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Evaluation of drying techniques on nutritional and volatile components of Bombay red onion *(Allium cepa)*

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ABSTRACT

In this study performance of three drying methods on nutritional and important volatile components of red onion were evaluated. Onion (*Allium cepa* L.) is a strong-flavoring vegetable consumed in different ways, mainly due to its distinctive flavor or, simply pungency. The shelf-life of fresh onion bulbs are 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 bulbs also reaches up to 50% in the production season in Fogera district. Consequently, onion bulbs had extremely variable market price during production and off-season in the district, which directlyinfluences both growers and consumers. The effects of different drying techniques on protein, carbohydrate, total sugar, fat, pyruvic acid, ascorbic acid, total phenol, total flavonoid, rehydration ratio, colour, 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 bulbs as the control. However, oven drying methods had a significant effect on onion physicochemical quality attributes at P <0.05 as compared to fresh onion bulbs.

Key words: Ascorbic acid, Flavonol, Phenol, Pyruvic acid, Rehydration

Onion (*Allium cepa* L.), an increasingly-used vegetable, ranking 3rd in terms of major vegetables produced around the world. Onion is a strongly-flavoured vegetable used for its distinctive flavour, aroma or, simply pungency (Kumar *et al.* 2007). Some researchers have also reported about its importance as a biological compound and its 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 (Corzo-Martinez *et al.* 2007). Onion bulb is a perishable agricultural produce which limits its economic importance for growers in Fogera district, Amhara region, Ethiopia (Endalew *et al.* 2014). Evaluation of different preservation techniques is a solution to extend the 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 a reasonable price (Miedema 1994). Processing and stabilizing the shelf-life of onion bulbs reduces its postharvest loss significantly. Minimal postharvest loss of onion bulbs has advantages for both growers and consumers (Ayalew *et al.* 2017). Dried onion products are sometimes preferred than fresh onion bulbs because of its simplicity of for use and greater shelf stability (Mazza and Lemaguer 1980). Drying of onion bulb is performed by applying heat energy to onion slices, does not only remove the moisture content, it also influences the nutrients and may disturb volatile and bioactive components of fresh onion bulbs. Hence, appropriate drying techniques should be selected and employed, viz. open air and hot air drying. The domestic demand for energy substantially exceeds the supply and, on the contrary, solar energy is an ideal way for drying of agricultural produce in sub-Saharan countries like Ethiopia. The supply of solar energy is abundant in almost all locations of the country (Gallali *et al.* 2000). These concerns have focused our attention to the potential of harnessing the opportunity by developing a modified direct solar dryer during the drying process. Two commercial dryers, oven and microwave were also evaluated in a 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 the control.

MATERIALS AND METHODS

Sample collection and preparation: Bombay red onion variety was collected from the Adet Agriculture Research Center since it isan abundantly produced onion in Fogera district, Ethiopia. Physiologically matured onion bulbs were harvested and immediately trimmed to remove contaminated, injured and other extraneous materials. Then, the inedible part of the onion bulb was removed and sliced

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uniformly at a slice thickness of 5mm. Finally, sliced onion was dried to a moisture content of 12% using three different drying methods. Oven dryer (Model number CT-c-1, bought at Shanghai, China), microwave dryer (model number OT-C-1, bought at Qingdao, China OT-C-1) and modified solar dryer. The drying temperature of the oven was adjusted to 50°C and for microwave, drying was performed at a 700W power level, based on the method followed by (Kaymak-Ertekin and Gedik 2005). However, the drying temperature of a modified direct solar dryer was uncontrolled so it was simply measured using a data logger mounted inside the cabinet of the dryer during the drying periods and the drying temperature was found to be 28–45°C. Dried onion slices were packed using polyethylene bags and kept for further analysis of the quality attributes of onion flakes.

Proximate composition analysis: The proximate compositions, such as moisture, crude fibre, crude protein, total carbohydrates, ash, and crude fat contents of onion flake and onion bulbs were determined according to the method (AOAC 1990).

Bioactive component analysis

Phenol content: Total phenolic content of onion sample was determined by Folin-Ciocalteu method as described by Gao *et al.* (2000).

Ascorbic acid content: Ascorbic acid content of the fresh and dehydrated onion samples was determined using the titration method (Ranganna 2005).

Flavonoid content: The aluminium tri-chloride method, as described by Padmaja *et al.* (2011), was used to determine the total flavonoid content of onion samples.

Pyruvic acid content: Pyruvic analysis was performed according to the method by Abayomi and Terry (2009) with slight modifications. Briefly, 10g of chopped onion was homogenized for 3 min in 10 ml distilled water. The homogenate was centrifuged for 10 min at 20000 rpm and the supernatant was removed for pyruvate assay. A total of 1.5 ml of supernatant was then diluted 10-fold in de-ionized water. An aliquot of 0.5 ml was added to 1 ml of 2, 4-dinitrophenyl hydrazine (0.0125%, v/v) in 2 mol/l HCl and 1.5 ml of de-ionized water in a boiling tube. The reaction mixture was vortexed and kept for 10 min at 37°C. After cooling, 5 ml of 0.6 mol/l NaOH was added, and the absorbance was measured at 420 nm with a spectrophotometer (model no-V1700, bought from Nanjing, China). The calibration curve was made by preparing pyruvic acid solutions at concentrations of 0.04–0.4 mmol/l in water and the pyruvic acid concentration was expressed in terms of (μmol/g fresh weight (FW).

Rehydration ratio: Rehydration ratios of dehydrated onion slices were determined by the method (Ranganna 1986). The rehydration characteristics of the dehydrated onion slices were studied in terms of the rehydration ratio.

Sensory analysis: A panel of 15 trained members evaluated the colour, appearance, texture, flavour, taste, and overall acceptability of onion flakes on a nine-point hedonic scale. The panellists were unaware of the project objectives.

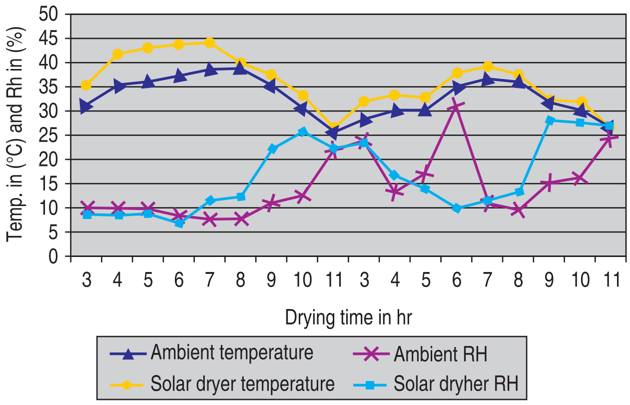

Fig 1 Drying temperature and relative humidity of the modified direct solar dryer.

Samples were coded with three-digit random numbers and then served. Panellists 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 colour using a nine-point hedonic scale (1=dislike extremely to 9=like extremely), a method described by Meilgaard *et al. (*1999).

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

RESULTS AND DISCUSSION

Drying environment of the direct solar dryer: As is observed (Fig 1) the maximum drying temperature of modified direct solar dryer was about 45°C. The drying temperature and relative humidity of the modified direct solar dryer was recorded usinga data logger mounted in the inner cabinet of the dryer.

Proximate composition of fresh and onion flake: The proximate compositions of fresh and dried flake of onion bulb samples are shown in Table 1. The dry matter content of Bombay red onion was found to be 73.76% by dry weight

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

Item	Protein (%)	Carbohydrate (%)	Ash (%)	Fat (%)
Fresh onion	2.73 ± 0.15a	12.35 ± 0.01a	47.36 ± 0.01a	1.08 ± 0.02a
SD onion-flake	2.70 ± 0.15a	12.65 ± 0.08a	47.12 ± 0.08a	1.21 ± 0.06a
MW onion-flake	2.72 ± 0.12a	12.71 ± 0.05a	47.03 ± 0.01a	1.02 ± 0.02a
OV onion-flake	2.69 ± 0.13b	12.12 ± 0.09b	47.12 ± 0.08b	0.98 ± 0.02b

Values are mean ± standard deviations of triplicate; SD, solar dryer; MW, microwave dryer; OV, oven dryer; and values with the same letter in the same column were not significantly different at P >0.05.

basis, which is a much higher than other researcher's finding and report. The proximate composition of Bombay red onion was different than the findings as reported by Kahane *et al.* (2001), but a similar result was reported by Nweinuka *et al.* (2005). Onion flake dried using a microwave and a direct solar dryer did not show significant difference at P>0.05 in terms of protein, carbohydrate, fat and ash content, but onion flake dried using an oven dryer changes significantly at P<0. 05, taking fresh onion bulb as the control. A similar finding was reported in Pramod *et al.* (2014). The proximate composition of onion slices by, dry weight basis, in this study also coincides with the findings as report by Mitra *et al.* (2011) at drying temperature of 35°C.

Bioactive components

Polyphenol: Polyphenols are well known to display antioxidant activity 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 found and reported in Shahidi *et al.* (1997). The major phenolics found in onion are quercetin, gallic acid, ferulic acid, and their glycosides as presented by Nitta *et al.* (2007). 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, (Table 2). Insignificant difference was observed at P>0.05 in polyphenol content of onion flake under all drying techniques. A similar effect of drying method on polyphenol content of onion was reported in Mazza and Maguer (1979).

Pyruvic acid content: The pungency change of onion throughout the drying of onion has been linked with the high temperature breakage of pyruvic acid molecules. Pyruvic acid changed significantly at different drying temperatures (Freeman and Mossadeghi 1970). Pyruvic acid is a trustworthy indicator of pungency. Pyruvic acid is an unwavering product from the hydrolysis of S-alk (en)yl-l-cysteine-sulphoxide. Pungency of onion slices reduces significantly at P<0.05 when dried at 70°C since the most volatile compounds have low boiling points (Mazza and Maguer 1979). Pyruvic acid contents of onion bulbs decrease with an increasing of the drying temperature. On the contrary, there is also a finding for which a high drying temperature resulted in a high pungency in the dried onion flake. It can also be explained that accelerated drying in the initial stages would retain this volatile compound in the product when it reaches the critical moisture content. 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 78.46, 77.50, 72.56 and 77.97 µmol/g, respectively. Sulphur composition has been reported as strongly influencing the flavour of onion. Another contradicting report was also found in Randle (1997) which 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 also been identified that can alter onion flavour.

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 flavonoid (µmol/g)
Fresh onion	185.65 ± 0.08a	57.65 ± 0.37a	78.46 ± 0.89a	4.67 ± 1.23a
SD dried onion	183.45 ± 0.26a	58.55 ± 1.02a	77.97 ± 0.78a	4.56 ± 0.48a
MW dried onion	185.35 ± 0.98a	61.45 ± 0.87a	77.50 ± 0.37a	4.65 ± 1.09a
OV dried onion	181.23 ± 0.14a	57.43 ± 0.87b	72.56 ± 0.59b	4.31 ± 0.98b

Values are mean ± standard deviations of triplicate; SD, solar dryer; MW, microwave dryer; OV, oven dryer; and values with the same letter in the same column were not significantly different at P >0.05.

Total flavonoid content: Different flavonoid have been identified and characterized. From these, quercetin derivatives are the most significant ones in all onion varieties which are significantly reduced during drying (Griffiths *et al.* 2002). Total flavonoid (quercetin and its glysosides) content of fresh onion and onion flake are given in Table 2 below and total flavonoids for fresh, oven, microwave, and solar dried onion were 4.67, 4.31, 4.65 and 4.56 µmol/g, respectively. In this experimental result the total flavonoids content did not change significantly at P<0.05 with different drying methods. A different result was reported by Slimestad *et al.* (2007) in which flavonoid content varied significantly at P<0.05 depending on the drying methods.

Ascorbic acid content: An increase in drying air temperature had a negative effect on the quality of ascorbic acid. This is due to the rupture at high temperatures and the sensitivity of ascorbic acid to heat to oxidation. The ascorbic acid content of fresh, oven-dried, microwave-dried, and solar-dried onions were 57.65 mg/100 g, 57.43 mg/100 g, 61.45 mg/100 g and 58.55 mg/100g, respectively (Table 2). 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 a significant difference in the loss of ascorbic acid content in the dried onion sample (Nuutila *et al.* 2003). The loss of ascorbic acid is directly related to its high volatile nature.

Sensory quality: Mean scores for aroma, flavour, taste, appearance, colour, and overall acceptability are shown in Table 3. 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

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 aceptability	8.5 ± 0.78	8.6 ± 0.53	8.6 ± 0.18	8.7 ± 0.65

Values are mean ± standard deviations of 15 panellists; SD, solar dryer; MW, microwave dryer and OV, oven dryer.

not vary significantly with the drying methods. A 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. A similar result was reported as the sensory quality of onion flake shows an insignificant difference at P >0. 05 as compared to fresh onion (Anjusangwan *et al.* 2010). Onion flake dried for two days, prepared using a modified direct solar dryer, was found acceptable by the panellists. The taste of onion flake had higher values than the fresh onion scores and this increment may be due to the high concentration of total sugars in onion flake than the fresh onion (Achanta and Okos 1998).

Rehydration: The rehydration characteristics of a dried product are widely used as an indicator of the dried product quality. Rehydration is a complex process that is influenced by both physical and chemical changes associated with drying and the treatments preceding dehydration. The reported rehydration ratio of onion was 6. 87 (Lewicki *et al.* 1998). 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 from 7. 875–. 65 depending on the drying method (Table 4). Each drying method had a significant difference at P<0. 05 in the rehydration ratio of dried onion flake. The rehydration ratio of solar and microwave dried onion products show an insignificant 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 reduced significantly by optimizing the drying process, as is shown in our findings. Thus, the negative factors regarding rehydration of the cells will be less than with a poor drying technique as stated in (Kumar *et al.* 2004).

It can be disclosed from this work that Bombay red onion in Ethiopia has better crude proteins, total carbohydrates, crude fat and bioactive components, such as ascorbic acid, pyruvic acid, flavonoid 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

Table 4 Rehydration ratio of onion flakes dried using different dryers

Item	Rehydration ratio (RR)
SD dried onion	7.87 ± 0.98ac
MW dried onion	6.86 ± 0.68bc
OV dried onion	5.65 ± 0.89abc

Values are mean ± standard deviations; SD, dryer; MW, microwave dryer; and OV, oven dryer and values with different letters are significantly different at P < 0.05.

that the modified direct solar drying method had a higher quality dried product than oven dried onion products. The quality parameters of dried onions were also influenced by the drying techniques. The drying condition of modified direct solar dryer was found as an appropriate technique to extend the shelf-life of onion bulbs while maintaining its physicochemical quality attributes.

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