Effects of packaging material and storage condition on physicochemical quality and shelf stability of dried tomato powder

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Abstract

The main purpose of this investigation was to study the effects of packaging material and storage condition on physicochemical and shelf life of dried tomato. Processing type Cochoro variety was collected from Maki (Ziwai). Storage study was carried out using 2*3*2*3 factorial CRD arrangement which consist two sample (sample dried at 90°C for 7 hours and 8 hours), three packaging material (Glass jar, plastic jar and plastic bag (low density polyethylene), the storage temperature (room temperature and refrigerated storage) and the storage period(1st, 2nd and 3rdmonths) respectively and three times replicate. The data were analyzed using SAS software. Every significant treatment effect was compared using Tukey at 5% probability level. The result indicated that there is slight decreasing of lycopene, vitamin C, pH, TSS, fat, protein, ash, fiber, rehydration ratio and increasing of moisture content, Water activity, TA, Carbohydrate, and microbial load. Furthermore, vitamin C and Lycopene content of stored tomato powder was decreased more in 3-months of storage period in plastic bag (low density polyethylene bag). But the degradation rate was lower in glass jar and plastic jar for both vitamin-C and Lycopene. In general the result showed that drying can reduce the amount of postharvest losses experienced by farmers and tomato sellers and dried tomato could contribute to daily intake of nutrition especially proximate composition better than fresh tomato.

Keywords: Tomato, oven drying, quality, shelf life, packaging, storage condition, storage period.

Tomato (Lycopersicon esculentum Mill.) is one of the most popular and widely grown plants in the world. It is one of the most economically important vegetable crops and is widely cultivated worldwide with a total production of 162 million tons and thus ranks third next to potato and sweet potato with respect to world vegetable production. The leading tomato-producing countries are China, United States of America, India, Egypt, Turkey, Iran, Mexico, Brazil and Indonesia. It is also popular and widely grown vegetable crop in Ethiopia. Since 1994 up to present, tomato acreage increased to 5338 ha with a total production of 55,635 Mg. Currently tomato is one of the regional export crops of the country. However, poor postharvest practices are serious concerns and contribute to the poor quality perception and high postharvest losses of domestically produced tomato. This is due to improper pre and postharvest management (sanitation, poor storage, packaging practices) and mechanical damage during harvesting, handling and transportation resulting from vibration by undulation and irregularities on the road mechanical can enhance wastages. It is distressing to note that much is being devoted to planting crop, so many resources spent on irrigation, fertilizer application and crop protection measures only to be wasted in few days after harvest.

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 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. Therefore in order to improve the quality of dried tomato products, industrial drying methods such as hot-air is preferred as control of product quality, achievement of hygienic conditions, and on reduction of product loss.

As the quality losses in the dried products may have adverse economic effects there is also a need for safe packaging which producer of tomato get by cheap and locally available

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materials should be utilized and storage conditions that should be simple to store and helps to retain the overall quality parameter of dried tomato. Thus, proper packaging and storage conditions for dried tomato could be designed to reduce quality losses during storage. Therefore, the objectives of this study were to quantify the losses in nutritional content and to determine the best packaging material and storage condition that result in optimum retention of the nutritional quality as well as ensuring shelf stability of dried tomato.

Material and Method

Sources of raw materials

An improved processing type tomato which is widely grown and known for its superior performance was collected from a local farmer in Ziwai (Maki), Ethiopia. The tomatoes were freshly hand harvested from field at their light red maturity stage, transported by car to JUCAVM and ripened to uniform red ripe stage. A total of 80 kg mature tomato fruits were required to complete the experiment in triplicates.

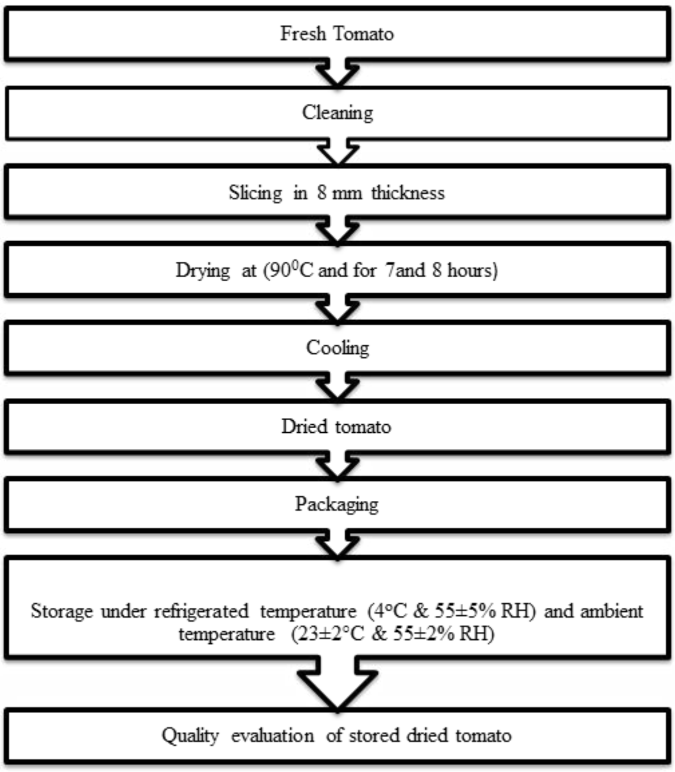
Sample preparation and drying process

The procedure for the whole study is depicted in Figure 1. Prior to drying, individual tomato fruits were measured by caliper (Fowler, US) and cut into 8mm thickness slices using sharp stainless steel knife. For the sake of keeping uniform drying slices of tomato for each run were placed in single layer on the sample trays. Then the sliced tomato samples were placed inside in the hot air oven at predetermined temperatures of 90°C for the duration of 7 and 8 hours which were fixed in preliminary trials. Next dried tomato slices were cooled for about an hour inside desiccators to prevent formation of condensation moisture in a sample to be packaged for storage study.

Experimental procedure

A sample of 70g was taken from the powdered tomatoes and packed in different packaging materials, stored under refrigerated at 4°C (55±5% RH) and ambient conditionat 23±2°C in dry (55±2% RH)and dark place for three months from February 2015 to April 2015 for storage study. Samples were withdrawn at one month interval for physicochemical analysis and microbial count. Analyses were done on the first days before storage, First month, Second and Third months of storage period. Samples to be used for analyses on each sampling date were individually packaged [figure 1].

Figure1. Flow chart depicting the process of tomato dehydration, packaging and storage



Result and Discussion

Moisture content (%)

When food product is exposed to an environment above or below their equilibrium point, the protective packages and its barrier level will determine how much the food will be impacted. As the analysis of variance showed the slight increase in moisture content was observed from first day (4%) and (3.6%) to maximum (5.41%) on 3rd months and minimum (4.64 %) during 1st month of the storage period respectively. This indicated that for the entire storage period of three months, only a slight increase in moisture content occurred. The difference between samples could be attributed to processing variation before storage.

The increasing in moisture content was significantly lower in powder sample packed in Glass jar (4.86%) and in plastic jar (4.96%) packages as compared to Plastic bag (low density polyethylene bag) packages (5.18%). This may be due to glass jar and plastic jar packages had lower permeability to vapor and O2 in comparison to plastic bag (low density polyethylene) packages. With regard to storage temperature, the samples stored at room temperature showed greater increase in moisture content when compared with refrigerated temperature and 3rd months of storage period was also significantly higher from the other periods of storage; this may be due to the interaction with temperature, variation of the relative humidity of the surrounding air and the hygroscopic nature of the product.

Crude protein (%)

Crude protein contents of dried tomato sample showed itis decreased significantly (p≤0.01) in stored tomato powder from 17.53% and 15.1% on day one to maximum decreasing rate 13.56% in polyethylene bag and 13.58% on 3rd month of storage period respectively (Table 1). Conversely, protein content decreased minimum from 17.53% and 15.1 % to 14.73 % at 1st month of storage period, 14.49 % in sample dried at 90oC for 7 hours, 14.41% in glass jar and 14.31% at refrigerated temperature, which was maximum retention of protein content during storage period. However there was no statistically significant difference between glass jar and plastic jar. This may be due to protein is often denatured by drying temperature, storage temperature and storage period. The differences between samples may be due to processing variation before storage. But Glass jar and plastic jar was offer increased stability to heat when compared with polythene bagandthe permeability ofglass jarand plastic jar is lower.

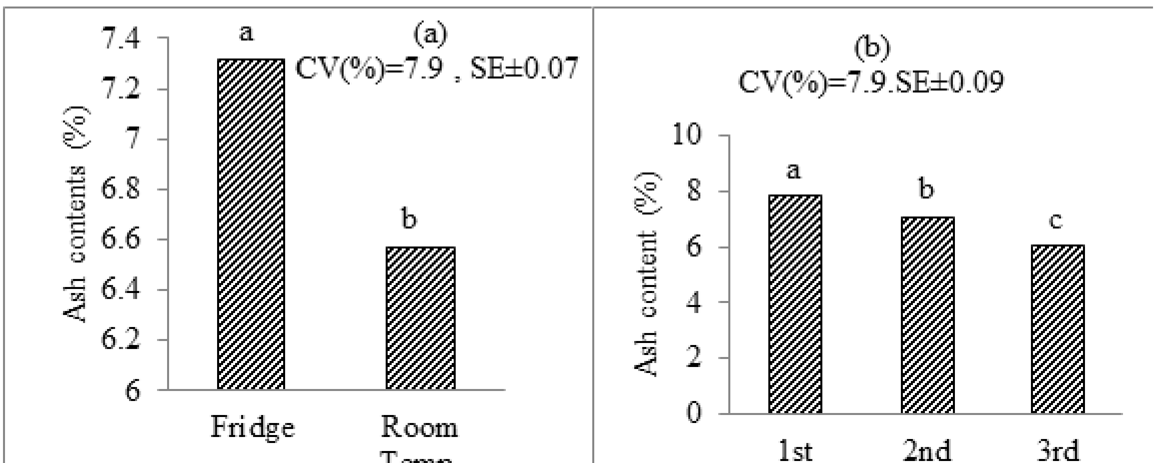
Table 1: Main effects of stored sample, packaging material and storage condition on ßeta-carotene contents of stored tomato powder

Sample	ß-carotene (mg/100g)	First day
Dried Sample		
S1	2.49±0.01a	5.11a
S2	2.34±0.01b	4.11b
Packaging material		
Glass jar	2.46±0.02a	
Plastic jar	2.42±0.02ab	
Plastic bag	2.42±0.02b	
Storage condition		
Refrigerated temp.	2.49±0.01a	
Room tem	2.34±0.01b	
Storage period		
1-Months	2.72±0.02a	
2-Months	2.44±0.02b	
3-Months	2.08±0.02c	
CV %	5.6	5.8

Ash (%)

The result illustrated that the ash content of stored tomato powder significantly (p≤0.001)decreased over the storage period from 11.6% and 11.5% on day one to 7.8% maximum value and (6%) to minimum value in 1st and 3rdmonth of storage period respectively [Figure 2]. And also ash content was significantly (p≤0.001)affected by storage temperature with decreasing rate from 11.6% and 11.5% to7.32% in refrigerated temperature, and 6.57% at room temperature storage condition respectively (Fig-2).These changes were not expected since ash is stable to heat, air and storage conditions; it might be due to some microorganisms exposed to be present during storage.These observations agree with the findings of Ibironke and Rotimi (2013) who found the minimal decreasing of ash contents in tomato powder dried at 75oC for 20 hours and stored at room and fridge temperature storage condition. In contrary to this Sarker et al. (2014) reported the increasing of ash content in stored tomato powder packed in HDPE, MDPE pouches, LAF

Figure 2. Effect of storage condition on Ash contents of stored tomato powder b) Effects of storage period on Ash content



pouches and stored in ambient temperature for six months of storage period also reported that significant increase in percentage ash content as storage continued in tomato paste stored in polyethylene and bottle for six week storage period.

β-carotene

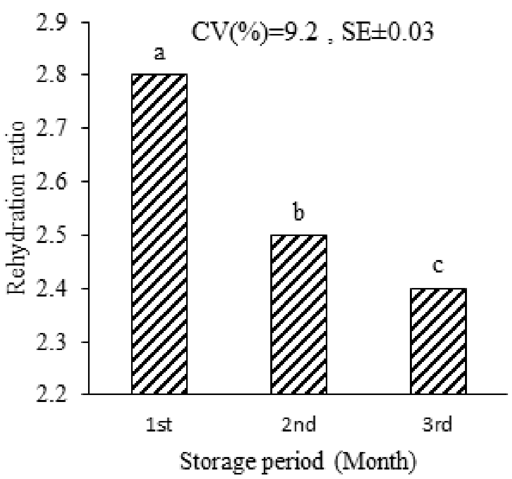
The β-carotene content of stored tomato powder in first day was 5.18 mg/100gand 4.11 mg/100g decreased to maximum 2.49 mg/100g in dried sample at 90oC for 7 and minimum 2.35mg/100gin low density polyethylene (plastic bag) packaging material in three months of storage period(Table 1). This may be because of β-carotene are heat and oxidation sensitive during processing and storage.

From packaging material the maximum retention 2.46 mg/100g is founded in sample packed in glass jar. This may be attributed to poor gas and oxygen barrier property as well as proper controlling of temperature and storage environment or humidity of plastic bag when compare with glass jar and plastic jar. On the other hand maximum 2.49 mg/100g retention was observed in sample stored in refrigerated temperature and minimum retention 2.34 mg/100g was founded at room temperature condition. This may be due to the fluctuation of temperature in room temperature storage than refrigerated temperature storage.

Crude Fiber (%)

As the result was displayed slight decreasing of crude fiber in the storage period were observed when compare with the initial values before storage which ranged from 17.54%,17.5% to 17.42% in first months, 16.77% in second months, 16.59% in third months of storage period respectively (Figure 3).

Figure 3: Effects of storage period on rehydration quality of stored tomato powder



These slight changes may be due to variation in processing condition. This is attributed to the fact that fiber content is stable macromolecular compounds to conditions of low water activity. This result was in line with the findings of Eze and Akubor (2012) who reported that crude fiber content of the samples subjected to different storage conditions were not significant in stored sample in dark cool place and stored over a hearth for eight weeks okra vegetables.

Physical Parameter

Water absorption capacities

The result of water absorption capacities of powder decreased slightly from the mean value of 4.1 and 3.96 on the first day to maximum 2.83 and minimum 2.44 which were observed on 1st and 3rd month of storage period respectively [Figure-3]. These slight reductions in water absorption capacities could be attributed to adsorption of moisture content during storage of the dried product, structural and chemical change during storage. Analogous to this Hossain and Gottschalk (2009) reported that rehydration ratio decreased linearly with the storage duration in dried tomato sample stored at room and in cool chamber storage condition for five months of storage periods.

Water activity

As the result revealed that the slight decreasing in water activity was founded from 0.45 in first day to maximum decreasing rate 0.37 in glass jar, in 1st months, and minimum decreasing 0.39, in 2nd months of storage period and at room temperature storage respectively. This may be due to Millard reaction. On the other hand slight increasing of water activity from 0.45 in first day to 0.41 in polyethylene (plastic bag) packed sample and 0.42 in 3rd month's storage period was observed [Table 2]. Similar to moisture content Aw also increased slightly due to the high rate of migration of water vapor from the storage environment to packaging material, high permeability of plastic bag and also following of increasing of moisture content with storage period.

Table 2: Effects of storage condition, packaging material and storage period on water activity of stored tomato powder

Treatment	Water activity (aw)
Storage condition	
Room temp.	0.39±0.004a
Refrigerated temp	0.38±0.004b
Packaging material	
Glass jar	0.37±0.005b
Plastic jar	0.38±0.005b
Plastic bag	0.41±0.005a
Storage period	
1- Months	0.37±0.005b
2- Months	0.37±0.005b
3- Months	0.42±0.005a
CV (%)	8.02

The result indicated that for the entire storage period, only a slight increase in water activity was found. So, the products could be safely stored for three months of storage period after which increase in its value may result into attack by micro-organism. This finding was in agreement with the work done. who observed the slight increasing of water activity in dried sweet pepper during ambient storage for four months of storage period and conclude the products could be stored up to 60 days of storage periodalso reported that the increasing of water activity in tomato powder packed Polypropylene (PP), Polystyrene (PS) and Polyvinyl chloride (PVC) than triple laminated Aluminium foil for six months of storage at 31±2oC and 65±5% RH and conclude PP, PS and PVC were found unsuitable for storage of dehydrated tomato powder as the moisture content and water activity increased.

Conclusion

The study showed that it is possible to reduce post-harvest loss and extend shelf life of tomato with minimum loss by drying process. The result indicated that there is slight decreasing of lycopene, pH, TSS, fat, protein, ash, fibre, rehydration ratio and increasing of moisture content, Water activity, TA, Carbohydrate, and microbial load. This is due to the interaction with temperature, variation of the relative humidity of the surrounding air and the hygroscopic nature of the product. The low bacterial counts and the absence of fungi in stored tomato powder seemed to be due to low pH, water activity, and moisture content. Furthermore, vitamin C content of stored tomato powder was decreased more in 3-months of storage period in plastic bag (low density polyethylene bag) and the decreasing rate of lycopene content was also higher in plastic bag (low density polyethylene) packaging material. But the degradation rate was lower in glass jar and plastic jar for both vitamin-C and lycopene. Finally, to retains nutritional quality, drying for 7 hours is recommendable. Even if slight increasing of moisture content occurred during storage the products could be stored in any one of the packaging materials up to three month of storage because the moisture content and water activity of the product was unfavourable for microbial growth. To ensure the maximum hygienic quality and minimum loss on physicochemical quality of dried tomato might be stored for maximum three months in glass jar and plastic jar at refrigerate temperature could retain than plastic bag (low density polyethylene) packaging material and store at room temperature storage. As the result showed dried tomato could contribute the daily intake of nutrition especially proximate composition superior than fresh tomato. Generally drying can reduce the post-harvest losses of tomatoes and extend shelf life with minimum degradation on quality.

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