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AN ASSESSMENT OF THE APPROPRIATE DRYING TEMPERATURE FOR MAXIMUM NUTRIENT RETENTION IN RED AND WHITE ONION FLAKES

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Abstract
This study investigated the optimal drying temperature for nutrient retention in red and white onion flakes, vital for preserving their culinary and health benefits. Onions are widely valued for their flavor and nutritional properties, including vitamins, minerals, and antioxidants. However, the drying process, commonly employed for long-term storage, can lead to significant nutrient degradation if not conducted under optimal conditions. To assess the impact of various drying temperatures, onion samples were subjected to a range of controlled temperatures (32°C,34°C,37°C, 39°C, 42°C, 44°C and 50°C) using a laboratory oven dryer. Nutrient analyses were performed post-drying, focusing on key compounds such as vitamin C, flavonoids, and oxalate-containing compounds. The results indicated a temperature-dependent decline in nutrient retention, with lower drying temperatures (39°C and 42°C) preserving more micronutrients compared to higher temperatures. Notably, red onions demonstrated higher resilience in nutrient retention than white onions at elevated temperatures. This research underscored the importance of selecting appropriate drying temperatures to maximize the nutritional quality of onion flakes, providing valuable insights for both industrial processing and consumer practices aimed at enhancing the health benefits of dehydrated onions.

Keywords: *Maximum nutrient retention, Red onion flasks, White onion flasks, drying temperature*

INTRODUCTION

Onions contribute significant nutritional value to the human diet and have medicinal properties and are primarily consumed for their unique flavor or for their ability to enhance the flavor of other foods (Armand *et al.*, 2018). It is a member of the *Alliacea* family and is farmed for its seasoning and flavoring-filled bulbs, which are used every day in every home (Carr *et al.*, 2010). Nigeria is one of the leading countries in Africa producing white, red and cream onion. (Oniya *et al.*, 2021). In Nigeria, production is concentrated in the north, more especially in the dry tropical zone. The most popular preservation approach is drying which is a combination of heat and mass transfer process that has the ability to reduce post-harvest losses (Sarkar *et al.* 2022). Zaman *et al.* (2021) stated that this method of preserving vegetables like onions is regarded to be the most effective and profitable to prolong shelf life and improve food stability. Ayemene *et al.* (2020) reported that onions are dried from the initial moisture content of about 82% or less to 4% for safe storage and processing.

Onion flakes, a popular dehydrated food product, are known for their extended shelf life and convenience in food preparation. However, the process of transforming fresh onions into flakes can significantly affect their nutritional profile, particularly the retention of vitamins, minerals, and bioactive compounds.

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Numerous studies have explored the impact of different drying methods and conditions on nutrient retention, highlighting the challenges of preserving the nutritional quality of dehydrated onion products. The extent of nutrient retention depends on the drying method, temperature, and duration, with lower temperatures generally helping to preserve nutrients better (Krokida *et al.*, 2003). Temperature and drying duration are critical factors affecting nutrient retention during dehydration. Higher temperatures accelerate the degradation of heat-sensitive nutrients, while longer drying times can increase the likelihood of oxidation and nutrient loss. Onion varieties differ in their initial nutrient composition, which can affect how much of these nutrients are retained after dehydration. Block (2010) noted that red and yellow onion varieties, which contain higher levels of quercetin and other flavonoids, may retain these compounds more effectively during freeze drying than during air drying.

Although, the influence of hot air drying on food quality is well known, the understanding of processes caused by dewatering that adversely affect onion properties are limited, the major challenge during drying of onion is to reduce the moisture content of the material to the desired level without substantial loss of flavor, taste, color and nutrients (Raquel *et al.*, 2012). Thus, this research focus on investigating the maximum temperature in retention of nutrients in red and white onion flasks.

2.0 METHODOLOGY

Red and white onions were purchased from a local market at Oja- Oba, Ado- Ekiti, Ekiti State, Nigeria. The red and white onions were sorted out manually to separate blemish or infected ones from the batch. The unsliced raw red and white onions each were subjected to proximate analysis and the elemental contents and vitamins were determined at Afe - Babalola laboratory, Ado-Ekiti, Ekiti State, Nigeria. The red and white onions were sliced into 2mm thickness each to ensure effective drying of the flakes. The flakes for each sample of the onions were oven dried by using a laboratory oven (Model DNP SSE-12) at eight different temperatures of 32, 34, 37, 39, 42, 44, 47 and 50°C. This was replicated thrice for each of the sample

2.2.1. Moisture content (MC): 2.0g of the sample(s) were placed in an oven maintained at 100 - 103°C for 16 hours with the weight of the wet sample and the weight after drying recorded. The drying was repeated until a constant weight was obtained. Equation 1 was used to calculate the moisture content of the samples

$$MC = \frac{M_2 - M_1}{M_1 - M_0} \times 100 \quad (1)$$

Where, MC is the wet basis moisture content, M_1 is the initial weight of onion and moisture can, $M_0$is the initial weight of the moisture can and M_2 is the equilibrium weight of onion and moisture can.

2.2.2. Ash content (AC): 2.0g of each of the oven-dried samples in powder form were accurately weighed and placed in crucible of known weight. These were ignited in a muffle furnace and ash for 8 hours at 550°C. The crucible containing the ash was then removed, cooled in a desiccator and weighed and the ash content expressed in term of the oven-dried weight of the sample. The ash content was determined using Equation 2

$$AC = \frac{M_3 - M_0}{M} \times 100 \quad (2)$$

M_0 is the initial weight of the beakers M_3 is the weight of the beakers containing the ash and M is the weight of the dry matter of the test sample.

2.2.3. Protein: The protein nitrogen in 1g of the dried samples was converted to ammonium sulphate by digestion with concentrated H_2SO_4 and in the presence of $CuSO_4$and Na_2SO_4. Crude protein was calculated by multiplying the value of the deduced nitrogen by the factor 6.25mg. The crude protein was determined using Equation 3

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Crude Protein = Deduced nitrogen × 6.25mg (3)

2.2.4. Crude fibre: 2.0g of each sample was weighed into separate beakers, the samples were then extracted with petroleum ether by stirring, settling and decanting 3 times. The contents were filtered to remove insoluble materials, which was then washed with distilled water, then with 1% HCI, next with twice ethanol and finally with diethyl ether. The crude fibre was determined using

Equation 4

$$Crude\ fibre = \frac{(W_2-W_1)-(W_3-W_1)}{W} \times 100 \quad (4)$$

Where; W_1 is weight of fibre residue before drying, W_2 is weight of fibre residue after drying,

W_3 is weight of fibre residue after ignition and W is weight of fibre

2.2.5 Determination of calcium, potassium and sodium

The ash of each sample obtained was digested by adding 5ml of 2 MHCL to the ash in the crucible and heated to dryness on a heating mantle. The filtrate was made up to mark with distilled water stoppered and made ready for reading of concentration of Calcium, Potassium and Sodium on the Jenway Digital Flame Photometer(PFP7 Model) using the filter corresponding to each mineral element.

2.2.6 Determination of magnesium and iron using AAS Buck Scientific 211

The digest of the ash of each sample above as obtained in calcium and potassium determination was washed into 100ml volumetric flask with de-ionized or distilled water and made up to mark. Each of the trace mineral elements was read at their respective wavelengths with their respective hollow cathode lamps using appropriate fuel and oxidant combination.

2.2.7 Determination of beta carotene (Vitamin A)

2g of the sample was weighed into a 250ml volumetric flask, 50ml of petroleum ether: Acetone (2:1v/v) mixture was added to the extract the ß-Carotene. Working standard of ß-carotene of range 0-50ppm or /ml were prepared from stock Beta carotene solution of 100ppm concentration. The absorbance of samples as well as working standard solutions were read on a Cecil 2483 UV Spectrophotometer at a wavelength of 450nm against blank.

2.2.8 Determination of ascorbic acid (Vitamin C)

10g of the sample was blended and homogenized with 50ml of 50% meta-phoshonic acid-acetic acid solution. The mixture was quickly transferred into a 100ml volumetric flask and shaken gentle until a homogenous dispersion was obtained then it was diluted up to mark with 5% metaphoric acid-acetic acid solution. The mixture was filtered and the clear filtrate was stored in another 100ml volumetric flask prior to spectro-photometric assay. The absorbance of working standards as well as sample extract were read on Cecil 2583 spectrophotometer at a wave length of 512nm.

2.2.9 Determination of flavonoids

The total flavonoids content was estimated using the procedure described by Zhichen *et al.* A total of 1 ml of sample were diluted with 200µl of distilled water separately followed by the addition of 150 µl of sodium nitrate (5%) solution. The total flavonoids content was expressed as rutin equivalent mg RE/100g extract on dry weight basis using standard curve.

2.2.10 Determination of oxalate content

This was determined using Dye method. 2g each of the samples was extracted with dilute HCl, 10ml concentrated ammonia and then precipitated with calcium chloride as calcium

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oxalate. The precipitate was then washed with 25ml of hot 25% H_2SO_4 and dissolved in hot water and titrated with 0.05M $KMnO_4$ to determine the concentration of oxalate.

2.3 Statistical Analysis

All data were analyzed using Statistical Package for the Social sciences (SPSS) software, version.

3.0. RESULTS AND DISCUSSION

Table1 to 4 depicts the average value of proximate, elemental and vitamin content of the raw unsliced red and white onion, average proximate analysis of red and white onion flakes, average mineral analysis of red and white onion flakes and average vitamins and anti-nutrients analysis of red onion and white flakes dried at different drying temperature respectively.

3.1. Effect of Drying Temperature on the proximate composition of White and Red Onions

Moisture content is a vital biological property that affects various aspects of agricultural materials, including their growth, development, quality, storability, and overall performance. The moisture content of the red and white onion at the raw state (Table 1) was obtained as 82.61% and 83.20% respectively. The values are collaborate with the findings of Smith and McNeil (2020) that the moisture content of a raw red and white onion ranges between 80 to 90% respectively. Also, the moisture content of the red and white onion flasks (Table 2) decreased as the temperature increased. Additionally, the values of the moisture content of 24.36 % (32^{O}C) to 16.85% (50^{O}C) and 20.74 % (32^{O}C) and 12.85% (50^O) obtained for red and white onion flasks respectively indicate that most of the nutrients are retained at this drying temperature. This result is in-line with the findings by Singh and Verma (2021) and Moreno *et al.* (2018). The raw protein content of the raw red and white onions was obtained as 2.41% and 2.70%, respectively. This result was higher than the values range between 0.8 to 1.1% recommended in literature (Liguori *et al.*, 2017; Lee and Lee 2018; Makinde *et al.*, 2020). This could be due to soil and environmental control. Furthermore, the highest protein content (3.58% and 3.6%) for the red and white onion flasks was obtained at 44°C and 42°C drying temperature respectively. The raw fiber content of the raw red (4.05%) was found to be lower than that of raw white onions (4.36%). This result is same as the findings by Lee and Lee (2019) and Singh *et al*. (2020). However, at 39°C drying temperature, the red onions flasks has the highest crude fiber content (4.6%), while white onions flasks has 4.60% at 44^{O}C. The raw fat content of the red and white onions was 1.85% and 2.15%, respectively, which is lower than the value obtained by Lawal and Matazu (2015) at 6.50% but within the same range as the white onion at 2.17% but less than the range obtained by Nwinuka *et al.* (2005). The red onion has the highest fat content at 34°C at 2.39%, and the white onion has the highest at 37°C at 2.46%. The analysis of variance also reveals that there is significant difference in the proximate composition of the red and white onion flakes at $p < 0.05$.

3.2. Effect of Drying Temperature on the Mineral Composition of White and Red Onions

Minerals, including sodium, potassium, calcium, magnesium, and iron, play crucial roles in human health, and the preservation of these nutrients during the drying process is vital. The highest sodium content (Table 3) of the red and white onion flasks was obtained as 12.53ppm and 15.53ppm respectively when the drying temperature was at 42^{O}C. This result is in agreement with the report of minerals (Togrond, *et al.*, 2017) that drying onions at temperatures around 40°C allows for a more gradual moisture removal. It had its highest calcium content of both the red and white onion flasks was obtained 71.60ppm and 46.50ppm respectively at 39°C.

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Furthermore, the calcium content of both onion flasks increased as the drying temperature increases. However, it was observed that the red onion flasks retained more nutrient than that of the white onion flasks. This is confirmation with the reported opined by (Cho *et al*., 2012) that red onions have been shown to retain a higher mineral content than white onions during the drying process. Studies indicate that increased drying temperatures can lead to significant losses of potassium. The potassium content of the both the red and white was obtained as 217.53ppm and 266.06ppm respectively at the drying temperature of 42°C. However there was decrease in the potassium content of both flasks when the drying temperature was between 44ᴼC, 47ᴼC and 50ᴼC. This can be attributed to the thermal degradation and solubility of certain minerals, which may leach into the drying medium or degrade under excessive heat (Karam *et al.*, 2014). The iron content of the raw red and white onion flasks was obtained as 0.49ppm and 0.97ppm respectively at the drying temperature of 32ᴼC. However, it was observed that at drying temperatures of 39ᴼC and 42ᴼC, the iron content (0.71ppm) of the red onion flasks was stable. This is collaboration with the findings of Muraleedharan *et al.* (2014), losses at elevated temperatures, minerals such as iron and zinc tend to remain relatively stable. The phosphorus content of the raw red (48.52ppm) and white (53.91ppm) was found to be in range with the values gotten by Jayeeta *et al.* (2012). The red and white onion flasks had its highest content of 58.94ppm and 66.21ppm at 42°C. Takeda *et al.* (2021) reported that high phosphorus content in onion helps to make bones stronger and repair damaged tissues. Thus, this implies that the high phosphorus content in both flasks can helps to keep bones strong and repair damaged tissues. The magnesium content of the red and white onion flasks was observed to increase as the temperature increased from 32ᴼC to 42ᴼC but decreases from 44ᴼC to 50ᴼC. This implies that there can be loss in the magnesium content as the drying temperature increases beyond 50ᴼC. This result is in-line with the findings of Muraleedharan *et al.* (2014) that magnesium are more susceptible to losses at elevated temperatures.

3.3. Effect of Drying Temperature on the and Anti-nutrients analysis of White and Red Onions

From Table 1, the vitamin A content of both raw red and white onion bulb was found to be 2.31mg/100g and 2.85mg/100g while the vitamin C was found to be 8.50mg/100g and 10.24mg/100g respectively. However, Table 4 depicts that between drying temperature of 32ᴼC and 42ᴼC there was increase in both vitamin A and vitamin C content of both flasks but these vitamins decreases between drying temperatures of 44ᴼC to 50ᴼC. This trend agreed with the findings by Sharma *et al*. (2002) who reported that vitamin losses as the duration of drying was extended. The Oxalate and the flavonoid content of the raw red and white onion (Table 4) was 58.13mg/100g and 66.90mg/100g and 72.66mg/100g and 81.26mg/100g respectively. However, the flavonoid content of both raw red and white onion was found to be greater than the value gotten by Lawal and Matazu, (2015) at 61.20mg/100g and 64.20mg/100g. From Table 4, it was observed that increased in drying temperature leads to increase in the oxalate and flavonoid content of both the red and white flasks. This findings is in agreement with the findings by (Carocho and Ferreira, 2015). Additionally, the high flavonoid content contributes healthily as antioxidants that is, it prevents heart diseases, strokes and cancer. The analysis of variance indicate that there was a significant difference in the vitamins content of both flasks at $p< 0.05$.

Conclusion and Recommendations

Assessment of the appropriate drying temperature for maximum nutrient retention in red and white onion flakes meant for food purposes was carried out .It is concluded from the result obtained that the maximum moisture and ash content of the red and white onion can be retained by oven drying at a lower temperature of 32 ºC while the maximum fat, fibre, protein and carbohydrate content was retained by oven drying at a high temperature range of 37 ºC to 50 ºC .The maximum elemental content of the red and white onion was retained by oven drying at high temperature ranges of 39 ºC to 47 ºC. The maximum Vitamin A and C, oxalate, and flavonoid content of the red and white onion can be retained by oven drying at high temperature ranges of 39 ºC to 44 ºC. This research not only contributes to better practices in food preservation but also highlights the importance of temperature control in the food processing industry. Future studies should explore the long-term effects of storage on nutrient retention and the sensory qualities of dried onion flakes, further enriching our understanding of how to preserve the nutritional values of this essential ingredient.

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Table

RAW	PARAMETERS														
	MC (%)	ASH (%)	FAT (%)	Fibre (%)	Protein (%)	Sodium (PPM)	Calcium (PPM)	Potassium (PPM)	Iron (PPM)	Phosphorus (PPM)	Magnesium (PPM)	Vit A (IU/100G)	Vit C (IU/100G)	Oxalate (MG/100G)	Flavonoids (MG/100G)
Red onion	82.61	2.91	1.85	4.05	2.41	8.47	50.70	192.53	0.41	48.52	21.73	2.31	8.50	58.13	72.66
White onion	83.20	2.48	2.15	4.36	2.70	10.96	42.73	214.63	0.81	53.91	25.17	2.85	10.24	66.90	81.26

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Table 2: Average Proximate analysis of Red and White Onion Flakes Dried at Different Drying Temperatures

PARAMETERS	SAMPLES	DRYING TEMPERATURE (°C)							
		32	34	37	39	42	44	47	50
Moisture content (%)	Red Onion	24.63	21.85	21.81	18.25	18.10	17.37	17.19	16.85
	White onion	20.74	18.32	18.32	17.92	17.59	15.92	15.19	12.85
Ash (%)	Red Onion	3.16	3.01	2.85	2.74	2.68	2.52	2.44	2.31
	White onion	2.40	2.39	2.33	2.20	2.15	2.19	2.16	2.18
Fat (%)	Red Onion	2.14	2.39	2.28	2.18	2.27	2.32	2.38	2.97
	White onion	2.33	2.39	2.46	2.21	2.13	2.18	2.23	2.21
Fibre (%)	Red Onion	3.86	3.94	4.26	4.62	4.52	4.39	4.35	4.28
	White onion	4.18	3.87	3.64	3.95	4.52	4.60	4.24	4.08
Protein (%)	Red Onion	2.37	2.74	2.89	3.30	3.42	3.58	3.43	3.37
	White onion	3.04	3.18	3.26	3.29	3.61	3.52	3.18	3.12

Table 3: Average Mineral Analysis of Red and white onion Flakes Dried at Different Drying Temperatures

MINERALS (ppm)	SAMPLES	DRYING TEMPERATURE (°C)							
		32	34	37	39	42	44	47	50
Sodium	Red Onion	9.30	10.30	10.80	12.50	12.53	12.53	11.40	10.13
	White onion	13.36	13.80	14.20	14.53	15.53	15.20	14.43	13.86
Calcium	Red Onion	58.40	64.40	69.33	71.60	70.37	68.57	67.60	64.16
	White onion	42.83	45.16	46.13	46.50	46.36	43.63	42.86	40.54
Potassium	Red Onion	210.70	214.57	215.32	216.67	217.53	216.60	215.37	212.73
	White onion	232.60	241.43	249.26	265.26	266.06	262.16	248.43	240.56
Iron	Red Onion	0.49	0.53	0.58	0.71	0.71	0.69	0.60	0.53
	White onion	0.97	0.98	1.21	1.29	1.31	1.34	1.37	1.35
Phosphorus	Red Onion	52.72	56.19	56.91	58.31	58.94	58.42	57.95	52.66
	White onion	61.25	64.51	65.12	65.92	66.21	65.63	64.73	65.12
Magnesium	Red Onion	22.53	29.81	33.75	34.92	35.14	34.64	33.81	28.53
	White onion	25.70	28.16	30.41	31.26	31.84	29.33	27.56	27.56

Table 4: Average Vitamins and Anti-nutrients analysis of Red onion and White flakes Dried at Different Drying Temperature

PARAMETERS	SAMPLES	DRYING TEMPERATURE (°C)							
		32	34	37	39	42	44	47	50
Vitamin A(IU/100g)	Red Onion	2.46	2.63	2.92	3.43	3.29	3.23	3.07	2.68
	White onion	2.65	2.91	3.12	3.37	3.25	2.87	2.61	2.54
Vitamin C (mg/100g)	Red Onion	3.16	3.01	2.85	2.74	2.68	2.52	2.44	2.31
	White onion	2.40	2.39	2.33	2.20	2.15	2.19	2.16	2.18
Oxalate (mg/100g)	Red Onion	2.14	2.39	2.28	2.18	2.27	2.32	2.38	2.97
	White onion	2.33	2.39	2.46	2.21	2.13	2.18	2.23	2.21
Flavonoid (mg/100g)	Red Onion	3.86	3.94	4.26	4.62	4.52	4.39	4.35	4.28
	White onion	4.18	3.87	3.64	3.95	4.52	4.60	4.24	4.08