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Article

Evaluation of Different Drying Techniques on Bombay Red Onion *(Allium cepal L.)* Basic Nutritional and Volatile Components

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Abstract: Onion (Allium cepa L.) is a strong-flavoring vegetable consumed in different ways. It is mainly due its distinctive flavor or simply pungency. Onion has also important natural compounds effective for medical functions such as inhibition of bone resorption, lower risk of cardiovascular disease and cancer. This importance is directly related to high content of organo-sulphur compounds. Shelf life of fresh onion bulb is short enough about two weeks at ambient storage conditions in Fogera district, Amhara region, Ethiopia. This is mainly due to the presence of high moisture in fresh onion bulbs. Postharvest loss of onion bulb reaches up to 50% in the production season in Fogera district. Consequently onion bulb had extreme variable market price during production and off season in the district which directly influences both the growers and consumers. In this study the effect of different drying techniques on nutritional and volatile components of onion were evaluated. Effect of different drying techniques on protein, carbohydrate, total sugar, fat, pyurvic acid, ascorbic acid, total phenol, total flovonol, rehydration ratio, color and sensory properties of onion slice were evaluated and found insignificant at ($P > 0.05$) for microwave and modified direct solar dryers taking fresh onion bulb as a control. But oven drying method had significant effect on onion physicochemical quality attributes at ($P < 0.05$) as compared to fresh onion bulbs.

Keywords: Onion; drying; bioactive; nutritional and organoleptic

1. Introduction

Onion (Allium cepa L.), an increasingly used vegetable, ranking third from major vegetables produced in the world. Onion is a strong-flavoring vegetable used in a wide variety of ways mainly for its distinctive flavor, aroma or simply pungency [1]. Some researcher also reported about its importance as a biological compound and medical functions such as inhibition of bone resorption, lower risk of cardiovascular disease and cancer. Such medical use is also directly related with their high content of organo-sulphur compounds [2]. Onion bulb is a perishable agricultural produce which limits its economical importance for growers in Fogera district, Amhara region, Ethiopia [3]. So evaluation different preservation techniques is a solution to extend shelf life of onion bulbs by keeping its physicochemical quality attributes, hence it will be available in all seasons and localities to meet the demand of the consumer at reasonable price [4]. Processing and stabilizing shelf life of onion bulb reduce its postharvest loss significantly. Minimal postharvest loss of onion bulbs has the advantages for both the growers and consumers [5]. In the production of processed commercial foods such as soups, sauces, sausage, and meat food products dried onion (onion flake) is basic ingredient used as flavoring agent. Dried onion products are sometimes preferred than fresh onion bulbs because of its simplicity of for use and greater shelf stability [6]. Drying of onion bulb is performed by applying heat energy on onion slice does not only remove moisture content, it also influence the nutrient and may distract volatile and bioactive component of fresh onion bulbs. Hence appropriate drying techniques should be selected and employed. Major drying methods of agricultural products are open air and hot air drying techniques. Open air drying methods mainly practiced in rural areas while hot air drying techniques mainly used in urban areas [7]. Both drying method have their own merits and demerits on nutritional values, bioactive component loss, color, shrinkage and other organoleptic properties of agricultural produces like onion bulb [6]. The domestic demand for energy substantially exceeds supply and on the contrary solar energy is an ideal way for drying of agricultural produces in sub-Saharan countries like Ethiopia. The supply of solar energy is abundant in almost all locations of the country [8]. These concerns has focused our attention to the potential of harnessing the opportunity by developing modified direct solar dryer and evaluate its effect on nutritional and bioactive components of onion bulb during drying process. Two commercial dryers such as oven and microwave dryers were also evaluated as comparison test. Therefore in this study the effect of three drying methods on nutritional and bioactive components of onion bulbs were evaluated taking fresh onion bulbs as control.

2. Materials and methods

2.1. Sample collection and preparation

Bombay red onion variety was collected from Adet agriculture research center since it is abundantly produced onion in Fogera district,Amhara region, Ethiopoa. Trimming was performed to remove contaminated, injured and other extraneous materials. Then inedible part of onion bulb was removed and sliced uniformly at slice thickness of 5 mm. Finally sliced onion was dried up to a moisture content of 12% using three different drying methods. Drying temperature of oven was adjusted at 50^{o}C and for microwave drying was performed at 700W power generation level a method by [9]. But drying temperature of modified direct solar dryer was uncontrolled so it was simply measured using data logger mounted at inside cabinet of dryer along the drying periods and the drying temperature was founds as 28^{o}C to 45^{o}C. Dried onion slice was packed using polyethylene bags and set further analysis of quality attributes of onion flakes.

2.2.Proximate composition analysis

Proximate composition

The proximate compositions such as moisture, crude fiber, crude protein, total carbohydrate, ash and crude fat contents of onion flake and onion bulbs were determined according to a method [10].

2.3. Bioactive component analysis

2.3.1 Total phenol content

Total phenolic content of onion sample was determined by Folin-Ciocalteu method as described by [11]. Distilled water of 0.44 mL and 0.02 mL of Folin reagent were added to 0.02 mL of extract/suspension of the sample (2 mg/mL). After 3 minutes resting, 0.4 mL of 20% Na_2CO_3 was added. The mixture was vortexed and incubated for 20 min at 40°C using a water bath; there after the absorbance was read against a blank at 760 nm using a UV–spectrophotometer. The total phenolic content was determined using the standard curve (y = 0.022 x; r^2 = 0.9945) obtained with Gallic acid. The contents were expressed as mg of Gallic Acid Equivalent/100g of the samples.

2.3.2. Ascorbic acid content

Ascorbic acid content of the fresh and dehydrated onion samples were determined using titration method by [12]. The reduction of 2, 6-dichlorophenol indophenol dye by ascorbic acid and expressed in mg per 100 g.

2.3.3. Total Flavonol content

Aluminum tri-chloride method, as described by [13] was used to determine the total flavonoid content onion samples. One hundred (100)µL of extract/suspension was mixed with 1.49 mL of distilled water before introduction of 0.03 ml of 5% $NaNO_2$. After 5 min resting, 0.03 ml of 10% $AlCl_3$ was added and the mixture allowed to rest. After 6 min, 0.2 ml of 1 M NaOH and 0.24 ml distilled water were respectively added and the mixture was vortexed and the absorbance was measured at 510 nm using UV–spectrophotometer.The flavonoid content was determined using the standard curve ($y = 0.1972 x$; $r^2 = 0.9972$) obtained with Catechin. The contents were expressed as mg CE/g of onion sample.

2.3.4. Pyruvic acid content

Pyruvic analysis was performed according to a method by [14] with slight modifications. Briefly, 10gm of chopped onion was homogenized for 3 min in 10mL distilled water. The homogenate was centrifuged for10 min at 20,000 rpm and the supernatant was removed for pyruvate assay. Supernatant of 1.5mL were then diluted 10-fold in de-ionized water. An aliquot of 0.5mL was added to1 mL of 2, 4-dinitrophenyl hydrazine (0.0125 %; v/v) in 2mol/L HCl and 1.5mL de-ionized water in a boiling tube. The reaction mixture was vortexed and kept for 10 min at 37°C temperature and after cooling 5mL of 0.6 mol/L NaOH was added, and the absorbance was measured at 420 nm with Shimadzu UV-1700 spectrophotometer. The calibration curve was made by preparing pyruvic acid solutions at concentrations 0.04–0.4 mmol/L in water and the pyruvic acid concentration were expressed in terms of (µmol/g fresh weight (FW)).

2.3.5. Rehydration ratio

Rehydration ratios of dehydrated onion slice were determined method by [15]. The rehydration characteristics of the dehydrated onion slice were studied in terms of the rehydration ratio.

2.3.6. Sensory analysis

Trained panelists of 15 members evaluated the color, appearance, texture, flavour, taste and overall acceptability of onion flakes on a nine-point hedonic scale. The panelists were unaware of the project objectives. Samples were coded with three-digit random numbers and then served. Panelists were provided with a glass of water, and were instructed to rinse and swallow water between samples. They were given written instructions and asked to evaluate the overall acceptability of the products based on their appearance, texture, taste, flavour and color using a nine-point hedonic scale (1=dislike extremely to 9=like extremely) a method described by [16].

2.4. Statistical analysis

Data collected from the experiment were analyzed using statistical analysis such as descriptive statistics and analysis of variance (ANOVA).

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3. Result and discussion

3.1.Drying environment of direct solar dryer

As it is observed in the figure-one below the maximum drying temperature of modified direct solar dryer was about 45°C. Drying temperature and relative humidity of modified direct solar dryer was recorded using data logger mounted at the inner cabinet of the dryer.

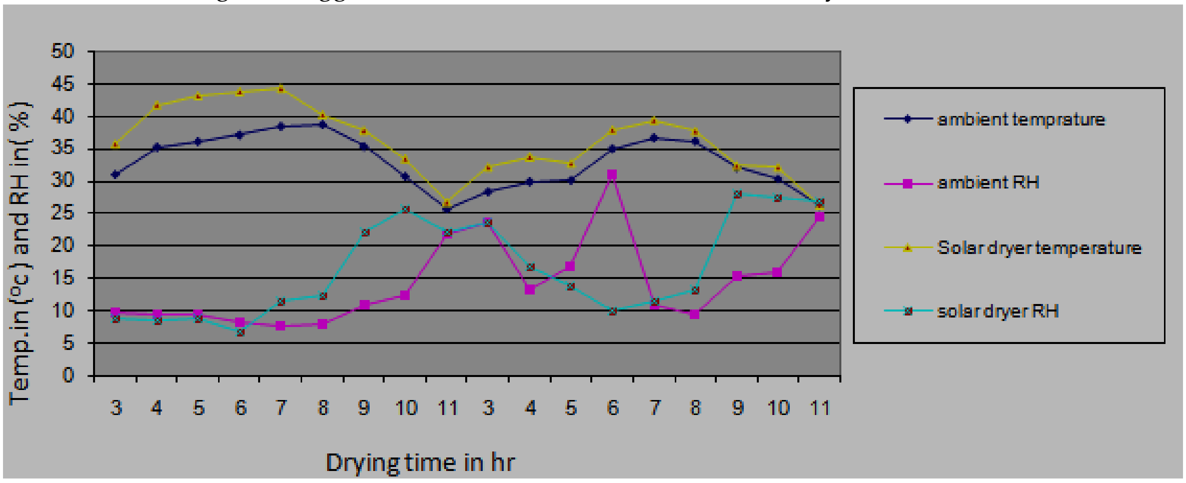

Figure 1. Drying temperature and relative humidity of modified direct solar dryer cabinet

3.2. Proximate composition of fresh and onion flake

The proximate compositions fresh and dried flake of onion bulb samples was shown in table-one below. In this study the dry matter content of Bombay red onion was found as 73.76% in dry weight basis which is a big higher than other researcher's finding and report. Proximate composition of Bombay red onion was different than the finding and report by [17]. But similar result was reported by [18]. Onion flake dried using microwave and direct solar dryer did not show significant difference ($P>0.05$) in terms of protein, carbohydrate, fat and ash content but onion flake dried using oven dryer changes significantly at ($p<0.05$) taking fresh onion bulb as control. Similar finding was reported by [19]. The proximate composition of onion slice in (dry weight basis) in this study also coincides with finding and report by [20] at drying temperature of 35°C.

Table 1. Fresh onion bulb and onion flake nutritional content /dry weight basis/

Item	Protein[%]	Carbohydrate[%]	Ash[%]	Fat[%]
Freshonion	2.73 ± 0.15^a	12.35 ± 0.01^a	47.36 ± 0.01^a	1.08 ± 0.02^a
SDonionflake	2.70 ± 0.15^a	12.65 ± 0.08^a	47.12 ± 0.08^a	1.21 ± 0.06^a
MWonionflake	2.72 ± 0.12^a	12.71 ± 0.05^a	47.03 ± 0.01^a	1.02 ± 0.02^a
OVonionflake	2.69 ± 0.13^b	12.12 ± 0.09^b	47.12 ± 0.08^b	0.98 ± 0.02^b

*Values are mean ± standard deviations of triplicate, SD =Solar dryer, MW=Microwave dryer, OV= Oven dryer and values with the same letter on the same column were not significantly different at ($p>0.05$)

3.3. Bioactive component

3.3.1. Total polyphenol

Polyphenols are well known to put on display as antioxidant activity all the way through a diversity of mechanisms, including free radical scavenging, lipid peroxidation and chelating of metal ions in addition to having many other biological activities, such as anti-histamine as founded and reported by [21]. The major phenolics found in onion are quercetin, gallic acid, ferulic acid, and their glycosides [22]. Polyphenol content of fresh, microwave dried, oven dried and solar dried onion was found as 185.65 (GAE)/100g, 185.35 (GAE)/100g 181.23/100g and 183.45/100g respectively as shown in table-2 below. Insignificant difference at ($P>0.05$) was observed in polyphenol content of onion flake in all drying techniques. Similar effect of drying method on ployphenol content of onion was reported by [23].

3.3.2. Pyruvic acid content

Pungency change of onion throughout drying of onion has been linked with high temperature breakage of pyruvic acid molecules. Pyruvic acid changed significantly at different drying temperatures [24]. Pyruvic acid is a trust worthy indicator of pungency. Pyruvic acid is unwavering product from the hydrolysis of S-alk (en)yl-l-cysteine sulphoxide. When the onion cell is ruptured by cutting and chopping, the enzyme alliinase hydrolyse S-alk (en)yl-l-cysteine sulphoxide. Pungency of onion slice reduces significantly at ($p<0.05$) when dried at 70^{o}C since most volatile compounds have low boiling point [23]. Pyruvic acid contents of onion bulbs decrease with an increasing of drying temperature. On the contrary there is also a finding for which high drying temperature had high pungency in the dried onion flake. It can also be explained that accelerated drying in the initial stages would retain this volatile compounds locked into the product when it reaches the critical moisture content. In this study Pyruvic acid concentration in fresh and dried onion flakes by microwave and modified direct solar dryer did not change significantly at ($p>0.05$). Onion flake dried using oven drying changes significantly at ($p<0.05$). Pyruvic acid content for fresh, microwave dried, oven dried and solar dried onion samples were found as 78.46μmol/g, 77.50μmol/g,72.56 μmol/g and 77.97μmol/g respectively. Sulfur composition has been reported as strongly influence the flavor of onion. Another contradicting report was also found by [25] who stated that there was an increase of pyruvic acid with respect to the fresh sample during drying at different temperatures. Pyruvic acid content in onion depends on several factors such as dry matter, sugar content, cultivars, maturity and sulphur nutrition. Several environmental factors have been also identified, that can alter onion flavor.

3.3.3. Total flavonol content

Different flavonols have been identified and characterized. From these quercetin derivatives are the most significant ones in all onion varieties which are significantly reduced during drying [26]. Total flavonol (quercetin and its glysosides) content of fresh onion and onion flake are given in table-two below and total flavonol for fresh, oven, microwave, and solar dried onion were 4.67μmol/g,4.31 μmol/g, 4.65 μmol/g and 4.56μmol/g respectively. In this experimental result total flavonol content did not change significantly at ($p<0.05$) with different drying methods. Different result was reported by [27] in which flavonol content varied significantly at ($p<0.05$) along drying methods.

3.3.4. Ascorbic acid content

An increase in drying air temperature had a negative effect on quality of ascorbic acid. This is due to the rupture down at high temperatures and the sensitivity of ascorbic acid to heat to oxidation humiliation. The ascorbic acid content of fresh, oven dried, microwave dried and solar dried onions were shown in table-2 below and the values were 57.65 mg/100g, 57.43 mg/100g, 61.45mg/100g and 58.55 mg/100grespectively. The statistical analysis on the relationship between drying methods and ascorbic acid content did not show any significant correlation at ($p>0.05$). Other research results show loss of ascorbic acid content at significant difference in the dried onion sample [28]. This is due to the volatile nature of flavouring components and also ascorbic acid is known as if it was temperature dependent.

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Table 2. Effect of drying techniques on bioactive and antioxidants of onion

Item	Total phenol (GAE)/100g	Ascorbic acid mg/100g	Pyruvic acid mg CE/g	Total flavonol µmol/g
Fresh onion	185.65±0.08^{a}	57.65±0.37^{a}	78.46±0.89^{a}	4.67±1.23^{a}
SD dried onion	183.45±0.26^{a}	58.55±1.02^{a}	77.97±0.78^{a}	4.56±0.48^{a}
MW dried onion	185.35±0.98^{a}	61.45±0.87^{a}	77.50±0.37^{a}	4.65±1.09^{a}
OV dried onion	181.23±0.14^{a}	57.43±0.87^{b}	72.56±0.59^{b}	4.31±0.98^{b}

*Values are mean ± standard deviations of triplicate, SD=solar dryer, MW=microwave dryer, OV=oven dryer and values with the same letter on the same column were not significantly different at (p>0.05)

3.3.5. Sensory quality

Mean scores for aroma, flavour, taste, appearance, colour and overall acceptability shown in table thee below. In this study, sensory qualities of onion flake dried by different drying methods were investigated as compared to fresh onion and show no significant difference at (p>0.05). The sensory scores of all the sensory attributes except taste did not vary significantly with the drying methods. Nearly similar result was observed that there was no significant variation in sensory scores of samples dried at 50°C, but colour, varied significantly (P<0.05). Similar result reported as sensory quality of onion flake show insignificant difference at (P>0.05) as compared to fresh onion [29]. Onion flake dried for two days prepared using modified direct solar dryer was found acceptable by the panelists. The taste of onion flake had higher values than the fresh onion scores and this increment may be due to high concentration of total sugars in onion flake than the fresh onion [30].

Table 3. Onion flake sensory quality attributes

Item	Fresh onion	MW dried onion	OV dried onion	SD dried onion
Aroma	8.9±0.90	9.0± 0.45	9. 0± 0.88	9.0±0.71
Flavour	9.0± 0.80	8.5± 0.56	8.2± 0.79	8.9±0.61
Taste	7.6±0.12	7.8± 0.79	8.1± 0.95	8.3±0.34
Appearance	9. 0±0.96	8.2±0.92	8.4± 0.86	8.7± 0.78
Colour	8.7± 0.68	8.5±0.45	8.6± 0.23	8.6±0.35
Overall acceptability	8.5±0.78	8.6±0.53	8. 6± 0.18	8.7±0.65

*Values are mean ± standard deviations of 15 panelists, SD=solar dryer, MW=microwave dryer and OV=oven dryer

3.3.6 Rehydration

The rehydration characteristics of a dried product are widely used as indicators of quality dried product. Rehydration is a complex process that is influenced by both physical and chemical changes associated with drying and the treatments preceding dehydration and reported rehydration ration of onion was 6.87 [31]. The result found in the experiment was nearly similar with the one reported previously. The rehydration quality parameter data of onion slice is given in table-4 below. The drying process causes changes in the permeability of the cell walls, loss of osmotic pressure and solute migration which affects the rehydration ratio. The rehydration ratio of onion slice ranges 7.87 to 5.65 along the drying methods. Each drying method had significance difference at (p<0.05) in rehydration ratio dried onion flake. The rehydration ratio of solar and microwave dried onion products show insignificance difference at (p>0.05). When rehydrating a dried product, it will never regain the same condition as before drying. The less elastic cell walls and the reduced water holding capacity of protein and starch, all decrease the rehydration ratio of the products but this phenomenon will be reduce significantly by optimizing drying process as it is in our finding. So, the negative factors regarding rehydration of the cells will be less than with a poor drying technique as stated [32].

Table 4. Rehydration ratio of onion flake

Item	Rehydration Ratio[RR]
SD dried onion	7.87±0.98^{ac}
MW dried onion	6.86±0.68^{bc}
OV dried onion	5.65±0.89^{abc}

*Values are mean ± standard deviations, SD=solar dryer, MW=microwave dryer and OV=oven dryer and values with different letter significantly different at ($p < 0.05$).

4. Conclusion

It can be disclosed from this work that Bombay red onion in Ethiopia has better crude proteins, total carbohydrates, crude fat and bioactive components like ascorbic acid, pyruvic acid, falvonol and phenol content. The overall interpretation of this present investigation may offer a scientific basis for increased and versatile utilization of these carbohydrate-rich onions as a food component and carbohydrate supplement. In this study it appeared that modified direct solar drying method had more quality dried product than oven dried onion products. The quality parameters of dried onions were also influenced by the drying techniques. Drying condition of modified direct solar dryer was found as an appropriate technique of extending shelf life of onion bulbs with keeping its physicochemical quality attributes.

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