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RESEARCH ARTICLE

Pickled Cucumber Production for Hypertension Patients

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Abstract

Hypertension is considered as the most important modifiable risk factor for life-threatening diseases and diet can play an important role in its prevention and treatment. Low-sodium diets for hypertension have been prescribed frequently. Patients restricted to low sodium diet for long time, have often rejected large portions of their food, resulting that to weight loss, medical problems and in some cases, symptoms of malnutrition develop. The objective of this work was to carry out laboratory scale cucumber fermentations in brine containing both $CaCl_2$ and KCl, separately, as the only salt, as well as citric acid and acetic acid separately without any salt to produce pickled cucumber suitable for hypertension patients. The produced cucumber pickles were examined for chemical composition, Na, K, Ca and sensory properties. The obtained results indicated that manufacturers could make several acceptable pickle products suitable for hypertension patients.

INTRODUCTION

Hypertension is not only among the common and leading causes of morbidity and mortality in the world, but also is the most important modifiable risk factor for life-threatening diseases (**Zeng et al., 2011**). Hypertension is considered a serious health problem and diet can play an important role in its prevention and treatment (**Sánchez et al., 2011**). Though, the exact cause of hypertension is not known, many factors such as heredity, obesity, diabetes, hyperlipidemia, abnormal metabolism, unhealthy life-style, stress etc. are associated with hypertension (**Zhong et al., 2010**).

Low-sodium diets for hypertension, congestive heart failure, and diseases associated with the retention of extracellular fluid have been prescribed frequently. Patients restricted to low sodium diet for months or even years have often rejected large portions of their food because they say it is "tasteless". Low food intake resulting in weight loss complicates their medical problems and in some cases, symptoms of malnutrition develop (**Wohl and Goodhart, 1968**) .

Pickling along with drying and dehydration is one of the oldest food preservation techniques (**USDA, ERS 2007**). Pickling is defined as a process in which salt and/or vinegar is added in solution as a way to preserve a food (**Fleming and Moore, 1983**)

Cucumbers are consumed in a variety of ways in both raw and processed forms. Forty percent of the world's cucumber crop is used for fermented cucumber production. Before modern technology, cucumbers were fermented in tanks or containers ranging in size and material (i.e. wooden tanks or barrels). The containers are typically filled with cucumbers and salt brines added to reach an equilibrated salt content of 5-8% (**Breidt, 2006; Breidt et al., 2007; Hutkins, 2006**). The average salt content of finished pickle products has declined over the last decade from 4-6% to the 2-4% (**Lucier and Lin, 2000**). The fermentation naturally occurring, acid tolerant lactic acid bacteria present on the surface of the raw cucumber fruits consume the glucose and fructose that are present in fresh cucumbers and produce lactic acid. The fermentation reduces the pH below 3.6. CaCl2 is added at 0.1 %-0.4 % concentration to maintain the firmness of fermented cucumbers (**Etchells et al., 1977; Fleming et al., 1987; Tang**

and McFeeters, 1983). The combination of NaCl, calcium, and acids produced from the lactic acid bacteria results in a fermented cucumber that possesses a firm, crisp texture that can be stored for a year or more (**Fleming and McFeeters, 1981**).

About 30 y ago, calcium chloride (CaCl2) equilibrated at 20 to 40 mM began to be added to cucumber fermentation brines because it helped maintain the firmness of fermented cucumbers better than NaCl alone (**Thompson and others 1979; Hudson and Buescher 1980; Tang and McFeeters 1983**).

Recycling of the fermentation brines is now widely practiced by the industry (**Geisman and Henne 1973; Palnitkar andMcFeeters 1975**).

However, the salt concentration in fermented cucumbers is above levels normally consumed in foods so it must be partially washed out before the cucumbers are made into consumer products. This process results in a large volume of brine with high biological oxygen demand (BOD) and salt concentrations too low to be used for recycling. **Fleming et al., (1995)** were not successful in brining cucumbers without NaCl. However they did demonstrate fermentation of cucumbers with reduced NaCl (4%) in pilot scale fermentations (**Fleming et al., 2002**), but found it necessary to blanch cucumbers prior to fermentation to obtain adequate firmness retention of the cucumbers.

The objective of this work was to carry out laboratory scale cucumber fermentations in brine containing both $CaCl_2$ and KCl, separately, as the only salt, as well as citric acid and acetic acid separately without any salt to produce pickled cucumber suitable for hypertension patients

Materials and Methods

Materials :

- Cucumber fruits size 2A (25-32 mm diameter) were obtained from local market
- Sodium chloride was purchased from Al-Nasr Salines Co. - El Arish- North Sinai
- Citric acid ($C_6H_8O_7H_2O$) E330 manufacture : TTCA OC., Ltd China
- Calcium chloride , food grade anhydrous was obtained from local market
- potassium chloride food grade was purchased from local market
- vinegar (5% acetic) produced by Agro Corp, Obour City – Cairo - Egypt
- other all chemicals were obtained from Sigma-Aldrich (USA).

Methods

-Fermentations

Fermentations were done by filling 55% of the volume of glass jars (1100 mL for size 2A cucumbers) with cucumbers and 45% of the volume with a cover brine containing all components at concentrations as follow:

1- 8% NaCl + 0.5% citric acid
2- 1.1 % CaCl2 + 0.5% acetic acid
3- 1.1% CaCl2 + 0.5 % citric acid
4- 3% KCl +0.5% citric acid
5- 5% KCl +0.5% citric acid
6- 7% KCl +0.5% citric acid
7- 2.5 % citric acid
8- 1.25 % acetic cid
9- 2.5 % acetic acid
10- 5 % acetic acid

After filling jars with cucumbers and brine solution, they were closed

- Chemical analyses

- pH was determined with a Fisher Accumet pHmeter, model 825MP, (Pittsburgh, Pa., U.S.A.) which was calibrated with pH 4 and 7 buffers.
- T.S.S. were determined according to the **AOAC (1990)**.
- Total acidity: Total acidity was determined according to the **AOAC (1970)** and expressed as citric acid
- Moisture content: was determined according to the **AOAC (1990)**.
- total nitrogen (6.25), were determined according to the **AOAC (1990).**
- total lipids (petroleum ether) of cucumber were determined according to the method described in **AOAC (1990)**.
- Ash content, was determined according to the **AOAC (1990)**.
- total carbohydrates of cucumber samples were calculated by differences.

- sodium and potassium determinations were measured by flame-photometer as described by **Amrutkar et al., (2013**).
- Calcium determined using the dye binding method described by **Gindler and King (1972)**.

- Sensory evaluation:
Sensory properties were evaluated as described by **Balatsouras and Doutsias, (1983),** where the final products from all treatments of different varieties were presented to 10 untrained member panelists for organoleptic evaluation. The panelists were requested to assess the samples for taste, color, texture and overall acceptability by 10 points in scale levels of quality.

- Statistical analysis:
All determinations were carried out in triplicate (except fatty acid composition) and data is reported as mean. Significant differences ($p<0.05$) were calculated using Duncan's multiple range test, followed the method reported by **Steel and Torrie, (1980)**.

Results and Discussion

The pH and TSS of the different studied brines (before and after pickling) were determined and the obtained results are tabulated in table (1).

From the presented data it could be noticed that, the pH values of all studied treatments ranged from 1.9 to 3.8 before pickling process. These values slightly changed after pickling process, where they ranged from 2.1 to 3.3. the obtained results showed also that, addition of either acetic acid or citric acid (0.5%) led to initial conditions of pickling media not suitable for pathogens. In the same time using high concentrations of citric or acetic acid without NaCl or $CaCl_2$ or KCl led to lower pH values comparing with the other treatments.

These results are in harmony with those observed by **McFeeters and Perez-Diaz, (2010),** who found that, the equilibration of pH inside and outside the cucumber took 3 days and reached 2.9 and 3 after 17 days , respectively.

Regarding to TSS results, the obtained results showed that, the TSS contents ranged from 0.2% to 7.8 % (before pickling) and from 0.5 % to 3.5 % (after pickling). The tabulated data illustrated that TSS contents were increased for acid treatments after pickling, while the other treatments were decreased.

The changes in pH and TSS after pickling may be as a result of equilibration and to the action of lactic acid bacteria during fermentation **(Bell et al., 1972)**.

Table (1): The effect of studied treatments on brine characteristics before and after pickling

	Before pickling		After pickling	
	pH	TSS	pH	TSS
Control	3.6^{a}	7.8^{a}	3.1^{b}	3.5^{a}
1.1 % $Ca Cl_2$ + 0.5 % acetic	3.8^{a}	0.8^{f}	3.3^{a}	0.5^{f}
1.1 % $Ca Cl_2$ + 0.5 % citric	3.7^{a}	0.8^{f}	3.1^{b}	0.5^{f}
3% K Cl + 0.5 % citric	3.7^{a}	2.8^{d}	3.2^{ab}	1.8^{d}
5% K Cl + 0.5 % citric	3.6^{a}	4.7^{c}	3.2^{ab}	3.0^{c}
7% K Cl + 0.5 % citric	3.6^{a}	6.8^{b}	3.1^{b}	3.3^{b}
2.5% citric	1.9^{c}	0.5^{g}	2.1^{e}	0.7^{e}
1.25% acetic	2.5^{b}	0.2^{h}	2.7^{c}	0.7^{e}
2.5% acetic	2.4^{b}	0.2^{h}	2.5^{d}	0.6^{ef}
5% acetic	2.0^{c}	1^{e}	2.2^{e}	0.7^{e}

Values bearing the same superscript within the same column are not significantly different (P> 0.05)

The effect of different studied treatments on chemical composition of pickled cucumber comparing to fresh one were examined, where moisture, protein, fat, ash and carbohydrates were determined and the obtained results were presented in table (2).

From the presented data in table (2), it could be observed that, the higher the concentration of different studied salts the lower the moisture content , where the lowest moisture content was recorded for the control sample (8% NaCl) followed by 7% KCl, while the highest moisture content was recorded for 2.5% acetic acid treated sample.

The opposite situation of moisture contents was observed for ash content, where the higher the concentration of different studied salts the higher the ash content.

Table (2): The effect of studied treatments on chemical composition of pickled cucumber

	Moisture	Protein	Fat	Ash	Carbohydrates
Fresh	96.50^{c}	0.40^{bc}	0.18^{e}	0.13^{defg}	2.79^{c}
Control	95.20^{f}	0.50^{a}	0.20^{e}	0.40^{a}	3.70^{a}
1.1 % $Ca Cl_2$ + 0.5 % acetic	96.35^{cd}	0.36^{cd}	0.39^{a}	0.14^{def}	2.66^{c}
1.1 % $Ca Cl_2$ + 0.5 % citric	97.23^{ab}	0.30^{e}	0.26^{d}	0.15^{cde}	2.06^{d}
3% K Cl + 0.5 % citric	96.04^{de}	0.31^{de}	0.27^{cd}	0.17^{cd}	3.21^{b}
5% K Cl + 0.5 % citric	95.80^{e}	0.41^{bc}	0.24^{d}	0.20^{c}	3.25^{b}
7% K Cl + 0.5 % citric	95.34^{f}	0.43^{b}	0.25^{d}	0.25^{b}	3.73^{a}
2.5% citric	97.30^{ab}	0.40^{bc}	0.25^{d}	0.09^{fg}	1.96^{d}
1.25% acetic	97.57^{a}	0.44^{b}	0.30^{bc}	0.08^{g}	1.61^{e}
2.5% acetic	97.11^{b}	0.42^{b}	0.33^{b}	0.09^{fg}	2.05^{d}
5% acetic	97.19^{ab}	0.39^{bc}	0.26^{d}	0.10^{fg}	2.06^{d}

Values bearing the same superscript within the same column are not significantly different (P> 0.05)

Concerning to the results of carbohydrate contents in same table, it could be noticed that the higher the salt concentration of different used salts the higher the carbohydrate content this may be due to the solute equilibrium between the brine and the cucumber, while low salt concentration and acid only treatments had low carbohydrate contents comparing with the previous treatments.

In relation to protein and fat contents results presented in table (2), it could be observed that there were slight changes in their contents as a result of using different pickling treatments.

The effect of different studied treatments on sodium, potassium and calcium contents as well as the daily value of both of them of pickled cucumber comparing to fresh one were examined and the obtained results were presented in table (3).

The presented data in table (3), showed obviously that, traditional pickling method (control) using 8% salt and 0.5% citric acid led to slight decrease in both potassium and calcium content comparing with fresh sample, while sodium content was increased from 24 to 1390 mg/100g.

Concerning to the results of calcium chloride treatments from the same table (3), it could noticed that, there were slight changes in sodium and potassium contents, while calcium content was increased from 21 mg/100g (in fresh sample) to 148 and 150 mg/100g (in 1.1% CaCl2 + 0.5% acetic and 1.1% CaCl2 + 0.5% citric, respectively).

Regarding to the results of potassium chloride treatments from the same table (3), it could observed that, there were slight changes in sodium and calcium contents, while potassium content was increased from 125 mg/100g (in fresh sample) to 720, 1165 and 1640 mg/100g (in 3, 5 and 7 % CaCl2 + 0.5% citric, respectively).

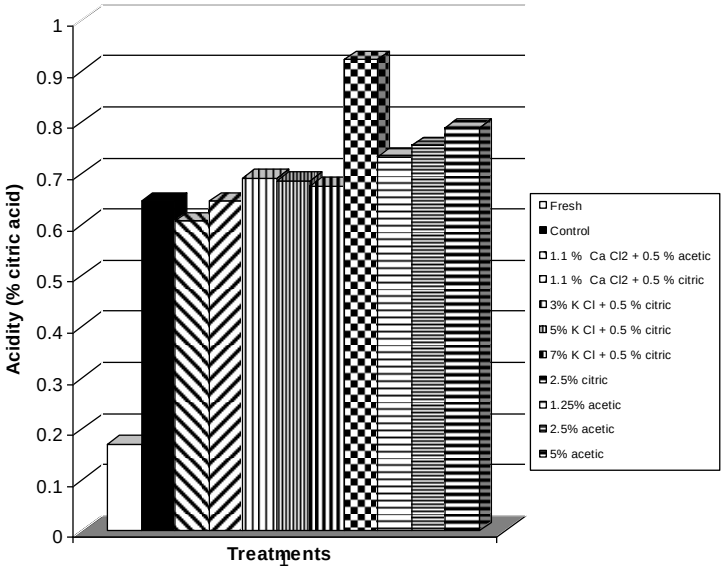
In relation to the effect of different acid treatments on minerals content, the presented data illustrated that, both studied acid treatment led to decrease both sodium, potassium and calcium contents comparing with fresh sample.

Table (3): The effect of studied treatments on sodium, potassium and calcium contents and their daily values of pickled cucumber.

	Sodium		Potassium		Calcium	
	mg/100 gm	Daily value (%)	mg/100 gm	Daily value (%)	mg/100 gm	Daily value (%)
Fresh	24^{b}	1.00^{b}	125^{d}	3.57^{d}	21^{b}	2.10^{b}
Control	1390^{a}	57.90^{a}	114^{de}	3.16^{de}	16^{cd}	1.60^{cd}
1.1 % $Ca Cl_2$ + 0.5 % acetic	23^{b}	0.95^{b}	133^{d}	3.69^{d}	148^{a}	14.80^{a}
1.1 % $Ca Cl_2$ + 0.5 % citric	21^{bc}	0.87^{bc}	135^{d}	3.75^{d}	150^{a}	15.00^{a}
3% K Cl + 0.5 % citric	19^{bcd}	0.79^{bcd}	720^{c}	20.57^{c}	15^{cd}	1.50^{cd}
5% K Cl + 0.5 % citric	20^{bc}	0.83^{bc}	116^{5b}	33.28^{b}	16^{cd}	1.60^{cd}
7% K Cl + 0.5 % citric	22^{b}	0.91^{b}	1640^{a}	46.85^{a}	18^{bc}	1.80^{bc}
2.5% citric	15^{cde}	0.62^{cde}	89^{ef}	2.54^{ef}	14^{cd}	1.40^{cd}
1.25% acetic	13^{de}	0.54^{de}	82^{fg}	2.34^{fg}	14^{cd}	1.40^{cd}
2.5% acetic	12^{e}	0.50^{e}	78^{fg}	2.22^{fg}	13^{d}	1.30^{d}
5% acetic	11^{e}	0.45^{e}	55^{g}	1.57^{g}	14^{cd}	1.40^{cd}

Values bearing the same superscript within the same column are not significantly different (P> 0.05)
RDI for Na 2400mg/day – for K 3500 mg/day – for Ca 1000 mg/day

From the same table, it could be noticed that , 100 gm of traditional fermented cucumbers supply the human body by 57.9 % of the recommended daily intake of sodium for normal persons, leading that to high risk for hypertension patients. On the other hand, potassium chloride treatments led to increase the daily value from 3.57% in fresh sample to 20.57, 33.28 and 46.89 % for 3, 5 and 7% KCl treatments, respectively. While calcium treatments led to increase the daily value from 2.1% in fresh sample to 15% approximately.



Fig(1): The effect of different studied treatments on total acidity (as % citric) of pickled cucumber

Concerning to the results of total acidity of fermented cucumber presented in fig (1), it could be observed that, total acidity of all studied treatments was increased after pickling where the highest acidity value was recorded for 2.5% citric acid treatment (0.922%) followed by 5% acetic acid treatment (0.789%) then 2.5% acetic acid treatment (0.754 %). While, the lowest acidity percentage was recorded for 1.1% CaCl2 +0.5% acetic (0.606 %). These increment in total acidity after pickling for all studied treatments are in harmony with that reported by **Felming et al., (1995)**, who found that, tetratable acidity of pickled cucumber was increased from 0.39 % to 0.87 % after 8 days of pickling.

The effect of different pickling treatments on the organoleptic characteristics of the produced pickled cucumber was examined and the obtained results were presented in table (4).
The effect of studied treatments on the color of produced cucumber in table (4), showed that, control sample had the highest color score (8.14) followed by calcium chloride treatments and 5% potassium chloride treatment (7.35) then 1.25% acetic acid treatment (7.21).

Table (4): The effect of studied treatments on sensory properties of pickled cucumber.

	Color	Taste	Odor	Texture	Over all acceptability
Control	8.14^{a}	8.00^{a}	7.50^{a}	6.92^{c}	7.71^{a}
1.1 % $Ca Cl_2$ + 0.5 % acetic	7.35^{b}	5.91^{c}	7.35^{b}	7.71^{a}	6.46^{b}
1.1 % $Ca Cl_2$ + 0.5 % citric	7.35^{b}	5.25^{e}	7.14^{c}	7.35^{b}	5.78^{de}
3% K Cl + 0.5 % citric	6.78^{c}	5.74^{d}	6.42^{e}	6.00^{e}	5.92^{c}
5% K Cl + 0.5 % citric	7.35^{b}	6.65^{b}	6.78^{d}	6.64^{d}	6.53^{b}
7% K Cl + 0.5 % citric	5.96^{f}	4.85^{f}	6.00^{f}	5.21^{g}	5.71^{ef}
2.5% citric	6.50^{e}	4.81^{f}	6.00^{f}	5.75^{f}	5.36^{h}
1.25% acetic	7.21^{b}	5.83^{cd}	6.28^{e}	7.25^{b}	5.85^{cd}
2.5% acetic	6.64^{d}	5.18^{e}	5.15^{g}	6.96^{c}	5.61^{fg}
5% acetic	6.85^{c}	3.90^{g}	5.15^{g}	6.89^{c}	5.49^{g}

Values bearing the same superscript within the same column are not significantly different (P> 0.05)

Concerning to taste results from the same table (4), it could be noticed that, the best taste score (8) was recorded for control sample followed by 5% KCl, 1.1% CaCl2 with acetic acid , 1.25 acetic acid and 3% KCl which scored 6.65, 5.91, 5.83 and 5.74 , respectively. While the results of taste showed refusing of both 5% acetic acid, 2.5% citric acid and 7% KCl. The refusing of 7% KCl sample may be as a result of the noticeable bitterness of high level of KCl **(Bell et al., 1972).**

Regarding to odor results, it could be noticed that, the highest odor score was recorded for control sample (7.5) followed by CaCl2 with acetic, CaCl2 with citric, 5% KCl and then 3% KCl , which recorded 7.35, 7.14, 6.78 and 6.42, respectively.

On the other hand, texture results in the same table showed that CaCl2 treatments recorded higher values compared with all studied treatments followed by 1.25 and 2.5 % acetic acid then control sample.

Concerning to over all acceptability, the obtained results illustrated that, control sample had the highest score (7.71) followed by 5% KCl, CaCl2 with acetic, 3% KCl and 1.25 % acetic, where their scores were 6.53, 6.46, 5.92 and 5.85, respectively.

These results are in agreement with those reported by **Bell et al., (1972)**, who found that, potassium chloride treated cucumbers (during pickling without salt) were rated lower values of each organoleptic characteristics than those of sodium chloride treated cucumber.

Conclusion

Salt free fermented cucumber could be produced by using either $CaCl_2$ or KCl or citric acid or acetic acid separately. All studied treatments resulted in products with acceptable sensory properties, except 7% KCl, 2.5% citric acid and 5% acetic acid (in relation to taste), so the products of bitter or acidic taste could be submerged in clean water for 24 h before consuming and adding some natural flavoring agents (such garlic or paprika).

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