Effects of Natural Preservatives on Juice Quality of Three Different Pineapple (Ananas comosus L.) Varieties in Ghana

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EFFECTS OF NATURAL PRESERVATIVES ON JUICE QUALITY OF THREE DIFFERENT PINEAPPLE (*Ananas comosus L.*) VARIETIES IN GHANA

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ABSTRACT

Pineapple (Ananas comosus) is a widely consumed tropical fruit, but its high perishability limits its shelf life. This study assessed the juice yield and the effects of natural preservatives (rosemary and clove) on the quality of three pineapple varieties (Smooth Cayenne, Sugar Loaf, and MD2). A 3 × 3 Factorial Completely Randomized Design was used, with variety and preservative as factors, each at three levels. Smooth Cayenne had the highest juice yield (700ml). Sugar Loaf juice preserved with rosemary had the highest crude fiber, fat, carbohydrate, protein, and ash, while the unpreserved Sugar Loaf variety had the highest crude moisture content. MD2 juice preserved with rosemary had the best Total Soluble Solids (TSS) and sweetness, while Smooth Cayenne with clove had the highest vitamin C content. Mineral analysis showed no significant differences in copper, potassium, phosphorus, and zinc on day one, but significant variations emerged by day ten due to preservative interactions. Sensory and chemical analyses confirmed that rosemary and clove effectively preserved the juice without compromising sensory attributes or nutritional quality. This study highlights the potential of natural preservatives in extending pineapple juice shelf life while maintaining its quality.

Keywords: Extract Carbohydrate, Sugar Loof, Smooth Cayenne, MD2, Pineapple (*Ananas comosus*).

Introduction

Pineapple (Ananas comosus) is the most widely consumed member of the Bromeliaceae family and is believed to have originated in Brazil before spreading to other parts of the world, including Ghana. It is a commercially important tropical fruit due to its high economic and nutritional value. Over the years, technological advancements have enabled all-year-round availability of this seasonal crop through processing into products such as canned pineapple slices and juices (Pandhare et al., 2018). The demand for pineapple juice continues to rise, with Ghana's retail pineapple juice market estimated at 17.00 million USD in 2014 and projected to reach 84.56 million USD in 2024, representing an annual growth rate of 13.96% (NEPAD; Kleemann, 2016). Currently, four major pineapple varieties Sugar Loaf, Smooth Cayenne, MD2, and Queen Victoria are cultivated in Ghana, each with distinct morphological and sensory characteristics. Due to growing concerns about the adverse effects of added sugars and synthetic preservatives, consumers are shifting toward organically produced and processed juices. In Europe, pineapple flavour ranks among the top five most preferred juice flavours in countries such as Spain, France, the United Kingdom, Malta, the Netherlands, Germany, and Cyprus (Williams & Marshall, 2023). Despite its high nutritional value comprising 13-19% sugars (sucrose, glucose, fructose), bromelain, citric and malic acids, vitamins A and B, and 81.2-86.2% water content pineapple is highly perishable, making postharvest spoilage a significant economic concern. This necessitates processing and preservation techniques to extend shelf life and maintain juice quality. Preservation methods such as the use of natural preservatives and thermal treatment have proven effective in reducing microbial and enzymatic spoilage (Asri, 2019; Ameh et al., 2015; Islam et al., 2014). To address the challenge of postharvest losses and extend the shelf life of pineapple juice, this study aimed to assess the juice yield and the effects of natural preservatives (Rosemary and Clove) on the quality of three pineapple varieties (Smooth Cayenne, Sugar Loaf, and MD2). Specifically, the study sought to evaluate the impact of natural preservatives on the nutritional composition (proximate and chemical properties) of pineapple juice from different varieties and assess the effect of natural preservatives on the mineral content of pineapple juice from the selected varieties. The increasing use of natural food preservatives such as herbal extracts and spices has gained traction due to their potential as healthier alternatives to synthetic preservatives. Rosemary (Salvia rosmarinus) is known for its anti-inflammatory, analgesic, antioxidant, and antimicrobial properties, making it an effective inhibitor of microbial growth and oxidative spoilage (Veenstra & Johnson, 2021). Similarly, cloves exhibit bactericidal properties that help prevent lipid peroxidation during food processing and storage, making them suitable as natural food preservatives (Ashwini et al., 2023). However, little research has been conducted to determine the most suitable pineapple variety for juice production in Ghana, particularly in relation to juice yield, nutritional composition, and the impact of natural preservatives on juice quality. This study will provide insights into the suitability of different pineapple varieties for juice production and the potential of natural preservatives such as rosemary and clove to enhance juice quality and shelf life.

MATERIALS AND METHODS

Experimental Location

The study was carried out at the Department of Horticulture laboratory of Kwame Nkrumah University of Science and Technology (KNUST), Kumasi.

List of Materials

The materials used include: three varieties of pineapple fruits (smooth cayenne, sugar loaf and MD2)- fifty (50) pieces of each variety totalling One hundred and fifty (150) pineapple fruits, clove oil, rosemary Oil, stainless knife, minMAX juicer, dispenser, refractometer, thermometer, holding bottles, plastic containers, gas burner, Camry weighing scale, ice chest, pH meter, distilled water, beakers, measuring cylinder, conical flask, spatula, pipette, burette, chopping board, indicators and refrigerator.

Sample source and selection

Three varieties of pineapple fruits (Smooth Cayenne, Sugarloaf and MD2) of uniform sizes and maturity and at full ripe stage (with brix level between 15.1% to 15.3% for all the three selected varieties, measured with a refractometer) without defects were outsourced from a local farm (ACOPPS and AMOPPA Cooperative Organic Producers and Exporters Society Limited) in the Central Region of Ghana. Natural preservatives, that is clove oil (manufactured by Hemani International KEPZ, Karachi – Pakistan; manufactured under license from Hemani Herbal LLC, Longwood, FL32750, USA, +184 44 HEMANI with Batch Number: 30CL20/21, MFG: 08/2020, EXP: 07/2024) and rosemary oil (manufactured by Hemani international KEPZ, Karachi – Pakistan; manufactured under license from Hemani Herbal LLC, Longwood, FL32750, USA, +18444 HEMANI with Batch Number: 30RM20/21, MFG: 07/2020, EXP: 06/2024) were obtained from a local essential oils and powder shop at Ahodwo- Kumasi in the Ashanti Region of Ghana. The collection of plant materials used in this study was carried out in accordance with relevant local and national guidelines and regulations

Plate 1: Clove Oil

Plate 2: Rosemary Oil

Experimental Design

The experimental design was a 3 x 3 Factorial Completely Randomized Design which was replicated three times. Factor one was variety at three levels (Smooth cayenne, Sugarloaf and MD2 and factor two preservatives at three levels (clove oil, rosemary oil, and no preservative or control).

Processing of the Pineapple Juice

The pineapple fruits were peeled by removing the crown, skin and base using a sharp stainless-steel knife. The peeled fruits were diced into 200 grams (weighed with a Camry scale) pieces, and then juiced using a minMAX juicer (MNJ-1299, England).

Treatment of Juice with Preservatives

Three replications of 1 litre each of the extracted juice were inoculated with 0.1ml of either of the preservatives (clove oil, rosemary oil and control), mixed, bottled and then pasteurized at 62°C for 20mins making up the experimental samples. Thus, Sample A (Sugarloaf), Sample B (Smooth Cayenne), and Sample C (MD2) with different treatments respectively and then refrigerated at 7°C for 10 days.

Pineapple fruits
↓
Removal of Crown and eyes
↓
Slices
↓
Juice Extraction
↓
Addition of essential oils / natural preservatives
↓
Mixing
↓
Bottling
↓
Bottle Pasteurization (62ºC for 20 mins)
↓
Refrigerated Storage (7ºC for 10 days)

Fig. 1: Flow sheet for the preparation of the pineapple juice

Plate 3: Sliced Pineapple Fruit Weighed before Juicing

Plate 4: Juice Yield Obtained from Smooth Cayenne

Plate 5: Juice Yield Obtained from Sugar Loaf

Plate 6: Juice Yield Obtained from MD2

Plate 7: Samples of Pineapple Fruit Juice

Proximate Analysis

Crude Fat

Crude fat content was determined using a Soxhlet extraction method with petroleum ether (b.p. 40-60°C) as the solvent. A 2 g dried sample was placed in an extraction thimble and inserted into the Soxhlet apparatus. A pre-weighed solvent flask was attached, and 150-200 mL of petroleum ether was added. Extraction was conducted for 2-3 hours, after which the solvent was evaporated at 105°C for 30 minutes. The remaining fat was weighed to determine the percentage of crude fat in the sample.

Crude Fibre

A 1.25% sulphuric acid solution and a 1.25% sodium hydroxide solution were used for fibre determination. A 2 g fat-free dried sample was digested in 200 mL of hot sulphuric acid and boiled for 30 minutes under reflux. The sample was filtered, washed, and further digested in 200 mL of boiling sodium hydroxide solution for another 30 minutes. The residue was filtered, washed with 95% ethanol, dried at 105°C, weighed, and then ashed at 550°C for 30 minutes. The crude fibre content was calculated based on weight loss.

Ash Content

A 2 g sample was weighed into a dry, tared porcelain crucible and ashed in a muffle furnace at 550°C for 4 hours. After cooling in a desiccator, the residue was weighed to determine ash content as a percentage of the original sample.

Crude fat

Crude fat content was determined using a Soxhlet extraction method with petroleum ether (b.p. 40-60°C) as the solvent. A 2 g dried sample was placed in an extraction thimble and inserted into the Soxhlet apparatus. A pre-weighed solvent flask was attached, and 150-200 mL of petroleum ether was added. Extraction was conducted for 2-3 hours, after which the solvent was evaporated at 105°C for 30 minutes. The remaining fat was weighed to determine the percentage of crude fat in the sample.

Crude Fibre

A 1.25% sulphuric acid solution and a 1.25% sodium hydroxide solution were used for fibre determination. A 2 g fat-free dried sample was digested in 200 mL of hot sulphuric acid and boiled for 30 minutes under reflux. The sample was filtered, washed, and further digested in 200 mL of boiling sodium hydroxide solution for another 30 minutes. The residue was filtered, washed with 95% ethanol, dried at 105°C, weighed, and then ashed at 550°C for 30 minutes. The crude fibre content was calculated based on weight loss.

Ash Content

A 2 g sample was weighed into a dry, tared porcelain crucible and ashed in a muffle furnace at 550°C for 4 hours. After cooling in a desiccator, the residue was weighed to determine ash content as a percentage of the original sample.

Moisture Content

Moisture content was determined by drying a 5 g sample at 105°C until a constant weight was achieved. The percentage of moisture was calculated using the formula:

Moisture content (%)=Fresh sample weight - Dry sample weight fresh sample weight×100\text{Moisture content (\%)} = \frac{\text{Fresh sample weight - Dry sample weight}}{\text{Fresh sample weight}} \times 100Moisture content (%)=Fresh sample weight fresh sample weight - Dry sample weight×100

Protein Content

Crude protein was determined using the Kjeldahl method. A 2 g sample was digested in a Kjeldahl flask using H_2SO_4 and a Kjeldahl catalyst (Selenium, $CuSO_4$, Na_2SO_4 mixture) until a clear digest was obtained. The digest was diluted, and 10 mL aliquots were distilled with 40% NaOH, collecting the distillate in 4% boric acid. The ammonia content was determined by titration with 0.1 N HCl. The percentage of nitrogen was calculated using:

%N=14(A−B)N×1001000×0.2\% N = \frac{14 (A - B) N \times 100}{1000 \times 0.2}%N=1000×0.214(A−B)N×100

where A and B are titration volumes of the sample and blank, respectively. Crude protein content was derived using the factor 6.25 (Total Nitrogen × 6.25).

Nitrogen-Free Extract (NFE)

The carbohydrate content was calculated by subtraction:

%NFE=100−(%CP+%CF+%Ash+%EE)\% NFE = 100 - (\% CP + \% CF + \% Ash + \% EE)%NFE=100−(%CP+%CF+%Ash+%EE)

where CP = Crude Protein, CF = Crude Fiber, Ash = Total Ash, EE = Ether Extract.

Chemical Analysis

Total Soluble Solids (TSS)

Total soluble solids were determined by the AOAC (2012) method. A 4 g sample was dried in a metal dish at 100°C for 21 hours, then cooled and reweighed. Drying was repeated until the weight change was minimal. TSS was calculated as:

%TSS=Final Sample Weight - Initial Sample WeightSample Weight×100\% TSS = \frac{\text{Final Sample Weight - Initial Sample Weight}}{\text{Sample Weight}} \times 100%TSS=Sample WeightFinal Sample Weight - Initial Sample Weight×100

Total Titratable Acidity (TTA)

A 10 mL sample was mixed with distilled water and phenolphthalein indicator, then titrated with 0.1 N NaOH until a persistent pink endpoint was observed. TTA was calculated using:

%TTA=0.1M NaOH×Volume of NaOH (L)×90.08×100Sample Weight\% TTA = \frac{0.1 M \text{ NaOH} \times \text{Volume of NaOH (L)} \times 90.08 \times 100}{\text{Sample Weight}}%TTA=Sample Weight0.1M NaOH×Volume of NaOH (L)×90.08×100

pH Determination

The pH was measured using a digital pH meter, calibrated with buffer solutions. The Nernst equation was used to convert millivolt readings to pH values:

E=Eo−RTzFln⁡QE = E^o - \frac{RT}{zF} \ln QE=Eo−zFRTlnQ

Where E is reduction potential, E° is standard potential, R is the gas constant, T is the temperature (K), z is ion charge, F is the Faraday constant, and Q is the reaction quotient.

Vitamin C (Ascorbic Acid)

Vitamin C content was determined by redox titration. A 20 mL sample was diluted with 150 mL distilled water and titrated with 0.005 M iodine solution using starch as an indicator. The end-point was identified as the first permanent blue-black colouration (Satpathy et al., 2021).

Mineral Analysis

The mineral composition was analyzed using Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) (Varian 720-ES). The operating conditions were:

- RF power: 1.0 kW
- Viewing geometry: Axial
- Plasma gas flow rate: 15.0 L min^{-1}
- Auxiliary gas flow rate: 1.50 L min^{-1}
- Nebulizer gas flow rate: 0.75 L min^{-1}
- Replicate reading time: 9.0 s

Samples were analyzed in triplicate following Okem et al. (2014).

Data Collection and Statistical Analysis

A structured questionnaire was used to gather data from 20 pineapple juice-producing companies across four selected regions in Ghana. The survey covered aspects such as company details, fruit procurement, processing, preservatives used, packaging, sales, and storage. Interviews and personal observations were conducted to determine the pineapple varieties used, juice yield obtained, and preservatives applied in production.

All collected data were subjected to Analysis of Variance (ANOVA) using STATISTIX version 10.0. Tukey's Honest Significant Difference (HSD) test was used for mean separation, with a significance level set at $p \leq 0.01$

EFFECT OF PRESERVATIVES ON CHEMICAL PROPERTIES OF JUICE PREPARED FROM THREE VARIETIES OF PINEAPPLE ON DAYS ONE AND TEN

Effect of preservatives on pH of juice prepared from three varieties of pineapple on day one.

Analysis of Variance (ANOVA) showed that there were no significant differences ($p>0.01$) between the interaction of preservatives and variety for pH at day one as well as the individual effect (Table 1).

Table 1: Effect of preservatives on pH of juice prepared from three varieties of pineapple on day one

	Varieties			
Preservatives	MD2	Sugar Loaf	Smooth Cayenne	Means
Rosemary	5.48[a*]	5.70[a]	5.57[a]	5.58[a]
Cloves	5.51[a]	5.72[a]	5.62[a]	5.62[a]
Control	5.48[a]	5.68[a]	5.42[a]	5.53[a]
Means	5.491[a]	5.70[a]	5.54[a]	
HSD (0.01): Varieties=0.149, Preservatives=0.149, Interaction=0.335				

*Any two means in the same column followed by different letters differ significantly ($p=0.01$)

Effect of preservatives on pH of juice prepared from three varieties of pineapple on day ten.

Analysis of Variance (ANOVA) showed a significant difference ($p<0.01$) between the interaction of preservatives and variety for pH at day ten (Table 2). The highest pH (5.43) was recorded by juice made from the MD2 variety with no preservative and the lowest (5.15) was juice made from the MD2 variety and preserved using Rosemary. Considering the effect of the preservatives only, there were no significant differences. With reference to the varieties only, there were no significant differences.

Table 2: Effect of preservatives on pH of juice prepared from three varieties of pineapple on day ten

Varieties				
Preservatives	MD2	Sugar Loaf	Smooth Cayenne	Means
Rosemary	5.15[c*]	5.35[ab]	5.32[ab]	5.27[a]
Cloves	5.30[b]	5.34[ab]	5.32[ab]	5.32[a]
Control	5.43[a]	5.29[b]	5.23[bc]	5.32[a]
Means	5.29[a]	5.33[a]	5.29[a]	
HSD (0.01): Varieties=0.052, Preservatives=0.052, Interaction=0.116				

*Any two means in the same column followed by different letters differ significantly (p=0.01)

Effect of preservatives on Total Soluble Solids (TSS) of juice prepared from three varieties of pineapple at day one.

Analysis of Variance (ANOVA) showed a significant difference ($p<0.01$) between the interaction of preservatives and variety for Total Soluble Solids (TSS) on day one (Table 3). The highest Total Soluble Solids (TSS) (14.01) was recorded by juice made from the MD2 variety preserved using Cloves and the least (0.91) was juice made from Sugarloaf and Smooth Cayenne varieties using Rosemary variety preservative. Considering the effect of the preservatives only, juice with no preservative recorded the highest Total Soluble Solids (TSS) (12.00) and the least was juice preserved with Rosemary (10.11). With reference to the varieties only, juice made from MD2 gave the highest Total Soluble Solids (TSS) (13.26) and the lowest (10.45) was juice from the Smooth Cayenne variety.

Table 3: Effect of preservatives on Total Soluble Solids (TSS) of juice prepared from three varieties of pineapple at day one

Varieties				
Preservatives	MD2	Sugar Loaf	Smooth Cayenne	Means
Rosemary	12.46[b*]	9.01[d]	9.01[d]	10.11[c]
Cloves	14.01[a]	10.14[c]	10.14[c]	11.42[b]
Control	13.34[ab]	12.31[b]	10.36[c]	12.00[a]

Means	13.26^{a}	10.45^{b}	9.81^{c}	
HSD (0.01): Varieties=0.530, Preservatives=0.530, Interaction=1.191				

*Any two means in the same column followed by different letters differ significantly (p=0.01)

Effect of preservatives on Total Soluble Solids (TSS) of juice prepared from three varieties of pineapple on day ten.

Analysis of Variance (ANOVA) showed a significant difference ($p<0.01$) between the interaction of preservatives and variety for Total Soluble Solids (TSS) at day ten (Table 4). The highest Total Soluble Solids (TSS) (12.46) was recorded as juice made from the MD2 variety preserved using Rosemary and the least (9.70) was juice made from the Sugarloaf variety with preservative Rosemary. Considering the effect of the preservatives only, juice with no preservative recorded the highest Total Soluble Solids (TSS) (11.12) and the least was juice preserved with Cloves (10.55). With reference to the varieties only, juice made from MD2 gave the highest Total Soluble Solids (TSS) (11.94) and the least (9.11) was juice from the Sugar Loaf variety.

Table 4 Effect of preservatives on Total Soluble Solids (TSS) of juice prepared from three varieties of pineapple at day ten.

Varieties				
Preservatives	MD2	Sugar Loaf	Smooth Cayenne	Means
Rosemary	12.46^{a*}	8.13^{g}	11.56^{c}	10.72^{b}
Cloves	11.13^{d}	9.50^{f}	11.03^{d}	10.55^{c}
Control	12.23^{b}	9.70^{e}	11.43^{c}	11.12^{a}
Means	11.94^{a}	9.11^{c}	11.34^{b}	
HSD (0.01): Varieties=0.079, Preservatives=0.079, Interaction=0.178				

*Any two means in the same column followed by different letters differ significantly (p=0.01)

Effect of preservatives on Total Titratable Acidity (TTA) of juice prepared from three varieties of pineapple at day one

Analysis of Variance (ANOVA) showed a significant difference ($p<0.01$) between the interaction of preservatives and variety for Total Titratable Acidity (TTA) on day one (Table 5). The highest Total Titratable Acidity (TTA) (0.00078) was recorded as juice made from a Smooth Cayenne variety preserved using Rosemary and the least (0.00043) was juice made from Sugarloaf preserved with clove. Considering the effect of the preservatives only, juice preserved with clove (0.0006) as well as no preservative (0.0006) recorded the highest Total Titratable Acidity (TTA) and the least was juice preserved with Rosemary (0.00060). With reference to the varieties only, juice made from Smooth Cayenne gave the highest Total Titratable Acidity (TTA) (0.00076) and the least (0.00046) was juice from the Sugarloaf variety.

Table 5: Effect of preservatives on Total Titratable Acidity (TTA) of juice prepared from three varieties of pineapple on day one

Varieties				
Preservatives	MD2	Sugar Loaf	Smooth Cayenne	Means
Rosemary	0.00055[f*]	0.00046[h]	0.00078[a]	0.00060[b]
Cloves	0.00065[d]	0.00043[i]	0.00075[b]	0.00061[a]
Control	0.00064[e]	0.00049[g]	0.00074[c]	0.00062[a]
Means	0.00061[b]	0.00046[c]	0.00076[a]	
HSD (0.01): Varieties=0.0000, Preservatives=0.00000, Interaction=0.00000				

*Any two means in the same column followed by different letters differ significantly ($p=0.01$)

Effect of preservatives on Total Titratable Acidity (TTA) of juice prepared from three varieties of pineapple at day ten.

Analysis of Variance (ANOVA) showed a significant difference ($p<0.01$) between the interaction of preservatives and variety for Total Titratable Acidity (TTA) at day ten (Table 6). The highest Total Titratable Acidity (TTA) (0.00077) was recorded as juice made from the Smooth Cayenne variety with no preservative and the least (9.10) was juice made from the Sugarloaf variety using Cloves preservative. Considering the effect of the preservatives only, juice with no preservative (0.00062) recorded the highest Total

Titratable Acidity (TTA) and the least was juice preserved with Rosemary (0.00051). With reference to the varieties only, juice made from Smooth Cayenne gave the highest Total Titratable Acidity (TTA) (0.00065) and the lowest (0.00045) was juice from the Sugar loaf variety.

Table 6: Effect of preservatives on Total Titratable Acidity (TTA) of juice prepared from three varieties of pineapple on day ten

Varieties				
Preservatives	MD2	Sugar Loaf	Smooth Cayenne	Means
Rosemary	0.00060[cd*]	0.00046[e]	0.00046[e]	0.00051[c]
Cloves	0.00059[d]	0.00042[f]	0.00074[b]	0.00058[b]
Control	0.00061[c]	0.00047[e]	0.00077[a]	0.00062[a]
Means	0.00060[b]	0.00045[c]	0.00065[a]	
HSD (0.01): Varieties=0.0000094, Preservatives=0.0000094, Interaction=0.000021				

*Any two means in the same column followed by different letters differ significantly (p=0.01)

Effect of preservatives on Vitamin C of juice prepared from three varieties of pineapple on day one.

Analysis of Variance (ANOVA) showed a significant difference ($p<0.01$) between the interaction of preservatives and variety for Vitamin C at day one (Table 7). The highest Vitamin C (25.24) was recorded as juice made from the Smooth Cayenne variety with no preservative and the lowest (5.28) was juice made from MD2 variety with no preservative. Considering the effect of the preservatives only, juice with no preservative (13.69) recorded the highest Vitamin C and the least was juice preserved with Rosemary and Cloves. With reference to the varieties only, juice made from Smooth Cayenne gave the highest Vitamin C (20.74) and the least (7.82) was juice from the MD2 variety.

Table 7 Effect of preservatives on Vitamin C of juice prepared from three varieties of pineapple at day one.

Varieties				
Preservatives	MD2	Sugar Loaf	Smooth Cayenne	Means
Rosemary	7.04^{e*}	10.27^{cd}	19.08^{b}	12.13^{b}
Cloves	11.15^{c}	9.10^{d}	17.90^{b}	12.72^{b}
Control	5.28^{e}	10.56^{cd}	25.24^{a}	13.69^{a}
Means	7.82^{c}	9.98^{b}	20.74^{a}	
HSD (0.01): Varieties=0.794, Preservatives=0.794, Interaction=1.784				

*Any two means in the same column followed by different letters differ significantly (p=0.01)

Effect of preservatives on Vitamin C of juice prepared from three varieties of pineapple on day ten.

Analysis of Variance (ANOVA) showed a significant difference ($p<0.01$) between the interaction of preservatives and variety for Vitamin C at day ten (Table 8). The highest Vitamin C (21.72) was recorded as juice made from the Smooth Cayenne variety with no preservative and the lowest (5.28) was juice made from the MD2 variety with Rosemary and cloves. Considering the effect of the preservatives only, juice with no preservative (15.26) recorded the highest Vitamin C and the least was juice preserved with Rosemary and Cloves. With reference to the varieties only, juice made from Smooth Cayenne gave the highest Vitamin C (18.68) and the least (9.10) was juice from the MD2 variety.

Table 8: Effect of preservatives on Total Vitamin C of juice prepared from three varieties of pineapple on day ten

Varieties				
Preservatives	MD2	Sugar Loaf	Smooth Cayenne	Means
Rosemary	6.45^{f*}	10.27^{d}	17.02^{b}	11.25^{b}
Cloves	$7.33e^{f}$	9.10^{de}	17.31^{b}	11.25^{b}
Control	13.50^{c}	10.56^{d}	21.72^{a}	15.26^{a}
Means	9.10^{c}	9.98^{b}	18.68^{a}	
HSD (0.01): Varieties=0.878, Preservatives=0.878, Interaction=1.973				

*Any two means in the same column followed by different letters differ significantly (p=0.01)

EFFECT OF PRESERVATIVES ON MINERAL COMPOSITION OF JUICE PREPARED FROM THREE VARIETIES OF PINEAPPLE ON DAY ONE AND TEN

Effect of preservatives on copper of juice prepared from three varieties of pineapple on day one

Analysis of Variance (ANOVA) showed that there were no significant differences ($p>0.01$) between the interaction of preservatives and variety for copper on day one as well as the individual effects (Table 9).

Table 9: Effect of preservatives on copper of juice prepared from three varieties of pineapple on day one

Varieties				
Preservatives	MD2	Sugar Loaf	Smooth Cayenne	Means
Rosemary	4.52^{a*}	5.38^{a}	5.01^{a}	5.01^{a}
Cloves	5.63^{a}	5.18^{a}	4.04^{a}	5.01^{a}
Control	3.03^{a}	4.30^{a}	3.34^{a}	3.56^{b}
Means	4.34^{a}	5.01^{a}	4.12^{a}	
HSD (0.01): Varieties=1.33, Preservatives=1.33, Interaction=3.00				

*Any two means in the same column followed by different letters differ significantly (p=0.01)

Effect of preservatives on copper of juice prepared from three varieties of pineapple on day ten

Analysis of Variance (ANOVA) showed a significant difference ($p<0.01$) between the interaction of preservatives and variety for copper content at day ten (Figure 1). The highest Copper content (5.48) was recorded by juice made from the MD2 variety and preserved with Cloves and the least (3.20) was juice made from the MD2 variety but with no preservative.

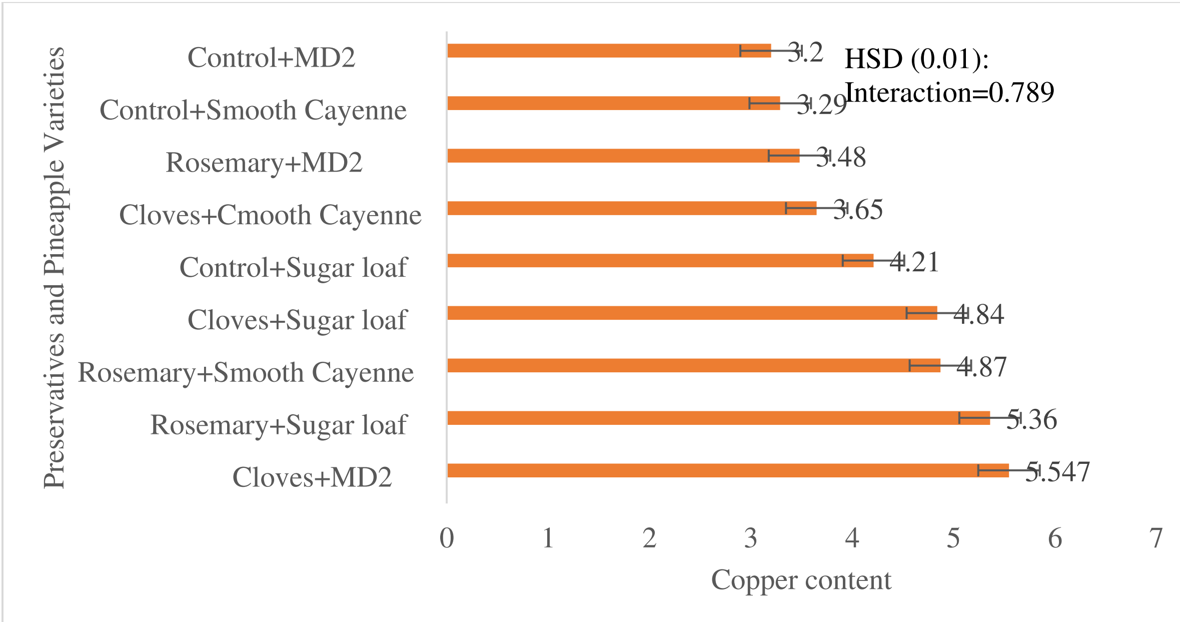

Figure 1: Effect of preservatives and varieties of pineapple on copper of juice prepared from three varieties of pineapple on day ten

Effect of preservatives on Iron content of juice prepared from three varieties of pineapple on day one

Analysis of Variance (ANOVA) showed a significant difference ($p<0.01$) between the interaction of preservatives and the variety of Iron content on day one (Table 10). The highest Iron content (44.80) was recorded as juice made from the Sugarloaf variety and preserved using Rosemary preservative and the least (11.06) was juice made from the MD2 variety with no preservative. Considering the effect of the preservatives only, juice preserved with Rosemary (26.66) recorded the highest Iron content and the least (18.15) was juice without preservatives. With reference to the varieties only, juice made from Sugarloaf gave the highest Iron content (34.07) and the least (12.86) was juice from the MD2 variety.

Table 10: Effect of preservatives on Iron content of juice prepared from three varieties of pineapple on day one

Varieties				
Preservatives	MD2	Sugar Loaf	Smooth Cayenne	Means
Rosemary	14.50^{cd*}	44.80^{a}	20.70^{bcd}	26.66^{a}
Cloves	13.03^{cd}	31.00^{ab}	22.03^{bcd}	22.02^{ab}
Control	11.06^{d}	26.43^{bc}	17.01^{bcd}	18.15^{b}
Means	12.86^{c}	34.07^{a}	19.90^{b}	
HSD (0.01): Varieties=6.31, Preservatives=6.31, Interaction=14.17				

*Any two means in the same column followed by different letters differ significantly (p=0.01)

Effect of preservatives on Iron content of juice prepared from three varieties of pineapple at day ten

Analysis of Variance (ANOVA) showed a significant difference ($p<0.01$) between the interaction of preservatives and variety for Iron content at day ten (Table 11). The highest Iron content (31.28) was recorded by juice made from the Sugarloaf variety and preserved using Rosemary preservative which was similar to Sugarloaf juice preserved with cloves (29.1) and the least (9.49) was juice made from the MD2 variety with no preservative. Considering the effect of the preservatives only, juice preserved with Rosemary (20.1 and Cloves (20.40) recorded the highest Iron content and the least (14.57) was juice without preservatives. With reference to the varieties only, juice made from Sugarloaf gave the highest Iron content (26.41) and the least (13.13) was juice from the MD2 variety.

Table 11: Effect of preservatives on Iron content (Fe) of juice prepared from three varieties of pineapple on day ten

Varieties				
Preservatives	MD2	Sugar Loaf	Smooth Cayenne	Means
Rosemary	16.32^{bcd*}	31.28^{a}	14.24^{cd}	20.61^{a}
Cloves	13.57^{d}	29.91^{a}	17.71^{bc}	20.40^{a}

Control	9.49[e]	18.05[b]	16.18[d]	14.57[b]
Means	13.13[c]	26.41[a]	16.04[b]	
HSD (0.01): Varieties=1.684, Preservatives=1.684, Interaction=3.783				

*Any two means in the same column followed by different letters differ significantly (p=0.01)

Effect of preservatives on Potassium content of juice prepared from three varieties of pineapple at day one

Analysis of Variance (ANOVA) showed that there were no significant differences ($p>0.01$) between the interaction of preservatives and variety for Potassium content on day one as well as the individual effects (Table 12).

Table 12: Effect of preservatives on Potassium of juice prepared from three varieties of pineapple on day one

Varieties				
Preservatives	MD2	Sugar Loaf	Smooth Cayenne	Means
Rosemary	1.61[a*]	1.33[a]	1.80[a]	1.58[a]
Cloves	1.37[a]	1.27[a]	1.59[a]	1.41[a]
Control	1.06[a]	1.39[a]	1.25[a]	1.23[a]
Means	1.35[a]	1.33[a]	1.55[a]	
HSD (0.01): Varieties=0.373, Preservatives=0.373, Interaction=0.838				

*Any two means in the same column followed by different letters differ significantly (p=0.01)

Effect of preservatives on Potassium content of juice prepared from three varieties of pineapple on day ten

Analysis of Variance (ANOVA) showed a significant difference ($p<0.01$) between the interaction of preservatives and variety for Potassium content at day ten (Figure 2). The highest Potassium content (1.83) was recorded as juice made from the Smooth Cayenne variety and preserved with Cloves and the least (1.08) was juice made from the Smooth Cayenne variety but with no preservative.

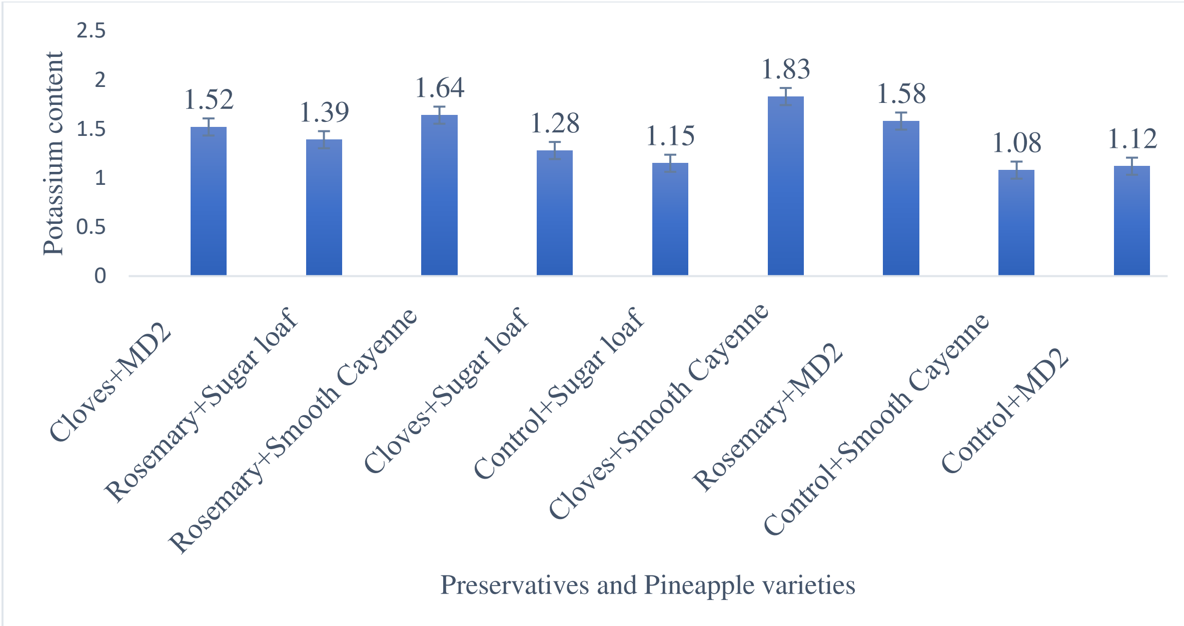

Figure 2: Effect of preservatives on Potassium content of juice prepared from three varieties of pineapple on day ten

Effect of preservatives on Manganese content of Juice Prepared from three varieties of pineapple on Day One

Analysis of Variance (ANOVA) showed a significant difference ($p<0.01$) between the interaction of preservatives and a variety of Manganese content on day one (Table 13). The highest Manganese content (18.94) was recorded by juice made from MD2 variety without preservatives and the least was juice made from Sugarloaf and Smooth Cayenne with no preservative and also preserved with cloves. Considering the effect of the preservatives only, there were no significant differences between the means. With reference to the varieties only, juice made from MD2 gave the highest Manganese content (15.47) and the least was both Sugarloaf (8.05) and MD2 variety (9.10).

Table 13: Effect of preservatives on Manganese content of juice prepared from three varieties of pineapple at day one

Varieties				
Preservatives	MD2	Sugar Loaf	Smooth Cayenne	Means

Rosemary	12.01^{bc*}	7.35^{c}	10.10^{bc}	9.81^{a}
Cloves	15.49^{ab}	8.09^{c}	8.05^{c}	10.54^{a}
Control	18.94^{a}	8.71^{c}	8.88^{c}	12.18^{a}
Means	15.47^{a}	8.05^{b}	9.01^{b}	
HSD (0.01): Varieties=2.872, Preservatives=2.872, Interaction=6.453				

*Any two means in the same column followed by different letters differ significantly (p=0.01)

Effect of preservatives on Manganese content of juice prepared from three varieties of Pineapple on day ten

Analysis of Variance (ANOVA) showed a significant difference (p<0.01) between the interaction of preservatives and a variety of Manganese content on day one (Table 14). The highest Manganese content (14.83) was recorded by juice made from MD2 variety without preservatives and the least was juice made from Sugar Loaf and Smooth Cayenne with no preservative. Considering the effect of the preservatives only, juice preserved with cloves gave the highest Manganese and the least from Rosemary. With reference to the varieties only, juice made from MD2 gave the highest Manganese content (12.53) and the least was juice from both Sugarloaf (7.68).

Table 14: Effect of preservatives on Manganese content of juice prepared from three varieties of pineapple at day one

Varieties				
Preservatives	MD2	Sugar Loaf	Smooth Cayenne	Means
Rosemary	10.79^{bc*}	7.00^{ef}	9.53^{cd}	9.11^{b}
Cloves	11.97^{b}	8.48^{de}	10.23^{bcd}	10.23^{a}
Control	14.83^{a}	$7.55e^{f}$	5.86^{f}	9.41^{ab}
Means	12.53^{a}	7.68^{c}	8.54^{b}	
HSD (0.01): Varieties=0.820, Preservatives=0.820, Interaction=1.843				

*Any two means in the same column followed by different letters differ significantly (p=0.01)

Effect of preservatives on Phosphorus content of juice prepared from three varieties of pineapple at day one

Analysis of Variance (ANOVA) showed that there were no significant differences (p>0.01) between the interaction of preservatives and variety for Phosphorus content at day one as well as the individual effects (Table 15).

Table 15: Effect of preservatives on Phosphorus of juice prepared from three varieties of pineapple at day one

Varieties				
Preservatives	MD2	Sugar Loaf	Smooth Cayenne	Means
Rosemary	0.30^{a*}	0.18^{a}	0.20^{a}	0.22^{a}
Cloves	0.40^{a}	0.20^{a}	0.18^{a}	0.25^{a}
Control	0.20^{a}	0.16^{a}	0.16^{a}	0.17^{a}
Means	0.30^{a}	0.18^{a}	0.18^{a}	
HSD (0.01): Varieties=0.125, Preservatives=0.125, Interaction=0.282				

*Any two means in the same column followed by different letters differ significantly (p=0.01)

Effect of preservatives on Phosphorus of juice prepared from three varieties of pineapple on day ten.

Analysis of Variance (ANOVA) showed a significant difference ($p<0.01$) between the interaction of preservatives and variety for Phosphorus content at day ten (Figure 3). The highest Phosphorus content (0.49) was recorded by juice made from MD2 variety and preserved with Cloves and the least (0.14) was juice made from Sugarloaf without preservatives.

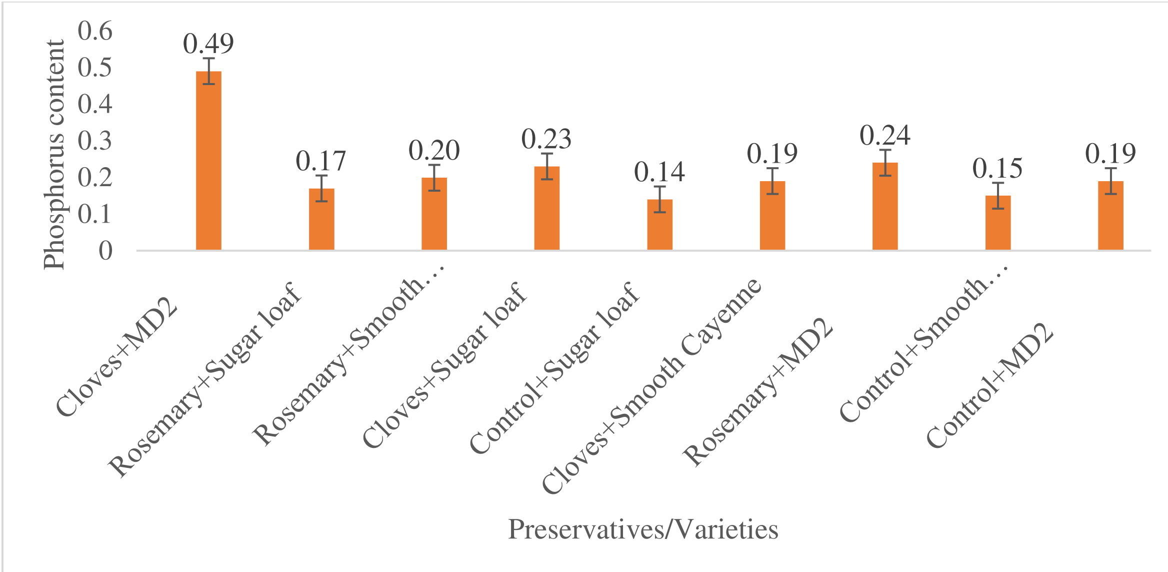

Figure 3: Effect of preservatives on Phosphorus content of juice prepared from three varieties of pineapple on day ten

Effect of preservatives on Zinc content of juice prepared from three varieties of pineapple at day one

Analysis of Variance (ANOVA) showed that there were no significant differences (p>0.01) between the interaction of preservatives and variety for Zinc content on day one as well as the individual effects (Table 16).

Table 16: Effect of preservatives on Zinc of juice prepared from three varieties of pineapple on day one

Varieties				
Preservatives	MD2	Sugar Loaf	Smooth Cayenne	Means
Rosemary	9.86^{a*}	3.68^{a}	6.50^{a}	6.68^{a}
Cloves	11.12^{a}	5.82^{a}	8.10^{a}	8.34^{a}
Control	7.81^{a}	9.01^{a}	6.27^{a}	7.68^{a}
Means	9.60^{a}	6.15^{b}	7.01^{ab}	
HSD (0.01): Varieties=3.360, Preservatives=3.360, Interaction=7.546				

*Any two means in the same column followed by different letters differ significantly (p=0.01)

Effect of preservatives on Zinc content of juice prepared from three varieties of pineapple at day one

Analysis of Variance (ANOVA) revealed a significant difference ($p<0.01$) in the interaction between preservatives and variety regarding Zinc content on day ten (Table 17). Highest Zinc content (11.45) was recorded by juice made from MD2 variety and preserved with cloves and the least were juice made from Sugar loaf and preserved with cloves. Considering the effect of the preservatives only, juice preserved with cloves gave the highest Zinc (7.57(which was similar to juice with no preservative and the least (6.02) from Rosemary. With reference to the varieties only, juice made from MD2 gave the highest Zinc content (8.86) and the least was juice from both Smooth Cayenne (6.60).

Table 17: Effect of preservatives on Zinc content of juice prepared from three varieties of pineapple at day ten

Varieties				
Preservatives	MD2	Sugar Loaf	Smooth Cayenne	Means
Rosemary	8.27^{bc*}	4.09^{f}	5.70^{e}	6.02^{b}
Cloves	11.45^{a}	4.14^{f}	7.11^{cd}	7.57^{a}
Control	6.87^{de}	8.47^{b}	7.01^{cd}	7.45^{a}
Means	8.86^{a}	5.57^{c}	6.60^{b}	
HSD (0.01): Varieties=0.564, Preservatives=0.564, Interaction=1.267				

*Any two means in the same column followed by different letters differ significantly ($p=0.01$)

EFFECT OF PRESERVATIVES ON CHEMICAL PROPERTIES OF JUICE PREPARED FROM THREE VARIETIES OF PINEAPPLE

According to Mehta et al. (2019), pineapple is characterized by a high level of acidity, with its pH influenced by various factors such as storage conditions and consumption temperature. For instance, the pH of pineapple juice has been reported to range from 2.51 to 3.91, depending on whether it is stored at room temperature, refrigerated, or frozen. In relation to the present study, Analysis of Variance (ANOVA) conducted on day one indicated that the interaction between preservative treatments and pineapple varieties did not result in any statistically significant differences in pH levels ($p > 0.01$). At day ten, however, highest pH (5.43) was recorded by juice made from MD2 variety with no preservative and the least (5.15) was juice made from MD2 variety and preserved using Rosemary. The recorded pH values above 3.91 could be due to the stage at which the fruit was harvested. Fernando et al. (2000) noted that fruit pH tends to rise with increased respiration rates due to accelerated acid metabolism and the accumulation of cations. In the present study, the highest Total Soluble Solids (TSS) value (14.01) was observed in juice produced from the MD2 pineapple variety treated with clove extract, whereas the lowest TSS (0.91) was recorded in juices from the Sugarloaf and Smooth Cayenne varieties preserved with rosemary extract. When considering the effect of preservatives alone, juices without any preservation treatment exhibited the highest TSS value (12.00), while those treated with rosemary recorded the lowest (10.11). Assessing the influence of variety independently, MD2 juice exhibited the highest TSS (13.26), while Smooth Cayenne juice had the lowest (10.45).

Sugars, as essential biochemical constituents of fruit, are critical indicators of fruit quality. Their concentrations vary depending on factors such as the fruit's ripening stage, species, and soil conditions. Previous studies have demonstrated a strong correlation between sugar levels and fruit maturity (Ersoy et al., 2007). Furthermore, the sweetness of pineapple is largely determined by the relative concentrations of fructose, glucose, and sucrose (Bartolome et al., 1996; Shinjro et al., 2004; Zhang et al., 2010). In the current experiment, the highest TSS (12.46) was recorded in juice from the MD2 variety treated with rosemary, while the lowest value (9.70) was found in juice made from the Sugarloaf variety, also preserved with rosemary. These findings highlight varietal differences, likely attributable to underlying genotypic variations between MD2 and Smooth Cayenne. Interestingly, it was initially anticipated that Sugarloaf would exhibit the highest sugar content. However, Dhar et al. (2008) previously reported that sugar accumulation peaks during the third ripening stage, suggesting that the stage at which the fruit was harvested may have significantly influenced sugar levels in the juice samples.

Total Titratable Acidity (TTA), an important quality parameter that reflects fruit sourness, is typically expressed as citric acid content in pineapple. TTA is primarily influenced by the developmental stage of the fruit and is relatively stable under shortterm environmental changes, unlike malic acid, which fluctuates in response to environmental conditions, particularly light exposure (Chuenboonngarm et al., 2007). Similar findings were reported by Policegoudra and Aradhya (2007), who observed a reduction in acidity and an increase in both TSS and total sugars during room temperature storage in mangoes.

Previous research suggests that the reduction in titratable acidity (TA) during fruit storage is associated with the utilization of organic acids in metabolic processes. This metabolic shift often results in a concurrent increase in sugar content, as observed in pomegranate fruits (Kulkarni & Aradhya, 2005). The gradual decline in acidity, coupled with rising total soluble solids (TSS) and sugar levels, is considered a natural part of the ripening process that contributes to flavor development (Tehrani et al., 2000). During ripening, organic acids are either metabolized through respiration or transformed into sugars, leading to a noticeable decrease in acidity levels (Fernando et al., 2000). As noted by Joomwong (2006), both TSS and acidity are key determinants of the overall consumption quality of fruits.

In the present study, variations were observed in the Total Titratable Acidity (TTA) of pineapple juice across two time points. On day one, the highest TTA value (0.00078) was recorded in juice prepared from the Smooth Cayenne variety treated with rosemary extract. By day ten, the highest TTA (0.00077) was still observed in the Smooth Cayenne variety but without any preservative treatment. The lowest TTA values were recorded in juice derived from the Sugarloaf variety preserved with clove extract, registering 0.00043 and 0.00042 on days one and ten, respectively.

Pineapples are recognized as excellent sources of vitamin C, containing approximately 47.8 mg per 100 g of fresh fruit (United States Department of Agriculture, 2007a, b). However, due to their highly perishable nature, pineapples are often processed to enhance shelf life, a practice that typically results in diminished vitamin C content. This loss is largely attributed to the susceptibility of ascorbic acid to degradation when exposed to water, heat, and oxygen. The extent of vitamin C loss also varies depending on the processing method, with longer thermal treatments leading to greater oxidation of the vitamin (Passmore & Eastwood, 1986).

The results of this study demonstrated that the highest vitamin C concentration on day one (25.24 mg/100 mL) was found in juice from the Smooth Cayenne variety with no preservative, while the lowest value (5.28 mg/100 mL) occurred in juice made from the MD2 variety, also without any preservative. A similar trend was observed on day ten, with the highest vitamin C content (21.72 mg/100 mL) again recorded in Smooth Cayenne juice without preservative, and the lowest (5.28 mg/100 mL) in MD2 juice treated with a combination of rosemary and clove extracts. These findings suggest that the Smooth Cayenne variety possesses inherently higher vitamin C levels than the MD2 and Sugarloaf varieties, likely due to genotypic differences. The observed reduction in vitamin C content over the storage period supports earlier findings that ascorbic acid is highly vulnerable to environmental conditions, including exposure to water, heat, and oxygen (Uckiah et al., 2009).

EFFECT OF PRESERVATIVES ON MINERAL COMPOSITION OF JUICE PREPARED FROM THREE VARIETIES OF PINEAPPLE AT DAY ONE AND TEN

Copper is a trace mineral, which assists in the absorption of iron and regulates blood pressure and heart rate (Debnath *et al*., 2012). Results obtained in this study showed that were no significant differences ($p>0.01$) between the interaction of preservatives and variety for copper at day one as well as the individual effects. However, at day ten, highest Copper content (5.48) was recorded by juice made from MD2 variety and preserved with Cloves and the least (3.20) was juice made from MD2 variety but with no preservative. It is possible that there was a leaking of copper leachates from the Cloves into the juice; cloves contain eugenol which has been to have a solvent effect on certain metals, including copper. Iron is useful for the prevention of anemia and other related diseases (Oluyemi *et al*. 2006). At day one highest Iron content was recorded by juice made from Sugar loaf variety and preserved using Rosemary preservative and the least was juice made from MD2 variety with no preservative. The increased amount of iron concentration due to the addition of Rosemary to juice prepared from MD2 in this current study could be attributed to higher enzymatic activities that preserves the iron content. Similarly, at day ten; Sugar loaf preserved with Rosemary recorded the highest iron level of 31.28mg/l whereas MD2 with no preservative recorded the lowest iron level of 9.49mg/l. The Recommended Daily Allowance (RDA) of iron for infants, children and adults according to Menzie *et al.,* (2008), ranged from 6 – 15mg/kg. Iron aides in the development and advancement of connective tissues and hormones. Its consumption is likewise essential for the production of hemoglobin and the oxygenation of red blood cells. Generally, there was high iron for juice preserved with the natural preservatives (rosemary and clove) as compared that of no preservative for both day one and day ten. This may be due to the fact that; rosemary contains iron-rich compounds like rosmarinic acid and caffeic acid. When added to pineapple juice, rosemary can infuse some of its iron content into the juice. Cloves are also a good source of iron and can significantly contribute to the iron content. The iron from clove can be enhanced by the vitamin C present in the pineapple, which can improve iron absorption. And generally, there was a reduction in iron from day one to day ten. The major mineral elements present in pineapple fruits are K, Ca, Mg, and P (Krueger *et. al.,* 1992). The present study revealed that there were no significant differences ($p>0.01$) between the interaction of preservatives and variety for Potassium content at day one. At day ten however, highest Potassium content was recorded by juice made from Smooth Cayenne variety and preserved with ClovesThe incorporation of clove extract was found to influence the potassium content in pineapple juice, particularly in the Smooth Cayenne variety, which demonstrated a notable richness in this essential mineral. Among the various mineral elements analyzed, potassium emerged as the most prevalent across all cultivars, aligning with findings by Ekpete et al. (2013).

Manganese, an essential trace element known for its role in energy metabolism and immune function (Muhammad et al., 2011), also showed considerable variation among treatments. On day one, the highest manganese concentration was recorded in juice derived from the MD2 variety without any preservative treatment. In contrast, the lowest levels were observed in juice from the Sugarloaf and Smooth Cayenne varieties, both with and without clove preservation. A similar pattern was maintained at day ten, where

MD2 juice without preservative again exhibited the highest manganese content (14.83 mg/100 mL). These observations are consistent with the findings of Mulyaningsih and Yusuf (2018), who reported that manganese is vital for the activation of enzymes that protect tissues from damage and facilitate the digestion and utilization of nutrients.

Phosphorus, a key nutrient involved in energy transfer and the synthesis of adenosine triphosphate (ATP), plays a central role in cellular metabolism. Though roselle has been reported to contain approximately 0.004% phosphorus (Nnam & Onyeke, 2004; Adanlawo & Ajibade, 2006), its concentration in pineapple juice showed different trends. Analysis of Variance (ANOVA) on day one revealed no significant interaction effects between preservative treatment and variety on phosphorus content ($p > 0.01$). However, by day ten, the highest phosphorus level was recorded in juice produced from the MD2 variety preserved with cloves, while the lowest was observed in Sugarloaf juice with no preservative.

Zinc, an essential micronutrient absorbed by plants in the Zn^{2+} form, plays critical physiological roles in living organisms. It contributes to the structural and functional integrity of cellular membranes, supports protein synthesis and gene expression, and is integral to enzyme structure and energy metabolism, particularly within the Krebs cycle. Adequate zinc availability is directly linked to improved crop yields, both in quality and quantity, due to its interactions with other nutrients such as phosphorus, iron, and nitrogen. In this study, ANOVA results on day one indicated no significant differences ($p > 0.01$) in zinc content arising from the interaction between preservative type and pineapple variety. However, at day ten, juice made from the MD2 variety preserved with cloves exhibited the highest zinc concentration, while the lowest was recorded in Sugarloaf juice also treated with clove extract.

CONCLUSION

This study evaluated the impact of natural preservatives (rosemary and clove) on the nutritional and sensory quality of pineapple juice from three varieties: Sugar Loaf, MD2, and Smooth Cayenne. The proximate analysis revealed that juice from the Sugar Loaf variety preserved with rosemary had the highest crude fiber, fat, nitrogen-free extract carbohydrate (NFE), protein, and ash content. In contrast, the Sugar Loaf variety without preservatives had the highest moisture content on both day one and day ten. The juice from the MD2 variety preserved with rosemary exhibited the highest total soluble solids (TSS) and sweetness, while Smooth Cayenne juice preserved with clove contained the highest vitamin C content. The study further found that the levels of copper, potassium, phosphorus, and zinc in pineapple juice were not significantly affected by the preservatives or pineapple variety on day one. However, significant differences emerged in the interaction of preservatives and varieties for these elements by day ten. Sensory and chemical analyses confirmed that rosemary and clove effectively preserved the juice without compromising its sensory attributes or nutritional composition. Given similar processing conditions, pineapple juice manufacturers and processors are encouraged to use fully ripened Smooth Cayenne pineapples for juice production to achieve higher juice yields. Additionally, natural preservatives like rosemary and clove should be adopted to enhance and retain essential nutrients and sensory qualities. Future studies should explore the effects of these natural preservatives on the quality of juice prepared from mango varieties such as Keitt and Kent

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Author contributions

G.O.B.: Contributed to conceptualization, investigation, formal analysis, and data collection. Also involved in reviewing and editing the manuscript

E.K.T.: Led the conceptualization, investigation, formal analysis, data collection, and data analysis. Additionally, contributed to writing the original draft and participated in the review and editing process.

P.K.K.: Contributed to conceptualization, methodology, and supervision.

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Declarations

Ethics approval and consent to participate

This study was approved, and ethical clearance was obtained from the Kwame Nkrumah University of Science and Technology, (KNUST) , department of Horticulture

Consent for publication

All authors consent to publication.

Competing interests

The authors declare no competing interests.

Data Availablity

Not Applicable