**Quality Evaluation of Value Added Products (Powder and Paste) Developed from Stored Garlic Bulbs (*Allium sativum* L.)**

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**Abstract**

The garlic bulbs of after eight months of storage were used for the development of the value added products (i.e. garlic paste and powder) and the quality evaluation of the garlic paste and powder was investigated and compared with the products developed from the fresh garlic bulbs. Physico-chemical characteristics like moisture content, water activity, flavour strength, colour, total soluble solids, pH and titrable acidity were determined. Moisture content, total soluble solids, pH, titrable acidity and change in colour of garlic paste were found to be increased whereas flavour strength was decreased with the increase of the storage period respectively. The quality characteristics of garlic powder namely, moisture content, water activity, pH, total soluble solids and change in colour were increased with the increase of the storage period whereas flavour strength and titrable acidity of garlic powder were decreased with the increase of the storage period.

**Keywords:** Garlic bulbs, value addition, garlic paste, garlic powder, storage

**Introduction**

Spices have played significant role in the antiquity of evolution, exploration and trade as these had a worldwide recognition as condiments and flavours in human intake as well as in cure of illnesses. India is also the largest producer, consumer and exporter of spices and spice products. Spice exports from India reached US$ 3.1 billion in 2017-18 (FAOSTAT, 2018).

Garlic (*Allium sativum* L.) is an important and second most extensively grown Allium crop. It has been known all over the globe as a precious spice since ancient times for food preparations and curing numerous diseases and physiological ailments. The world production of garlic is placed at 28.16 million tonnes in 1.57 million hectares of area in the year 2017. In the world, India is the second in the garlic production with 5.27 per cent share (FAO, 2017). India produced over 1.69 million tons in the year 2017-18 in the area of 0.32 million hectares. In India 78 per cent share of the garlic was produced by Rajasthan, Madhya Pradesh, and Uttar Pradesh states (Madhu et al., 2019). The chemical composition of the garlic includes enzymes, protein, vitamins (B1, B2, B6, C), flavonoids, minerals (Ca, Cu, Fe, Mn, P, K), antioxidants and thiosulfinates. Garlic is mostly used in preparation of pickles, food processing, pharmaceutical and medicinal usage, ayurvedic formulations etc.

Storage of garlic for extended availability during lean season particularly of bulbs of satisfactory quality is a multidimensional issue, which comprises various pre and post-harvest parameters. The storage losses of the garlic are very high due to the lack of proper storage structures. The physiological weight losses and losses due to diseases are the main storage losses in garlic. The post-harvest losses during storage are up to 40 per cent under ambient conditions causing the increase of the market price at a micro level and decrease availability at the macro level (Tripathi and Lawande, 2006; Naresh et al., 2013; Sekara et al., 2017).

Almost 80 per cent of garlic produce is stored by farmers and businessmen for domestic supply throughout the year (Tripathi et al., 2009). Traditional methods of garlic storage lead to physiological loss and deterioration due to pests and insects. Many of the garlic and onion growers in Khurda and Ganjam districts of Odisha store by binding and hanging them in bunches in the house (Naresh et al., 2013). Very few researchers have studied the post-harvest losses of garlic bulbs influenced by storage conditions like temperature, relative humidity and various storage structures (Lawande, 2018; Dhall and Ahuja, 2013; Tripathi et al., 2009; Tripathi and Lawande, 2006; Cantwell and Suslow, 2002; Cantwell, 2004; Miedema, 1994; Takagi, 1990).

Garlic offers very good scope for value addition. The most of garlic is consumed as such in developing nations and a few efforts are made to produce garlic dehydrated flakes, slices, powder, paste, pickeld garlic, garlic salt, oil, and oleoresin. Among all these products, dehydrated flakes and powder of garlic are important from export point of view. Dehydrated products are uniform in flavor than stored bulbs. India exports large amount of dehydrated products of garlic (flakes, garlic oil and dehydrated garlic powder) to Japan, United Kingdom, Italy, Turkey, Germany and France. Moisture loss due to respiration, transpiration and microbiological spoilage are the major causes, which limit shelf life during storage of garlic bulb. High losses during storage have generated an interest in the development of garlic products such as granulates, powder, flakes, paste and oil and oleoresins.

Major factors associated with the spoilage of garlic paste are improper handling, action of naturally occurring enzymes, growth of spoilage microorganisms, chemical reactions and structural changes during storage (Devi et al., 2016). Garlic paste can be one of the products of garlic that can be stored for long periods without much alteration in the freshness of the material and can also be considered as a minimally processed food (Devi et al., 2016). However, the quality of the paste deteriorates during storage only if the type of packaging material and storage conditions do not match.

The main objective of the present study is to develop and quality evaluation of paste and powder from under storage garlic bulbs and comparison of quality characteristics of the garlic paste and powder prepared from the fresh garlic bulbs However, published literature is rather limited on details of storage of garlic bulbs, paste and powder. For process upgradation, quality improvement, intensive engineering and technological support are necessary.

**Material and Methods**

**Raw Material**

Garlic bulbs which are fully matured and cured of yamuna safed-3 variety were procured from local market of Udaipur, Rajasthan for the investigation. The procured garlic bulbs were cleaned and healthy garlic bulbs of 30 mm or more in size were used for conducting experimental trials.

**Product Development**

Availability of raw garlic at cheaper prices in many developing nations offers a very attractive opportunity for processors to produce the garlic products at competitive prices. The powder being a good value added product, transportation cost to far distances becomes negligible and good export earnings are possible. Dehydrated garlic slices; garlic powder and garlic paste are used mainly as a condiment in various preparations, for flavoring in food industry and also serves as carminative and stimulant in many medical preparations.

**Garlic Paste**

Garlic bulbs (Var. Yamuna safed-3) after 8 months (240 days) of storage were used for preparing paste. The process of preparation of garlic paste involves the unit operations viz., clove separation, cleaning, grading, peeling of cloves and grinding of cloves. The healthy garlic bulbs were graded and the cloves were separated by using garlic bulb breaker cum clove separator (Mudgal et al., 2009; Mudgal, and Sahay, 2009). After that, the separated cloves were kept in a hot air oven for 15 min at 50°C to loosen the skin from clove. The peeling of clove was done by using garlic peeler developed by Mudgal and Champawat, 2011. The peeled cloves were blanched at 90 °C temperature for 5 minutes (Ahmed et al., 2000). Then these blanched cloves were ground by using laboratory size grinder. The grounded material was passed through a 14-mesh sieve to get uniform size garlic paste.

**Garlic Powder**

Garlic bulbs of after 8 months of storage were used for powder preparation. The common method for preparing garlic powder is time-consuming, laborious and uneconomical. The process involves sorting bulb breaking and clove separation, slicing, drying and pulverising (grinding). The healthy garlic bulbs were graded and the cloves were separated by using garlic bulb breaker cum clove separator (Mudgal et al., 2009; Mudgal, and Sahay, 2009). In this process the garlic bulbs are broken, the cloves and papery husks are separated by aspiration. After that, the separated cloves were kept in a hot air oven for 15 min at 50°C to loosen the skin from clove. The peeling of clove was done by using garlic peeler developed by Mudgal and Champawat, 2011 and then sliced into 4-6 mm thickness manually using a stainless steel knife. The sliced cloves were dried in convective tray dryer at 55 °C and the grinding of dried clove slices was done in laboratory mechanical grinder.

**Quality Analysis of Garlic Paste and Powder**

Quality analysis is an essential aspect in food processing. The quality control plays a vital role to get the best quality finished product in food processing industries. The quality control is a continuous process and it must be executed at every phase beginning from pre-processing to packaging and until it reaches to consumer.

**Moisture Content**

Garlic samples were weighed before and after drying. Garlic samples were dried using hot air oven at 105° C for 24 hours until the constant weight was obtained. The moisture content was calculated as follows:

Moisture content (per cent wb.)

Where,

Mw= Sample weight before drying (kg)

Md= Sample weight after drying (kg)

**Water Activity (aw)**

Water activity (aw) is a measure of the availability of water to participate in such reactions. Moisture plays an important role in the stability of fresh, frozen and dried foods. The measurement of water activity is a key parameter in the quality control of moisture sensitive products or materials. If there is too much water in a product, there is a risk of microbial growth and water migration. This can lead to clumping, changes in consistency and reduced shelf life. A digital water activity meter (Make: Novaina, Model: Labwift-aw) was used for measuring aw of the selected garlic samples.

**Flavour Strength**

Flavour strength was determined by the modified method, based on the oxidation of volatile content of garlic powder by chloramine-T as reported by Shankaranarayana et al., 1981. 15 g of garlic sample was suspended with 250 ml of distilled water in round bottom flask connected with steam distillator (JSGW India). Antifoam and glass bends was added to ensure the uniform boiling. About 100 ml of distillate was collected by dipping the tip of the solution containing 35 ml 10 N sulphuric acid, 15 ml water and 20 ml Chloramine-T. The Chloramine-T left after reaction was calculated by adding 10 ml potassium iodide solution and titrating the liberated iodine with sodium thiosulfate using starch as indicator. A reagent blank was carried out under the same conditions. The difference in the titric values between the blank and the experimental corresponds to the Chloramine-T consumed by steam distillate of garlic sample volatile content.

Flavour strength (per cent) = (V x N x 100)/ (W x F)

Where,

V = Difference in volume (ml) of thiosulfate between blank and the experiment.

N = Normality of thiosulfate

W = Weight of garlic powder used for oxidation

F = Factor, i.e. the experimental value of (ml) Chloramine – T per g of garlic oil (90 for garlic).

**Colour**

For the measurement of colour of samples combination of digital camera, computer and Adobe Photoshop 7.0 software provides a less expensive and more versatile way to determine colour parameters of food products than traditional colour measuring equipment’s and also good colour of sample depends upon the intensity of light and distance between sample and camera. This colour measuring technique involves setting up a lighting system, high resolution digital camera to capture images of food samples as reported by Spyridon et al. (2000).

The colour of the garlic bulb was measured by using the method reported by Spyridon et al., 2000 and Madhu et al., 2017. Digital camera (Sony 7.2 megapixels) was used to capture the image of the sample. The L, a, b values of samples were measured by using Adobe Photoshop 7.0 software. The colours of the samples represents in terms of L (whiteness/darkness), a (redness/greenness), b (yellowness/ blueness). To obtain L\*, a\* and b\* values the following formulas were used.

L\* = ; a\* = ; b\* =

Change in colour (ΔE) was calculated using the following equation

∆E= [(L– L\*) + (a– a\*) + (b – b\*)2]0.5

**pH**

The pH of garlic powder was measured by digital pH meter (Eutech, pH Testr 2). The sample was diluted in the ratio of 1:2, i.e. 5 g of sample was diluted with 10 ml of distilled water.

**Total Soluble Solids (TSS)**

The TSS were calculated as per Ranganna (2002) by using handheld refractometers (RHB-18ATC; ERMA, Japan). Firstly, the refractometer was calibrated using distilled water. The paste was squeezed by using muslin cloth and the drops obtained were used for the measurement of TSS.

**Titrable Acidity**

The titrable acidity of the powder was calculated in terms of citric acid (per cent). 5 g powder was diluted in 95 ml distilled water making the volume to 100 ml and filtered through Whatman no. 41 filter paper. This sample was titrated against 0.1 N NaOH to pH 8 using phenolphthalein indicator. The following equation was used to determined titrable acidity.

**Results and Discussion**

**Quality characteristics of fresh garlic and its products**

Data on some important physico-chemical constituentsof fresh garlic and its products (paste and powder) is presented in the Table 4.1. Results showed that initial moisture content of the fresh garlic was 62.76±0.09 per cent and for garlic paste and powder (prepared from fresh garlic) it was 62.76±0.09 and 6.02±0.5 per cent respectively. The flavour strength of the fresh garlic was found to be 0.526±0.01 per cent and for garlic paste and powder it was reported as 0.592±0.01 and 0.323±0.02 per cent respectively. The water activity of the fresh garlic was found to be 0.789±0.01 per cent and for garlic paste and powder it was reported as 0.814±0.01 and 0.365±0.02 per cent respectively. The colour value of the fresh garlic was reported as L\*= 92±0.14, a\* = -1±0.09, b\*= -9±0.02 and for garlic paste and powder it was reported as L\*= 76±0.12, a\* = -1±1.25, b\*= -21±0.3 and L\*= 82±0.01, a\* = -5±0.02, b\*= 3±0.03 respectively.

Fresh garlic contained pH 6.20±0.1, titrable acidity 0.47±0.01 per cent and total soluble solids 32.1±0.3 °BX. These results were in agreement with the values reported by Otunola *et al*., 2010; Sajid *et al*., 2014. Garlic paste prepared with fresh garlic cloves contained pH 5.80±0.1, titrable acidity 0.51±0.02 per cent and total soluble solids 34.3±0.2 °BX. These findings were in confirmation with results reported by Ahmed *et al*., 2001; Ahmed and Shivhare, 2001: Carbonell-Barrachina *et al*., 2003; Constenla and Lozano, 2005: Casado *et al*., 2012; Algadi *et al*., 2014; Mutasim *et al*., 2016.

Garlic powder prepared with fresh garlic cloves contained pH 5.42±0.02, titrable acidity 1.25±0.03 per cent and total soluble solids 35.5±0.57 °BX. These results are in agreement with the results reported by Kim *et al*., 1980; Rahman *et al*., 2005; Li and Xu, 2007; Marian and Usha, 2016; Park *et al*., 2008 and Park *et al.,* 2018.

**Table 4.1: Some important physico-chemical constituents of garlic and its products**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameters** | | **Fresh Garlic** | **Garlic paste** | **Garlic powder** |
| **Prepared from Fresh bulbs** | **Prepared from Fresh bulbs** |
| Moisture content, per cent | 62.76±0.09 | | 62.76±0.09 | 6.02±0.5 |
| pH | 6.20±0.1 | | 5.80±0.1 | 5.42±0.02 |
| per cent Titrable acidity | 0.47±0.01 | | 0.51±0.02 | 1.25±0.03 |
| Total soluble solids (°BX) | 32.1±0.3 | | 34.3±0.2 | 35.5±0.57 |
| Flavour strength | 0.526±0.01 | | 0.592±0.01 | 0.323±0.02 |
| Colour value |  | |  |  |
| L\* | 92±0.14 | | 76±0.12 | 82±0.01 |
| a\* | -1±0.09 | | -1±1.25 | -5±0.02 |
| b\* | -9±0.02 | | 21±0.3 | 3±0.03 |
| Water activity | 0.789±0.01 | | 0.814±0.01 | 0.365±0.02 |

**Quality characteristics of stored garlic and its products**

Data on some important physico-chemical constituentsof stored garlic and its products (paste and powder) is presented in the Table 4.2. Results showed that moisture content of the stored (240 days) garlic was 52.66±0.05 per cent and for garlic paste and powder (prepared from stored garlic) it was 52.54±0.02 and 6.01±0.4 per cent respectively. The flavour strength of the garlic was found to be 0.432±0.02 per cent and for garlic paste and powder it was reported as 0.415±0.02 and 0.298±0.01 per cent respectively. The water activity of the garlic was found to be 0.701±0.01 per cent and for garlic paste and powder it was reported as 0.695±0.02 and 0.325±0.01 per cent respectively. The colour value of the stored garlic was reported as L\*= 78±0.12, a\* = 1±0.08, b\*= 18±0.01 and for garlic paste and powder it was reported as L\*= 74±0.13, a\* = -1±1.15, b\*= 20±0.2 and L\*= 78±0.02, a\* = -3±0.03, b\*= 7±0.2 respectively.

stored garlic contained pH 5.91±0.01, titrable acidity 0.52±0.02 per cent and total soluble solids 33.5±0.4 °BX. These results were in agreement with the values reported by Otunola *et al*., 2010; Sajid *et al*., 2014. Garlic paste prepared with stored garlic contained pH 5.60±0.2, titrable acidity 0.55±0.01 per cent and total soluble solids 0.55±0.01 °BX. These findings were in confirmation with results reported by Ahmed *et al*., 2001; Ahmed and Shivhare, 2001: Carbonell-Barrachina *et al*., 2003; Constenla and Lozano, 2005: Casado *et al*., 2012; Algadi *et al*., 2014; Mutasim *et al*., 2016.

Garlic powder prepared with stored garlic cloves contained pH 5.52±0.03, titrable acidity 1.03±0.02 per cent and total soluble solids 35.8±0.01 °BX. These results are in agreement with the results reported by Kim *et al*., 1980; Rahman *et al*., 2005; Li and Xu, 2007; Marian and Usha, 2016; Park *et al*., 2008 and Park *et al.,* 2018.

**Table 4.2: Some important physico-chemical constituents of stored garlic and its products**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters** | **Stored Garlic** | **Garlic paste** | **Garlic powder** |
| **Prepared after 240 DAS** | **Prepared after 240 DAS** |
| Moisture content, per cent | 52.66±0.05 | 52.54±0.02 | 6.01±0.4 |
| pH | 5.91±0.01 | 5.60±0.2 | 5.52±0.03 |
| per cent Titrable acidity | 0.52±0.02 | 0.55±0.01 | 1.03±0.02 |
| Total soluble solids (°BX) | 33.5±0.4 | 36.4±0.3 | 35.8±0.01 |
| Flavour strength | 0.432±0.02 | 0.415±0.02 | 0.298±0.01 |
| Colour value | | | |
| L\* | 78±0.12 | 74±0.13 | 78±0.02 |
| a\* | 1±0.08 | -1±1.15 | -3±0.03 |
| b\* | 18±0.01 | 20±0.2 | 7±0.2 |
| Water activity | 0.701±0.01 | 0.695±0.02 | 0.325±0.01 |

\*DAS-Days after storage

**Conclusion**

Physico-chemical characteristics like moisture content, water activity, flavour strength, colour, total soluble solids, pH and titrable acidity were determined. Moisture content, total soluble solids, pH, titrable acidity and change in colour of garlic paste were found to be increased whereas flavour strength was decreased with the increase of the storage period respectively. The quality characteristics of garlic powder namely, moisture content, water activity, pH, total soluble solids and change in colour were increased with the increase of the storage period whereas flavour strength and titrable acidity of garlic powder were decreased with the increase of the storage period.

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