Effect of drying temperature and storage duration on physicochemical composition and microbial analysis of dried Onion powder

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ABSTRACT

Onion is a strong astringencies flavored potential spice because of sulfur containing polyphenol compounds or vegetable which is used for food seasoning and medicinal value. Onion is a perishable crop due to high initial moisture content. This leads to spoilage of onion or post-harvest loss. For this matter this perishable crop need the techniques to extend the shelf life of onion. During on season onion production is glut in the market this leads to reduction in onion price whereas off season the price is very high. For this reason drying is good technic to extend the shelf life of onion. For this experiment Bombay red onion variety was dried at three different drying temperatures (50, 60 and 70°C) and stored at room temperature for three months in plastic bottle. Physico-chemical (color, water activity, moisture, pH, TA, vitamin C, and pyruvic acid content) and microbial analysis were analyzed. The results show that there is no interaction effect between drying temperature and storage duration. Drying temperature and storage duration were negatively affecting the quality of dried onion powder from three months storage whereas microbial load increased at lower drying temperature and maximum storage duration.

Key words: Drying, storage duration, Pyruvic acid, vitamin C.

INTRODUCTION

Onion is one of the most important commercial condiments grown and consumed widely all around the world (Kumar et al., 2015). Onion (Allium Cepa) is a strong-flavored potential vegetable widely used as food seasoning or medicine. It is the largest vegetable cultivated, produced and consumed in the world (Kaymak-Ertekin, and Gedik, 2005). Its consumption is due to the presence of bioactive chemical components of different nutritional and health benefits. Polyphenols, fructopolysaccharides, and many other health promoting compounds determine to a large extent the majority of research on onion (Kumar et al., 2015). Onion is rich in sulfur containing polyphenolic compounds responsible for the strong astringenic flavor (Corzo-Martinez, et al., 2007). Onion has high initial moisture content rounding 88%. So, onion is a perishable vegetable due to spoilage easily by organisms, enzymes, and vinegar flies. So onion needs process or semi process to extend the shelf life of onion. Processing and stabilizing of onion bulb have the advantage of both the growers and consumers (Ayalew et al., 2017). The excess production of onion results in a glut in the market and reduction in onion prices. However, marketing of fresh onion during the season is a great problem because of its shorter postharvest shelf life. Shorter shelf life as well as lack of appropriate processing and preservation techniques also results in loss of the product.

Drying, which decreases the water content of the raw product to the level that minimizes its biochemical, chemical and microbiological deterioration is one of the oldest methods of food preservation and represents a very important process in the food industry (Kaymak-Ertekin, and Gedik, 2005). Drying of onion bulb is performed by applying heat energy on onion slice, it does not only remove moisture content, it also influences the nutrient and may distract volatile and bioactive component. Dried onion products are sometimes preferred than fresh onion bulbs because of its simplicity of use and greater shelf stability (Mazza and Lemaguer 1980). Therefore, the aim of this
study is to know the effect of drying temperature and storage duration on physicochemical composition and microbial analysis of onion powder in three months storage.

MATERIAL AND METHODS

Sample collection and preparation

Bombay red onion variety was procured from local farmers near the town of Zeway, in central rift valley of Ethiopia. Before drying, bulbs were washed, root were removed, peeled and sliced to 5 mm thickness (Mitra et al., 2011).

Drying process and storage condition

The sliced onion were placed inside hot air oven (Model: Leicester, LE67 5FT, England) at specific temperature until a constant mass was achieved. Then, dried samples were cooled and ground into powder. Then, the sample used for analysis before storage (day 1 data) were packed in polyethylene bag but the sample used for storage quality were packed in plastic bottle and stored at room temperature for three months (90 days). The sample were collected at 30 days intervals and stored frozen at -20°C until analysis.

Experimental design

The experiment was carried out as two-factorial design with three replications. The first factor was oven drying temperature with three levels (50, 60 and 70°C) and the second factor was storage durations with four levels (1, 30, 60 and 90 days).

Determination of physicochemical composition

Total color change (ΔE)

The total color change of each sample was measured using color chromameter (Model: Accuprobe HH06M, America). Color measurement were recorded using hunter L*, a* and b* scale (Hassani and Sharifi, 2012) after the required white color calibrations. Total color change was calculated to estimate the extent of change in color of dried onion sample using Equation 1:

\[
\Delta E = \sqrt{(L_o - L^*) + (a_o - a^*) + (b_o - b^*)}
\]

Where, \(\Delta E\) = total color change, \(L_o\), \(a_o\), \(b_o\) are color parameter of fresh onion varieties, \(L^*, a^*, b^*\) color parameters of dried onion powder.

Water activity (\(a_w\))

The water activity of the sample was determined by LabMaster-aw instrument (Novasina AG, CH-8853 lachen, Switzerland) according to ADOGA (2005).

Moisture content

The moisture content of each sample was determined according to the method elaborated in AOAC (2011) 925.09 and calculated as percent loss in weight using Equation 2:

\[
\text{Moisture(\%)} = \frac{M_i - M_d}{M_i} \times 100
\]

Where; \(M_i\) = initial mass before drying, and \(M_d\) = final mass after drying.

pH

The pH value was determined using digital pH meter according to AOAC (2011) official method 981.12.

Titratable acidity (TA)

Titratable acidity was determined using the classical method described by Akhtar et al. (2010). TA was calculated using Equation 3:

\[
\text{TA (\%)} = \frac{\text{Titre} \times M \text{ NaOH} \times F}{0.1 \times \text{Weight of sample}} \times 100
\]

Vitamin C

Vitamin C content of samples was determined according to the method described by Sadasivam and Manickam (2005)

Pyruvic acid content

Pyruvic acid content, as an index of the flavor strength of onion was measured in μmol/g with a spectrophotometric method (Schwimmer and Weston, 1961).

Microbial analysis

Total viable load interims of bacteria and fungi in the onion
Color

Color is one of the most important qualities affecting its visual appearance. The deterioration of color during drying has a negative impact on its acceptability (Shitanda and Wanjala, 2006; Dadali et al., 2007). Discoloration was the main sign of deterioration of dried onion during 3 months of storage at room temperature (Singh and Kumar, 1984). There was significant (P<0.05) change in color of dried onion powder during drying and storage (Tables 1 and 2). Theonion dried at 50°C have highest L*, a*, b* and ΔE value than the drying temperature (60°C and 70°C). The maximum average of L*, a*, b* and ΔE are 47.52, 6.23, 51.74 and 56.38 respectively. These results indicate that drying temperature significantly affect color of dried onion powder. ‘L*’ and ‘a*’ value of onion decreased during three months storage period at ambient conditions. The top L* value of onion powder (47.11) was recorded from day one storage duration but there is no significant difference (P>0.05) at 30 days storage duration. After 30 days statistically (P<0.05) decreased to 43.11. Also a* value was significantly decreased from 7.39 to 3.4 during three months storage duration. Whereas b* increased from 46.04 to 52.05. This increment of b* value indicate that the sample become yellow color during three months storage condition. Generally under total color change there is no significant difference between 30, 60 and 90 days storage duration. The findings of the present study conform from the previous findings (Kumar and Sagar, 2009) that red pigment (anthocyanin) degrades (manifested by decrease in a* value) and non-enzymatic browning takes place (decrease in the L* and increase in the b* values) during storage. This may be due to faster rate of colour degradation at higher temperature. These results are in

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**Table 1**: Effect of drying temperature on color of stored onion powder.

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
<th>ΔE</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>47.52±1.83a</td>
<td>6.23±1.86a</td>
<td>51.74±2.87a</td>
<td>56.38±26.35a</td>
</tr>
<tr>
<td>60</td>
<td>45.42±1.78b</td>
<td>5.14±2.04b</td>
<td>49.22±2.94b</td>
<td>54.72±23.36ab</td>
</tr>
<tr>
<td>70</td>
<td>42.33±2.05c</td>
<td>4.07±1.76bc</td>
<td>46.91±3.17c</td>
<td>52.67±20.24b</td>
</tr>
<tr>
<td>P value</td>
<td>&lt;0.01</td>
<td>0.02</td>
<td>&lt;0.01</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Values with different letter superscripts are significantly different at p<0.05.

**Table 2**: Effect of storage duration on color of stored onion powder.

<table>
<thead>
<tr>
<th>Storage duration (days)</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
<th>ΔE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>47.11±2.46a</td>
<td>7.39±1.45a</td>
<td>46.04±2.69c</td>
<td>16.23±6.38b</td>
</tr>
<tr>
<td>30</td>
<td>46.08±2.41a</td>
<td>5.41±1.45b</td>
<td>48.00±2.71b</td>
<td>66.82±3.18a</td>
</tr>
<tr>
<td>60</td>
<td>44.11±2.46b</td>
<td>4.43±1.45bc</td>
<td>51.09±2.70a</td>
<td>67.63±3.20a</td>
</tr>
<tr>
<td>90</td>
<td>43.11±2.46b</td>
<td>3.40±1.45c</td>
<td>52.05±2.69a</td>
<td>67.69±3.21a</td>
</tr>
<tr>
<td>P value</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Values with different letter superscripts are significantly different at p<0.05.
agreement with the work of Lewicki et al. (1998) who reported that color was decreased with increasing of storage duration in storage stability of dried onion which was stored in plastic bottle under constant temperature of 25°C. Also Ahmed and Shivhare (2001) reported that there was decrease in a* value and L* but increase in b*values during storage of onion paste for 71 days.

**Water activity (aw)**

Water activity ($a_w$) is an important index for dried powder because it can greatly affect the shelf life of the powder produced. It measures the availability of free water in a food system that is responsible for any biochemical reactions. Water activity of dried onion powder was presented in Tables 3 and 4. There is no interaction effect between drying temperature and storage duration. The maximum average of water activity (0.334) is observed from the sample dried at 50°C however the sample dried at 60 and 70°C have statistically the same water activity. Water activity was increased from 0.287 to 0.321 during three months storage duration. The lower drying temperature and long storage duration had highest water activity, which indicate that the sample will have shorter shelf life. These results were consistent with other researchers in green onion dried at 50 to 70°C. García et al. (2010) found $a_w$ values in the range 0.29–0.40, which increased up to 0.62–0.65 after a period of storage of 126 days at room temperature. Also Juliana et al. (2012) reported that water activity of dehydrated onion increased during 12 month storage.

### Table 3: Effect of drying temperature on physicochemical composition of stored onion powder.

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>aw</th>
<th>pH</th>
<th>Titratable acidity</th>
<th>Moisture content</th>
<th>Vitamin C</th>
<th>Pyruvic acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>0.334±0.006a</td>
<td>4.45±0.12a</td>
<td>0.30±0.02b</td>
<td>8.40±0.71a</td>
<td>1.41±0.12a</td>
<td>5.17±0.34a</td>
</tr>
<tr>
<td>60</td>
<td>0.285±0.032b</td>
<td>4.37±0.09a</td>
<td>0.32±0.02a</td>
<td>7.35±0.69b</td>
<td>1.32±0.16a</td>
<td>4.99±0.21a</td>
</tr>
<tr>
<td>70</td>
<td>0.282±0.021b</td>
<td>4.38±0.19a</td>
<td>0.33±0.02a</td>
<td>6.85±1.10b</td>
<td>1.04±0.10b</td>
<td>4.77±0.17b</td>
</tr>
<tr>
<td>P value</td>
<td>&lt;0.01</td>
<td>0.08</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Values with different letter superscripts are significantly different at p<0.05.

### Table 4: Effect of storage duration on physicochemical composition of stored onion powder.

<table>
<thead>
<tr>
<th>Storage duration (days)</th>
<th>aw</th>
<th>pH</th>
<th>Titratable acidity</th>
<th>Moisture content</th>
<th>Vitamin C</th>
<th>Pyruvic acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.287±0.03b</td>
<td>4.55±0.12a</td>
<td>0.29±0.02c</td>
<td>6.91±0.83c</td>
<td>1.36±0.18a</td>
<td>5.14±0.28a</td>
</tr>
<tr>
<td>30</td>
<td>0.290±0.04b</td>
<td>4.44±0.11b</td>
<td>0.31±0.02b</td>
<td>7.17±0.82bc</td>
<td>1.30±0.18ab</td>
<td>5.04±0.29ab</td>
</tr>
<tr>
<td>60</td>
<td>0.310±0.03ab</td>
<td>4.34±0.06c</td>
<td>0.32±0.02a</td>
<td>7.73±0.99ab</td>
<td>1.22±0.20bc</td>
<td>4.93±0.27ab</td>
</tr>
<tr>
<td>90</td>
<td>0.321±0.03a</td>
<td>4.26±0.05c</td>
<td>0.33±0.02a</td>
<td>8.33±1.06a</td>
<td>1.14±0.22c</td>
<td>4.79±0.28b</td>
</tr>
<tr>
<td>P value</td>
<td>0.02</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>0.02</td>
<td>0.03</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Values with different letter superscripts are significantly different at p<0.05.

**pH**

The present study show that storage period significantly (P<0.05) affect the pH value of onion powder whereas onion drying temperature did not significantly affect pH value of onion powder (P>0.05). Table 3 shows that, pH value of onion powder at all drying temperatures were statistically the same (P>0.05). The maximum average of pH (4.55) was registered from the sample which was on day one or before storage. The minimum (4.26) was recorded from day 90 storage duration. This result implies pH value decreases with increment of storage duration. The decrease in pH value of onion powder during storage might be attributed to the availability of more readily utilizable carbohydrate molecules by the microbes and thereby formation of acid. It is an established fact that a decrease in pH is usually attributed to the metabolic activity of bacteria (Jay, 1996). This finding is line with the work of Sarker et al. (2014) who reported that pH value of stored tomato powder decreased with increment of storage duration until six months. pH of tomato powder decreased from 4.3 to 3.77 after storage of six months. The pH value 3.77 is most suitable for different processing of tomato products because pH < 4.5 often lowers the proliferation of microorganisms in the final product during industrial processing (Giordano et al., 2000). Also these observations
agree with the findings of Shankaralingam (2004), who observed that the pH of carrot powder was decreased with increasing of storage duration.

**Titratable acidity**

The acidity of onion powder gradually increase significantly at (P<0.05) throughout the storage period (Table 4). The maximum average of titratable acidity (0.33) was observed from day 90 storage duration. Also there is no significant difference (P>0.05) with day 60 storage duration (0.32). Increase in titratable acidity of onion powder might be due to acids produced by microorganism and it also due to oxidation of sugar in to acid during processing and is influenced by storage temperature (Gould and Russel, 1992). Similar observation were reported by Sarker et al. (2014) and Safdar et al. (2010) who observed the increasing acidity content of stored tomato powder packed in different packaging material and who observed the decreasing of pH contents of tomato paste during storage at 25°C, 6°C and -10°C respectively. Also the result is in line with the observations of Sharma et al. (2013) in dehydrated and stored quality of Anardana.

**Moisture content**

Analysis of variance show that the moisture content of onion powder was significantly (P<0.05) affected by drying temperature and storage period (Tables 3 and 4). During drying highest moisture content (8.4) observed from at 50°C drying temperature. However on storage duration the moisture content of onion powder was increase for all samples. The maximum average of moisture content (8.33) was observed from the sample at 90 days storage duration. This may be due to interaction with temperature, variation of the relative humidity of the surrounding air and the hygroscopic properties of onion powder. This finding is in agreement with the work done by Algadi et al. (2014) who observed the moisture content of onion powder during ambient storage and gradually increased.

**Vitamin C**

Vitamin C content of onion powder was significantly affected with storage period. A decline in vitamin C content was found with increase in drying temperature and storage duration (Tables 3 and 4). At 50 and 60°C dried onion powder has statistically the same vitamin C content. Whereas at 70°C dried onion powder has the least vitamin C content (1.04). During storage duration on day 90 the dried onion powder has the least vitamin C but the highest one is on first day. The observed decrease in vitamin C content might be due to degradation of ascorbic acid molecules forming dehydro ascorbic acid by oxidation (Lal et al., 2009). Hellmann and Rembialowska (2006) reported that there is a decrease in the ascorbic acid content of onions under ambient storage while Biezanowska-kopec et al. (2011) observed an increase in the ascorbic acid content of onions under refrigeration storage. These results are in line with the results of Sharma et al. (2013) in dehydrated and stored quality of Anardana.

**Pyruvic acid (μmol/g)**

The pyruvic acid had decreased in all powdered samples during the storage period of three months, and results are presented in Table 4. The maximum average of pyruvic acid (5.14) was observed from first day or before storage of dried onion powder. After storage pyruvic acid of dried onion powder was slightly decreased to 4.79. This reduction of pyruvic acid content during drying temperature and storage period may be due to the degradation of the capsaicinoid pigments (pungency components) present in the onion. This result was in agreement with Tummala et al., (2008) who reported that the pyruvic acid of onion powder had decreased in all powder samples packed in PE and plastic bottle during the storage period of 180 days.

**Microbial load of onion powder**

Microbiological quality is a common criterion used to determine the acceptability and shelf life of dehydrated products; however drying process is not lethal to all microbes. Microbial load count of the dehydrated foods depends on handling quality of utensils used during the processing period (Jay, 1996). From this study drying temperature significantly affects the microbial load of dried onion powder. Table 5 shows that the peak bacterial count (4.67x10⁴) was recorded from the sample dried at 50°C. On the other hand, very low bacterial (3.33x10⁴) were detected from the sample dried at 70°C during storage duration. Also the maximum fungal count (1.34x10⁴) was recorded from the sample dried at 50°C. In addition to drying temperature, storage duration also affect microbial load of dried onion powder. During storage duration microbial loads were increased from 2.14x10⁴ to 6.44x10⁴ for bacterial count and from 0x10⁴ to 2.56x10⁴. Furthermore, the maximum values of fungus (3x10⁴) were observed from Bombay Red onion variety dried at 50°C on 90 days storage duration. There was no fungus detected from all treatments on day one storage duration (Table 5).

However, they appeared after 30 days storage duration on wards and followed a significantly (P < 0.05) increasing trend in all the treatments. This result agrees with Shankaralingam (2004), who reported that an increase in total plate count at each storage interval in carrot powder.
on 30 days storage duration. This is also in agreement with the findings of Chidanandaiah et al. (2009); Kumar and Tanwar (2011); Bhat et al. (2013a) and Bhat et al. (2013b) who also reported the similar results in meat patties, chicken nuggets, chicken seekhkababs and chicken meat balls respectively. In general, the results obtained from present study showed that the onion powder which was stored for 90 days have the highest microbial counts while the onion powder which not stored has lower microbial counts. These low microbial counts of stored onion powder seemed to be due to lower pH, water activity, and moisture content at which the growth of microorganisms was not possible. Famurewa et al. (2013) reported that the microbial load of tomato paste packed in polyethylene and plastic bottle maximum (12x10³cfu/g) and (3x10³cfu/g) minimum which was higher than that reported in this study and also similar observation was reported on fungi with this study. Neena et al. (2013) reported that result higher than this study and also observe mould count on storage stability of leaf curl resistant cultivar of produced tomato powder.

**CONCLUSION**

In general, storage duration and drying temperature are affecting physicochemical quality of dried onion powder. The present study showed that the best quality of onion powder was obtained from the sample dried at 50°C during three months storage duration. However, the best microbial quality of onion powder was observed at 70°C during three month storage duration. In addition during storage duration all samples show that degradation of physicochemical quality of dried onion powder. For this reason, further research should be done using different packaging materials that differs from the present study and different storage condition to give conclusive recommendation about quality profile of the studied onion varieties under different drying temperature along with best shelf life.

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<table>
<thead>
<tr>
<th>Drying temperature</th>
<th>bacteria</th>
<th>fungus</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>4.67x10⁴ᵃ</td>
<td>1.34x10⁴ᵃ</td>
</tr>
<tr>
<td>60</td>
<td>4.01x10⁴ᵇ</td>
<td>1.00x10⁴ᵇ</td>
</tr>
<tr>
<td>70</td>
<td>3.33x10⁴ᶜ</td>
<td>1.01x10⁴ᵇ</td>
</tr>
<tr>
<td>Storage duration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2.14x10⁴ᵈ</td>
<td>0x10⁴ᵈ</td>
</tr>
<tr>
<td>30</td>
<td>3.22x10⁴ᶜ</td>
<td>0.45x10⁴ᶜ</td>
</tr>
<tr>
<td>60</td>
<td>4.20x10⁴ᵇ</td>
<td>1.45x10⁴ᵇ</td>
</tr>
<tr>
<td>90</td>
<td>6.44x10⁴ᵃ</td>
<td>2.56x10⁴ᵃ</td>
</tr>
</tbody>
</table>

Values with different letter superscripts are significantly different at p<0.05.
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