EFFECT OF DRYING TEMPERATURE AND DURATION ON NUTRITIONAL QUALITY OF COCHORO VARIETY TOMATO (*lycopersicon esculentum* L.)

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Abstract
*Tomato (Lycopersicon esculentum L.) is popular vegetable among all parts of the world. However, marketing of fresh tomato during peak season is a great problem because of its short postharvest life and traditional ways of managing the postharvest. Therefore, drying is one of the most convenient method, dried product have grater shelf life compared to the fresh produce and facilitates the availability of products in un-seasons. During drying, some nutritional quality parameters may degraded and thus affect general quality characteristic of the dried tomato. The main objective of present investigation is to study the effects of duration and temperature of oven drying on nutritional property of dried tomato. This studies were carried out in two factorial design arranged in completely randomized design (3*2) which consist three levels of drying temperature (70^{o}C,80^{o}C and 90^{o}C) and two levels of duration of drying (7and 8 hours) based on preliminary trials. The data were analysed using SAS software (version 9.2). Every significant treatment effect was compared using Tukey at 5% probability level. As the result indicated that the drying processes (interaction effects of duration and temperature) affect the nutritional quality of dried tomato. Furthermore, vitamin C content of the samples dried at 90^{o}C for 7 and 8 hours were badly affected recording an average value of 2.03mg/100g of vitamin C compared to fresh and those dried at 70^{o}C and 80^{o}C for 7 and 8 hours with average values of 7.03 mg/100g, 3.86 mg/100g, 3.7 mg/100g, 3.16 mg/100g and 2.83 mg/100g respectively.*

Keywords: tomato, oven drying, drying temperature, vitamin C, lycopene

Received: 10.02.2017 Received in revised form: 12.05.2017 Accepted: 17.05.2017

1. INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is most economically important vegetable crops one of the most popular and widely grown plants in the world as well as in Africa and Ethiopia (Osemwegie, *et al*., 2010 & Wiersinga and Jager, 2009). Many varieties of tomato are cultivating in different parts of Ethiopia among Cochoro variety of tomato is a commonly cultivating in Jimma zone, it is one of the early maturing variety and one of the high yielding variety with better nutritional quality of fruits with extended shelf life (Jiregna 2013).
However, poor postharvest practices are the serious concerns and contribute to the poor quality perception and high postharvest losses of domestically produced tomato (Genova *et al*., 2006). These losses may be attributed to improper postharvest sanitation, poor storage, packaging practices and mechanical damage during harvesting, handling and transportation (Idah *et. al*., 2007). Tomato cultivation and yield have linear association with seasons, there is a high fluctuations in tomato prices in markets of developing countries some time produce is wasted or unutilized because of abundant availability and sometime too shortage for consumers because of scarcity.
To increase the shelf life of tomatoes, different preservation techniques are being employed that comprise of manipulation of storage temperature and relative humidity (Esa et al., 2015), addition of chemical preservatives, protection against spoilage through waxing (Tuba et al., 2011) modified atmosphere packaging (Majidi et al., 2014), dehydration and processing into other products. But, the success of these methods depends on how it meets certain requirements of the product quality for consumption. On the other hand most of the reported methods cannot extend shelf life maximum for one month.
Several processing technologies have been employed on an industrial scale to preserve food products and to extend shelf life; the

major ones are canning, freezing and drying. Among these, drying is especially suited for developing countries with poorly established low-temperature and thermal processing facilities. Drying of fruit and vegetable are not familiar in Ethiopia because of the lack of extended research and technology. Drying is attractive technology because it is a very simple and can easily adaptable by farmers and small scale processor with minimal capital investments. It offers a highly effective and practical means of preservation to reduce postharvest losses and offset the shortages in supply (Sheshma *et al*., 2014). Similar to other fruits and vegetable tomato can be dried using various methods such as sun drying, spray drying, oven drying and also more sophisticated and high capital cost drying technologies such as infrared radiation and freeze drying (Gowen *et al*., 2008; Lewicki, 2006). Generally, the choice of a drying technology depends on its efficiency in terms of energy consumption, final quality of food product and cost related issues. Preservation of nutritional quality characteristics are significantly influences the operational parameters of the drying method. Criterion such as maximum product temperature, long duration and environmental humidity during drying affect the final product quality (Humberto *et al*., 2001). More specifically, the duration and temperature of the drying process are the important factors affecting and nutritive value of the final products (Yang and Atallah, 1985; Krokida and Marinos 2003).

Even though processing of tomatoes using sun drying with cut pieces, drying of whole tomatoes, spray drying and convection drying using solar or mechanical systems have been used for many years (Baloch *et al.*, 1997; Collins *et al*., 1997; Hawlader *et al.*, 1991; Olorunda,*et al*.,1990; Shi *et al.*, 1999; Zanoni *et al*., 1999), traditional sun-drying is a slow process requires 7 to 12 days compared with other drying methods and quality losses may result from high moisture content, colour degradation by browning and microbial growth during storage (Okos *et al*., 1992; Lewicki *et al*., 2002). Therefore, in order to improve the quality of dried tomato products, industrial drying methods such as hot-air processing's preferred (Doymaz, 2007) to control product quality and to achieve hygienic conditions, to avoid reduction of product loss.

Therefore, the objectives of this study were to quantify the losses in nutritional quality after drying, establish appropriate drying temperature, duration of drying for tomato.

2. MATERIALS AND METHODS

Raw materials collection:

An improved (Cochoro) variety of tomatoes which is widely grown in Maki area and known for its superior performance was collected from a local farmer in Ziwai (Maki), Jimma, Ethiopia. The tomatoes were freshly hand harvested from the field at their light red maturity stage, transported carefully to the department of postharvest management laboratory in college of Agriculture and Veterinary Medicine and allowed ripened to uniform red ripen stage.

Sample preparation and drying process

Prior to drying, individual tomato fruits were measured by callipers and cut into 8mm thickness slices using sharp stainless steel knife (Jayathunge *et al*., 2012). To get uniform drying, tomato slices were placed in single layer for drying in hot air oven at predetermined temperatures of 70°C, 80°C and 90°C for the duration of 7 and 8 hours which were fixed depends on preliminary trials, dried tomato slices were cooled for about an hour inside desiccators to prevent re-absorption of moisture and packed in polythene bag for analysis and stored in dry place for further analysis.

Determination of Nutritional properties:

Moisture content, ash content, crude fiber, crude protein was determined by the methods determined by the AOCS (2012). Carbohydrate content determined by the difference method Onyeike *et al*. (1995). Vitamine C determined by spectroscopy (Sadasivam and Manickam 1997) and lycopine and β-Carotene was determined by procedure reported by Nagata and Yamashita (1992).

A. Experimental Designs

The present study was carried out using a two factor factorial design. The factor one represented the drying temperature with three levels (70^{0}C, 80^{0}C and 90^{0}C) and second factor is time of drying with two levels (7 and 8 hours) with triplicate, in this study total runs conducted were 18.

B. Statistical Analysis

Initially, all the collected data from objective measurements and subjective assessments were determined for normality, and variance homogeneity tested by distribution graphs and subjected to the Analysis of Variance (ANOVA) using SAS version 9.2 computer software (SAS Institute Inc., 2008). Data were compared on the basis of standard deviation of the mean values. Every significant treatment effect within the evaluated parameters was compared using Tukey at 5% probability level.

3. RESULTS AND DISCUSSION

The analysis of variance of the results indicated that there is interaction effect between temperature and duration of drying in all parameters during drying study. The result of proximate composition for both experiments was calculated as dry basis. Effects of drying temperature and duration of drying on the proximate composition of dried tomato are presented in Table 1.

Moisture

There was significant ($p \leq 0.001$) difference in moisture content between control (fresh) and dried tomato sample. The moisture content of the fresh tomato before drying was determined as 88% (wet basis). The maximum dry moisture content value (7.87%) was recorded in sample dried at 70^{o}C for 7 hours and minimum value (4.23%) was recorded in sample dried at 90^{o}C for 8 hour. The experimental result indicated that as drying temperature and duration of drying increased the moisture contents of dried tomato is decreased significantly. This is attributed to the evaporation rate (migration of moisture) which increased with increasing temperature and duration of drying. The reduction of moisture content of the product at studied duration and temperature combination to less than 10 % is desirable and hence contributes for better shelf stability. However there was no statistically significant difference between samples dried at 80^{o}C for 7 hours and 8 hours.

The result is in line with the report of Onuegbu *et al*. (2013), who stated that the dried samples were significantly different ($p \leq 0.05$) in moisture content from the fresh samples. Obviously there was very high moisture content (96.26%) in the fresh tomato than the moisture content of (4.24) oven dried samples at 60^{o}C. Similarly Mozumder *et al*., (2012), reported that there is high moisture content (95% ±1) in fresh tomatoes than in oven dried samples at 68^{o}C for 7 hours (6.9%). Damodaran *et al*., (2008) reported that water plays an essential role in the chemical and physical processes within foods. One of the importance of decreasing the moisture contents of product is to reduce the water activity where microorganisms cannot grow.

Table 1: Effects of duration and drying temperature on proximate composition (dry base)

Duration (hours)	Temp (^{O}C)	Moisture	Ash	Crude Fat	Protein	Crude fiber	Carbohydrate
7	70	7.87^a	10.86^a	2.8^b	13.95^{ac}	9.63^b	55.73^{ab}
	80	5.52^c	11.02^{ab}	1.79^b	14.9^{bc}	6.65^{bc}	58.74^{ab}
	90	4.82^{ed}	11.59^{ab}	1.43^b	16.59^{bc}	5.91^d	60.1^a
8	70	6.83^b	11.22^a	2.14^b	18.5^{bc}	4.71^b	55.41^b
	80	5.29^{dc}	10.2^{ab}	1.45^b	18.54^b	6.48^{dc}	58.86^{ab}
	90	4.23^e	11.2^{bc}	1.3^a	19.41^b	5.22^d	60.15^a
CV		4.20	12.30	8.10	9.01	6.10	4.15

Values in column with different letters as superscripts are significantly different at $p<0.05$

Ash
Ash is inorganic residue remaining after the water and organic matter has been removed by heating of a given food and this parameter is calculated on dry basis. It is a measure to indicate the total amount of minerals present within a food. The result of the present study revealed that the ash contents of tomato fruit was affected significantly ($p \leq 0.001$) by interaction between duration and temperature of drying. The maximum ash content (dry base) was found as 10.86% and 11.22 % in sample dried at 70°C for 7 and 8 hours respectively, which is higher than the control (fresh) and other treatment combinations (Table 1). The result showed that the ash content was raised at low temperature and short duration of drying. This could be as a result of the removal of moisture which tends to increase the concentration of nutrients (Morris *et al*., 2004).
However, ash content decreased with increment of duration and temperature (Table 1). Although there was decreasing of ash content observed, it can be seen from the result there was more ash in dried tomato sample than control (fresh) tomato; this implies that there are more combustible materials in dried tomato than control (fresh). But there was no statistically significant difference between samples dried at 90°C for 7 hours and 80°C for 7 and 8 hours.
The result was in-line with findings of Onuegbu *et al*. (2013) who reported that the ash content of fresh tomato was lower (0.43%) than those oven dried tomato samples at 60°C. Analogous to this, Idah *et al*. (2014) revealed that ash content decreases with increase in drying temperature because of denaturing of the samples at higher temperatures.

Crude Fat (%)
As result illustrates, there was significant ($p \leq 0.001$) difference in crude fat content between dried and control (fresh) tomato samples influenced by interaction effects of duration and temperature of drying. The result showed that as duration and drying temperature increased the fat content decreased. This could be attributed to the oxidation of fat at higher temperature and long duration than at lower temperature for short duration. On the other hand the lowering of fat in dried tomato may have contribution in reducing rancidity of product during storage and cholesterol level in the diet. Results from this study are similar to finding of Famurewa and Raji (2011) who reported that the fat content (1.75%) of fresh tomato samples was higher than (1.25 %) oven dried samples at 50°C.

Protein (%)
There was significant ($p \leq 0.001$) difference between dried and control (fresh) samples regarding crude protein content affected by interaction of duration and temperature of drying. The protein content in control samples was higher than the samples dried at 70°C for 7 hours (13.95%). The result indicated that decreasing of protein content is more in samples dried at low temperature and short time than in sample dried at high temperature and long duration. This shows the high temperature and long duration involved in drying denature the protein contents in dried tomatoes. However, there was no significant difference between the samples dried at 70°C for 8 hours and 80°C and 90°C for 7 hours. In accordance with this, Idah *et al*. (2014) stated that as drying temperature increased from 50°C to 70°C, they observed protein contents of dried tomato decreased from 14.68 to 13.97%.

Crude Fiber(%)
The fiber content was significantly affected ($p \leq 0.001$) by interaction of duration and temperature of drying. The result revealed that the maximum (9.63%) on dry base and the minimum crude fiber content (4.24%) was found in control (fresh) samples and in samples dried at 70°C for 7 hours respectively. These indicates that the presence of more crude fiber content in control (fresh) tomato sample than in dried tomato sample. In addition the crude fiber contents of dried tomato decreased as duration and temperature increased. This was as a result of high temperature and long duration involved during drying process can disrupt the cellular matrix of the products (Onifade *et al*., 2013).

However there was no significant difference between samples dried at 70^{o}C for 7 and 8 hours and also between 90^{o}C for 7 and 8 hours. These result is similar with the findings of Mozumder *et al*.(2012) who stated that crude fiber content of oven dried samples at 68^{o}C for 24±2 hours was 5.9%.

Total Carbohydrate (%)

There was significant ($p \leq 0.001$) difference in total carbohydrate contents of dried and control tomato samples affected by interaction of duration and temperature of drying. The highest total carbohydrate content (dry base) (60.15%) was found in samples dried at 90^{o}C for 8 hours while the lowest (8.44%) was found in fresh (control) samples. However there was no significant difference between samples dried at 70^{o}C for 7 hours, 80^{o}C for 7 and 8 hours. The result indicated that the total carbohydrate content of dried tomato increased with duration and temperatures of drying. This is expected because carbohydrate content was obtained by difference; since the other proximate composition was slightly degraded with increasing of duration and temperature of drying.

Similar result was observed by Onuegbu *et al*.(2013) who reported that lower total carbohydrate content (0.43%) in control samples than oven dried samples at 60^{o}C and also conforms with observation of Jorge *et al*.(2013) who stated that the carbohydrate content of dried tomato was concentrated on average 15 times, when compared with the fresh tomato fruits. David and White Field (2000) reported as dried foods are high in carbohydrates. The results of all the proximate analysis is presented in the Table 1**.**

Lycopene

The Lycopene content was significantly affected ($p \leq 0.001$) by interaction of duration and temperature of drying. The results showed that, lycopene contents ranged from 13.9 mg/100g to 86.3 mg/100g in control (fresh) samples and in samples dried at 90^{o}C for 8 hours respectively (Table 2). However there was no statistically significant difference between samples dried at 90^{o}C, 80^{o}C and 70^{o}C for 8 hours and samples dried at 90^{o}C for 7 hours.

The results indicated that lycopene content increased with temperatures and duration of drying. This may be due to drying increases the lycopene by destructing the tomato cells and breaking the connection between lycopene and matrix, damaging the lycopene-protein complex and releasing free lycopene by *cis*-isomerisation (Hadley, 2002; Shi, 2000). Dehghan-Shoar *et al*., (2011) proposed that when lycopene is extracted from its natural form, it bonds strong. Similar trend of lycopene contents in dried tomatoes has been reported by Abano *et al*., (2011) who dried tomatoes at 50, 60, 70 and 80°C and observed 2.96 mg/100g lycopene in fresh tomato and 59.10 mg/100g in dried tomato fruit. According to Hadley *et al*. (2002) fruit and vegetable processing, especially the thermal, is negatively reflected on the content of bioactive substances, but carotenoids (lycopene) are quite thermostable.

β- Carotene content

There were significant ($p \leq 0.001$) differences in β- carotene content between dried and control (fresh) samples. The maximum β- carotene content was 16.9 mg/100g and the minimum was 8 mg/100g in fresh sample and in dried sample at 90^{o}C for 8 hours respectively. The findings depicted that there was continuous decrease in of β-carotene with increasing of temperatures and duration of drying. This could be attributed to β-carotenes is more heat and air oxidation sensitive than lycopene (Regier et al., 2005). However there is no statistically significant difference between samples dried at 70^{o}C and 80^{o}C for 7 hours and also between dried sample at 70^{o}C, 80^{o}C, and 90^{o}C for 8 hours. Similar findings were reported by Charles et al. (2014) who stated that there was sharp decrease in ß-carotene content of tomato samples as boiling or frying time increased and suggested that ß-carotene is a heat labile compound, and could be more available in raw tomato than the processed counterpart.

Table 2. Interaction effects of temperatures and duration of drying on Lycopene, β-arotene and Vitamin C in mg/100g contents of dried tomato (wet-basis)

Duration (hours)	Temperature (^{O}C)	Lycopene	β-carotene	Vitamin C
7	70	6.16^{c}	13.16^{a}	3.86^{a}
	80	72.33^{b}	12.56^{a}	3.16^{ab}
	90	76.66^{ab}	10.66^{ab}	2.40^{ab}
8	70	76.33^{ab}	9.73^{b}	3.70^{bc}
	80	83.33^{a}	9.23^{b}	2.83^{cd}
	90	86.66^{a}	8.33^{b}	2.03^{b}
CV		5.75	8.72	7.21

Values in column with different letters as superscripts are significantly different at $p<0.05$.

Onuegbu et al. (2013) also found decreasing of β-carotene in tomato sample oven dried at 60°C than fresh sample.

Vitamin C

The result showed that there was significant ($p\leq0.001$) difference in vitamin C contents between dried and control (fresh) tomato sample affected by interaction effects of temperature and duration of drying. As a result drying temperature and duration had an adverse effect on vitamin C content of dried tomato samples (Table 2). Samples dried at 90°C for 7 and 8 hours were estimably affected recording an average value of 2.03mg/100g of vitamin C compared to the value recorded in control (fresh) sample (7.03 mg/100g). The lower value of vitamin C or the damage of vitamin during drying was primarily due to heat (high temperatures and long duration of drying) and might be oxidation and light (Silva *et al*., 2012).

However there was no statistically significant difference between dried sample at 70°C for 7 and 8 hours. Similar finding were reported by Charles *et al*. (2014) who reported that Vitamin C progressively decreased as the processing temperature and duration increased and suggested that it does not require excessive heat treatment. The result is also in accordance with the report of Fasuyi (2006) who confirmed that higher ascorbic acid content in fresh leaves is due to absence of heat treatment that does easily degrade this compound. In addition Toor and Savage (2006) also investigated that drying tomatoes at $42^{0}C$ during 18 hours led to ascorbic acid losses between 17and 27% according to tomato varieties studied.

4. CONCLUSIONS

In developing countries such as Ethiopia, tomato is a seasonal product. In addition, it is highly perishable and records huge losses during the period of maximum production. On the other hand, now-a-days in Ethiopia many agro-processing industries are emerging in an alarming rate due to the current opportunity. However they process limited amounts of crops. So in order to make it available on the market as long as possible after harvest, the preservation technology is needed. One of the most important methods of reducing tomato losses is drying which is a common form of food preservation. It reduces the weight of the product; by this minimize the costs of storage space and transportation.

The study showed that it is possible to reduce postharvest loss and extend shelf life of tomato with minimum loss by drying process. The results indicated that both duration of drying and temperature had great influence on the proximate composition of tomatoes. As drying time and temperature increased moisture, fat, vitamin C, β-carotene decreased while carbohydrate, protein, lycopene increased, this may be concentration of nutrient as moisture content removed. But fiber, ash content increases at 70°C and 80°C for 7 and 8 hours

duration and declined at 90°C for 7 and 8 hours, this could be attributed to denature the quality of dried tomato. There is also significant difference between dried and the control tomato sample (fresh) this may be because thermal processing especially drying may concentrate the nutritional value of tomatoes. On the other hand reduction in the moisture content in this study decreased the perishability and microbial loads of dried product; by this it can extend the shelf life, thereby making them available year around as well reduce cost of storage and transportation.
In addition the decrease in fat content can minimize the rancidity of the product during storage. Generally from drying study proximate composition of dried tomato showed that drying of tomato slices at 90°C for 7 and 8 hours can help in providing acceptable quality which is a major criterion in dried products as opposed to lower drying temperatures and control (fresh tomato).

5. ACKNOWLEDGEMENTS

Authors are highly thankful to the Authorities of College of Agriculture and Veterinary Medicine and Department of Post-Harvest Management, Jimma University for their partial financial support and creating the facilities to complete this research successfully.

6. CONFLICT OF INTEREST

Authors are not having any conflict of interest.

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