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Effect of Drying Methods and Packaging on the Nutritional Values of Onions (*Allium cepa* L.) Bulbs

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Authors' contributions

This work was carried out in collaboration between both authors. Authors ETA and VTT designed the study, performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript, managed the analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

This research work was designed to give an insight on physiochemical properties of *Allium cepa*. The purpose of this study was to determine the effects of three drying methods on the physiochemical properties of onion bulbs and to determine the effective packaging material on the physiochemical properties of onion. Freshly harvested onion bulbs at a fully matured stage and fully ripe was purchased from a commercial farm at Locco farms from Song LGA of Adamawa State, Nigeria. The experiment consists of six treatments which include oven drying plastic container, oven drying polythene bags, sun drying plastic container, sun drying polythene bags, shade drying plastic container and shade drying polythene bags. The experiment was replicated three (3) times and data was collected on parameters such as color, bulk density, fat, carbohydrate and, fiber. The various drying methods used were capable of preserving the nutrients in *A. Cepa* without total loss of any nutrient. Shade dried and oven dried samples were found to be more nutritive, on the other hand, oven drying and sun drying were faster in drying than the shade drying method. Oven drying was more cost effective and gave the lowest moisture content in this study, suggesting higher capacity to prevent microbial growth and decay in the dried samples, thus confers a greater

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increase in shelf-life on the dried samples. On the other hand, plastic container packaging was found to be better in terms of maintaining physical and chemical properties of the dried samples followed, by polythene bags. Further study should be carried out on the factors that affect the storability of onion bulbs in both dried and fresh samples.

Keywords: Open sun drying; shade drying; hot air oven; onions bulbs and sensory evaluation.

1. INTRODUCTION

Allium cepa plants crop belongs to the family *Alliacease* [1] and is considered as one of the oldest cultivated crops in most countries of the world [2] which is believed to have originated in Central Asia [3]. Onion is the generic name of the *Allium cepa* family. It was said to been cultivated 6000 years BC in the nail valley. It is mostly used as food and medicinal purposes [4]. The annually consumption per capita is about 5.5 kg of onions worldwide [5]. It is the second most cultivated horticultural vegetable with a worldwide production of about 64.5 million tons on 3.45 million ha area [6]. Onions are natural food additives which have been in used for thousands of years. Onions is one of the vegetables which is used in our daily dietary due to its importance taste enhancer and flavouring material in the diet. It contains essential oils, which provide the taste and flavour. It is a good sources of vitamin C, calcium, iron and a-carotene. It is used as a whole, ground paste or liquid form mainly for seasoning and flavouring food [7]. It is used as preservative in many pharmaceutical preparations [8] and many studies have reported its preventive and curative effects for eye inflammation, fight against infections due to its sulfur compounds, respiratory problem and its anti atherogenic effects [9]. It is valued for its distinct pungent flavor and is an essential ingredient for the cuisine in many regions. The onion is preferred mainly because of its green leaves, immature and mature bulbs that used either raw or cooked as a vegetable. The bulb used in soups, spice, sauces, condiments, in medicine, seasoning of many foods and for the preparation of value added edible products such as powder, flakes and salts [10]. Studies on the physicochemical composition of onion shows that contains mainly carbohydrates along with proteins, some minerals, vitamins, and phenolic compounds [11,12].

Dehydration is one of the suitable methods of preservation of onion. Dehydrated onions are simple to use and have longer shelf life than fresh one [13]. For these reasons, preservatives practices are necessary to reduce the postharvest losses [14]. The common preservation techniques used for onion worldwide are mostly solar drying or sun [3] and hot air drying [15]. Dehydration of plants can be done using different methods such as natural drying (drying in the shade) and hot air drying. It is mostly applied in subtropical regions where sunlight is present all year round. Reduction of postharvest losses represents a large business opportunity [16]. In the same way, drying is an effective method that increases the shelf life of the final product by slowing the growth of microorganisms and preventing certain biochemical reactions that may alter the organoleptic characteristics [17]. Nevertheless, sun and oven drying methods are still widely used to produce dried products because of their low costs [18]. Onions are highly seasonal crop which in the peak season are sold at very cheap prices [19] and its abundant supply during the peak season results in spoilage of large quantities [20]. Good packaging for onions must meet the following criteria: strong enough to retain the required weight of onions under the conditions of transport and storage, allow sufficient ventilation for the air around the bulbs to maintain relative humidity in the required range, and in many circumstances, provide a means of displaying legally required and commercially necessary information [21].

The purpose of this study was to determine the effects of three drying methods on the physiochemical properties of onion (*A. cepa* L.) bulbs and to determine the effective packaging material on the physiochemical properties of onion (*A. cepa* L.)

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was carried out in the Laboratory of Food Science and Technology

Department, School of Agriculture and Agricultural Technology, Modibbo Adama University of Technology, Yola Adamawa State. The Food Science and Technology Laboratory is

located at latitude 9° 20' 43" N and longitude 12° 30' 8" E, at an altitude 203.5m above sea level. 2.2. Yola has an annual mean minimum and maximum temperature of of 15 2°C and 39°C respectively [22].

2.2 Sample Collection

50 kg of freshly harvested onion bulbs at a fully matured stage and fully ripe was purchased from a commercial farm at Loko, Song L.G.A of Adamawa State. The onion bulbs were of almost uniform colours, undamaged, free from any diseases and buries, which were selected for the experimental purpose. They were then cleaned and partially socked in salt water for 10mm, so as to deactivate microbial loads.

2.3 Treatment and Experimental Design

The experiment consist of six (6) treatment which include oven drying plastic container, oven drying polythene bags, sun drying plastic container, sun drying polythene bags, shade drying plastic container and shade drying polythene bags. And it was laid in Completely Randomized Design (CRD). The experiment was replicated three (3) times as shown in Fig 1.

2.4 Preparation of Onion bulbs for Drying

The selected onion bulbs was cleaned and socked into salt water for 10mm to deactivate microbial activity on the surface of the bulbs. The bulbs would be slices into uniform pieces so as to maintain uniform drying. After drying, the dried product was packaged in into two packaging materials (polythene bags and plastic containers).

2.5 Drying Procedures

2.5.1 Open sun drying

The sliced of onion bulbs was evenly spread on wide white polythene and placed under open sun so as to allow good absorption of solar energy. Dried samples was crushed into smaller flask and passed 1.0 mm sieve and packaged in the packaging materials provided.

2.5.2 Shade drying

The sliced of onion bulbs was properly spread on a wide white polythene and place it in a well-ventilated zero energy chamber, where Natural current of air was used to dry the samples.

2.5.3 Hot air oven

The laboratory hot air oven was used to dry the samples. The oven was run for 25 minutes at temperature of 60°C so as to obtain a stable condition before placing the sample in the chamber. The dry samples was crushed and be packaged in an air tight packaging material.

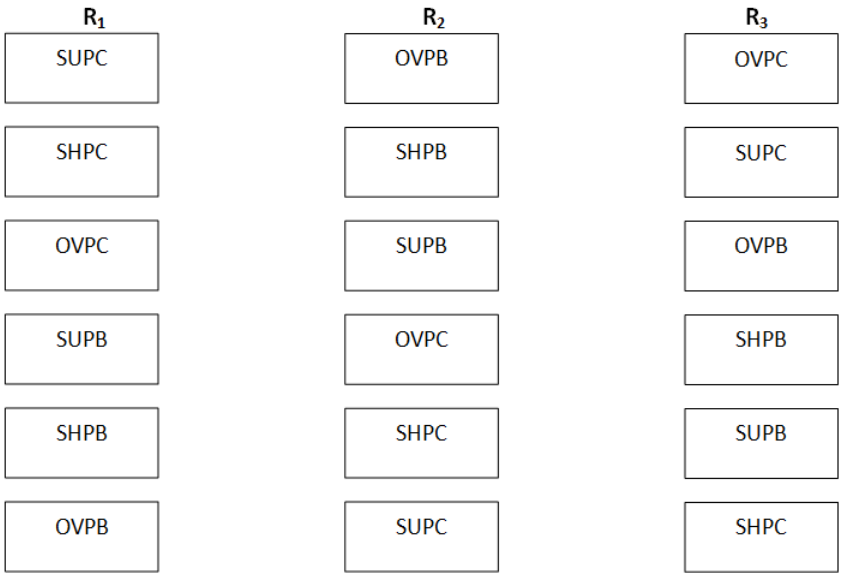

Fig. 1. Experimental layout

Keys: SH = Shaded Dried, SU = Sun Dried, OV = Oven Dried, PB = Polythene, PC = Plastic Container

2.6 Physical Properties

2.6.1 Colour determination

The colour of dried onion samples was determined using visual organoleptic method by trained laboratory technologist, caterers and marketers who are familiar with the sample [23].

2.6.2 Bulk density

Bulk density was determined as described by [24]. Ten grams (10 g) of sample will be weighed in 25 cm^3 graduated measuring cylinder and was firmly tapped 30 times on a bench top to settle the sample volume.

Bulk density

$$\text{Bulk density}\left(\frac{g}{m^3}\right)=\frac{mass}{volume}$$

2.7 Chemical Composition

2.7.1 Determination of content

Five grams of sample was placed in a thimble and inserted into soxhlet apparatus and the oil extracted using hexane as solvent. The mass of soxhlet was noted before extraction. The mass of flask and oil after extraction would be noted from which the mass and percentage mass of oil was calculated [24].

$$\%\ \text{oil content} = \text{x}\,100 \ = \frac{\text{mass of flask} + \text{mass of oil}}{\text{mass of sample}}$$

2.7.2 Determination of fiber

Five grams of sample was poured into 600m1 beaker and 200m1 hot H_2S0_4 was added. The beakers was placed on digestion apparatus with pre-heated plates. It was boil and filter through white man GF/F paper by gravity. The beaker was rinse with distilled water. The residue was wash on the paper with distilled water until the filtrate is neutral [25].

2.7.3 Carbohydrate determination

This was determining according to [25] by obtaining the differences, by subtracting from 100 the sum of the percentage moisture, ash, protein, fat and fiber.

% carbohydrate = 100 - (sum of moisture, ash, protein, fat, fiber)

2.8 Moisture Content

The moisture contents of each sample were determined according to the method elaborated in AOAC [26] 925.09 and calculated as percent loss in weight using Equation 5.

Moisture (%) = $\frac{M_i - M_d}{M_i}$ X 100 when; Mi = initial before drying, and M = final mass after drying. The storage period lasted for 12 weeks

2.9 Data Analysis

The data was subjected to the analysis of variance (ANOVA) using Statistical Analysis System and means separated using Least Significance Difference at 5% level of significance

3. RESULTS AND DISCUSSION

3.1 The Effect of Drying Methods and Packaging Materials on Chemical Composition of Dried Onions

The result of the effects of drying methods and packing material on chemical composition of dried onions is presented in Table 1, the result

Table 1. Effect of drying methods and packaging materials on chemical composition of dried onions

Samples	% M.C	% Ash	% Fiber	% Protein	%CHO	%DM	Lipid
SHPB	22.57	6.47	7.00	5.50	61.87	77.20	0.64
SHPC	22.60	4.40	2.03	6.57	44.20	78.03	0.85
SUPB	21.33	18.67	5.47	5.50	48.23	79.07	0.96
SUPC	22.60	6.53	2.38	5.40	63.83	79.20	0.75
OVPB	18.33	4.33	5.03	5.03	66.07	77.20	0.75
OVPC	25.00	6.33	3.47	4.05	59.90	75.17	1.10
P of F	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
LSD	0.64	0.59	0.49	0.45	4.04	1.18	0.12

shows highly significant (P≤0.01) difference in all the parameters measured in the chemical composition.

3.1.1 Moisture content

The result in Tables 1, showed that the result further revealed that combination of oven drying and plastic container had the highest moisture content of 25.0% followed by shade dried plastic container and sun-drying and plastic container with values of 22 6% each. The least moisture content was however recorded in oven drying and polyethylene bag packaging (18.33%). The interaction between shade dried and sun dried as well as oven dried + polythene bag got higher mean values.

The moisture of dried samples was significantly difference (P≤ 0.05) among all the three drying methods. During the storage period shade dried sample had highest mean value of 22.58% while sun dried sample and oven dried sample recorded the least mean value at 21.96% and 21.67% respectively at four weeks. On the other hand, polythene bag recorded the lowest value of moisture percentage with 15.50% while plastic container recorded the highest mean at twelve weeks and this could be attributed to the low density of PC than PB as a result of migration of moisture from the storage environment to the packaging materials. This results agreed with that of [21], that the polythene bag recorded the lowest value of moisture percentage while plastic container recorded the highest mean at twelve weeks and this could be attributed to the low density of PC than PB as a result of migration of moisture from the storage environment to the packaging materials.

3.1.2 Ash content

The result of ash content in Table 1. Ash rate also increase as storage period increases. The result showed a significant difference (P ≤ 0.05) among all the treatment combination. Sun-dried onions package in polybag was more superior than other treatment which had a value of 1867% while the least value was obtained in oven dried onions package in polythene bag (4.33%).

The effect of drying methods and packaging materials on ash content of dried onions result showed that there was increase of ash content as the drying temperature increase and this result in agreement with the findings of [27] who reported that ash content increases as the drying temperature increased, but the result disagreed with Morris [28] who reported that the decrease in ash content could be as a result of moisture removal which tends to increase the concentration of other nutrients. Sun dried polythene bag sample recorded the highest value with 18.67% which differ significantly (P ≤ 0.05) from sun dried plastic container with 6.53%. The interaction between shade dried and oven dried sample recorded the lowest mean value with 8.00% and 5.33%respectivtily which differ significantly from interaction of sun dried that recorded the highest value with 12.60% at 12 weeks. This study agrees with [27] who recorded that the ash content of onion is affected due to the drying methods and packaging materials.

3.1.3 Protein content

The result of protein content of dried onions can be seen in Table 1. which shows a significant difference (P ≤ 0.05) among the treatment for protein content the result indicated that the combination of shade drying and plastic container retained highest percentage of protein (6.57%) followed by shade dried polythene bags and sun dried polythene bags (5.50%) respectively, oven dried plastic container however, had the lowest value of 4.05% of protein content.

The result showed that there was increase in protein rate as the storage period increase. Likewise, shade dried plastic container prove to be better in terms of maintaining protein content during the storage period.

The protein content of shade dried sample recorded the highest mean values with 5.50% and 6.57% while sun dried sample recorded the least mean values with 5.50% and 5.40% at four and twelve weeks This may be attributed to the enclosed drying environment and lower drying temperature of shade dried sample On the other hand, Likewise, the interaction between shade dried and polythene bag and as well as sun dried and polythene bag samples recorded the highest mean values with while the interaction between oven dried and polythene bag and as well as oven dried and plastic container recorded least mean values at 12 weeks and the result showed significant difference (P ≤ 0.05). This results is in agreement with that of [29], whose study recorded that there are effects of drying methods and packaging materials on protein contents of dried onions.

3.1.4 Lipid content

The result of lipid content of dried onions is presented in Table 2. The result showed that

drying method by oven had the better lipid content than shade and sun drying. There was no much difference of lipid content between the interactions shade dried and sun dried. Oven dried plastic container retain highest amount of lipid content with (1.10%) followed by sundried plastic bag with (0.96%) and the least was shade dried plastic bags with (0.64%).

The percentage of lipid content decreases as the drying temperature increased at 30°C to 32°C,, this result showed less significant difference (P ≤ 0.05) among the drying methods at initial stage but all the drying methods differ significantly from each other. The oven dried sample recorded the highest value with 1.10 % while sun dried and oven dried sample recorded 0.76% and 0.86%. This result agreed with finding of [30] who reported decrease of lipids content in spinach due to the application of heat that is capable of destroying them. All the two packaging materials recorded similar value with 2.88% at four weeks but at twelve weeks there was significant difference (P ≤ 0.05) among the two packaging materials.

3.1.5 Fiber content

The fiber content of dried onions at different drying methods is shown in Table 1. In terms of fiber content however, the result indicated highly significant (P ≤ 0.05) difference with shade-drying polythene bag having the highest fiber content value of 7.00%, followed by Sun Dried Polythene Bags and Oven Dried Polythene Bags with values of 5.47% and 5.03% respectively. The least value was however recorded in Shade Dried Plastic Container (2.03%).

The fiber content of all the drying method in polythene bags sample had highest mean value than the plastic Container, followed by sun dried sample with 40.65% while the sun dried sample recorded the least mean value with 3.93%. The result showed less significant difference (P≤0.05) among all the three drying methods. But all the three drying methods differ significantly which shows that Shade Dried Polythene Bags Dried sample recorded the highest fiber content with 7.0% followed by 5.47% and 5.03% for sun and oven dried plastic container samples at twelve weeks respectively while the interaction between shade dried plastic container and sun dried plastic container recorded the least mean values with 2.03% and 2.38% at four and twelve weeks respectively. This results is in agreement with that of [31], whose study recorded that there are effects of drying methods and packaging materials on fiber contents of dried onions.

3.1.6 Carbohydrate content

The carbohydrate content of onions is presented in Table 2. The result of the carbohydrate composition of dried onions revealed a less significant difference (P ≤ 0.05) in all the treatment with oven drying and plastic bags having the highest carbohydrate (66.07%) content when compared with other treatment. The least value was however obtained in sun-drying and plastic bag (48.23%) but was not significantly different with all other treatments.

The carbohydrate content increases as the drying temperature increased, the oven dried sample recorded the highest mean value with 63.30% followed by 56.4% and 63.04% for oven, sun and shade drying 12 weeks respectively. This result showed less significant difference (P≤0.05) between oven dried and sun dried samples. Fruits and vegetable have poor source of carbohydrate at fresh form. However, after drying, the carbohydrate content of vegetables increases as reported by [32]. This result agreed with [32] reported that low carbohydrate content of fresh vegetables showed that they supply little or no energy value when consumed except when supplanted with other foods. The recorded highest mean value with 66.07% in oven dried polythene bags while the recorded the lowest mean value with 48.23% in sun dried polythene bags.

3.2 Dry Matter Content

For dry matter content, the result also shows a significant difference for all the treatment. The result shows in Table 2, that oven drying and polythene bag packaging gave the best dry matter content of 89.50% with the least value obtained in oven drying and plastic container packaging (59.90%).

Nitrogen and potassium are the most important materials influencing dry matter contents of onions bulb according to Hansen (2010), the dry mater of onions bulb and composition different in inside the onions depending on the length of storage period. The percentage dry matter content result shows that their was less significant different (P≤0.05) among the drying methods and packaging materials. Oven dried, polythene bags have the highest mean value with 89.50% while sun dried polythene bag with

Table 2. Effect of drying method and packaging material on sensory evaluation of dried onions

Samples	Aroma	Colour	Taste	Texture	0/A
SHPB	7.60	7.833	7.27	7.47	7.60
SHPC	7.27	7.70	7.07	7.30	7.83
SUPB	7.20	7.43	7.83	7.43	7.53
SUPC	7.90	8.03	8.07	7.40	7.90
OVPB	7.47	7.27	7.20	7.67	7.60
OVPC	5.33	6.90	7.30	7.60	7.90
P<F	<0.15 1	<0.003	<0.248	<0.364	<0.529
LSD	0.548	0.498	0.986	0.377	0.603

Keys:
SH = Shade Dried
SU = Sun Dried
OV= Oven Dried
PB = Polythene Bag
PC = Plastic Container

Score scale
Like Extremely = (I)
Like Very Much = (H)
Like Moderately = (G)
Like Slightly = (F)
Not Like Nor Dislike = E
Dislike Slightly = (D)
Dislike Moderately = (C)
Dislike Very Much = (B)
Dislike Extremely = (A)

79.07%. The interaction between the SHPC and SUPC show no significant different with 77.20%. The lowest mean value with 75.17% in oven dried and plastic container.

3.3 Storage Stability

The effect of storage on colour, taste, aroma and consistency. The result showed that almost all the parameters evaluated, shade dried sample had higher mean value followed by oven and sundried respectively Likewise, oven dried recorded the highest mean value in almost all the parameters evaluated followed by plastic container and polythene bag respectively.

The storage period least for twelve weeks in polythene bag and plastic container During the storage time, samples were evaluated for colour, taste, aroma, consistency and as well as overall acceptability There was less significant difference (P≤0.05) among the drying methods and packaging materials on the overall acceptability, at four, eight and twelve weeks respectively Similarly, there was less significant difference on aroma and taste between the interaction at four and twelve weeks respectively But the interaction between shade dried and plastic container, oven dried and plastic container and as well as sun dried and plastic container recorded highest mean values with 8.07% and 8.03% equally on colour and taste at twelve weeks respectively On the other hand, oven dried plastic container hand the recorded lowest mean value with 5.33% at twelve weeks.

Colour is an important attribute because it is usually the first physical property that the consumer observes, retention of food colour, after some processing may be used to predict the extent of quality or deterioration of food resulting from exposure to heat. The degree of ripeness of the fruit prior to drying affects the final colour of dried products In this result agreed with Salunlche et al. [33] reported that rapid loss of colour of fruits and vegetables was attributed to their exposure to atmospheric gasses which result in fading out the desirable colour. At four weeks, sun dried plastic container has the highest mean 8.1% and oven dried and shade dried samples have less mean value of 7.2% and 7.7% respectively.

But all the three drying methods have different mean value of shade dried with 8.0% and sun dried 7.4% while oven dried 7.2% after twelve weeks of storage and this could be attributed to the exposure of onions fruits to salt treatment prior to drying Moreover, the odourless and static chemical property of plastic that ensures unimpaired taste and colour of the content make it advantageous for food packaging. Likewise, the interaction between shade dried and plastic container as well as sun dried and plastic container recorded the highest and equal mean value of 8.00% at four weeks of storage, shade dried and polythene bag, sun dried and polythene bag and as well as oven dried and polythene bag recorded the least and equal mean value of 7.00% at four weeks of storage

3.4 Sensory Evaluation

The mean sensory scores of colour, taste, aroma, consistency and overall acceptability (0/A) of stew maid from dried onions. The result shows that the stew prepared from Sun Dried Plastic Container had higher scores for all the attributes. Followed by Shade Dried Polythene

Bags. The least of the entire attribute was Oven Dried Plastic Containers.

4. CONCLUSION

There is need to process and preserve onions during its peak period so as to make it available all year round. The use of shade or oven drying and polythene bags or plastic container should be adopted for proper preservation of nutritive value. Onions for immediate processing should be harvested at fully ripe stage and free from decay and disease for better quality during processing and storage. Further studies should be carried out on the factors that affect the storability of both dried and fresh onions for its availability to the increasing demand.

In this study, the various drying methods used were capable of preserving the nutrients in the food crops without total loss of any nutrient. Shade dried and oven dried samples were found to be more nutritive, on the other hand, oven drying and sun drying were faster dried than the shade drying method. Oven drying was more cost effective and gave the lowest moisture content in this study, suggesting higher capacity to prevent microbial growth and decay in the dried samples, thus confers a greater increase in shelf-life on the dried samples. On the other hand, plastic container packaging was found to be better in terms of maintaining physical and chemical properties of the dried samples followed by polythene bags.

Food drying is one of the methods that is used to preserve some perishable agricultural produce; in order to ensure their availability almost all year round, and to reduce postharvest losses and achieve food security.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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