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Influence of different types of sodium chloride (NaCl) on cucumbers (*Cucumis sativus* L.) preserved by lactic fermentation

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Abstract When vegetables are immersed in water and salt, they create an anaerobic environment beneficial to acidifying bacteria - lactobacilli - present on the surface of all living organisms abundant above the leaves and roots that grow near the soil. As soon as the plants are submerged in the water, the fermentation begins. *Lactobacillus* bacteria start consuming sugars for fruits and vegetables and produce, among others, lactic acid.
The lactic acid produced by these bacteria is a natural preservative that inhibits the growth of rotting bacteria and other aortic pathogens such as mold. A similar microbial activity is also found in a healthy healthy intestine, the bacteria that exert the same function in both the intestine and the vessel.
This paper presents the evolution and influence of lactic fermentation on cucumbers (*Cucumis sativus*) using different sources of water and salt.
The largest amount of lactic acid (0.097%) was obtained using non-iodized salt, recrystallized and fountain water.

Key words

Cucumis sativus, *Lactobacillus spp.*, salt, lactic acid

Cucumis sativus is a vegetable plant of the *Cucurbitaceae* family and is widely grown [15]. It comes from India and is grown in tropical and temperate regions. It is grown in many varieties due to the variety of fruits [11].
Consumed as food, the raw cucumber cucumber has a 20kcal per 100 grams intake, of which carbohydrates are about 3.63g, 0.11g fat, 0.65g protein, 0.027mg vitamin B_1, 0.033mg vitamin B_2, vitamin B_3 0.098g, traces of vitamin B_6 and B_9, vitamin C 2.8 mg, iron, magnesium, phosphorus, potassium and zinc [17].
Nowadays, two methods of picking are used, which, although leading to seemingly similar results, are very different. In the case of pickles in vinegar, vegetables are seasoned and then immersed in a boiled and chilled solution of vinegar [2]. This process leads to the destruction of the natural cultures of bacteria and enzymes [3]. Vinegar is a more acidic product and not necessarily healthier when consumed in large quantities. In the case of commercial pickles, the finished product is often subjected to pasteurization, which leads to the killing of all lactic bacteria and, together with them, to the loss of benefits for the fermented foods [4].
According to some medical studies, giving up the practice of lactic-fermentation and pasteurizing most foods have compromised the health of our intestinal flora [5], resulting in mass proliferation of many new viruses and the multiplication of intestinal parasites and pathogens, even for people whose hygiene is impeccable [1].
Salt pickles are instead lactic-fermented [6]. There are two basic methods for making these pickles. In the case of the first method, the vegetables are chopped, salted and then stuffed into jars, and they are virtually fermented in their own juice [7]. The second, more common, is to prepare a brine in which vegetables will be submerged [8].
Lactic fermentation is not suitable for industrial production, because the results are not always predictable [9]. In rare cases jars may explode or pickles may not retain the desired texture [10]. The varieties of pickled vinegar are more viable from this point of view [14]. Many benefits of lactic fermented pickings are sacrificed for the sake of the perfect consistency of the result [11].
Instead, salt creates a selective medium, reducing the type of bacteria that can develop, and providing lactic acid producing bacteria with a competitive advantage [16]. Salt also extends the potential for long-term conservation, slowing the fermentation and activity of pectin digesting enzymes [12].
Lactic fermented slices are easier to digest than fresh vegetables and fruits [13]. They contain numerous beneficial enzymes, as well as antibiotic and anti-cancer drugs [14]. Also, eating small amounts of meals at tables, leads to the development of a healthy intestinal flora. This results in a general improvement in the well-being of the body [18].
Of the many varieties of cucumbers best suited for pickling are those with thin skin, dark green, with the

smallest seeds and fleshy core. Also preferred are cucumbers with sprigs or spikes, as they increase the surface of cucumbers, facilitating and accelerating the penetration of brine into them [16].
Cucumis sativus fruits are picked when they are green, and they can be eaten raw or pickled. Also, seedless varieties are used in the food decoration industry [14].
For pickles, cucumbers are used, whose shape is not so pleasing to the eye, those with irregular shape, too thick or crooked, or with the peeling peel. For brining, brine or vinegar is commonly used in combination with various aromatic plants [11]. The milling process reduces the vitamin content of vegetables but keeps them at elevated levels relative to other preservatives (eg. boiling) [17]. In addition, it keeps them for longer. The great taste and the many uses it has in gastronomy make the pickled cucumber a piece of resistance to human food.

Material and Method

Only fresh cucumbers have been used for picking because the dehydrated, during the fermentation, rehydrates and is filled with lemon juice.
Before being pickled the cucumbers were sorted by quality and size. Table no. 1.

Table 1

Characteristics of cucumber

Size	Length mm	Diameter mm	Number of cucumbers/kg
Big size	90-120	20-45	8-12
Medium size	70-90	25-30	20-25
Small size	30-60	10-25	90-150

The saline solutions prepared for the preservation by milling had a concentration of 40 g/l NaCl, the pH of the initial solutions ranged from 8.07 to 8.2, for variants with different water sources (drinking water and fountain water), and for the different types of salt used.
The iodine-based iodine salt used in the experiment showed 36.52 mg of potassium iodide (KI) / kg of salt (NaCl), so that the amount of potassium iodate (KI) in the solution was 0.146 mg / 100 ml solution. The solution prepared with iodized recrystallized salt showed 0.2106 mg of potassium iodate / 100 ml of solution.
From the combination of the experimental factors, 8 variants resulted, which are presented in Table no. 2.

Table 2

Experimental variants

Experimentat variant	The type of salt used for preservation	Sursa de apă utilizată pentru lichidul de umplere
S1	Non-iodized rock salt	Drinking water
S2	Non-iodized rock salt	Fountain water
S3	Iodized rock salt	Drinking water
S4	Iodized rock salt	Fountain water
S5	Non-iodized recrystallized salt	Drinking water
S6	Non-iodized recrystallized salt	Fountain water
S7	Iodized recrystallized salt	Drinking water
S8	Iodized recrystallized salt	Fountain water

Preserved cucumber jars were stored in the dark at 15-20ºC.
The fermentation of the cucumbers began 3 days after their solution.
After a period of 6 weeks, during which time the fermentation process was followed, some chemical parameters influencing the performance of the lactic fermentation, namely the pH of the solution, the total acidity expressed in lactic acid as well as the salt concentration of the solution.

Results and Discussions

Following the data in table no. 3 it can be noticed that there are differences in the values obtained for the eight variants taken in the research, the lactic fermentation process resulting in both the non-iodized salt and the iodine salt used in brine, but the water has influenced the amount of lactic acid that has formed.
The initial pH level dropped from 8 to 3.57-3.77, the total acidity expressed in lactic acid was between 0.077-0.097% and salt content in brine varied between 1, 83 - 2.10%. The fermentation process was normal for all experimental variants, irrespective of the salt used in brine preparation. (Table 3).

Table 3

Analyses for brine used in cucumbers

Sample	pH	Total acidity lactic acid %	NaCl %
S1	3,70	0,077 f	2,10 a
S2	3,77	0,083 e	2,06 b
S3	3,75	0,080 e	2,09 a
S4	3,72	0,093 b	1,93 c
S5	3,79	0,090 c	1,87 d
S6	3,67	0,097 a	1,96 b
S7	3,68	0,087 d	1,83 e
S8	3,57	0,097 a	2,00 b

SD for total acidity 0,1-0,27
SD for NaCl 0,14-0,16

Experimental variants S4, S6 and S8 show statistically ensured differences, of which 0.01 are very significantly positive versus S5 taken to control (Table no. 4).

Table 4

Unilateral influence of acidity in the used recipes

Recipe	Acidity % lactic acid		Difference ±D	Signification of difference
	Obtained values	%		
S5	0,09	100	0,00	Mt.
S1	0,08	88,0	-0,01	000
S2	0,09	98,8	0,00	-
S3	0,08	95,0	0,00	0
S4	0,09	108,1	0,01	***
S6	0,09	109,7	0,01	***
S7	0,09	100,4	0,00	-
S8	0,10	110,9	0,01	***
	DL (p 5%)		0,008	
	DL (p 1%)		0,011	
	DL (p 0,1%)		0.015	

The amount of salt in lactic fermented pickles is of major importance as preservative not only as a spice. In Table 5 the values obtained for the NaCl concentration of 1.83-2.10% for the recipes used are in line with those of the specialty literature recommended for lactic fermentation [14]. Variants S1 and S3, recorded 0.23, respectively 0.21 significantly different values from the control variant (S5).

Table 5

Unilateral influence of sodium chloride in used recipes

Recipe	Sodium chloride (NaCl)		Difference ±D	Signification of difference
	Obtained values	%		
S5	1,87	100,0	0,00	Mt.
S1	2,10	112,3	0,23	**
S2	2,06	110,1	0,19	*
S3	2,09	111,4	0,21	**
S4	1,93	103,2	0,06	-
S6	1,96	104,6	0,09	-
S7	1,83	97,5	-0,05	-
S8	2,00	106,8	0,13	-
	DL (p 5%)		0,14	
	DL (p 1%)		0,19	
	DL (p 0,1%)		0.27	

The changes that occurred in the chemical composition of the cucumbers placed to pickled, after lactic fermentation are shown in table no. 6, and refer to the three categories of fresh fruit and pickled fruits. It is found that the water of the pickled cucumbers remains almost in the same quantity as in the fresh ones.
The amount of protein, lipids, carbohydrates and sugars decreases due to the diffusion in brine of soluble

albuminoids and their partial decomposition by microorganisms. The amount of inverted sugar decreases a lot, and after a long time it completely disappears. Also, the sugar content is greatly reduced and lactic acid is formed instead. The values determined by us are in line with those found in the literature [12, 14]. Plain cucumbers also reduce the cellulose content, which is explained by its partial hydrolysis.

The pickled cucumbers, kept in the dark, at 2-6 ˚C temperatures, were greenish in color, with a yellow-olive shade, were not crushed or hollowed inside, they were crunchy, tastefully acidized and salty and with a characteristic aroma of used spices.

Table 6

Changes in cucumber fruits following lactic fermentation

Analysed item %	Fres fruits			Pickled fruits
	Small size	Medium size	Big size	
Water	96.63	95.40	95.12	95.90
Protein	0.69	0.56	0.71	0.38
Lipids	0.08	0.10	0.22	0.12
Carbohidrates	3.42	3.54	3.63	1.24
Sugars	1.67	1.69	1.72	0.82
Inverted sugar	0	0.98	0.57	0
Cellulose	0.64	0.68	0.76	0.45

After 4 months of storage under the above-mentioned conditions, the juice from cucumbers was clear, free from moldy smell and without the puddling phenomenon. The salt content varied between 2.7 and 3.5% and the lactic acid content between 0.5-0.9% (Table 7).

Table 7

Composition of brine on cucumbers

Brine analysed item	%
Alcohol in volume	0.212
Volatile acidity	0.070
Water	90.249
Fixed acidity (lactic acid)	1.431
Inverted sugar	0.111
Natriun Chloride (NaCl)	2.756
Ash (without NaCl)	0.055

Following the evolution of certain mineral elements in the composition of lactic fermented cucumbers (Table no. 8), after 4 months of storage, it can be seen that the calcium level increases by 33.33% and the magnesium by 53.49% to fresh cucumbers fruits.

In the case of phosphorus and potassium content in lactic fermented cucumbers, after 4 months of storage, we can see a decrease of 30.77% for phosphorus and 27.43% for potassium to fresh cucumbers fruits.

Table 8

Comparison of the mineral content of fresh cucumbers and lactic fermented cucumbers

Analysed item %	Fres fruits			Pickled fruits
	Small size	Medium size	Big size	
Calcium mg	16	18	20	24
Magnesium mg	13	14	16	22
Phosphorus mg	24	26	28	18
Potassium mg	147	152	164	112

The images of finished products obtained for each experimental variant are shown in Figure 1.

Fig. 1. Finished products in jars. Source: photo original.

Following the evolution of vitamin content in cucumbers preserved by lactic fermentation (table 9), after 4 months of storage, for all the analysed elements, we can see a decrease of them, as follows: C vitamin decrease with 43,53% to fresh cucumbers fruits, B_9 vitamin (folic acid) decreased by 61.13%, A vitamin decreased by 28.88% and K vitamin decreased by 55.83% to the fresh cucumbers fruits.

The values determined for cucumbers preserved by lactic fermentation have values similar to those determined by other authors [9, 12, 17], but have a much higher level compared to industrially preserved cucumbers, in pasteurized or sterilized preserve [3, 5, 8].

Table 9

Comparison of the vitamin content of fresh cucumbers and lactic fermented cucumbers

Analysed item %	Fres fruits			Pickled fruits
	Small size	Medium size	Big size	
C vitamin mg	2,8	2,9	2,8	1,6
Folic acid µg	7,1	8,2	9,4	3,2
A vitamin UI	105	109	115	78
K vitamin µg	16,2	17,5	15,2	7,2

Conclusions

From the above data we concluded that the largest amount of sugar is found in cucumbers with middle age, while the percentage of sugar those young and old is lower.

Cellulose content increases as cucumbers get old, therefore the best lactic fermented pickles are middle-aged, who give a tasty, nourishing and easy-to-eat product.

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