Physiological and Biochemical Changes in Peeled Garlic during Refrigerated Storage

Kalyani Gorrepati, Yogesh Bhagat

Abstract: Peeled garlic cloves packed in polypropylene films, stored at refrigerated storage conditions of 4±1°C were analyzed for respiration rate, total phenol, pyruvic acid, flavonoids content, weight loss, number cloves sprouted/rooted at 0, 10, 20, 30, 40, 50 days of refrigerated storage. At 0 days garlic cloves had respiration rate, total phenol content, pyruvic acid and flavonoid content of 16.59 mL CO₂ kg⁻¹ h⁻¹, 34.64 mg GAE/100g, 45.71 μ mole pyruvate/g and 15.01 mg QE/100g 7 respectively. No significant weight loss was observed during storage up to 20 days. By the end of 50 days of storage weight loss of 3.7% was observed. Up to 40 days of storage no sprouting and rooting was observed. By 50 days of storage, up to 60% of the cloves were rooted. In general, decrease in O₂ and increase in CO₂ concentration was observed in the package during storage. Respiration rate, phenol content and flavonoids increased initially and then decreased by the end of storage. No significant difference was observed in pyruvic acid content during storage.

Keywords: Garlic, Storage, Respiration, Phenol, Pyruvic acid, Flavonoid

Introduction

Garlic is one of the regularly added ingredients in the Indian food preparations for specific taste and flavor. Apart from adding taste and flavor to the food, they provide many health benefits due to its sulfur containing compounds. Though garlic is regularly consumed, it is cumbersome and time taking to peel the cloves for everyday use. Availability of peeled garlic for ready to cook or ready to use purpose obviates the peeling before food preparation there by reducing the overall food preparation time. Although peeled garlic offers convenience, due to the removal of protective layer by peeling, deleterious internal and external changes happen to the clove thereby reduce storage life. Surface discoloration, sprouting, rooting are the major visible quality parameters apart from the invisible nutritional changes during the storage of peeled garlic. Storage at 0 to 5°C is imperative to maintain good quality. Storage temperatures above 5°C will result in pink and brown discoloration on the damaged areas, it also favor root and sprout development (Cantwell 2016). Refrigeration is the main storage facility available in almost all the households. Polypropylene films are also easily available in the markets. Garlic can be peeled at leisure time and stored in polypropylene films under refrigerated condition for everyday use. The present work was carried out to study the changes in the gas composition in the package, rate of respiration and nutritional components of peeled garlic during refrigerated storage in the polypropylene films.

Materials and Methods

Garlic variety 'Bhima Omkar' harvested in the rabi season (winter crop: October to March) of 2015-16 was taken for the experiment. Harvested and cured bulbs stored for one month at ambient conditions before the experiment. Garlic bulbs were broken; cloves were manually peeled, washed with water and surface dried using blotting paper under fan. The cloves weighing 50g were then packed in polypropylene films of 100 gauge and sealed to an equal size. The packets were prepared in triplicates and stored at refrigerated conditions of 4±1°C. Before refrigerated
storage, garlic samples were analyzed for the rate of respiration, total phenol, flavonoids and pyruvic acid content. During storage, three packets were taken out from the refrigerator and the nanalyzed for gas composition, respiration rate, total phenolics, flavonoids and pyruvic acid in 10days interval i.e on 10, 20, 30, 40 and 50 day of storage.

**Weight Loss**

Weight of the peeled garlic was noted down after taking out of the storage on the respective date and the weight loss was calculated in percentage with respect to sample weight at day '0'.

**Sprouting/Rooting**

The number cloves sprouted or rooted were counted visually and the percentage of sprouting/rooting was calculated based on the total number of cloves stored.

**Gas Composition within the Package**

The CO₂ and O₂ concentrations inside the packages were measured by head space gas analyzer (Checkmate 9900 O₂/CO₂, PHI Dansensor, Denmark). The head space gas in the packages was sucked to the sensor of the analyzer through the hypodermic hollow needle through the septum attached to the packaging material in order to prevent the tearing of the package due to the piercing of needle, and the displayed values of evolution rate of CO₂ and O₂ concentration (%) were recorded.

**Rate of Respiration**

The rate of respiration was measured using head space gas analysis technique with the help of CO₂/O₂ analyzer (Model: Checkmate 9900 O₂/CO₂, PHI Dansensor, Denmark) and expressed as ml CO₂ kg-1 h-1. Peeled garlic cloves were trapped in one-liter airtight container having twist-top lid fitted with a subascale septum at the center 63 of the lid. The containers were kept at room temperature for 4 h for accumulation of respiratory gases at the head space. After specified time the head space gas was sucked to the sensor of the analyzer through the hypodermic hollow needle and the displayed value of evolution rate of CO₂ concentration (%) was recorded. Rate of respiration was calculated on the basis of rate of evolution of CO₂ from the sample per unit weight per unit time.

**Total Phenol**

Garlic cloves were crushed to paste and 2 g sample taken from the homogenized paste was used for the analysis of total phenol content. Total phenol content of the samples was analyzed by using the Folin-Ciocalteau (FC) reagent by following the method of Singleton and Rossi (1965) to determine total phenolic content using gallic acid standard (0.1, 0.2, 0.3, 0.4 & 0.5 mg/ml).

Results were expressed as mg gallic acid equivalents (GAE)/100 g of fresh sample.

**Total Flavonoid**

Total flavonoid content was measured by the aluminum chloride colorimetric assay by following the method mentioned by Albishi et al. (2013). One milliliter of extracts of peeled garlic or standard solution of quercetin (50, 100, 150, 200, 250 and 500 µg/mL) was added to 10 mL volumetric flask containing 4 mL distilled water. To the flask, 0.3 mL of 5% NaNO₂ was added.

After 5 min, 0.3 mL 10% AlCl₃ was added. After 6 min, 2 mL 1 M NaOH solution were added and the total volume was made upto 10 mL with distilled water. The solution was mixed well and the absorbance was measured against a prepared reagent blank at 510 nm. Total flavonoid content was expressed as mg quercetineq (QE)/100 g fresh sample.

**Pyruvic Acid**

The content of pyruvic acid was estimated using dinitro phenyl hydrazine (DNPH) reagent by following the method of TeareKetter and Randle (2016) using sodium pyruvate standard. The amount of pyruvic acid expressed as μmole pyruvate/g of fresh sample.

**Statistical Analysis**

Data was analyzed using GLM procedure of SAS 9.4. The results were tested by analysis of variance (ANOVA) and Tukey's test at a significance level of 0.05.
Results and Discussion

Weight Loss

During refrigerated storage, weight loss of peeled garlic 93 increased from 0.61% to 3.17%. There was no significant weight loss up to 20 days of storage. Whereas, significant increase in weight loss was observed after 30 days of storage (Table 1). Difference in weight loss on 30th, 40th and 50th day of storage was not significant. This indicates that, moisture loss in peeled garlic happened only after 20 days of storage. Siddiq et al. (2013) also reported a relatively high weight loss of fresh cut onions in the last 7 days of storage than during the first 14 days at 4°C for 21 days of storage.

Table 1 Changes in the Nutritional Properties of Peeled Garlic during Storage

<table>
<thead>
<tr>
<th>Days of storage</th>
<th>Weight loss (%)</th>
<th>Total phenol (mg GAE/100g)</th>
<th>Total pyruvic acid (umole pyruvate/g)</th>
<th>Total flavonoid (mg QE/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-</td>
<td>34.64ab</td>
<td>15.01*</td>
<td>45.71bc</td>
</tr>
<tr>
<td>10</td>
<td>0.61a</td>
<td>37.91ab</td>
<td>13.89d</td>
<td>70.71bc</td>
</tr>
<tr>
<td>20</td>
<td>0.76c</td>
<td>48.82a</td>
<td>19.17c</td>
<td>80.24e</td>
</tr>
<tr>
<td>30</td>
<td>2.59c</td>
<td>43.46bc</td>
<td>13.93e</td>
<td>55.24e</td>
</tr>
<tr>
<td>40</td>
<td>3.15c</td>
<td>29.41b</td>
<td>15.09c</td>
<td>54.64e</td>
</tr>
<tr>
<td>50</td>
<td>3.17c</td>
<td>22.88c</td>
<td>14.47c</td>
<td>30.24e</td>
</tr>
</tbody>
</table>

*Means with at least one similar letter are not significantly different

Sprouting or Rooting

No sprouting or rooting was observed up to 40 days of storage. By 50 days of storage, 60% of the peeled garlic cloves started rooting (Data not shown). If the garlic bulbs are stored for longterm, period required for sprout growth upon removal from storage will be shorter (Takagi 1990). In the present study, one month old stored bulbs with proper curing were taken for the experiment and which might be the reason for non-sprouting of cloves during storage and also for rooting which was observed only by 50 days of storage.

Gas Composition within the Package

O₂ concentration during storage showed a sudden significant decrease till first 10 days of storage (20.27% to 7.11%) and then a gradual decrease was observed. Simultaneously, CO₂ concentration significantly increased after 10 days (0.27% to 4.63%) till 20 days (7.97%) and thereafter remained almost constant. Equilibrium of O₂ and CO₂ concentration of around 6% was observed between 10 to 20 days of storage (Fig. 1). O₂ and CO₂ concentrations and time for stabilization of O₂ and CO₂ concentration within the package depends upon the respiration of the garlic cloves and the permeability of the packaging material.

A decrease in O₂ and increase in CO₂ concentration in sliced onions during storage was also reported by Liu and Li (2006).

Fig 1 Gas composition within the package of peeled garlic during storage

Rate of Respiration

Rate of respiration of peeled garlic was 16.59 mL CO₂ kg⁻¹ h⁻¹ at 0 days before refrigerated storage while it was significantly decreased (13.25 mL CO₂ kg⁻¹ h⁻¹) upon refrigeration storage for 10 days. Thereafter sudden
fluctuation was observed till 50 days of storage (Fig 2). Maximum respiration rate was observed at 40 days (24.72 mL CO₂ kg⁻¹ h⁻¹) and later decreased by 50 days of storage (16.54 mL CO₂ kg⁻¹ h⁻¹). Burlo-Carbonell et al. (2000) also reported there spiration rate of peeled garlic as 17.5 mL CO₂ kg⁻¹ h⁻¹ at 5°C. Low temperature in there refrigeration storage might be the reason for decrease in the respiration rate upon refrigerated storage. Berno et al. (2014) also reported that the use of a low temperature reduced the respiratory rate by 12%, on average, on the first storage day during the storage of fresh cutions. Increase in the respiration during storage might be due to the onset of senescence of the peeled garlic. By the end of 50 days of storage garlic started rooting and the quality of the cloves started deteriorating. This might be the possible reason for decrease in respiration rate after 50 days of storage. Izumi et al. (1996) also reported a sharp increase in respiration followed by a decrease to a steady state during storage of carrot shreds. Similar kind of trend in respiration rates, initial increase and then after a decrease in whole and sliced mushrooms during storage was reported by Iqbal et al. (2009).

Total phenol content in garlic varies depending on cultivar, cultivation practices and storage duration. Boyzin et al. (2008) reported total phenol in garlic extracted in 80% methanol as 50 mg GAE/100 g. Qusti et al. (2010) reported 367.6 mg GAE/g in dried samples of garlic and 61.4 mg GAE/g in fresh weight. Othman et al., (2011) reported total phenol content in garlic as 37.60±2.31 mg GAE/100 g. Bhatt and Patel et al., (2013) reported total phenolic content in chemically (methanolic) extracted raw garlic as 67.5 mg GAE/100 g. Our results were in the range reported by Othman et al. (2011). Slight increase in the total phenol content immediately after refrigerated storage might be due to cold stress. By the end of storage, cloves started rooting and the phenolic content decreased. Wearing off the property or the enzymes producing such substances with the storage time maybe the reason behind decreased phenol content by the end of storage (Zhan and Hamauzuy2004 and Tuji et al. 2013).

Pyruvic Acid

Total pyruvic acid content at 0' days was 15.01 µmole pyruvate/g. There was no significant change in the pyruvic acid content during storage up to 50 days. In contrary Cantwell et al., (2003) reported a decrease in pungency (pyruvate concentrations) after 2-3 weeks storage. Thereduction of pungency resulting from minimal processing is most likely due to cell disruption caused by the peeling, cutting and sanitation procedures through the volatilization, leakage and leaching of the substances responsible for the pungency (Berno et al. 2014). In the present study, there was no much cell disruption as whole garlic was manually peeled without any mechanical damage and stored. This might be the reason for maintaining the constant pyruvic content throughout the storage.

Total Flavonoid

Total flavonoid content showed a significant sudden increase from 0' days (45.71 mg QE/100g) to 10 days (70.71 mg QE/100g) and up to 20 days (80.24 mg QE/100g) and then started decreasing. By the end of 50 days of storage, total flavonoid content was 30.24 mg QE/100g (Table 1). The increase in the flavonoid content after refrigerated storage may be attributed to the stress due to low temperature. Flavonoid content decreases by the end of storage. Other studies have also shown a reduction of quercetin content in fresh-cut onions during storage (Berno et al. 2014).
Conclusions

Peeled garlic cloves can be packed in 100 gauge polypropylene packages and stored up to 40 days under refrigerated conditions of 4 °C without sprouting and rosetting with minimum weight loss of 3.15%. Decrease in O2 and increase in CO2 concentration can be attained in the 100 gauge polypropylene package during refrigerated storage. Refrigerated storage had no significant effect on pyruvic acid content of peeled garlic up to 40 days. Total phenol content and flavonoid content increased up to 20 days of storage and then decreased till the 50 days of storage.

References


