



## **Effect of Three Pickling Agents on the Physico-chemical Properties of Two Varieties of Cucumber Stored under Tropical Ambient Conditions**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. Author ABD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors BKM, PK and PKT managed the analyses of the study. Author PKT managed the literature searches. All authors read and approved the final manuscript.*

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### **ABSTRACT**

The experiment was conducted to determine the effect of three pickling agents on the physico-chemical properties of two varieties of cucumber (Poinsett and Marketmore) stored under ambient conditions for 90 days. A 2x3 factorial design in a Completely Randomized Design with 3 replications was used for the study. The treatment consisted of two varieties of cucumbers (Poinsett and Marketmore) and three pickling solutions (Brine, Vinegar and Brine + Vinegar). The study revealed that Brine + Vinegar solution recorded the highest firmness (19.17N) while Brine solution recorded the least firmness of 8.25N. For the pH, there were no significant differences between the two varieties of cucumber, the pickling solutions and their interaction. Brine + Vinegar solution recorded the highest titratable acidity (12.03%) while Brine solution recorded the least titratable acidity (3.90%). For the interaction, Marketmore in Brine + Vinegar recorded the highest mean (13.10%), while Marketmore and Poinsett in Brine recorded the least means for titratable acidity (3.73% and 4.07% respectively). For the total soluble solids, no significant difference was observed between the two varieties. Brine solution and Brine + Vinegar solution recorded the

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highest total soluble solids (3.70 Brix and 3.01 Brix respectively). Vinegar solution recorded the least (1.65 Brix) total soluble solids. For the interaction, Marketmore and Poinsett in Brine recorded the highest total soluble solid (3.67 Brix and 3.73 Brix respectively) while Marketmore and Poinsett in Vinegar recorded the least mean for the total soluble solid content (1.63 Brix and 1.67 Brix respectively).

*Keywords: Sour; shelf-life; brine; saline; deterioration.*

## 1. INTRODUCTION

Cucumbers are the fourth most widely cultivated vegetable crop around the world after tomatoes, cabbages, and onions [1]. Cucumber (*Cucumis sativus*) belongs to the Cucurbitaceae family. Other important members of this family include watermelon muskmelon, pumpkin and squash [2]. According to [3] about 80% of the world's production of cucumber is in Asia with China leading production (60%) followed by Turkey, Russia, Iran and the United States of America. Cucumber is a fruit vegetable that has received little or no processing in Ghana, contrary to how it is processed and used in other parts of the world such as Europe, Asia and America. Cucumber fruits are often used to garnish meals and used in vegetable salads. Surpluses are often displayed in the market for sale, after which they mostly go bad after ripening. Vegetable consumption in Ghana is relatively low as compared to other African countries; however, it is expanding rapidly. Opportunities therefore exist in the agro-food sector for manufacturing industries to add value to the local agricultural products. Pickling of cucumbers is a promising venture, not only because it can serve the growing middle class of the economy, but it could also become a huge export commodity. Pickles, derived from the Dutch word *pekel*, meaning brine, have been around for thousands of years dating as far back as 2030 BC when cucumbers from native India were pickled. Pickles are created by immersing fresh fruits or vegetables in an acidic liquid or saltwater brine until they are no longer considered raw or vulnerable to spoilage [4]. A number of studies have been conducted on the use of Brine in the preservation of cucumber fruits. However, very little research has been done on the use of vinegar in the preparation of cucumber pickles. The aim of this work, therefore, was to determine the effect of three pickling agents (Brine, Vinegar and Brine + Vinegar) on the physico-chemical properties of two varieties of cucumbers (Marketmore and Poinsett) stored under tropical ambient conditions for 90 days.

## 2. MATERIALS AND METHODS

### 2.1 Experimental Site

The experiment was conducted at the Horticulture Department of KNUST, Kumasi-Ashanti Region of Ghana, where the two varieties of cucumber were cultivated from 15<sup>th</sup> October, 2019 to 5<sup>th</sup> December, 2019.

### 2.2 Experimental Design and Procedure

The experimental design used was a 2x3 factorial completely randomized design which was replicated three times. The first factor consisted of two varieties of cucumber. The second factor was three pickling agents which were Brine, Vinegar and Brine + Vinegar. The cucumbers were harvested when they were dark green and horticulturally mature, with a size of 6-10 inches in length and 1.5-2.5 inches in diameter. Cucumbers were taken to the laboratory and thoroughly washed. Brine was prepared with 5% concentration of salt. Vinegar of 5% concentration was diluted in water in a ratio of 1:3. Brine of 5% concentration of salt and vinegar were mixed in a ratio of 1:1. The two varieties of cucumbers were packed in glass jars, covered with different pickling solutions and stored for three months. Each treatment was replicated three times.

### 2.3 Parameters Studied

#### 2.3.1 Determination of firmness in cucumbers fruits

A hand held digital penetrometer was used to determine the firmness of the cucumber. This was done by first placing the cucumber fruit on a table, the tip (plunger) of the penetrometer was forced into the fruit at a uniform speed. The firmness of the fruit was displayed on the screen of the penetrometer after the tip had penetrated into the fruit.

### 2.3.2 Determination of total soluble solids in cucumber

A hand held digital refractometer was used to determine the total soluble solids in the cucumbers. This was done by extracting a juice from the fruit. Few drops of the juice were placed on the refractometer prism. The total soluble solids of the fruit were then displayed on the screen of the refractometer.

### 2.3.3 Determination of the pH of cucumber

The pH of the cucumber was determined using the pH meter. This was done by placing the sensor of the pH meter into a juice extracted from the fruit, which displayed the pH of the fruit on the screen.

### 2.4 Data Analysis

All data collected was subjected to the Analysis of Variance (ANOVA) technique using Student Edition of Statistix package version 9.0 and the least significant difference (LSD) was used to separate the means at 1%.

## 3. RESULTS

### 3.1 Firmness of Cucumber

From Table 1, it was observed that there were significant differences in the firmness of cucumbers in the pickling agents (interaction

between the two varieties and the pickling agents). Significantly firmer fruits were produced by Marketmore and Poinsett varieties which were pickled in Brine and Vinegar solution (19.67N and 18.70N respectively) which was similar to Poinsett variety pickled in Vinegar solution (16.17N) and softer fruits were produced by both varieties which were pickled in Brine solution which were similar to Marketmore variety in vinegar solution. For the pickling solutions, Brine + Vinegar produced the firmest fruits while Brine solution produced the softest fruits. Among the varieties, there were no significant differences between them.

### 3.2 pH of Cucumber

There were no significant differences between the interaction of pickling solutions and varieties as well as their individual effects (Table 2).

### 3.3 Total Titratable Acidity of the Different Cucumber

From Table 3, it was observed that interaction of cucumber varieties and pickling solutions were significant. Marketmore in Brine + Vinegar recorded the highest titratable acidity (13.10 g/L) while Marketmore and Poinsett in Brine recorded the least titratable acidity of 3.73 g/L and 4.07 g/L respectively. There were no

**Table 1. Firmness of cucumbers after 90 days of storage in pickling solutions (N)**

| Pickling solutions  | Variety            |                    | Means              |
|---|--------------------|--------------------|--------------------|
|   | Marketmore         | Poinsett           |                    |
| Brine   | 8.50 <sup>b</sup>  | 8.0 <sup>b</sup>   | 8.25 <sup>c</sup>  |
| Brine + Vinegar   | 19.67 <sup>a</sup> | 18.70 <sup>a</sup> | 19.17 <sup>a</sup> |
| Vinegar   | 11.70 <sup>b</sup> | 16.17 <sup>a</sup> | 13.67 <sup>b</sup> |
| Means   | 13.11 <sup>a</sup> | 14.28 <sup>a</sup> |                    |
| C.V.= 7.3   |                    |                    |                    |
| L.S.D. (1%): Treatments = 2.04 ;Variety = 1.44 ; Interaction = 3.52 |                    |                    |                    |

*Means followed by the same alphabets are not significantly different at  $p \geq 0.01$*

**Table 2. pH of cucumber after 90 days storage in pickling solutions**

| Pickling solution  | Variety             |                   | Means              |
|--|---------------------|-------------------|--------------------|
|  | Marketmore          | Poinsett          |                    |
| Brine  | 3.07 <sup>a</sup>   | 3.08 <sup>a</sup> | 3.075 <sup>a</sup> |
| Brine + Vinegar  | 2.99 <sup>a</sup>   | 3.36 <sup>a</sup> | 3.17 <sup>a</sup>  |
| Vinegar  | 3.7 <sup>a</sup>    | 3.73 <sup>a</sup> | 3.71 <sup>a</sup>  |
| Means  | 3.2533 <sup>a</sup> | 3.39 <sup>a</sup> |                    |
| C.V. = 15.05   |                     |                   |                    |
| L.S.D. (1%) Treatment = 1.02; Variety = 0.72; Interaction = 1.76 |                     |                   |                    |

*Means followed by the same alphabets are not significantly different at  $p \geq 0.01$*

significant differences between the two varieties of cucumber fruits. The means of the pickling solutions differed significantly. Brine + Vinegar recorded the highest titratable acidity (12.03g/L) while Brine recorded the least (3.90g/L) titratable acidity.

### 3.4 Total Soluble Solids of Cucumber

From Table 4, it was observed that there were significant differences in the total soluble solid content of the two varieties stored in the different pickling agents. The highest total soluble solid content was recorded by Marketmore and Poinsett in Brine solution (3.67 Brix and 3.73 Brix respectively), while Marketmore and Poinsett in Vinegar recorded the least Total soluble solid content (1.63 Brix and 1.67 Brix respectively). No significant difference was observed between the two varieties. For the pickling solutions, Brine solution and Brine + Vinegar solution recorded the highest mean for the total soluble solids (3.70 Brix and 3.01 Brix respectively) while Vinegar solution recorded the least (1.65 Brix).

## 4. DISCUSSION

### 4.1 Firmness

Fruit firmness measurement is a good way to monitor fruit softening and to predict bruising damage during harvest and postharvest handling [5]. From Table 1, it was observed that there were significant differences ( $P < 0.01$ ) in the cucumbers stored in the different pickling agents. Brine + Vinegar recorded the highest firmness (19.17N) for cucumber fruits. According to [6], cellulose in vegetables and fruits does not dissolve in acidic condition. The retention of the highest firmness in cucumber fruits stored in the Brine + Vinegar solution could be attributed to the high concentration of acetic acid in the solution, as in acidic surroundings, fruits and vegetables stay firm [6].

Cucumber fruits stored in 5% Brine solution recorded the least firmness (8.25N). This may be caused by salt stress as it significantly reduces the firmness of fruits and vegetables. Research also shows that storage in NaCl concentration (5% or less) causes greater pectin demethylation and tissue softening [7]. This may explain why the cucumbers in the Brine solution recorded the least firmness.

### 4.2 pH of Cucumber Fruits

The optimum value of cucumber is found between 5.1 and 5.7. However, there is a reduction in the pH of cucumbers during pickling. This is because the fermentation of vegetables due primarily to the activity of naturally occurring Lactic Acid Bacteria [8]. The lowering of the pH of cucumber pickle enables the reduction of the growth of spoilage microorganisms in order to prolong a longer shelf life of the cucumbers pickles.

### 4.3 Total Titratable Acidity of Cucumber Fruits

Titratable acidity deals with measurement of the total acid concentration contained within a food. This quantity is determined by exhaustive titration of intrinsic acids with a standard base. Titratable acidity is a better predictor of acid's impact on flavor than pH [9]. Cucumber stored in Brine + Vinegar solution recorded the highest titratable acidity (12.03g/L). The high values recorded for the solution can be attributed to the fact that they contain a higher concentration of acid (acetic acid) and therefore require a higher amount of base (NaOH) to complete their reaction.

### 4.4 Total Soluble Solids of Cucumbers

Salinity slightly increases the Total soluble Solid content of fruits crops [10].

**Table 3. Titratable acidity of cucumber 90 days after storage in pickling solutions (g/L)**

| Pickling solution | Variety            |                    | Means              |
|-------------------|--------------------|--------------------|--------------------|
|                   | Marketmore         | Poinsett           |                    |
| Brine             | 3.73 <sup>d</sup>  | 4.07 <sup>d</sup>  | 3.90 <sup>c</sup>  |
| Brine + Vinegar   | 13.10 <sup>a</sup> | 10.97 <sup>b</sup> | 12.03 <sup>a</sup> |
| Vinegar           | 6.70 <sup>c</sup>  | 6.70 <sup>c</sup>  | 6.70 <sup>b</sup>  |
| Means             | 7.84 <sup>a</sup>  | 7.24 <sup>a</sup>  |                    |

C.V. = 6.63

L.S.D. (1%): Treatment = 1.02; Variety = 0.72; Interaction = 1.76

*Means followed by the same alphabets are not significantly different at  $p \geq 0.01$*

**Table 4. Total soluble solids of cucumber after 90 days of storage in pickling solutions (□Brix)**

| Pickling solution | Variety            |                    | Means             |
|-------------------|--------------------|--------------------|-------------------|
|                   | Marketmore         | Poinsett           |                   |
| Brine             | 3.67 <sup>a</sup>  | 3.73 <sup>a</sup>  | 3.70 <sup>a</sup> |
| Brine + Vinegar   | 3.03 <sup>ab</sup> | 3.00 <sup>ab</sup> | 3.01 <sup>a</sup> |
| Vinegar           | 1.63 <sup>b</sup>  | 1.67 <sup>b</sup>  | 1.65 <sup>b</sup> |
| Means             | 2.77 <sup>a</sup>  | 2.80 <sup>a</sup>  |                   |

C.V. = 17.93

L.S.D. (1%) Treatment= 1.02; Variety = 0.72; Interaction = 1.76

*Means followed by the same alphabets are not significantly different at p≥0.01*

This is evident in the results as cucumbers stored in the Brine solution (3.65 Brix) recorded the highest means for total soluble content while cucumbers stored in Vinegar solution (1.65 Brix) recorded the least means for total soluble solids.

## 5. CONCLUSION

After the study, Marketmore and Poinsett variety were not significantly different in terms of firmness. Brine + Vinegar solution recorded the highest firmness (19.17N) while Brine solution recorded the least firmness of 8.25N. For the pH, there were no significant differences between the two varieties of cucumber, the pickling solutions and their interactions. There were no significant differences in the Titratable acidity of the two varieties. Brine + Vinegar solution recorded the highest titratable acidity (12.03g/L) while Brine solution recorded the least titratable acidity (3.90g/L). For the interaction, Marketmore in Brine + Vinegar recorded the highest mean (13.10g/L), while Marketmore and Poinsett in Brine recorded the least means for titratable acidity (3.73g/L and 4.07g/L respectively). In terms of the total soluble solid content, no significant difference was observed between the two varieties. Brine solution and Brine + Vinegar solution recorded the highest total soluble solids (3.70 Brix and 3.01 Brix respectively) while vinegar solution recorded the least (1.65 Brix) total soluble solid content. For the interaction, Marketmore and Poinsett in Brine recorded the highest total soluble solid content (3.67 Brix and 3.73 Brix respectively) while Marketmore and Poinsett in Vinegar recorded the least mean for the total soluble solid content (1.63 Brix and 1.67 Brix respectively).

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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