beckman DU 7500 spectrophotometer. A fresh 40g sample was heated in an 800W microwave oven (sharp R-209 HK) for 1min and then analyzed using the above assay to measure the inherent, non-enzymatically formed pyruvate. The standard was prepared by adding 25µl of Sodium pyruvate solutions in concentrations of 0, 2, 4 and 8mM (millimolar) instead of the onion filtrate. The enzymatically formed pyruvate was the difference of the amount of the total pyruvate and the non-enzymatically formed pyruvate. The results are reported as the percentage loss in pungency from a fresh onion sample at various moisture contents. Duplicate tests were performed at each drying temperature.

2.3.3 Microbial load reduction tests

Three media were used to examine the impact of drying on different groups of microorganisms. Tryptic Soy Agar was used to determine the aerobic plate counts, also known as Standard Plate Count or Total Plate Count. Aerobic plate counts were used to enumerate Mesophillic bacteria which grow aerobically and are used as general indicator of bacteria growth [14]. Dicholroan Rose Bengal Chloramphenicaol agar (DRBC) was used to enumerate yeast and mould populations. Yeast and mould counts are not accounted for in the aerobic plate counts because they grow too slowly. The last media was Caliform and Petrifilms used to enumerate coliforms. Coliforms are index organisms which can indicate the increased chances of pathogenic contamination [15]. Coliform measurements are important for onions since they are grown in contact with potentially contaminated soil.

Plate 1. Electrically powered dryer

Fresh onion sample from the three onion varieties were well mixed and then divided into 7 made up of 50g eachto measure the effect of drying on microbial load reduction. Six (6)of the samples were randomly chosen and dried with electrical dryer, kerosene dryer and solar dryer at three different temperatures, 50, 60, and 70 ºC. Each of the sample was placed on a 70% EtOH sterilized aluminum mesh drying tray (12 x 10cm) for drying. The samples along with the tray were removed periodically and weighed until they reach a calculated 10% MC. Sterilized tweezers were used to place 10g of the dried onion sample into a stomacher bag. The bags were sealed and samples were stored for 5 days before performing the plate count test. The fresh sample was stored in the same way.

A 90 ml butter field buffer dilution blank was added to the stomacher bag and mixed to contact the entire onion sample. The bags were placed in a refrigerator (4 ºC) for 10min to allow rehydration and then stomached for 1min before serial dilution were made from the contents in sterile 9 cm^3 peptone water dilution blanks. The dilution was vortexed for 10sec and then 0.1cm^3 were spread plated on Tryptic Soy Agar (TSA) and DRBC agar plates. Additionally, 1ml of each dilution was added to 3M coliform Petrifilms (St. Paul, MN). Duplicates of each dilution were made. TSA and Coliform Petrifilms were incubated at 35 ºC for 24hours. DRBC were left at room temperature for 5 days. The plates were enumerated after incubation and the results were recorded as Colony Forming Unit (CFU)/sample. The microbial load test was performed in triplicates.

2.4 Statistical Analyses

The results obtained were statistically analyzed using one-way classified analysis of variance (ANOVA) while statistical significance was considered at $p < 0.05$. Duncan Multiple Range Test was used to determine significant difference among the means of the various samples. Data were analyzed using the Software Statistical Packed for Social Sciences (SPSS) version 11.00 SPSS Inc, Chicago, IL, USA.

3. RESULTS AND DISCUSSION

3.1 Drying Characteristics of Onion Samples

Table 1 shows the drying characteristics of dried red, white and cream onions and Table 2 shows the chemical parameters of fresh and dried onion bulbs respectively.

Dried onions using the electrically powered dryer were crispy, bright in colour and retained a pronounced onion aroma. However, dehydration reduced the flavour and induced browning, especially with a low temperature of 50 ºC and a longer period of drying. The high temperature at 70 ºC at a shorter drying period produced onion with a higher pronounced and intense onion aroma. The extent of this assertion of changes depends upon the onion variety. This is consistent with the reports of Shama *et al.* [16 who found that the drying rate of onion slices was significantly influenced by temperature.

The changes in protein, fat, moisture and vitamin C contents were found to be very significant for the three varieties of onion. Protein and fat increased while moisture and Vitamin C contents decreased significantly ($p < 0.05$). Decreases in moisture content and vitamins were the most prominent changes in onion after drying. This trend is in agreement with the results by Sharma and Nath [17]. Table 2 also show the comparative compositional changes that occurred using the electrically powered dryer for three varieties at different temperatures. A higher temperature in drying of onions and other vegetables certainly has significant effects on the vitamins and minerals as reported by Yaldiz and Ertekin [18]. Vitamin C content was high at the beginning of the drying period and decreased significantly ($p < 0.05$) during drying. This is due to the unstable nature of Vitamin C when exposed to high temperatures. This agreed with Sharma *et al.* [16[who reported that Vitamin C losses increased as the duration of drying was extended in *Ziziphus mauritiona (Lamk*). The same trend was observed in Vitamin C content of dried tomatoes as reported by Idah *et al.* [19] and Rahman and Perera [20]. From Table 2, proteins, ash, crude fibre and fat contents increased because of the concentration of nutrients that do occur in dried products [21]. Heat increases protein content due to product dehydration that concentrates protein thus increasing the nutritional value of the dried onions. A similar trend is observed in other food products such as fish and tomatoes as reported by Ahmed *et al.* [22] and Idah *et al.* [19]. Similarly, the increase in crude fibre, fat, and ash contents in the dried onions can be attributed to moisture removal which leads to the concentration of all nutrients in the dried onions. These results are in agreement with earlier studies by Aliya *et al.* [23] in fish and meat products.

Table 1. Drying characteristics of dried red, white and cream onions

Mode of drying	Onion varieties	Mean drying temp °C	Drying period
Electrically powered dryer	Red onion	50	13.55
		60	12.10
		70	10.30
	White onion	50	14.10
		60	12.25
		70	10.55
	Cream onion	50	14.35
		60	13.15
		70	10.25

Table 2. Proximate composition and vitamin C for fresh and dried onions

Onion varieties	Moisture content (%)	Protein (%)	Fibre (%)	Ash (%)	Fat (%)	Vitamin C
Fresh red onion	87	1.5	0.5	0.6	0.5	7.38
Dried red onion						
at 50 °C	6.7	10.4	5.8	3.5	1.3	4.10
60 °C	6.5	10.3	5.7	3.4	1.2	3.86
70 °C	6.1	10.2	5.7	3.4	1.1	2.54
Fresh white onion	85.1	1.5	0.5	0.6	0.5	7.41
Dried white onion						
at 50 °C	6.8	10.3	5.6	3.4	1.5	4.69
60 °C	6.6	10.2	5.5	3.5	1.4	4.47
70 °C	6.2	10.2	5.5	3.4	1.3	3.79
Fresh cream onion	88.2	1.5	0.5	0.6	0.5	7.39
Dried cream onion						
at 50 °C	6.9	10.3	5.5	3.32	1.3	4.79
60 °C	6.6	10.2	5.6	3.37	1.2	4.05
70 °C	6.5	10.1	5.5	3.34	1.1	3.68

Therefore, this drying method has improved the quality of the dried onion products as it eliminated the excessive colour fading, contamination by dust, insect and other harmful effects by microorganisms commonly associated with open-air during drying and a long period of drying practices in a mostly rural community.

Drying rates at different levels of drying duration are significantly different from each other at p-value < 0.05. A high rate of moisture removal was observed in the electrically powered dryers for all drying samples at the initial stage of drying than in the later stages. This characteristics behaviour is due to various forms in which water is present in food products. From the curves shown (Figs 1 – 3) there was no constant rate of drying period in the entire process, all drying processes occurred at a falling rate and during the falling rate period, the drying process of onion was mainly controlled by diffusion mechanisms. In the initial, stage moisture migrations from the surface are faster and easily evaporated. As the drying progressed, the rate dropped due to internal moisture diffusion resulting in the falling rate. However, the thickness of the onion did not present a serious barrier. This is in agreement with earlier research the reports of Seifu *et al*. [24].

The graphs of drying temperatures versus drying rate curves (Figs 4 - 6) revealed that a higher drying rate was observed at higher temperature (70 °C) irrespective of the onion varieties in the electrically powered drying considered for the experiment. This is because as the temperature of air increases the drying air can heat the product, move over the product and provide latent heat for moisture evaporation thereby increasing the driving force for drying. Several authors reported considerable increases in drying rates when higher temperatures were used for drying various fruits, vegetables and crops [18,16].

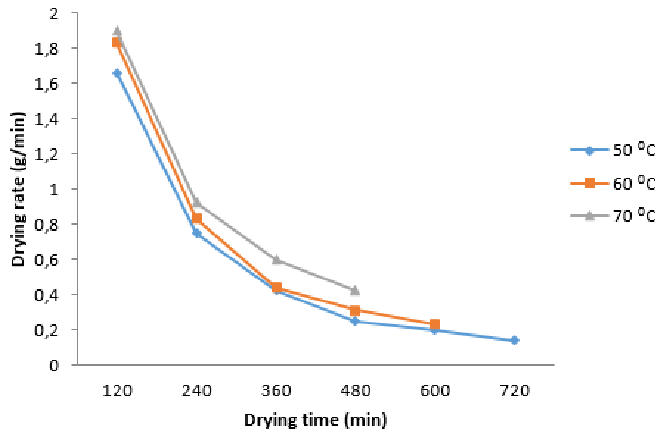

Fig. 1. Drying rate curve for red onion using an electric dryer

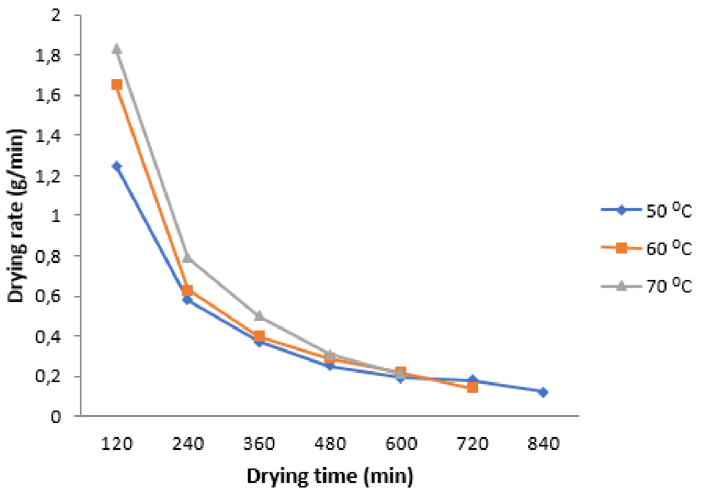

Fig. 2. Drying rate curve for white onion using an electric dryer

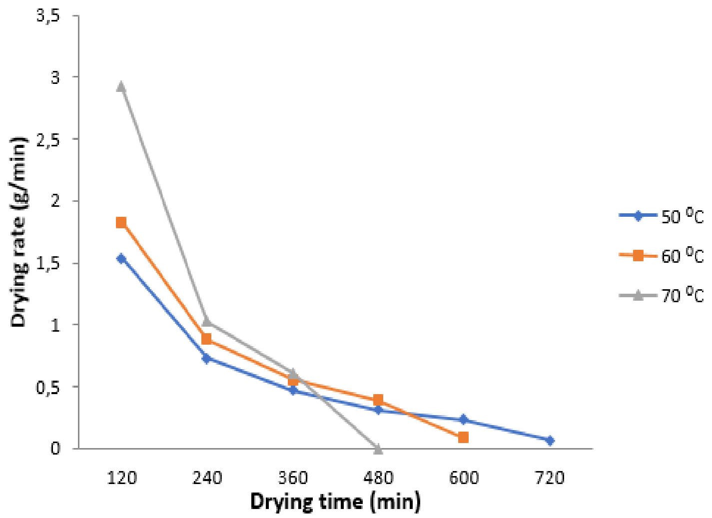

Fig. 3. Drying rate curve for cream onion using an electric dryer

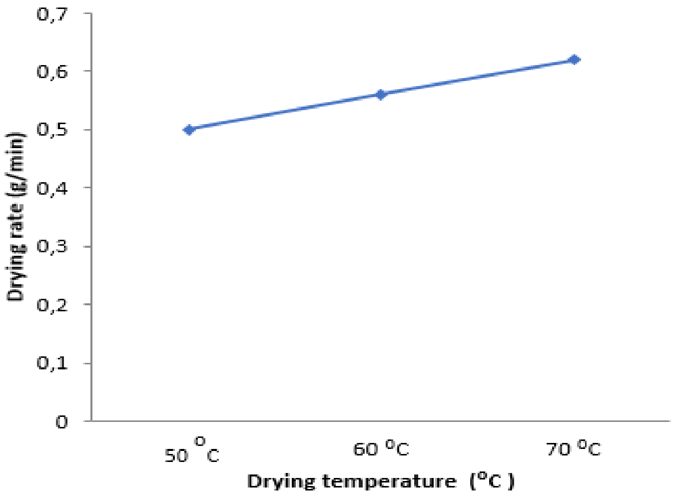

Fig. 4. Effects of drying temperatures on drying rate of red onion

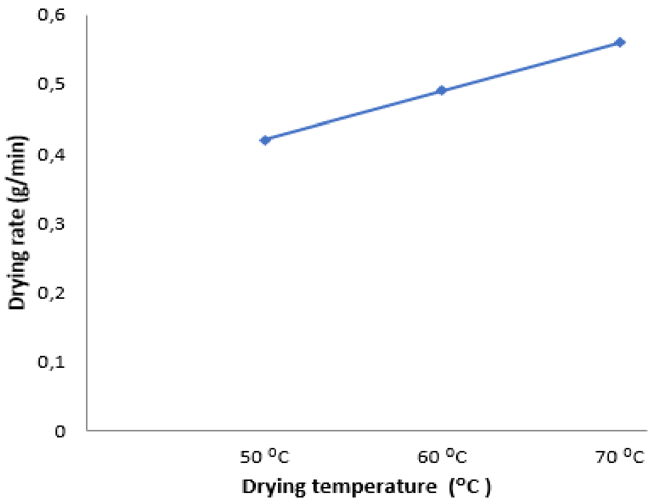

Fig. 5. Effects of drying temperatures on drying rate of white onion

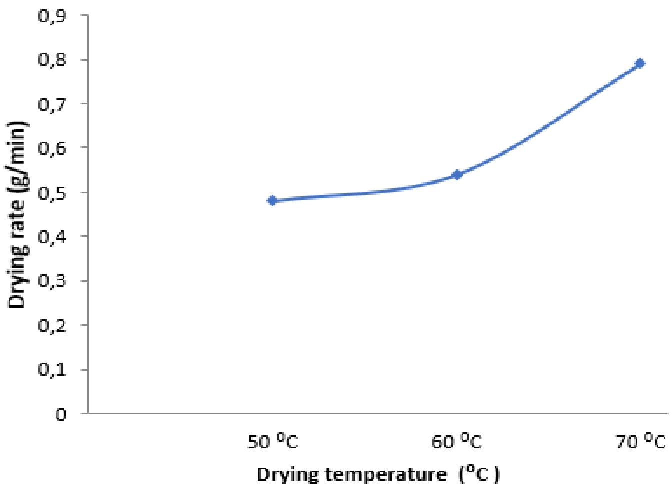

Fig. 6. Effects of drying temperatures on drying rate of cream onion

3.2 Effects of Drying on Pungency for all the Drying Trials

The results of changes in pyruvate levels at the end of the drying process are shown in Figs. 7 - 9. Pungency changes caused by drying had similar trends for red, white and cream onion samples dried using the fabricated electrical dryer. Although the measured pungencies varied with drying conditions and moisture during drying, the pungencies in the final samples with similar moisture content were similar, except for the 70 ºC trials. All the onion varieties with 70ºC trial showed a greater loss in pungency in the samples especially near the end of drying. This may be due to the high drying temperature that was used in drying, which is consistent with the finding of Seifu *et al*. [24]. Additional studies [25,26] have shown that accelerated drying in the initial stages would retain volatiles. This is because the volatiles becomes locked into the product when it reaches the critical moisture content.

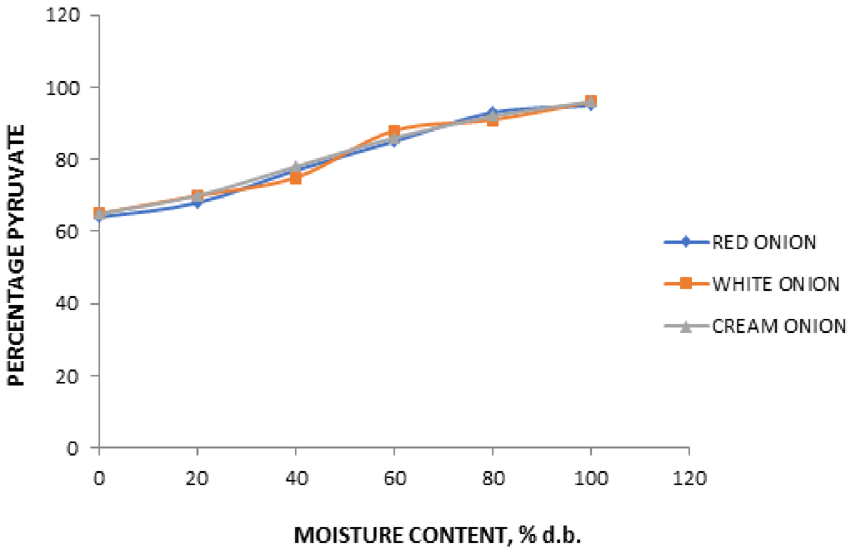

Fig. 7. Electric drying of onions at 50 ºC

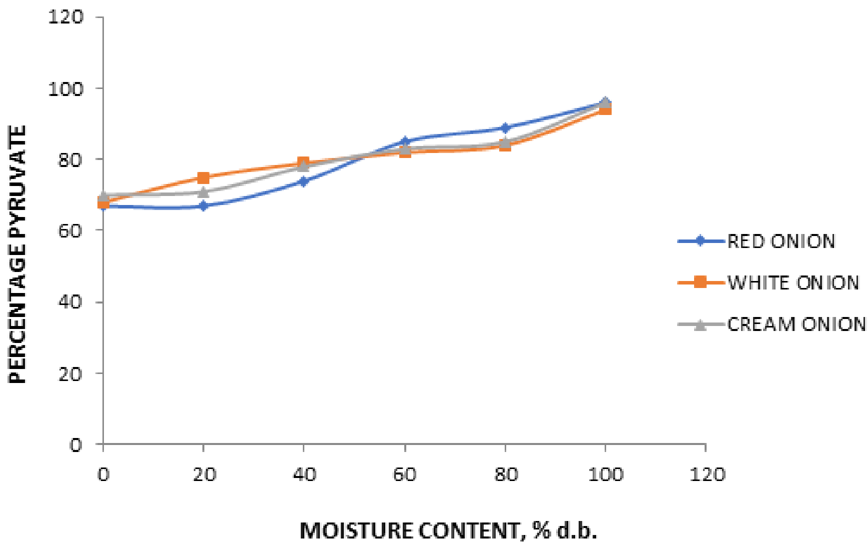

Fig. 8. Electric drying of onions at 60 ºC

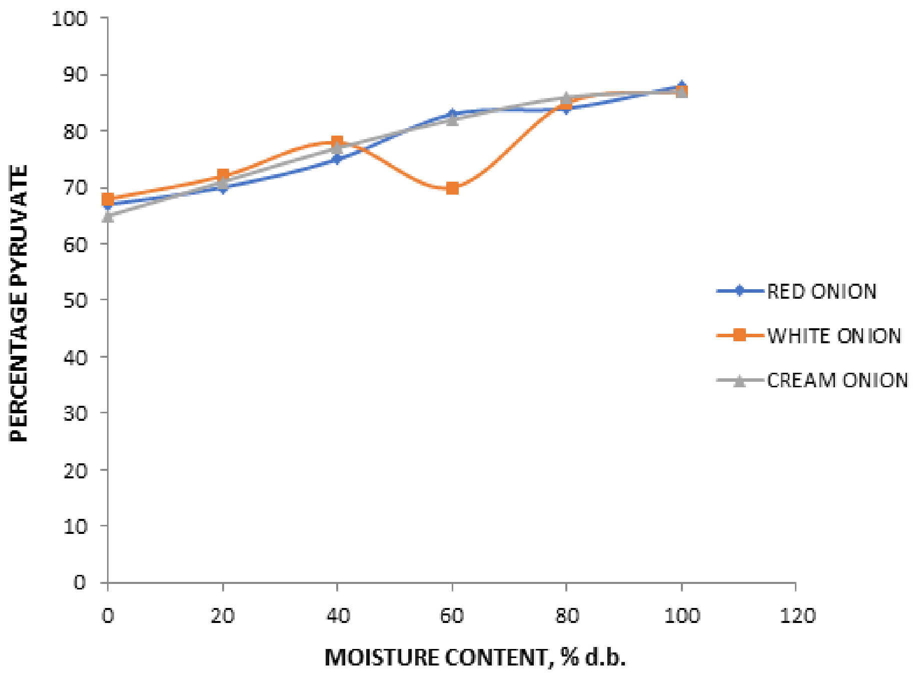

Fig. 9. Electric drying of onions at 70 ºC

3.3 Effects of Drying on Microbial Load for all the Drying Trials

The results of microbial counts from individual experiments of red, white and cream onions are summarized in Tables 3, 4 and 5. The final counts were composed primarily of aerobic spore formers. According to Matron [14], these are the predominant microorganisms in dehydrated species. Spore forming bacteria are likely to survive the drying process because they can survive in a high heat environment. The high survival of the aerobic spore formers and inactivation of other populations of microorganisms would account for similar final counts. The population that were reduced were most likely vegetative cells, which include coliforms.

Yeast and mould counts unlike coliform were not accounted for on the aerobic plate count (APC). Yeasts and moulds do not grow fast enough to appear on APC agar. In the experiments, yeast and mould counts were significantly different for the three drying methods with greater reductions in sample dried in the electric dryer. Greater reductions in the electricity were probably a result of greater heat fluxes from the electric emitter. This is consistent with the other research work reported by Kornacki and Johnson [15].

For the yeast and mould count, the dried samples had greater counts than the fresh samples. This might be a result of replication of organisms after drying, although properly dried products should be free of microbial multiplication [27]. Another reason could be that fresh onions contained antimicrobial action and allow for more accurate microbial counts as reported by Rahaman and Perera [20]. Coliform counts decreased as drying temperature increased while there was also a decrease in the yeast and mould as the drying temperature increased.

3.4 Effects of Drying on Sensory Properties of Dried Samples

The result of the mean score of the sensory evaluation studies on the effects of electrically dried onions is presented in Table 6. Samples of red, white, and cream onions were dried at 50 ºC, 60 ºC and 70 ºC with the electrically powered dryer. In these studies, the consideration was on the drying temperatures.

The sensory evaluation revealed that dried onions at 70 ºC with electrically powered dryers were most preferred in terms of appearance, colour, taste, flavour, aroma, and overall acceptability than other dried onions at 50 ºC and 60 ºC. These results might be due to high temperature cumulating to shorter time in drying which disallows browning of onion and retention of pungency [24]. Dried onions at 50 ºC with electrically powered dryers were least preferred in terms of appearance, taste, aroma, and overall acceptability. Tables 6 shows that in the electrically powered dryer, all the sensory parameters investigated on dried onions at 70 ºC were not significantly (p-value < 0.05) affected by the drying temperature.

Table 3. Microbial data for aerobic plate counts and yeast and mold counts of electrical dried samples for red onions

	Trail 1		Trail 2		Average	
	Fresh	**5.24**	**Fresh**	**5.24**	**Fresh**	**5.24**
Aerobic Plate Counts	50ºC	4.21	50ºC	3.23	50ºC	3.72
	60ºC	3.98	60ºC	3.71	60ºC	3.85
	70ºC	3.97	70ºC	3.37	70ºC	3.67
	Trail 1		Trail 2		Average	
	Fresh	5.27	Fresh	5.51	Fresh	5.39
Coliform Counts	50ºC	3.04	50ºC	2.40	50ºC	2.72
	60ºC	2.18	60ºC	2.40	60ºC	2.29
	70ºC	1.70	70ºC	1.00	70ºC	1.35
	Trail 1		Trail 2		Average	
	Fresh	4.56	Fresh	4.84	Fresh	4.70
Yeast and Mold Counts	50ºC	4.16	50ºC	4.12	50ºC	4.14
	60ºC	3.83	60ºC	4.00	60ºC	3.92
	70ºC	3.44	70ºC	3.44	70ºC	3.44

Table 4. Microbial data for aerobic plate counts and yeast and mold counts of electrical dried samples for white onions

	Trail 1		Trail 2		Average	
	Fresh	**5.31**	**Fresh**	**5.31**	**Fresh**	**5.31**
Aerobic Plate Counts	50ºC	4.21	50ºC	3.23	50ºC	3.72
	60ºC	3.98	60ºC	3.51	60ºC	3.75
	70ºC	3.97	70ºC	3.37	70ºC	3.67
	Trail 1		Trail 2		Average	
	Fresh	5.24	Fresh	5.41	Fresh	5.33
Coliform Counts	50ºC	3.04	50ºC	2.40	50ºC	2.72
	60ºC	2.18	60ºC	2.45	60ºC	2.32
	70ºC	1.70	70ºC	1.00	70ºC	1.35
	Trail 1		Trail 2		Average	
	Fresh	4.55	Fresh	4.64	Fresh	4.60
Yeast and Mold Counts	50ºC	4.36	50ºC	4.15	50ºC	4.26
	60ºC	3.63	60ºC	4.01	60ºC	3.82
	70ºC	3.54	70ºC	3.04	70ºC	3.29

Table 5. Microbial data for aerobic plate counts and yeast and mould counts of electrical dried samples for cream onions

	Trail 1		**Trail 2**		**Average**	
	Fresh	5.27	Fresh	5.26	Fresh	5.27
Aerobic Plate Counts	50^oC	4.31	50^oC	3.33	50^oC	3.82
	60^oC	3.68	60^oC	3.51	60^oC	3.60
	70^oC	3.77	70^oC	3.27	70^oC	3.52
	Trail 1		Trail 2		Average	
	Fresh	5.24	Fresh	5.51	Fresh	5.38
Coliform Counts	50^oC	3.14	50^oC	2.30	50^oC	2.72
	60^oC	2.38	60^oC	2.50	60^oC	2.44
	70^oC	1.40	70^oC	1.10	70^oC	1.25
	Trail 1		Trail 2		Average	
	Fresh	4.36	Fresh	4.54	Fresh	4.45
Yeast and Mold Counts	50^oC	4.26	50^oC	4.22	50^oC	4.24
	60^oC	3.53	60^oC	4.10	60^oC	3.82
	70^oC	3.34	70^oC	3.34	70^oC	3.34

Table 6. Mean scores of the sensory evaluation of the onion samples dried with an electric dryer

Samples	**Appearance**	**Colour**	**Flavour**	**Aroma**	**Taste**	**Acceptance**
Electric (Red)						
50^0C	5.73 ± 2.12^a	5.52 ± 2.13^a	4.88 ± 0.42^a	5.93 ± 0.31^a	5.64 ± 0.04^a	5.02 ± 1.21^a
60^0C	6.47 ± 1.50^b	6.72 ± 1.11^b	6.23 ± 0.39^b	6.22 ± 0.51^b	6.01 ± 0.08^b	6.00 ± 1.59^b
70^0C	7.11 ± 0.13^c	7.75 ± 1.13^c	7.47 ± 0.67^c	7.56 ± 1.31^c	7.47 ± 0.12^c	7.01 ± 1.38^c
White						
50^0C	5.72 ± 0.11^a	6.41 ± 1.12^a	5.04 ± 0.24^a	5.06 ± 0.21^a	4.96 ± 0.02^a	5.22 ± 0.92^a
60^0C	6.04 ± 2.14^b	6.22 ± 1.05^b	5.87 ± 0.83^b	6.94 ± 0.91^b	5.94 ± 0.10^b	6.02 ± 2.03^b
70^0C	7.42 ± 1.13^c	7.71 ± 1.10^c	6.95 ± 1.25^c	7.63 ± 3.41^c	7.12 ± 0.16^c	6.92 ± 1.53^c
Cream						
50^0C	5.53 ± 0.14^a	6.52 ± 1.03^a	4.53 ± 0.26^a	5.11 ± 0.31^a	4.67 ± 0.20^a	5.42 ± 1.13^a
60^0C	6.54 ± 1.51^b	6.42 ± 1.13^a	6.15 ± 0.16^b	6.31 ± 0.21^b	5.27 ± 0.09^b	6.62 ± 1.17^b
70^0C	7.52 ± 1.13^c	7.74 ± 1.10^b	7.52 ± 0.94^c	7.53 ± 0.41^c	7.17 ± 0.26^c	7.02 ± 0.15^c
Mean	7.55	7.99	6.64	6.70	6.20	7.37
SD	0.9179	0.6563	1.3788	1.9559	1.1462	0.8957

A higher value indicates greater preference. Values are Means ± SD (n=20)
A column with different superscripts are significantly different at p<0.05

4. CONCLUSION

From the results obtained from the drying of Nigerian onion varieties, it was found out that a higher drying rate can be obtained with the electrically powered dryer thereby resulting in a faster drying process. The drying temperatures of the electrically powered dryers resulted in pungency degradation of the dried onion samples when compared with the fresh samples. At 70 ^oC, there was greater pungency retention. The use of an electrically powered dryer is efficient in the production of safely dried onion as it produced products with reduced microbial load accompanied by reduced moisture content. Dried onions at 70 ^oC were most preferred in terms of appearance, colour, taste, flavour, aroma.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by the personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Feiyue R, Camila AP, Zhihang Z, Michael TG, Joseph PK, Brijesh KT. Enhancement of phytochemical content and drying efficiency of onions (*Allium ceoa* L) through blanching. Journal of Science, Food and Agriculture. 2017;98:1300 – 1309.
2. FAO. Fruit Processing Toolkit: Dried Fruit. InPho, Food and Agricultural Organization (FAO), New York. 2015;13.
3. Sammi S, Masud T. Effect of different packaging systems on storage life and quality of Tomato (Lycopersicon esculentum varieties, Rio Grande) during different ripping stages. International Journal of Food. 2007;9:37-44.
4. Robertson GL. Food Packaging: Principals and Practice 3rd ed. Boca Raton: Taylor & Frances Group. 2013;3(5):26- 32.
5. Adejumo BA, Raji AO. Shelf Stability of Garri Packaged in Hessian Bag in Southwestern Nigeria. LAUTECH Journal of Engineering and Technology. 2011;6(2):19 – 24.
6. Himberto J, Vega-Mercado. Journal of Food Engineering. 2001;49:271 – 280.
7. Bio SBB, Ayemene CAK, Kan KPK, Doudjo S. Effects of onion bulb processing conditions on drying characteristics, physicochemical and functionl properties profile of onion (*Allium cepa* L.) powder. Journal of Food Science. 2020;852:3345.
8. Jain SK, Verma RC. Mass transfer and drying characteristics of osmotic ally dehydrated papaya cubes followed by Air drying, National convention held at Hyderabad in; 2004 - 2005.
9. Singh PR, Heldman DR. Food Science and Technology Academic Press Inc. 2009;653.
10. Mohanraji M, Chandrasekar P. Performance of a forced convection solar dryer intergrated with gravel as heat storage material for chilli drying, Journal of Engineering Science and Technology. 2009;4(3):305-314.
11. America Dehydrated Onions and Galic Association (ADOGA). Official standards and methods of the American Dehydrated Onion and Garlic Association for dehydrated onion and garlic products. ADOGA, San Francisco CA; 1997.
12. AOAC. Official methods of analysis (18th edition). Association of Official Analytical Chemists International. Maryland USA; 2005.
13. Anthon GE, Barret Diane M. Modified method for the determination of pyruvic acid with dinitrophenylhydrazine in the assessment of onion pungency. Journal of the Science of Food and Agriculture. 2003;83:1210 – 1213.
14. Matron R. Chapter 7, Aerobic plate count. Compedium of methods of the Microbiological Examination of foods, fourth Edition. APHA; 2001.
15. Kornacki J, Johnson J. Chapter 8, Enterobacteriaceae, coliform, and Escherichiacoli as Quality and Safety Indicators. Compedium of Methods for the Microbiological Examination of foods, Fourth Edition. APHA; 2001.
16. Sharma GP, Verma RC, Pathera PB. Thin-layer Infrared radiation drying of Onion slices. Journal of food Engineering. 2005;67(5):361- 366.
17. Sharma PK, Nath N. Dehydration characteristics of ten onion cultivars. Lentensmittel Technologies. 1991;28 (6):348- 351.
18. Yaldiz O, Ertekin C. Thin layer solar drying of some vegetables. Drying Technology. 2002;19(3&4):583-59.
19. Idah PA, Musa JJ, Olaleye ST. Effect of Temperature and Drying Time on Some Nutritional Quality Parameters of Dried Tomatoes. AU J.T. 2010;14(1):25-32.
20. Rahman MS, Perera CO. Drying and food preservation. Handbook of food preservation. Auckland, New Zealand: Horticulture and Food Research Institute of New Zealand; 1999.
21. Oladipo IC, Bankole SO. Nutritional and microbial quality of fresh and dried *Clarias gariepinus* and *Oreochromis niloticus*. International Journal of applied Microbiology and Biotechnology Research. 2013;1-6.

22. Ahmed A, Dodo A, Bouba A, Clement S, Dzudie T. Influence of traditional drying and smoke-drying on the quality of three fish species (*Tilapia nilotica, Silurusglanis*and *Arius parkii*) from Lagdo Lake, Cameroon. J. Anim. Vet. Advan. 2011;10(3):301-306.
23. Aliya G, Humaid K, Nasser A, Sami G, Aziz K, Nashwa M, Ponnerassery SS. Effect of the freshness of starting material on the final product quality of dried salted shark. Advance. J. Food Sci. Technol. 2012;4(2):60-63.
24. Seifu M, Tola YB, Mohammed A, Astatkie T. Effect of variety and drying temperature on physicochemical quality, functional property, and sensory acceptability of dried onion powder. Food Science and Nutrition. 2018;6(6):1641–1649.
25. Mazza G, Maguer ML. Volatiles retention during the dehydration of Onions (*Allium cepa L.).* Lebensm- Wiss U. Technol. 1997;12:333- 337.
26. Lee J, Kang H, Chang K, Kim S. Drying of onions and ginger using drying system controlled by microcomputer. Agricultural Chemistry and Biotechnology. 1995;38(1):78-82.
27. Lorenzo JM, Munekata PE, Dominguez R, Pateiro M, Saraiva JA, Franco D. Main Groups of Microorganisms of Relevance for Food Safety and Stability: General Aspects and Overall Description. Innovative Technologies for Food Preservation. 2018;53–107.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/74264