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EFFECT OF STORAGE MEDIA AND PRESERVATIVES ON THE PHYSICOCHEMICAL, MICROBIOLOGICAL AND SENSORY QUALITIES OF SCOTCH BONNET

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Abstract

The study evaluated the effect of different storage media on the physicochemical, microbial and sensory attributes of Scotch bonnet (*Capsicum chinense*) for six months. The Scotch bonnet samples were subjected to different treatments. Samples treatments: A (2.5% sea salt+ 2% white sugar), B (5% sea salt + 2% white sugar), C (10% sea salt + 2% white sugar), D (0.5% clove + 5% garlic + 5% ginger), and E (Control i.e distilled water). These analyses were carried out: pH, acidity, carotenoids content, sensory evaluation and microbiological assessment. The lycopene and beta-carotene contents of the samples ranged from 0.144-0.429 and 1.005-3.241mg/100ml respectively, while the total titratable acid (TTA) contents ranged between 0.027-0.198%. The pH (5.08-6.46) level was observed to fall within the normal range in most treated groups all through the storage period. Results of the organoleptic analysis showed that there were significant differences ($p<0.05$) in the firmness of the scotch bonnet among the tested samples, with group D having the highest score of 3.9. However, there was no significant difference in aroma, appearance, colour and overall acceptance for all samples. Treatment D outperformed other preservative methods in reducing spoilage and toxigenic microflora, thereby extending the shelf life of fresh Scotch bonnet peppers. The spices demonstrated potentials in minimizing pathogenic spoilage, which contributes to improved food safety and prolonged shelf-life. These findings suggest that spice-based treatments, particularly the combination of clove, garlic, and ginger, offer a viable natural preservation strategy for extending pepper shelf-life.

Introduction

Fruits and vegetables are very important food commodities all over the world (Iqbal *et al.*, 2019). Pepper (*Capsicum spp.)* is grown in many countries of the world and its production for culinary and vegetable uses has been increased from time to time (Liu *et al*., 2017). It is one of the most commercially important horticultural crops grown in tropical and sub-tropical regions of the world. It was observed that practically all fresh vegetables grown and consumed in Nigeria, and production is seasonal resulting in a glut during

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production is seasonal resulting in a glut during the season and scarcity at off seasons (Oyelade, 2025). Due to their soft texture, they are easily bruised or wounded as a result of harvesting, and other post-harvest handling operations such as packaging, transportation and storage. In Nigeria, yearly production losses of up to 40% postharvest occurs (Ogundele, 2022). From the nutritional point of view, peppers are generally considered as a balanced source of most essential nutrients, high content of vitamins, important antioxidants, rich in flavonoids and phytochemicals (Adewoyin, 2014). For a long time, spices have been employed for their pharmaceutical attributes and as culinary enhancement. The food industry widely employs artificial preservatives to retard the deterioration induced by microbial proliferation, enzymatic processes and oxidative reactions. They inhibit, retard or arrest processes such as fermentation, acidification and other forms of decomposition in food (Suleiman *et al.*, 2023).

Scotch bonnet, a variety of hot pepper is rich in health-promoting compounds like vitamins C, E, and pro-vitamin A, among others. Its pungency varies based on its origins. Additionally, they contain folate, an essential B-vitamin known for its role in reducing the risk of cardiovascular disease and cancer (Adekalu *et al.,* 2015). The diverse range of peppers, including chili, paprika, cayenne, and bell pepper, varies widely in heat levels, measured on the Scoville scale. Capsaicin, the primary component responsible for their heat, influences these ratings. Detaching peppers with their calyx/pedicel is a practice adopted by Nigerian farmers to minimize microbial entry points (Jatau *et al*., 2018). Due to the concern of consumers about the safety of consuming artificial preservatives on health and easy silage of pepper after harvest, there is a shift toward natural preservatives. This research aimed to improve the shelf life of Scotch bonnet by storing it in spices and brine solutions for six months.

Materials and Methods

Sample preparation

Freshly harvested Scotch bonnet pepper (commonly known as *ata rodo* in Yoruba Language, in Nigeria) was purchased from Mandate market located in Ilorin West Local Government Area, Kwara state and taken to the Food Laboratory of Nigerian Stored Products Research Institute. It was thoroughly washed under running water and kept in a sieve for the water to drain. The pepper samples were immersed in the already prepared treatment stated below and stored in kilner jars.

Group A: 2.5% sea salt+ 2% white sugar
Group B: 5% sea salt + 2% white sugar
Group C: 10% sea salt + 2% white sugar
Group D: 0.5% clove + 5% garlic + 5% ginger
Group E- Control (distilled water)

Lycopene and β-carotene Determination

As described by Sharoba (2009), the pepper samples were homogenized using a mortar and pestle in the presence of water bath containing squashed ice. Exactly 16 mL of acetone–hexane (4:6) solvent were added to 1.0 g of the homogenate and mixed in a test-tube to extract the carotenoids. An aliquot of the upper solution from the two phases formed was taken and its absorbance was measured at 663, 645, 505, and 453 nm in a UV-VIS spectrophotometer (Searchtech Instruments; UV1902PC, England). Lycopene and β-carotene contents were calculated according to the Nagata and Yamashita equations below as reported by Sharoba (2009).

Lycopene (mg per 100mL) = $-0.0458 \times A663 + 0.204 \times A645 + 0.372 \times A505 - 0.0806 \times A453$

β-carotene (mg per 100mL) = $0.216 \times A663 - 1.22 \times A645 - 0.304 \times A505 + 0.452 \times A453$, where A=Absorbance at specified wavelength

Determination of pH and Total Titratable Acidity (TTA) (%):

The titratable acidity and pH were measured as reported by Lawal *et al*. (2019). Ten (10) g of sample was blended and centrifuged at 5000 rpm for 20 min, at 4 °C. The supernatant was filtered and recovered for soluble solids, titratable acidity determination and pH. Titratable acidity was measured by titrating the supernatant with 0.1 N NaOH until a rose-pink colour, was achieved, and then recorded as gram citric acid/100 g fresh weight.

Sensory evaluation

Using the evaluation method described by Fashanu *et al*. (2019), the following sensory qualities were evaluated: aroma, appearance, colour, firmness, and general acceptability using a five-point hedonic scale (5 = like extremely, 4 = like moderately, 3 = like slightly, 2 = neither like nor dislike, and 1 = dislike), by 20-member untrained panellists,

Microbial Enumeration

Isolation of Moulds from Pepper Samples

One gram of pepper sample was placed in 9 ml of sterile distilled water, shaken in an orbital shaker and serially diluted up to 10^{-2}. Aliquots 0.1mL was then plated using the pour plate method on Potato Dextrose Agar (PDA) and incubated at 28 ºC for 7days. Visible fungal growth was sub cultured onto PDA to obtain pure cultures for identification. Isolates were continuously sub cultured until pure isolates were obtained. Pure fungal cultures were then stored safely in McCartney bottles in cool incubator at 4 °C to prevent contamination. Isolated fungi were identified according to the procedure described by Goh and Philip (2016).

Isolation of Bacteria from Pepper Samples

The pepper samples were manually ground into smaller sizes using a mortar and pestle that had been pre-sterilized with 70% ethanol. Bacterial species were isolated from the samples using the serial dilution agar plate technique (Goh and Philip, 2016). One gram of each of the processed products was aseptically transferred separately into 9 ml of sterile water to make a mixing stock. The homogenized mixture was serially diluted by taking 1 ml of the stock mixture into appropriately labelled test tube to make 10^{-1} of the mixture.

For enumeration of microorganisms present in the processed samples, 1 ml of the different dilutions was pipetted into sterile Petri dishes, containing molten nutrient agar (45 °C), eosin methylene blue agar (45 °C), and Salmonella Shigella agar, all prepared according to the manufacturer's guidelines. The plates were swirled thoroughly to allow even distribution. The inoculated media plates were then incubated using a Swiss *model* NU-5700, UK incubator at 37 ± 2 °C for 24 hours. After 24 hours of incubation, the colonies were counted using a colony counter (Stuart Scientific, UK). Microbial load of each sample was determined as CFU/ml and calculated using the formula:

CFU /ml = No. of colonies x dilution factor / volume of inoculum (Nishant and Pinky,2015).

Statistical Analysis

The data was subjected to analysis of variance (ANOVA) and tested for significance difference among treatments by New Duncan's Multiple Range (DMRT), F-Test at ($p<0.05$) using SPSS software package version 20.0.0 (IBM SPSS Statistics 2011, IBM Corporation).

Results and Discussion

Lycopene content of stored Scotch bonnet pepper

The lycopene content of the control and treated pepper samples ranged from 0.144–0.429 mg/100 g. Sample B had the highest lycopene content (0.429 mg /100g) all through the months, while Sample E (control) had the lowest lycopene content (0.157mg/100g). As can be seen from the result (Fig. 1), the lycopene content of all the samples was stable in month 1 and month 2, after which a gradual reduction was observed from months 3 to 6. This observed reduction on the lycopene content could be due to the effect of storage over a long time or environmental factor such as temperature.

This is consistent with the findings of Jatau *et al*. (2018), who reported that lycopene can decrease in content in a sample when subjected to temperature fluctuations or other environmental factors. Li and Yu (2023) added that growth variables like temperature and soil quality can also affect the amount of lycopene in fruits and vegetables. Pathak and Sagar (2023) corroborate that different food products may have varying levels of lycopene due to differences in processing and extraction processes. Moreover, storage conditions also impact the lycopene content of fruits, vegetables and their products. According to Xianquan *et al.* (2005), lycopene may isomerize to mono- or poly-cis forms with the presence of heat, oil or during dehydration. Re-isomerization may also take place during storage.

Beta-carotene content of stored Scotch bonnet pepper

Results from the study showed that the Beta-carotene contents of the samples ranged from 1.005 to 3.241 mg/100g (Fig. 2). A notable reduction in the beta-carotene content of sample E was observed as storage as the storage months increased. Although, there was also a decrease in the beta-carotene content of sample D, it had the highest beta-carotene content all through the storage period, this could mean that the treatment was able to preserve the beta carotene better than all other treatments. According to Adekalu *et al.* (2015), factors such as low temperature, oxygen deficiency, decreased humidity and absence of light tend to reduce carotenoid degradation during storage This is also in accordance with LLic *et al.* (2013) which reported that storage conditions and disinfection treatment can lead to compositional changes, loss of mass, beta-carotene and vitamin C in fruits and vegetables. Boiling, storage and absence of light; which promotes oxidative and thermal degradation affects beta-carotene which leads to decrease (Anjum *et al.*, 2008).

Plate 1: Picture showing stored pepper

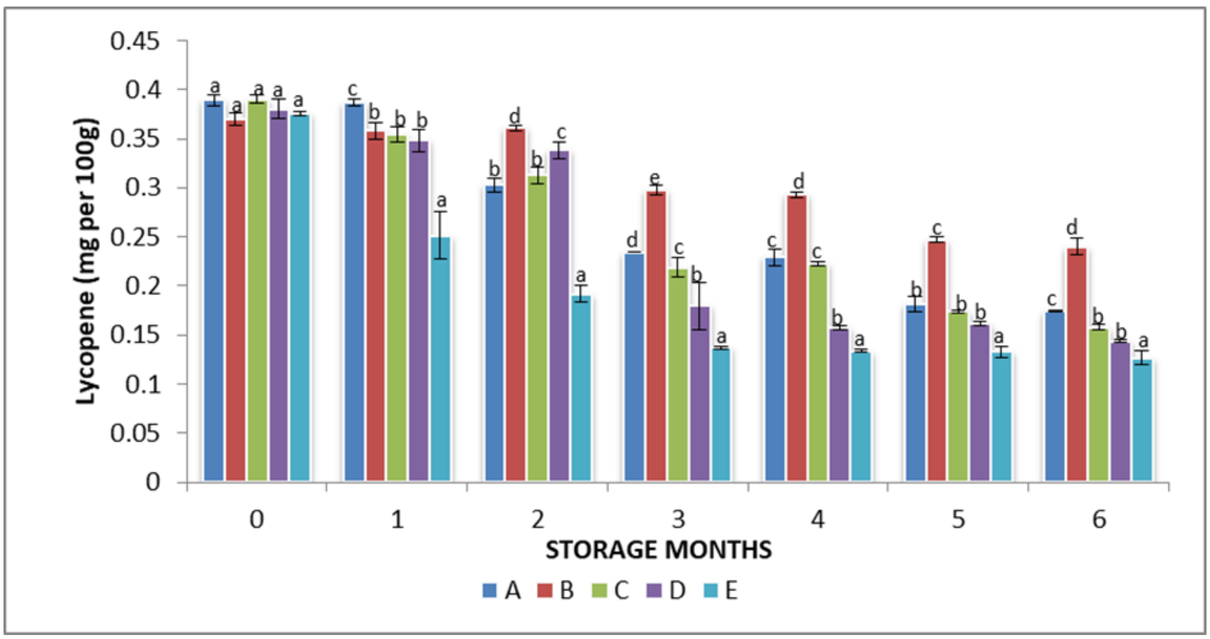

Figure 1. Effect of different storage media on the lycopene content of Scotch bonnet after six months storage. Readings show mean ± SSE: A= 2.5% salt + 2% sugar; B= 5% salt +2% sugar; C= 10% salt + 2% sugar; D= 0.5% clove +5% garlic + 5% ginger; E= control (distilled water).

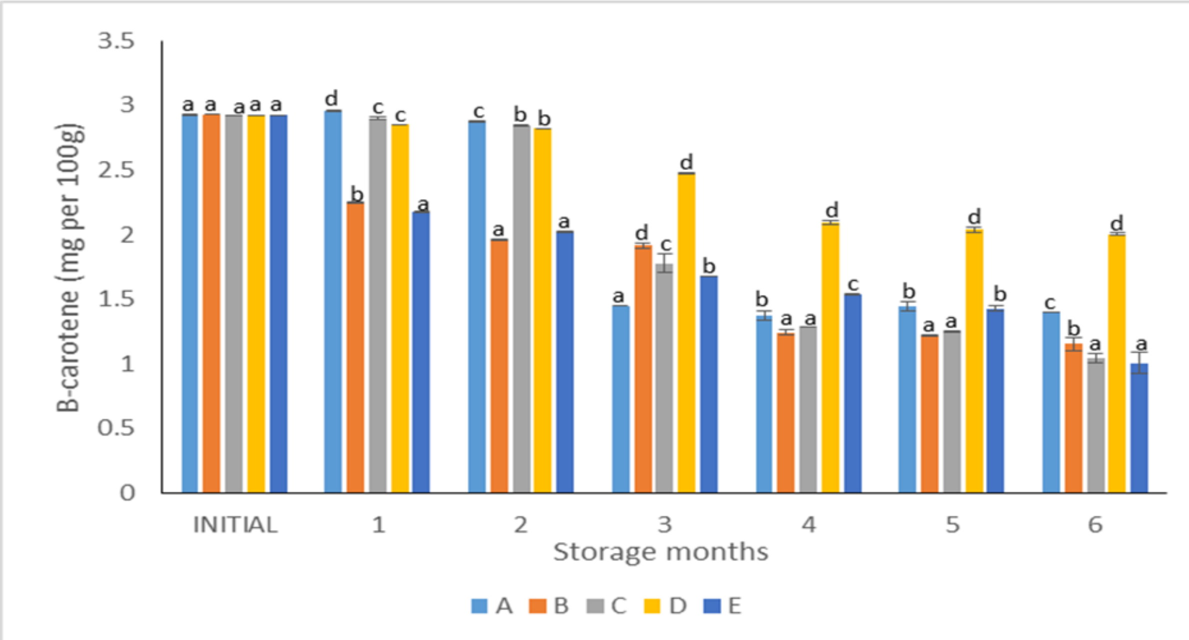

Figure 2. Effect of different storage media on the beta-carotene content of Scotch bonnet after six months storage. Readings show mean ± SSE: A = 2.5% salt + 2% white sugar; B = 5% salt +2% white sugar; C = 10% salt + 2% white sugar; D = 0.5% clove +5% garlic + 5% ginger; E = control (distilled water).

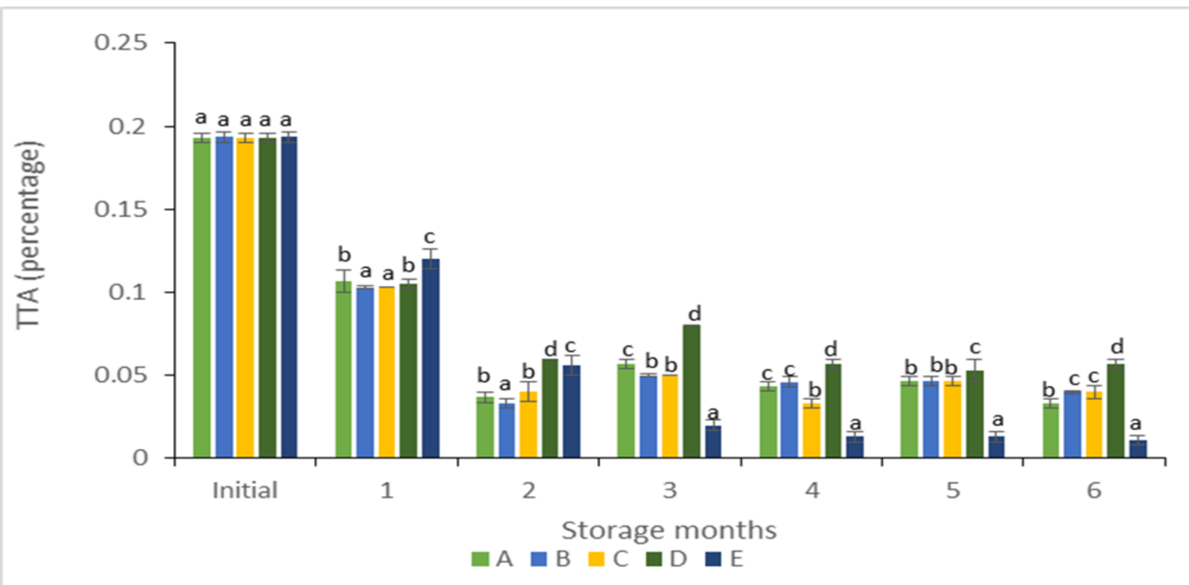

Figure 3. Effect of different storage media on the total titratable acidity of scotch bonnet after six months storage. Readings show mean ± SSE: A = 2.5% salt + 2% white sugar; B = 5% salt +2% white sugar; C = 10% salt + 2% white sugar; D = 0.5% clove +5% garlic + 5% ginger; E = control (distilled water).

Total Titratable Acidity (TTA) content of stored Scotch bonnet pepper

The TTA value recorded within the storage period ranged from 0.027 to 0.198%. There was no significant ($p>0.05$) difference in the TTA of control and treated samples at day 0, this was expected because they were all from the same source. Conversely, a significant difference was recorded in the first month between the control and the treated samples.

With increase in storage period, there was an observed decrease in the TTA content of all the samples with sample E having the lowest value while there was no significant difference between sample B and C. Sample D recorded the highest TTA content at the end of the storage period. The results in the present study agrees with Garuba *et al.* (2022) who reported that the decrease of TTA in fruits and vegetables at high relative humidity when packaged during storage period may be due to reduced rate of acid production from carbohydrates as a result of slow respiration rate. Sharma *et al.* (2018) also confirmed the decrease of the TTA of bell pepper powders stored for a period of three months. Barbosa *et al.* (2020) also reported an initial increase followed by a decrease at the end of the storage period of fresh-cut Bell peppers in modified atmosphere packaging

pH content of stored Scotch bonnet pepper

Though there was an increase in the pH values of all the samples, samples A, C and D were seen to be within the normal pH range of pepper (5.0- 6.5) all through the storage period. At the end of the storage period, sample E had the highest pH value. Tano *et al.* (2008) confirmed that the pH value of pepper tends to increase during ambient storage.

Sensory evaluation of stored Scotch bonnet pepper

Samples C and D consistently received higher scores in appearance, colour, and firmness, with overall acceptability values of 3.9 as seen in Table 1. Sample C showed superior colour (4.5±0.166) and firmness (3.90±0.79), likely due to higher salt concentrations enhancing structural integrity and pigment retention. This aligns with findings by Giannakourou and Taoukis (2003), who reported that salt brining slows softening and colour degradation by reducing water activity and microbial load. Sample D, treated with combination of clove, garlic and ginger, also maintained good firmness (3.90±1.79) and achieved a high overall acceptability score (3.90±0.21), supporting Zhang *et al*. (2016), who highlighted the effectiveness of natural plant-based antimicrobials.

In contrast, the control sample (E), stored in distilled water, consistently scored lower, especially in aroma (2.90±0.311) and firmness (3.30±0.153).

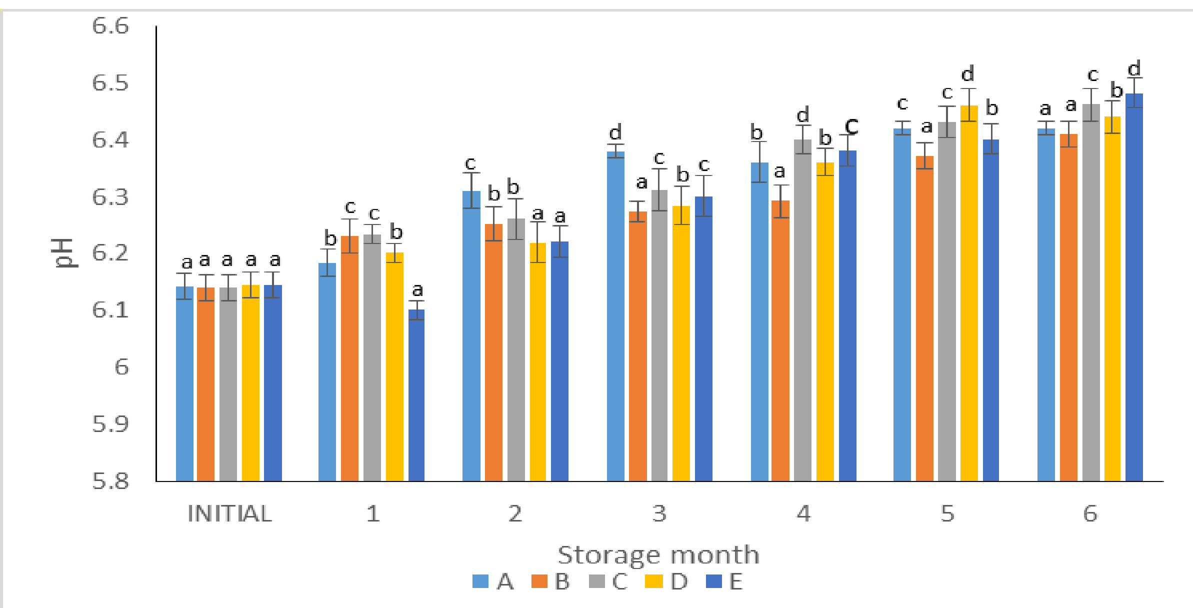

Figure 4. Effect of different storage media on the pH of scotch bonnet after six months storage.
Readings show mean ± SSE: A = 2.5% salt + 2% white sugar; B = 5% salt +2% white sugar; C = 10% salt + 2% white sugar; D = 0.5% clove +5% garlic + 5% ginger; E = control (distilled water).

Aroma scores showed no significant variation among samples ($p > 0.05$), indicating that while visual and textural qualities were preserved, aroma compounds may have degraded similarly across conditions. Overall, samples C and D were effective in maintaining the sensory quality of Scotch bonnet peppers during storage, making them suitable for small-scale preservation, especially in resource-limited settings without refrigeration.

Table 1: Effect of different storage media on the sensory attributes of Scotch bonnet six months storage.

Sample	Aroma	Appearance	Colour	Firmness	Overall Acceptance
A	3.10± 0.34^{a}	3.9±0.31^{ab}	4.0±0.29^{ab}	2.9±0.10^{a}	3.6±0.22^{a}
B	3.2±0.20^{a}	3.6±0.30^{a}	3.6±0.30^{a}	2.9±0.17^{a}	3.6±0.22^{a}
C	3.10±0.34^{a}	4.4±0.16^{ab}	4.5±0.16^{b}	3.90±0.79^{b}	3.9±0.18^{a}
D	3.20±0.24^{a}	3.7±0.67^{ab}	3.8±0.24^{ab}	3.90±1.79^{b}	3.90±0.21^{a}
E	2.90±0.31^{a}	3.60±0.22^{a}	3.70±0.30^{b}	3.30±0.153^{a}	3.40±0.22^{a}

Readings show mean of 20 panellist members on a 5- point hedonic scale, where 5 indicates like extremely and 1 indicates dislike: A = 2.5% salt + 2% white sugar; B = 5% salt + 2% white sugar; C = 10% salt + 2%white sugar; D = 0.5% clove + 5% garlic + 5% ginger; E = control (distilled water).

Microbial findings of stored Scotch bonnet pepper

From Table 2, sample D (5% Clove + 5% Ginger + 5% Garlic) had the highest inhibitory activity with the lowest total plate count of 1.1 x 10^2 CFU/g at the end of the storage period. This was closely followed by sample C (10% Salt + 2% White sugar) with a total plate count of 6.2 x 10^2 CFU/g and 1.1 x 10^2 CFU/g at the first and last month of storage respectively. The same decreasing trend was observed for moulds across the treatments except for sample E which had the highest total plate count and mould count of 5.4 x 10^2 CFU/g and 4.8 x 10^2 CFU/g respectively. The absence of *Salmonella* sp. or spp.???and coliforms shows that the samples were processed under hygienic conditions as the presence of these microorganisms in food commodities indicates faecal contamination (Uçar and Yilmaz, 2023). The control (sample E) had the highest microbial count of bacteria and Mould all through storage period. Pittia and Antonello (2016) opined that salt or sugar, whether in solid or aqueous form, attempts to reach equilibrium with the salt or sugar content of the food product with which it is in contact. This has the effect of drawing available water from within the food to the outside and inserting salt or sugar molecules into the food interior thus interfering with a microbial enzyme activity and weakening the molecular structure of its DNA. This explains the reduction in the microbial count of the treatments of sugar and salt at varying concentrations. Furthermore, Liu *et al*. (2017) affirmed that antibacterial and antifungal activities of commonly used spices such as clove, oregano, thyme, cinnamon, and cumin have exhibited significant antimicrobial activities against food spoilage bacteria like *B. subtilis* and *P. fluorescens*; pathogens like *S. aureus*, *V. parahaemolyticus*, and *S. Typhimurium*; harmful fungi like *A. flavus* and *A. niger*; and even antibiotic-resistant microorganisms such as MRSA. This corroborates findings in this research as the microbial load decreased with the treatments and increased concentration except for the control. Therefore, these spices could be used to decrease the possibility of food poisoning and spoilage, to increase the food safety and shelf-life of products, and to treat some infectious diseases.

Table 2: Effect of different storage media on the microbial load of scotch bonnet after six months storage.

Sample		Storage months Microbial count (CFU/g)					
		1	2	3	4	5	6
A	TPC	6.1x10^2	5.1x 10^2	5.3x 10^2	4.1 x 10^2	3.2x 10^2	5.1x 10^2
	Mould	5.0x10^2	4.7x 10^2	4.0x 10^2	3.8 x 10^2	4.0x 10^2	4.7x 10^2
	Salmonella	NG	NG	NG	NG	NG	NG
	Coliforms	NG	NG	NG	NG	NG	NG
B	TPC	6.4x 10^2	4.9 x 10^2	4.5x 10^2	4.0 x10^2	2.8x 10^2	4.9x 10^2
	Mould	4.3x 10^2	4.1 x 10^2	3.7x 10^2	3.4x 10^2	3.2x 10^2	4.1x 10^2

	Salmonella	NG	NG	NG	NG	NG	NG
	Coliforms	NG	NG	NG	NG	NG	NG
C	TPC	$6.2x\ 10^3$	$4.5x\ 10^3$	$3.3x\ 10^3$	$3.0\ x\ 10^3$	$2.5\ x10^3$	$1.1x\ 10^3$
	Mould	$5.0x\ 10^3$	$4.5x\ 10^3$	$3.5\ x\ 10^3$	$3.3\ x\ 10^3$	$3.0x\ 10^3$	$4.0x\ 10^3$
	Salmonella	NG	NG	NG	NG	NG	NG
	Coliforms	NG	NG	NG	NG	NG	NG
D	TPC	$6.2x\ 10^2$	$3.1x\ 10^2$	$2.5x\ 10^2$	$2.0x\ 10^2$	$1.3x\ 10^2$	$1.1x\ 10^2$
	Mould	$4.0x\ 10^2$	$3.3x\ 10^2$	$3.0x\ 10^2$	$2.8\ x\ 10^2$	$1.4x\ 10^2$	$1.3\ x\ 10^2$
	Salmonella	NG	NG	NG	NG	NG	NG
	Coliforms	NG	NG	NG	NG	NG	NG
E	TPC	$8.3x\ 10^2$	$7.2x\ 10^2$	$7.0\ x\ 10^2$	$6.1x\ 10^2$	$6.4x\ 10^2$	$5.4x\ 10^2$
	Mould	$7.2x\ 10^2$	$6.1x\ 10^2$	$5.2\ x\ 10^2$	$5.0x\ 10^2$	$4.9x\ 10^2$	$4.8\ x\ 10^2$
	Salmonella	NG	NG	NG	NG	NG	NG
	Coliforms	NG	NG	NG	NG	NG	NG

A = 2.5% salt + 2% white sugar; B = 5% salt + 2% white sugar; C = 10% salt + 2% white sugar; D = 0.5% clove + 5% garlic + 5% ginger; E = control (distilled water). NG: No Growth, ,TPC: Total Plate Count

Conclusion

The findings indicate that storage medium plays a critical role in preserving the nutritional quality, safety, and sensory appeal of Scotch bonnet peppers. Among all treatments, the spice-based mixture comprising clove, garlic and ginger (sample D) consistently outperformed other preservation methods across most parameters. It effectively maintained higher levels of beta-carotene, exhibited the least microbial growth, and achieved superior scores in sensory attributes such as firmness and overall acceptance. This suggests that spices with antimicrobial and antioxidative properties can serve as potent natural preservatives, extending the shelf-life of perishable vegetables such as Scotch bonnet while enhancing food safety. Conversely, the control group (sample E) exhibited the most rapid decline in nutritional and microbial quality, underscoring the importance of effective preservation interventions. Although, brine-based treatments (samples A, B, and C) provided moderate improvements in preservation, their efficacy was less pronounced compared to the spice-based method. Overall, the results support the viability of using natural spice mixtures as an alternative to synthetic preservatives in post-harvest handling of hot peppers. These findings offer valuable insights for small-scale producers, food processors, and consumers seeking sustainable and health-conscious methods to reduce post-harvest losses and improve food security. Future studies are encouraged to explore the synergistic effects of different spice combinations and to optimize concentrations for broader application in vegetable preservation.

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