Journal of Food Processing & Technology

Mutasim and Elgasim, J Food Process Technol 2016, 7:2
DOI: 10.4172/2157-7110.1000550

Research Article Open Access

Proximate Analysis of Garlic (*Allium sativum*) Paste Treated with Ascorbic and Citric Acids

Mutasim ZA[1]* and Elgasim AE[2]

[1]*Arab Center for Nutrition, Muharraq, Kingdom of Bahrain*
[2]*Faculty of food science and technology, Khartoum University, Sudan*

Abstract

The prime objective of the study was to develop a preservation method for garlic paste that could prevent adverse quality changes, render the paste more shelf stable and possibly retain chemical characteristics of fresh garlic. Three separate batches of fresh garlic bulbs of two Sudanese varieties (Dongla and Berber) harvested in December 2011 were collected, peeled manually, separated into individual sound cloves, divided into 5 equal portions and crushed in a blender until a smooth puree was obtained. Before crushing, portions were assigned randomly to chemical treatments (T_0 = no chemical additives (control); T_1 = 0.5 mg/g Ascorbic acid; T_2 = 2 mg/g Citric acid; T_3 = 0.25 mg/g Ascorbic acid + 1 mg/g Citric acid and T_4 = 0.5 mg/g Ascorbic acid + 2 mg/g Citric acid). The chemical additives (T_0-T_4) were added during bulb crushing. Each garlic treated portion was subdivided into 2 equal portions, packed in glass containers and hermetically closed, stored at 25°C or 40°C for 6 months and analyzed at an interval of 2 months. Proximate compositions were measured. The results indicated that storage temperature had a significant ($p \leq 0.05$) effect on the chemical composition except the fat content. Storage at high temperature (40°C) elevated the chemical composition of the garlic paste except the ash content. Irrespective of variety, storage for 6 months elevated moisture, fat, fiber, and ash contents. Sensory evaluation was measured. The results indicated that garlic variety (Dongola and Berber) had a significant ($p \leq 0.05$) effect on sensory evaluation of garlic paste. Storage at low temperature (25°C) elevated the sensory evaluation of garlic paste. Irrespective of variety, storage for 4 months elevated sensory evaluation except color. Organic acids (Ascorbic and citric acids) or their blends are recommended to produce a shelf stable garlic paste for up to 6 months at storage temperature of 25°C or less.

Keywords: Garlic paste; Sensory; Ascorbic acid; Citric acid; Proximate analysis

Introduction

Garlic is a very important cash crop in Sudan particularly in the Northern states (Dongla and Berber), where there is a long winter season and light soil. It is also grown on a very limited scale in the Gezira, Darfur and Kordofan states. The total annual area under garlic in Sudan was estimated to be about 100 hectares and annual production about 16,000 MT with an average yield of 1,778 Kg/ha. Cardiovascular disease (CVD) is responsible for 30% of all deaths and 10% of DALYs (disability-adjusted life years) WHO [1]. In Sudan, the burden of cardiovascular disease is increasing rapidly and it is now a public health concern. It has a major socio-economic impact on individuals, families and societies in terms of healthcare costs, work absenteeism and national productivity [2]. The International Agency for Research on Cancer (IARC) reported that the incidence rates of oral cancer in Sudan are 3.7% for men and 2.6% for women IARC [3]. Garlic and garlic extracts are believed to possess beneficial effects for the prevention of cardiovascular diseases [4-6]. Studies have shown that garlic also provides protection to the cardiovascular system by inhibiting platelet aggregation, protecting blood vessels and lipoproteins from damaging effects of free radical oxidation, and reducing serum cholesterol levels by inhibiting cholesterol synthesis [7,8]. The garlic paste manufacturing process dates back 40 years and stems from the need to find a product with an industrial or semi-industrial process able to compete in the international market. Another advantage is that the surplus from the nonmarketable part of the harvest (broken-up bulbs, loose cloves, etc.) may be used for paste manufacture. The consumption of processed garlic products (e.g. chopped and fried) has considerably increased over the last few years, probably due to its ease of use, when comparing to fresh garlic [9]. The main objective of the present work was to select a method for processing of garlic paste to prevent changes that occur in fresh garlic, make the product shelf stable and retain chemical characteristics of garlic paste.

Material and Methods

Preparation of garlic paste

Three separate batches of each fresh garlic bulbs of two Sudanese varieties (Dongla and Berber) were harvested in December 2011, collected, packed and transferred to the Department of Food science and Technology Laboratory, Faculty of Agric. University of Khartoum, Sudan. The garlic bulbs were peeled manually, separated into the individual sound cloves, cut in half and inner green shoots were removed. Prepared garlic cloves were divided into 5 equal portions and crushed by a blender until a smooth puree was obtained after 3 minutes. Before crushing, chemical additives were added during bulb crushing, no additive control (T_0), (Ascorbic acid 0.5 mg/g (T_1), 2 mg/g Citric acid (T_2), 0.25 mg/g Ascorbic acid +1 mg/g Citric acid (T_3), 0.5mg/g Ascorbic acid +2 mg/g Citric acid (T_4). Descriptive analysis was applied to select sensory attributes which best define the changes in color, texture and flavor when different concentrations additive

***Corresponding author:** Mutasim ZA, Arab Center for Nutrition, Muharraq, Kingdom of Bahrain, Tel: +973-33111595; Fax: +973-17346339; E-mail: mutasim.algadi@gmail.com

Received December 08, 2015; **Accepted** January 02, 2016; **Published** January 08, 2016

Citation: Mutasim ZA, Elgasim AE (2016) Proximate Analysis of Garlic (*Allium sativum*) Paste Treated with Ascorbic and Citric Acids. J Food Process Technol 7: 550. doi:10.4172/2157-7110.1000550

were used. The garlic paste was packaged in aseptic glass containers and hermetically closed. Samples were stored in incubator at 25°C and 40°C for six months and analyzed at an interval of 2 months.

Proximate analysis

Proximate analysis of garlic bulbs samples was determined according to the AOAC [9].

Sensory evaluation

The sensory analysis of garlic samples were carried out using a hedonic scale for acceptability. To determine the appropriate concentration of chemical additives. The samples were tested for color, flavor, texture and overall acceptance. the tests were carried out by an semi trained panel of 30 judges. The samples were evaluated at room temperature and under cool white fluorescent lighting. The panelists were asked to evaluate the descriptors, rating each sample on a 9-point hedonic scale.

Results and Discussion

Effect of garlic variety and storage temperature on proximate analysis of garlic paste

The interactive effect of garlic variety (Dongola and berber) and storage temperature (25°C and 40°C) on the moisture, protein, fat, and fiber contents of garlic paste are shown in Table 1. Results indicated storage temperature had a significant ($p \leq 0.05$) difference in the amount of moisture content between varieties. Dongola variety had significantly ($p \leq 0.05$) higher (63.15%) moisture content than Berber variety (62.72%). The moisture content of garlic was significantly ($p \leq 0.05$) affected by the temperature to which garlic paste was stored. Garlic paste stored at 40°C had the highest moisture content (63.58%) compared to that stored at 25°C (62.29%). The value obtained in this study was similar to the value obtained by Benkeblia, who reported that garlic contain 60-70% moisture content. Temperature had led to no significantly ($p \geq 0.05$) difference in the protein content between varieties. Berber variety had higher (3.57%) protein content than Dongola variety (3.32%). The protein content of garlic was significantly ($p \leq 0.05$) affected by the temperature in which garlic paste was stored. Garlic paste stored at 40°C had the highest ($p \leq 0.05$) protein content (3.80%) compared to storage at 25°C (3.09%). The value obtained in this study is lower than that obtained by Blumenthal and Mark [10], who reported that garlic contain 5% protein. Treatments had no effect ($p \geq 0.05$) on the fat content of the two varieties. Dongola and Berber varieties had (1.35%) and (1.32%) fat content respectively. The fat content of garlic was not significantly ($p \geq 0.05$) affected by the storage temperature. Garlic paste stored at 40°C had the highest fat content (1.41%) compared to that stored at 25°C (1.26%). The value obtained in this study was higher than that obtained by Blumenthal and Mark [10], who reported that garlic contain 0.15%, 0.68% and 0.60% fat content, respectively. Treatments had led to a significant ($p \leq 0.05$) difference in the amount of crude fiber between the varieties. Dongola variety had significantly ($p \leq 0.05$) higher crude fiber (4.20%) than Berber variety (4.12%). The crude fiber of garlic was not significantly ($p \geq 0.05$) affected by the temperature at which garlic paste was stored. Garlic paste stored at 40°C or 25°C had the same crude fiber (4.16%) content. The value obtained in this study was higher than that obtained by USDA [11], who reported that garlic contain 2.10% crude fiber. The interactive effect of variety and temperature on the ash and carbohydrate contents of garlic paste is depicted in Table 2. Results indicated that Dongla and Berber had similar ($p \geq 0.05$) ash content. Dongola and Berber varieties had 3.96% and 3.92% ash content respectively. The ash content of garlic was significantly ($p \leq 0.05$) affected by the temperature at which garlic paste was stored. Garlic paste stored at 25°C had the highest ($p \leq 0.05$) ash content (4.06%) compared to that stored at 40°C (3.82%). The value obtained in this study was within the range set by Casado, et al. [12], who reported that, the ash content of garlic ranged between 2.65% and 8.40%.Treatments had led to a significant ($p \leq 0.05$) difference in the amount of carbohydrates between varieties. Berber variety had significantly ($p \leq 0.05$) higher carbohydrates (24.37%) than Dongola variety (24.03%). The carbohydrates of garlic was significantly ($p \leq 0.05$) affected by the temperature at which garlic paste was stored. Garlic paste stored at 25°C had the highest carbohydrates (25.15%) compared to storage at 40°C (23.25%). The value obtained in this study was higher than the value obtained by Sowbhagya, et al., [13], who reported that garlic contain 21% carbohydrates.

Temperature (°C)	Variety		Average temp.
	Dongola	Berbar	
Moisture content (%)			
25°C	62.37 ± 2.15^{c}	62.21 ± 2.23^{d}	62.29^{B}
40°C	63.92 ± 1.73^{a}	63.23 ± 2.50^{b}	63.58^{A}
Average variety	63.15^{A}	62.72^{B}	
Protein content (%)			
25°C	2.93 ± 1.02^{c}	3.25 ± 1.28^{b}	3.09^{B}
40°C	3.72 ± 1.18^{ab}	3.88 ± 1.39^{a}	3.80^{A}
Average variety	3.32^{A}	3.57^{A}	
Fat content (%)			
25°C	1.29 ± 0.59^{ab}	1.23 ± 0.67^{ab}	1.26^{A}
40°C	1.40 ± 0.72^{a}	1.41 ± 0.10^{a}	1.41^{A}
Average variety	1.35^{A}	1.32^{A}	
Crude fiber (%)			
25°C	4.21 ± 0.61^{a}	4.10 ± 0.97^{ab}	4.16^{A}
40°C	4.18 ± 1.40^{a}	4.13 ± 1.23^{ab}	4.16^{A}
Average variety	4.20^{A}	4.12^{AB}	

Values are mean ± SD.
*Means in the same columns and rows bearing same superscript small letters are not significantly different ($p \geq 0.05$)
**Means in the same row with the same superscript capital letters are not significantly different ($p \leq 0.05$).
***Means in the same column bearing different superscript capital letters are significantly different ($p \leq 0.01$).

Table 1: Effect of garlic variety and temperature on moisture, protein, fat and fiber contents of garlic paste.

Effect of chemical treatments and storage periods on proximate content of garlic paste

The interactive effect of chemical treatment (T_0-T_4) and storage period (2-6 months) on the moisture, protein and fat contents are shown in Table 3. The chemical treatments had led to a significant ($p \leq 0.05$) change in the moisture content of garlic paste. Irrespective of the chemical treatment the moisture content of garlic paste increased ($p \leq 0.05$) with the increase of storage period. Likewise irrespective of the storage period untreated (control) garlic paste had the highest moisture content ($p \leq 0.05$) among all treatments under test. While control garlic paste had the highest moisture content (63.88%), garlic paste treated with T_4 had the lowest one (61.81%). The value obtained in this study for the control garlic was similar to the value obtained by Benkeblia [14], who reported that garlic contain 60-70% moisture. The moisture content of the control garlic (irrespective of storage period) was comparable to the values (66.57%) reported by Odebunmi, *et al.*

[15,16] for the Nigerian garlic and to that (65%) reported by Blumenthal and Hark [10]. Also Topno, et al. [17] found that garlic paste contain 63.04% moisture. Storage period had led to a significant ($p \leq 0.05$) difference in the protein content. Garlic paste stored for 2 months had significantly ($p \leq 0.05$) higher (4.60%) protein content compared to that stored for 6 months (2.19%). The protein content of garlic was significantly ($p \leq 0.05$) affected by the treatments to which garlic paste was subjected. Garlic paste treated with T_1 had the highest protein content (3.84%) compared to that treated with T_3 (3.17%).The value obtained in this study was lower than the value obtained by Banerjee, et al. [18], who reported that garlic contain 5% protein. Irrespective of storage period, control garlic paste had a protein content of 3.42% almost 1.7 times higher than that proposed by HSA guide. Also it is way, less than that reported for the Nigerian garlic (17.35% crude protein), according to Nwinuka et al. [19]. Spanish garlic had a protein content of 18.83% [20-22]. Discripancies in the findings of the different studies quoted here could be attributed to the fact that the latter investigators reported their protein content on dry weight basis while that of Banerjee, *et al.* [18] and the current study was on wet weight basis. Also varietal differences, geographical locations could account partially to the observed differences. Storage period had led to a significant ($p \leq 0.05$) difference in the fat content. Garlic paste stored for 6 months had significantly ($p \leq 0.05$) the highest fat content (2.03%) compared to that stored for 4months (1.50%). The fat content of garlic was significantly ($p \leq 0.05$) affected by the chemical treatments to which garlic paste was subjected. Garlic paste treated with T_2 had higher fat content (1.47%) compared to that treated with T_4 (1.20%). The value obtained in this study for the control samples (1.619%) was higher than that obtained by Blumenthal and Mark [10], or that of Nwinuka, *et al.* [19] who reported that garlic contain 0.15% and 0.68% fat content respectively. The interactive effect of chemical treatment and storage period on the crude fiber, ash and carbohydrate contents are shown in Table 4. Up to 4 months of storage ascorbic acid treatments alone did not ($p \geq 0.05$) affect the crude fiber of garlic paste. Generally crude fiber content of

Temperature (°C)	Variety		Average temp.
	Dongola	Berbar	
Ash content (%)			
25°C	4.07 ± 1.03^{a}	4.05 ± 1.10^{a}	4.06^{A}
40°C	3.85 ± 1.21^{ab}	3.79 ± 0.79^{ab}	3.82^{B}
Average variety	3.96^{A}	3.92^{A}	
Carbohydrates (%)			
25°C	25.13 ± 2.66^{a}	25.16 ± 3.21^{a}	25.15^{A}
40°C	22.93 ± 2.88^{bc}	23.57 ± 3.19^{b}	23.25^{AB}
Average variety	24.03^{AB}	24.37^{A}	

Values are mean ± SD.
*Means in the same columns and rows bearing same superscript small letters are not significantly different ($p \geq 0.05$)
**Means in the same row with the same superscript capital letters are not significantly different ($p \leq 0.05$).
***Means in the same column bearing different superscript capital letters are significantly different ($p \leq 0.01$).

Table 2: Effect of garlic variety and temperature on ash and carbohydrate contents of garlic paste.

Treatments	Storage period (months)			Average treat.
	2	4	6	
Moisture content (%)				
T_0	62.26 ± 1.29^{g}	63.60 ± 1.27^{e}	65.78 ± 0.74^{a}	63.88^{A}
T_1	61.29 ± 1.29^{jh}	63.21 ± 1.32^{f}	65.38 ± 1.00^{b}	63.29^{B}
T_2	59.88 ± 1.25^{j}	64.06 ± 1.20^{d}	64.29 ± 0.83^{d}	62.74^{C}
T_3	60.40 ± 1.37^{i}	63.56 ± 1.67^{e}	64.85 ± 0.85^{c}	62.94^{C}
T_4	59.21 ± 1.11^{k}	62.10 ± 1.45^{g}	64.11 ± 0.85^{d}	61.81^{D}
Average storage	60.61^{C}	63.31^{B}	64.88^{A}	
Protein content (%)				
T_0	4.15 ± 1.06^{bc}	3.87 ± 1.05^{d}	2.23 ± 0.32^{g}	3.42^{B}
T_1	5.23 ± 0.24^{a}	3.81 ± 0.81^{d}	2.46 ± 0.14^{f}	3.84^{A}
T_2	4.59 ± 0.66^{b}	3.21 ± 0.83^{e}	2.11 ± 0.18^{g}	3.30^{B}
T_3	4.29 ± 0.80^{c}	3.18 ± 1.13^{e}	2.05 ± 0.23^{g}	3.17^{BC}
T_4	4.72 ± 0.59^{b}	3.05 ± 0.96^{e}	2.10 ± 0.33^{g}	3.29^{B}
Average storage	4.60^{A}	3.42^{B}	2.19^{C}	
Fat content (%)				
T_0	1.61 ± 0.36^{cde}	1.39 ± 0.16^{g}	2.29 ± 0.14^{a}	1.43^{A}
T_1	1.31 ± 0.23^{f}	1.57 ± 0.36^{g}	2.03 ± 0.45^{b}	1.30^{B}
T_2	1.53 ± 0.31^{cdef}	1.45 ± 0.26^{g}	2.42 ± 1.02^{a}	1.47^{A}
T_3	1.49 ± 0.36^{def}	1.53 ± 0.18^{g}	1.78 ± 0.28^{g}	1.27^{B}
T_4	1.38 ± 0.29^{ef}	1.57 ± 0.30^{g}	1.65 ± 0.29^{cd}	1.20^{B}
Average storage	1.46^{B}	1.50^{C}	2.03^{A}	

Values are mean ± SD.
*Means in the same columns and rows bearing same superscript small letters are not significantly different ($p \geq 0.05$)
**Means in the same row with the same superscript capital letters are not significantly different ($p \leq 0.05$).
***Means in the same column bearing different superscript capital letters are significantly different ($p \leq 0.01$).
T_0 = Control
T_1 = Ascorbic acid (0.5 mg/g)
T_2 = Citric acid (2 mg/g)
T_3 = Ascorbic acid (0.25 mg/g) and Citric acid (1 mg/g)
T_4 = Ascorbic acid (0.5 mg/g) and Citric acid (2 mg/g)

Table 3: Effect of chemical treatments and storage periods on moisture, protein, and fat contents of garlic paste.

garlic paste increased ($p \leq 0.05$) with the increase of storage period. Garlic paste stored for 6 months had significantly ($p \leq 0.05$) higher crude fiber (4.86%) than that stored for 2 months (3.52%). The crude fiber of garlic was significantly ($p \leq 0.05$) affected by the treatments to which garlic paste was subjected. Garlic paste treated with T4 had significantly ($p \leq 0.05$) higher crude fiber (4.37%) compared to the control (3.96%). The value obtained in the current study was higher than the value obtained by USDA (2004), who reported that garlic contain 2.10%, 0.73% and 1.5% crude fiber respectively. Chemical treatments had no clear trend on ash content. Garlic paste stored for 6 months had significantly ($p \leq 0.05$) highest (5.18%) ash content compared to that stored for 2months (2.89%). The ash content of garlic was significantly ($p \leq 0.05$) affected by the treatments to which garlic paste was subjected. Garlic paste treated with T_3 had significantly ($p \leq 0.05$) higher (4.06%) ash content compared to the garlic treated with T_2. The control (T_0) garlic paste had an ash content of 4.0%. The value obtained in this study is similar to the value obtained by Casado, et al. [12], who reported that, the ash content of garlic ranged between 2.65% and 8.40%. Also the ash content of the current study is similar to that obtained by Nwinuka, et al. [19] who stated that Nigerian garlic has an ash content of 4.01%. However another study for Nigerian garlic found that it contained 1.33% ash [16]. Treatments had led to a significant ($p \leq 0.05$) difference in the amount of carbohydrates between chemical treatments. Garlic paste stored for 2months had significantly ($p \leq 0.05$) the highest carbohydrates (26.80%) compared to that stored for 6months (20.94%). The carbohydrates of garlic was significantly ($p \leq 0.05$) affected by the treatments to which garlic paste was subjected. Garlic paste treated with a T4 had significantly ($p \leq 0.05$) high carbohydrates (25.64%) compared to that of T_0 (23.11%). The value obtained in this study was higher than that obtained by Sowbhagya, et al. [13], who reported that garlic contain 21% carbohydrates, but lower than that (28%) stated by HSA [21].

Effect of variety and storage temperature on the sensory evaluation of garlic paste

The effect of garlic variety (Dongola and berber) and storage temperature (25°C and 40°C) on the sensory evaluation of garlic paste is depicted in Table 5. Results indicated that storage temperature had led to a significant ($p \leq 0.05$) difference in the color score. Dongola variety had significantly ($p \leq 0.05$) higher color score (5.23) than Berber variety (4.09). The color score of garlic was significantly ($p \leq 0.05$) affected by the storage temperature at which it was stored. Garlic paste stored at 25°C had the highest color score (5.29) compared to that stored at 40°C (4.53), indicating that low temperature storage preserved the color of garlic paste [22]. The variety had led to a significant ($p \leq 0.05$) difference in the flavor score. Dongola variety had significantly ($p \leq 0.05$) higher flavor score (2.30) than Berber variety (3.88). The flavor score of garlic was significantly ($p \leq 0.05$) affected by the temperature at which garlic paste was stored. Garlic paste stored at 25°C had the

Treatments	Storage period (months)			Average treat.
	2	4	6	
Crude fiber (%)				
T_0	3.72 ± 0.68^{g}	3.43 ± 0.25^{h}	4.72 ± 0.46^{b}	3.96^{B}
T_1	4.06 ± 0.62^{ef}	4.24 ± 0.91^{de}	4.53 ± 0.18^{c}	4.28^{A}
T_2	3.07 ± 0.31^{i}	3.91 ± 0.99^{f}	4.95 ± 0.78^{a}	3.98^{B}
T_3	3.06 ± 1.32^{i}	4.47 ± 0.95^{c}	5.07 ± 0.60^{a}	4.20^{A}
T_4	3.68 ± 0.42^{g}	4.42 ± 0.95^{cd}	5.01 ± 0.72^{a}	4.37^{A}
Average storage	3.52^{C}	4.09^{B}	4.86^{A}	
Ash content (%)				
T_0	2.93 ± 0.14^{g}	3.77 ± 0.48^{e}	5.30 ± 0.42^{ab}	4.00^{A}
T_1	2.83 ± 0.37^{g}	3.94 ± 1.12^{d}	5.22 ± 0.42^{b}	3.89^{B}
T_2	2.94 ± 0.17^{g}	3.66 ± 0.19^{f}	4.99 ± 0.24^{b}	3.86^{B}
T_3	2.86 ± 0.41^{g}	4.00 ± 0.39^{d}	5.33 ± 0.29^{a}	4.06^{A}
T_4	2.91 ± 0.33^{g}	3.64 ± 0.16^{f}	5.08 ± 0.15^{b}	3.88^{B}
Average storage	2.89^{C}	3.80^{B}	5.18^{A}	
Carbohydrates (%)				
T_0	24.72 ± 1.28^{e}	24.94 ± 1.25^{d}	20.17 ± 1.03^{k}	23.11^{D}
T_1	25.27 ± 1.19^{c}	24.57 ± 2.71^{e}	20.38 ± 1.14^{j}	23.41^{C}
T_2	28.00 ± 0.50^{a}	24.70 ± 1.80^{e}	21.25 ± 1.56^{h}	24.65^{B}
T_3	27.90 ± 2.30^{a}	24.26 ± 2.23^{f}	20.92 ± 1.33^{i}	24.36^{B}
T_4	28.10 ± 1.35^{a}	26.23 ± 2.11^{b}	21.98 ± 1.27^{g}	25.64^{A}
Average storage	26.80^{A}	24.94^{B}	20.94^{C}	

Values are mean ± SD.
*Means in the same columns and rows bearing same superscript small letters are not significantly different ($p \geq 0.05$)
**Means in the same row with the same superscript capital letters are not significantly different ($p \leq 0.05$).
***Means in the same column bearing different superscript capital letters are significantly different ($p \leq 0.01$).
T_0 = Control
T_1 = Ascorbic acid (0.5 mg/g)
T_2 = Citric acid (2 mg/g)
T_3 = Ascorbic acid (0.25 mg/g) and Citric acid (1 mg/g)
T_4 = Ascorbic acid (0.5 mg/g) and Citric acid (2 mg/g)

Table 4: Effect of chemical treatments and storage periods on fiber, ash and carbohydrate content of garlic paste.

highest flavor score (4.72) compared to storage at 40°C (4.46). Storage temperature had led to a significant ($p \leq 0.05$) difference in the texture score between varieties. Dongola variety had significantly ($p \leq 0.05$) higher texture score (5.37) than Berber variety (5.20). The texture score of garlic was significantly ($p \leq 0.05$) affected by the storage temperature to which garlic paste was stored. Garlic paste stored at 25°C had the highest texture score (4.87) compared to that storage at 40°C (4.70). Storage temperature had led to a significant ($p \leq 0.05$) difference in the overall acceptability between varieties. Dongola variety had significantly ($p \leq 0.05$) higher overall acceptability (5.50) than Berber variety (4.13). The overall acceptability of garlic was significantly ($p \leq 0.05$) affected by the temperature at which garlic paste was stored. Garlic paste stored at 25°C had the highest overall acceptability (4.96) compared to that stored at 40°C (4.66).

Conclusion

Interactive effect of chemical treatment (T_0-T_4) and storage period on the color, flavor and texture are shown in (Tables 6,7). Storage period had led to a significant ($p \leq 0.05$) difference in the color score. Garlic sample stored for 2 months had significant ($p \leq 0.05$) high color score (4.69) compared to that stored for 4months (4.63). The color score of garlic was significantly ($p \leq 0.05$) affected by the treatments to which garlic paste was subjected. Garlic paste treated with T_2 had significantly ($p \leq 0.05$) the highest color score (5.60) compared to that treated with T_4 (3.24). Treatments had led to a significant ($p \leq 0.05$) difference in the flavor score among chemical treatments. Storage for 6 months had significantly ($p \leq 0.05$) the lowest flavor score (4.57) compared to that stored for 2 months (4.62). The flavor score of garlic was significantly ($p \leq 0.05$) affected by the treatments to which garlic paste was subjected. Garlic paste treated with T_3 had significantly ($p \leq 0.05$) the high (5.34) flavor score compared to that treated with T_4 (3.37). Storage had led to a significant ($p \leq 0.05$) difference in the texture score of the stored sample. Samples stored for 4 months had

Temperature (°C)	Variety		Average temp.
	Dongola	Berbar	
Color			
25°C	5.36 ± 0.15^{a}	4.21 ± 0.23^{c}	5.29^{A}
40°C	5.09 ± 0.73^{b}	3.96 ± 0.50^{d}	4.53^{B}
Average variety	5.23^{A}	4.09^{B}	
Flavor			
25°C	5.45 ± 0.02^{a}	3.99 ± 0.28^{c}	4.72^{A}
40°C	5.15 ± 0.18^{b}	3.76 ± 0.39^{d}	4.46^{B}
Average variety	5.30^{A}	3.88^{B}	
Texture			
25°C	5.45 ± 0.59^{a}	4.29 ± 0.67^{c}	4.87^{A}
40°C	5.28 ± 0.72^{b}	4.11 ± 0.10^{d}	4.70^{B}
Average variety	5.37^{A}	4.20^{B}	
Overall acceptability			
25°C	5.65 ± 0.61^{a}	4.27 ± 0.97^{c}	4.96^{A}
40°C	5.34 ± 0.40^{b}	3.98 ± 0.23^{d}	4.66^{B}
Average variety	5.50^{A}	4.13^{B}	

Values are mean ± SD.
*Means in the same columns and rows bearing same superscript small letters are not significantly different ($p \geq 0.05$)
**Means in the same row with the same superscript capital letters are not significantly different ($p \leq 0.05$).
***Means in the same column bearing different superscript capital letters are significantly different ($p \leq 0.01$).

Table 5: Effect of garlic variety and storage temperature on sensorial evaluation of garlic paste.

Treatments	Storage period (months)			Average treat.
	2	4	6	
Color				
T_0	5.12 ± 0.29^{h}	5.18 ± 0.27^{g}	4.88 ± 0.74^{i}	5.06^{C}
T_1	5.68 ± 0.29^{c}	5.76 ± 0.32^{a}	5.35 ± 0.00^{e}	5.60^{A}
T_2	5.61 ± 0.25^{d}	5.74 ± 0.20^{b}	5.28 ± 0.83^{f}	5.54^{B}
T_3	3.63 ± 0.37^{m}	3.89 ± 0.67^{k}	3.96 ± 0.85^{j}	3.83^{D}
T_4	3.43 ± 0.11^{n}	2.59 ± 0.45^{o}	3.71 ± 0.85^{l}	3.24^{E}
Average storage	4.69^{A}	4.63^{B}	4.64^{B}	
Flavor				
T_0	5.15 ± 0.06^{f}	5.29 ± 0.05^{e}	4.94 ± 0.32^{i}	5.13C
T_1	5.36 ± 0.24^{d}	5.41 ± 0.81^{c}	5.06 ± 0.14^{h}	5.28^{B}
T_2	5.42 ± 0.66^{b}	5.53 ± 0.83^{a}	5.08 ± 0.18^{g}	5.34^{A}
T_3	3.62 ± 0.80^{m}	3.89 ± 0.13^{k}	3.95 ± 0.23^{j}	3.82^{D}
T_4	3.53 ± 0.59^{n}	2.78 ± 0.96^{o}	3.81 ± 0.33^{l}	3.37^{E}
Average storage	4.62^{B}	4.58^{A}	4.57^{A}	
Texture				
T_0	5.19 ± 0.36^{f}	5.44 ± 0.16^{d}	5.03 ± 0.14^{i}	5.22^{B}
T_1	5.44 ± 0.23^{e}	5.57 ± 0.36^{b}	5.15 ± 0.45^{h}	5.39^{A}
T_2	5.46 ± 0.31^{c}	5.59 ± 0.26^{a}	5.16 ± 0.02^{g}	5.40^{A}
T_3	4.08 ± 0.36^{l}	4.32 ± 0.18^{j}	4.28 ± 0.28^{k}	4.23^{C}
T_4	3.65 ± 0.29^{n}	3.44 ± 0.30^{o}	3.94 ± 0.29^{m}	3.68^{D}
Average storage	4.76^{B}	4.87^{A}	4.71^{C}	

Values are mean ± SD.
*Means in the same columns and rows bearing same superscript small letters are not significantly different ($p \geq 0.05$)
**Means in the same row with the same superscript capital letters are not significantly different ($p \leq 0.05$).
***Means in the same column bearing different superscript capital letters are significantly different ($p \leq 0.01$).
T_0=Control
T_1=Ascorbic acid (0.5 mg/g)
T_2=Citric acid (2 mg/g)
T_3=Ascorbic acid (0.25 mg/g) and Citric acid (1 mg/g)
T_4=Ascorbic acid (0.5 mg/g) and Citric acid (2 mg/g)

Table 6: Effect of chemical treatments and storage period on color, flavor and texture of garlic paste.

Treatments	Storage period (months)			Average treat.
	2	4	6	
Overall acceptability				
T_0	5.38 ± 0.68^{f}	5.53 ± 0.25^{c}	5.10 ± 0.46^{h}	5.34^{B}
T_1	5.77 ± 0.62^{b}	5.91 ± 0.91^{a}	5.42 ± 0.18^{e}	5.70^{A}
T_2	5.32 ± 0.31^{g}	5.43 ± 0.99^{d}	4.91 ± 0.78^{i}	5.22^{C}
T_3	3.90 ± 0.32^{l}	4.26 ± 0.95^{j}	4.24 ± 0.60^{k}	4.13^{D}
T_4	3.79 ± 0.42^{m}	3.40 ± 0.95^{n}	3.79 ± 0.72^{m}	3.66^{E}
Average storage	4.83^{B}	4.91^{A}	4.69^{C}	

Values are mean ± SD.
*Means in the same columns and rows bearing same superscript small letters are not significantly different ($P \geq 0.05$)
**Means in the same row with the same superscript capital letters are not significantly different ($P \leq 0.05$).
***Means in the same column bearing different superscript capital letters are significantly different ($P \leq 0.01$).
T_0 = Control
T_1 = Ascorbic acid (0.5 mg/g)
T_2 = Citric acid (2 mg/g)
T_3 = Ascorbic acid (0.25 mg/g) and Citric acid (1 mg/g)
T_4 = Ascorbic acid (0.5 mg/g) and Citric acid (2 mg/g)

Table 7: Effect of chemical treatments and storage period on overall acceptability of garlic paste.

significantly ($p \leq 0.05$) the highest texture score (4.87) compared to that stored for 6 months (4.71). The texture score of garlic was significantly ($p \leq 0.05$) affected by the chemical treatments to which garlic paste was subjected. Garlic paste treated with T_2 had significantly ($p \leq 0.05$) high texture score (5.40) compared to that treated with T_4 (3.68). Interactive effect of treatment and storage on the overall acceptability is shown in Table 3. Results indicated that treatments had led to a significant ($p \leq 0.05$) difference in the overall acceptability among stored samples. Samples stored for 4 months had significantly ($p \leq 0.05$) high overall acceptability (4.91) compared to that stored for 6 months (4.69). The overall acceptability of garlic was significantly ($p \leq 0.05$) affected by the treatments to which garlic paste was subjected. Garlic paste treated with T_2 had significantly ($p \leq 0.05$) high overall acceptability score (5.70) compared to that treated with T_4 (3.66).

References

1. WHO (2009) The global burden of disease. Health statistics and information systems.
2. Opie LH, Mayosi BM (2005) Cardiovascular disease in sub-Saharan Africa. Circulation 112: 3536-3540.
3. Koscielny J, Klüssendorf D, Latza R, Schmitt R, Radtke H, et al. (1999) The antiatherosclerotic effect of Allium sativum. Atherosclerosis 144: 237-249.
4. Rahman K (2001) Historical perspective on garlic and cardiovascular disease. J Nutr 131: 977-979.
5. Steiner M, Li W (2001) Aged garlic extract, a modulator of cardiovascular risk factors: a dose-finding study on the effects of AGE on platelet functions. J Nutr 131: 980S-4S.
6. Piscitelli SC, Burstein AH, Welden N, Gallicano KD, Falloon J, et al. (2002) The effect of garlic supplements on the pharmacokinetics of saquinavir. Clin Infect Dis 34: 234-238.
7. Agarwal KC (1996) Therapeutic actions of garlic constituents. Med Res Rev 16: 111-124.
8. Oliveira CM, Souza RJ, Yuri JE (2004) Harvest date and storage potential in garlic cultivars. HorticulturaBrasileira 22: 804-807.
9. AOAC (2003) Official Methods of analysis. Association of Official Analytical Chemist, Washington, USA.
10. Blumenthal, Mark (2000) Herbal medicine: expanded Commission E monographs. Integrative Medicine Communications.
11. USDA (2004) Agricultural Research Service. USDA Nutrient database for standard reference, Nutrient data laboratory, USA.
12. Casado FJ, Lopez A, Luis R (2004) Nutritional composition of commercial pickled garlic. Eur Food Res Technol 219: 355-359.
13. Sowbhagya, HB, Kaul TP, Suma PF, AppuRaob AG, Srinivasa P, et al. (2009) Evaluation of enzyme-assisted extraction on quality of garlic volatile oil. Food Chemistry 113: 1234-1238.
14. Benkeblia N (2007) Phenolic Compounds of Allium Species. RRBS 1: 135-140.
15. Odebunmi EO, Oluwaniyi OO, Bashiru MO (2010) Comparative Proximate Analysis of Some Food Condiments. J ApplSci Res 6: 272-274.
16. Odebunmi EO, Oluwaniyi OO, Bashiru MO (2009) Comparative proximate analysis of some food condiments. J App Sci Res 2: 1-3.
17. Topno PN, Vinothin, Jayapraksh SH, Varadaiah, V, Sheshagri SH, et al. (2011) Ginger-garlic paste in petort pouches and its quality. Journal of Food Process Engineering.
18. Banerjee SK, Mukherjee PK, Maulik SK (2003) Garlic as an antioxidant: the good, the bad and the ugly. Phytother Res 17: 97-106.
19. Nwinuka NM, Ibeh GO, Ekeke GI (2005) Proximate composition and levels of some toxicants in four commonly consumed spices. J Appl Sci Environ 9: 150-155.
20. Cardelle-Cobas A, Moreno FJ, Corzo N, Olano A, Villamiel M, et al. (2005) Assessment of initial stages of Maillard reaction in dehydrated onion and garlic samples. J Agric Food Chem 53: 9078-9082.
21. HSA (2006) Garlic: An Herb Society of America Guide.
22. GLOBOCAN (2008) International Agency for Research on Cancer.