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Effect of Some Spices Essential Oil and Extracts on Fermentation of Capers Buds

MUHAMMET ARGUN and MEHMET MUSA ÖZCAN*

Department of Food Engineering, Faculty of Agricultural, Selcuk University, 42031 Konya, Turkey

*Corresponding author: Fax: +90 332 2410108; Tel: +90 332 2232933; E-mail: mozcan@selcuk.edu.tr

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The flower buds of caper plant were exposed to fermentation in 10 % brine for 6 weeks, with the addition of the volatile oils and extracts of different concentrations were obtained from the plants of sage, rosemary, dill, and coriander. Fermentation was monitored by chemical (acidity, salt, pH) and microbiological analyses. Depending on high salt concentrations, the bacteria of lactic acid did not develop. The values of acidity were found low. It was observed that the volatile oils and extracts were effective on microbial activity. The unique effects of distinctions in the sorts of spices did not clearly emerge. The value of salt concentration exhibited a rapidly decrease in the first week.

Keywords: Caper, Brine, Fermentation, Essential oil, Extract.

INTRODUCTION

Capparis (*Capparaceae*) grows spontaneously in natural flora in all tropical and subtropical continents. In related to the taste of caper, it was said that the taste was reasoned from sulfurous compounds emerging the breakdown of glycoside^{1,2}. At just this point, Mathaus and Özcan³ considered that there were many chemical compounds such as glycosinolate alkaloid, flavonoid and lipid in various organs of caper and that among these, especially glycosinolate and that flavonoid raised the taste and medical value of caper. Alvarriuz *et al.*⁴ identified that in salt solutions containing salt 7 % and more, microbial development were not met and acidity of salt solution proceeds constantly, while, in lower concentrations, they recorded an increase in acidity of salt solution and microbial development. Sanchez *et al.*⁵ carried out a similar study and suggested that salt solutions in 7-10 % concentration influenced the fermentation and the most suitable concentration in storing final product was 10 %. Özcan⁶ determined that the samples of 6 % of salt and 0.5 % of lactic acid showed the most superior influence on the caper pickles produced, using lactic acid, in terms of sensory features. In this study, with the addition of the essential oils and extracts of various spices, obtaining different tastes and presenting the effects of these additions on caper pickle as well as the consumer tastes were aimed.

EXPERIMENTAL

The flower buds of *Capparis ovata* Desf. var. *canescens* were collected in several parties from the wild plants growing in Selçuklu, a central district of Konya, in June. The spices

used are sage (*Salvia officinalis* L.)⁷, rosemary (*Rosmarinus officinalis* L.), dill *Anethum graveolens* L.) and coriander (*Coriandrum sativum* L.).

The spice essential oils obtained with Clavenger apparatus were taken into the bottles⁸. Again, from the same spices, extract was obtained by the method of extraction we can define as taking a substance from an environment to another one *via* a solvent. For this, Soxhlet mechanism was utilized. After the solvent was completely removed from the mix of solvent and extract obtained, extract was obtained and kept in a suitable environment⁹. Caper flower buds collected and stored in suitable conservation conditions were put into the jars, totally 26 pieces, up to the 2/3 level of each jar. The remaining part of jars was filled with salt solution prepared in the concentration of 10 % to the brine. The essential oil of sage was orderly added into the different jars in the concentrations of 0.01, 0.03, and 0.05 %. The same procedure was applied to the salt solutions of different spices with the volatile oils obtained from rosemary, dill, and coriander. This time, all treatments were applied to different jars with the extracts obtained from four spices in the concentrations of 0.1, 0.3, and 0.5 %. Two pieces of jars, without adding any extract and volatile oil, were left to fermentation as control. All samples were subjected to fermentation at room temperature for six weeks. For following fermentation, with intervals of one week, totally six weeks, analyses of salt solution both chemically and microbiologically At the end of six months, chemical and microbiological analyses in the product continued 3 months in intervals of one month. Also completing the sensory analyses, all data were obtained.

Chemical analyses: Determination of lactic acid was carried out according to Anonymous¹¹ by weighing 5 g of sample, adding 20 mL of pure water and 2-3 drop of phenolphthalein onto it and titrating the solution with 0.1 N of NaOH. Determination of salt was carried out by weighing 1 g of sample, adding 10 mL of water and 1 mL of potassium chromate onto it and titrating the solution with AgNO₃, according to AOAC¹⁰. pH was determined by using Digital LCD-2 pH meter, according to Cemeroglu¹².

Microbial analyses: In microbiological analyses, microbiological specifications were determined by using Plate Count Agar (Merc) for total bacteria, Violet Red Bile Agar (Merc) for coliform group and Rogosa Agar (Merc) for lactic acid bacteria.

While preparing dilution, water with peptone was used. Incubation to media was conducted as two repetitive for lactic acid bacteria from dilutions of 10⁻², for the others 10⁻⁴ of dilutions. At the end of incubation, the numbers of colony were manually and expressed as log.kob/ml. Analyses were carried out according to Özçelik and Iç¹³. Results of the research were analysed for statistical significance by analysis of variance¹⁴.

RESULTS AND DISCUSSION

The fermentation results of caper buds obtained with the addition of essential oil and extracts of different spices in various concentrations are given in Tables 1 and 2, respectively. According to this, acidity values were generally found low, they taken the lowest value at the end of 3rd week. While the last acidity value is expected to be above 0.6, we can attribute that the values emerge below 0.6, likely depending on

high salt concentration, to the fact that lactic acids can't reproduce.

When the additions of salt solution on acidity are considered, both different spices additions and different concentrations largely showed a parallelism and their extreme influences were not observed on acidity fluctuations. However, in salt solution added sage extract in the concentration of 0.03 %, differently from the others, at the end of 2nd week, an increase was observed, but in the analyses carried out at the end of 3rd week, it was seen that it rapidly decreased.

Total acidity is of the most important characteristic of foods. According to this, until the end of 4th week, while it is observed that all values largely exhibits parallelism and is in increase, after this week, a rapidly decrease is observed. It can be evaluated that this decrease as starting of microorganisms, resistant to high salt concentration, which will raise the concentration of environment, to proliferate. It is seen that the volatile oil and extracts, also different concentrations of these presented parallelism. The salt concentration in salt solution is of major factors determining the course of fermentation. High salt concentration lags or even stops the development of lactic acid bacteria, while extremely low salt concentration causes the microorganisms leading to breakdown to develop and moderations¹⁵. Salt concentration of salt solution was initially determined and applied as 10 %. At the end of first week, it is seen that a rapid diffusion event came true. It was observed that the salts in salt solution passed rapidly into the nature of caper buds. During the fermentation of caper buds obtained from by additions of volatile oil and extracts in various concentrations of different spices, logarithmic mean values of

TABLE-1
CHEMICAL PROPERTIES OF CAPER PICKLING BRINE WITH SPICE ESSENTIAL OIL

Day	Range of product	Concentration (%)	Acidity (% Lactic) g (100 mL) ($\bar{x} \pm \sigma$)	pH ($\bar{x} \pm \sigma$)	Salt (%) g (100 mL) ($\bar{x} \pm \sigma$)
7.	Control		0.350 ± 0.01	4.94 ± 0.03	5.595 ± 0.21
	Sage essential oil	0.01	0.447 ± 0.03	4.93 ± 0.00	5.550 ± 0.37
		0.03	0.518 ± 0.14	4.91 ± 0.01	5.475 ± 0.26
		0.05	0.589 ± 0.11	4.89 ± 0.01	5.375 ± 0.15
	Rosemary essential oil	0.01	0.489 ± 0.05	4.91 ± 0.00	5.520 ± 0.15
		0.03	0.642 ± 0.03	4.87 ± 0.00	5.320 ± 0.01
		0.05	0.658 ± 0.12	4.86 ± 0.00	5.340 ± 0.07
	Dill essential oil	0.01	0.544 ± 0.01	4.90 ± 0.00	5.375 ± 0.01
		0.03	0.642 ± 0.02	4.88 ± 0.01	5.250 ± 0.24
		0.05	0.579 ± 0.05	4.89 ± 0.00	5.380 ± 0.50
	Coriander essential oil	0.01	0.679 ± 0.12	4.89 ± 0.01	5.330 ± 0.10
		0.03	0.625 ± 0.14	4.88 ± 0.00	5.380 ± 0.50
		0.05	0.658 ± 0.16	4.87 ± 0.00	5.330 ± 0.14
14.	Control		0.349 ± 0.04	5.03 ± 0.00	6.494 ± 0.25
	Sage essential oil	0.01	0.357 ± 0.08	5.02 ± 0.00	6.346 ± 0.20
		0.03	0.521 ± 0.01	5.00 ± 0.01	6.220 ± 0.10
		0.05	0.540 ± 0.04	4.97 ± 0.01	6.006 ± 0.15
	Rosemary essential oil	0.01	0.536 ± 0.05	5.00 ± 0.00	6.181 ± 0.17
		0.03	0.448 ± 0.02	4.93 ± 0.00	5.971 ± 0.24
		0.05	0.483 ± 0.05	4.93 ± 0.00	6.008 ± 0.19
	Dill essential oil	0.01	0.443 ± 0.10	5.02 ± 0.01	6.389 ± 0.20
		0.03	0.446 ± 0.04	5.01 ± 0.00	6.189 ± 0.15
		0.05	0.467 ± 0.05	5.01 ± 0.01	5.994 ± 0.07
	Coriander essential oil	0.01	0.483 ± 0.05	5.12 ± 0.01	6.573 ± 0.00
		0.03	0.405 ± 0.05	5.07 ± 0.00	6.318 ± 0.09
		0.05	0.450 ± 0.14	5.05 ± 0.00	6.270 ± 0.16

21.	Control		0.159 ± 0.06	5.22 ± 0.00	6.805 ± 0.27
	Sage essential oil	0.01	0.179 ± 0.04	5.20 ± 0.01	6.659 ± 0.07
		0.03	0.176 ± 0.08	5.16 ± 0.00	6.659 ± 0.18
		0.05	0.357 ± 0.05	5.11 ± 0.00	6.597 ± 0.15
	Rosemary essential oil	0.01	0.178 ± 0.04	5.10 ± 0.00	6.381 ± 0.14
		0.03	0.249 ± 0.05	5.03 ± 0.01	6.107 ± 0.27
		0.05	0.261 ± 0.08	5.03 ± 0.01	6.260 ± 0.18
	Dill essential oil	0.01	0.232 ± 0.11	5.12 ± 0.01	6.547 ± 0.25
		0.03	0.269 ± 0.12	5.11 ± 0.01	6.500 ± 0.04
		0.05	0.212 ± 0.05	5.09 ± 0.01	6.356 ± 0.19
	Coriander essential oil	0.01	0.125 ± 0.05	5.07 ± 0.00	6.467 ± 0.26
		0.03	0.180 ± 0.08	5.07 ± 0.00	6.453 ± 0.48
		0.05	0.141 ± 0.04	5.05 ± 0.00	6.223 ± 0.11
28.	Control		0.525 ± 0.06	5.04 ± 0.00	6.275 ± 0.22
	Sage essential oil	0.01	0.515 ± 0.12	5.08 ± 0.00	6.510 ± 0.27
		0.03	0.536 ± 0.13	5.06 ± 0.01	6.567 ± 0.35
		0.05	0.530 ± 0.07	4.99 ± 0.01	5.975 ± 0.15
	Rosemary essential oil	0.01	0.396 ± 0.05	5.03 ± 0.00	6.070 ± 0.55
		0.03	0.446 ± 0.14	4.94 ± 0.00	5.626 ± 0.22
		0.05	0.467 ± 0.03	4.95 ± 0.00	5.481 ± 0.16
	Dill essential oil	0.01	0.572 ± 0.05	5.03 ± 0.00	6.225 ± 0.01
		0.03	0.648 ± 0.01	5.01 ± 0.00	5.979 ± 0.13
		0.05	0.540 ± 0.14	4.98 ± 0.00	5.773 ± 0.71
	Coriander essential oil	0.01	0.495 ± 0.12	5.02 ± 0.00	6.194 ± 0.58
		0.03	0.485 ± 0.01	5.01 ± 0.00	6.044 ± 0.25
		0.05	0.425 ± 0.13	5.00 ± 0.02	5.938 ± 0.12
35.	Control		0.359 ± 0.02	4.72 ± 0.00	5.966 ± 0.25
	Sage essential oil	0.01	0.437 ± 0.05	4.60 ± 0.00	5.526 ± 0.05
		0.03	0.430 ± 0.10	4.66 ± 0.00	5.358 ± 0.14
		0.05	0.480 ± 0.08	4.63 ± 0.00	5.305 ± 0.38
	Rosemary essential oil	0.01	0.392 ± 0.02	4.57 ± 0.01	5.070 ± 0.27
		0.03	0.431 ± 0.11	4.51 ± 0.00	5.160 ± 0.47
		0.05	0.479 ± 0.07	4.50 ± 0.00	5.387 ± 0.58
	Dill essential oil	0.01	0.524 ± 0.10	4.54 ± 0.00	5.316 ± 0.25
		0.03	0.431 ± 0.04	4.54 ± 0.00	5.135 ± 0.16
		0.05	0.462 ± 0.15	4.53 ± 0.01	5.116 ± 0.35
	Coriander essential oil	0.01	0.348 ± 0.04	4.57 ± 0.01	5.597 ± 0.22
		0.03	0.533 ± 0.05	4.56 ± 0.00	5.181 ± 0.08
		0.05	0.430 ± 0.01	4.53 ± 0.00	5.626 ± 0.25
42.	Control		0.401 ± 0.12	4.59 ± 0.00	5.702 ± 0.32
	Sage essential oil	0.01	0.383 ± 0.10	4.62 ± 0.00	5.505 ± 0.45
		0.03	0.339 ± 0.04	4.61 ± 0.00	5.307 ± 0.18
		0.05	0.396 ± 0.02	4.56 ± 0.00	5.585 ± 0.25
	Rosemary essential oil	0.01	0.566 ± 0.09	4.63 ± 0.00	5.473 ± 0.32
		0.03	0.438 ± 0.04	4.57 ± 0.00	5.147 ± 0.38
		0.05	0.596 ± 0.03	4.56 ± 0.00	5.310 ± 0.31
	Dill essential oil	0.01	0.432 ± 0.08	4.64 ± 0.01	5.889 ± 0.27
		0.03	0.414 ± 0.02	4.64 ± 0.00	5.889 ± 0.06
		0.05	0.450 ± 0.08	4.60 ± 0.01	5.969 ± 0.55
	Coriander essential oil	0.01	0.356 ± 0.04	4.60 ± 0.00	5.307 ± 0.25
		0.03	0.363 ± 0.05	4.60 ± 0.00	5.924 ± 0.54
		0.05	0.404 ± 0.09	4.56 ± 0.00	5.070 ± 0.14

$\bar{x}$: Normal frequency curve. σ : Coefficient of variation

TABLE-2
CHEMICAL PROPERTIES OF CAPER PICKLING BRINE WITH SPICE EXTRACT

Day	Range of product	Concentration (%)	Acidity (% Lactic) g (100 mL) ($\bar{x} \pm \sigma$)	pH ($\bar{x} \pm \sigma$)	Salt (%) g (100 mL) ($\bar{x} \pm \sigma$)
7.	Control		0.350 ± 0.01	4.94 ± 0.00	5.595 ± 0.21
	Sage extract	0.1	0.428 ± 0.02	4.95 ± 0.00	5.520 ± 0.05
		0.3	0.527 ± 0.09	4.94 ± 0.00	5.320 ± 0.28
		0.5	0.591 ± 0.06	4.93 ± 0.00	5.310 ± 0.34
	Rosemary extract	0.1	0.360 ± 0.14	5.03 ± 0.01	6.118 ± 0.03
		0.3	0.450 ± 0.04	5.01 ± 0.00	6.065 ± 0.11
		0.5	0.511 ± 0.09	4.98 ± 0.00	5.625 ± 0.24

7.	Dill extract	0.1	0.511 ± 0.04	4.99 ± 0.00	5.770 ± 0.09
		0.3	0.598 ± 0.07	4.94 ± 0.00	5.290 ± 0.38
		0.5	0.602 ± 0.05	4.94 ± 0.00	4.340 ± 0.45
	Coriander extract	0.1	0.590 ± 0.11	4.94 ± 0.01	5.370 ± 0.36
		0.3	0.591 ± 0.04	4.94 ± 0.01	5.280 ± 0.12
		0.5	0.609 ± 0.13	4.94 ± 0.00	5.300 ± 0.21
14.	Control		0.349 ± 0.04	5.03 ± 0.00	6.494 ± 0.25
	Sage extract	0.1	0.355 ± 0.05	5.00 ± 0.00	6.289 ± 0.18
		0.3	0.631 ± 0.08	4.98 ± 0.00	6.158 ± 0.05
		0.5	0.443 ± 0.05	5.03 ± 0.01	6.205 ± 0.09
	Rosemary extract	0.1	0.269 ± 0.07	4.97 ± 0.00	6.518 ± 0.15
		0.3	0.260 ± 0.04	5.02 ± 0.00	6.255 ± 0.24
		0.5	0.263 ± 0.03	4.96 ± 0.01	6.056 ± 0.04
	Dill extract	0.1	0.450 ± 0.10	5.04 ± 0.00	6.506 ± 0.21
		0.3	0.405 ± 0.03	5.05 ± 0.00	6.474 ± 0.14
		0.5	0.450 ± 0.08	5.08 ± 0.00	6.929 ± 0.36
	Coriander extract	0.1	0.450 ± 0.01	5.07 ± 0.00	6.597 ± 0.48
		0.3	0.443 ± 0.15	5.07 ± 0.00	6.428 ± 0.25
		0.5	0.436 ± 0.05	5.08 ± 0.01	6.718 ± 0.18
21.	Control		0.159 ± 0.06	5.22 ± 0.00	6.805 ± 0.27
	Sage extract	0.1	0.171 ± 0.05	5.13 ± 0.00	6.375 ± 0.12
		0.3	0.180 ± 0.01	5.11 ± 0.00	6.305 ± 0.03
		0.5	0.175 ± 0.07	5.16 ± 0.00	6.305 ± 0.24
	Rosemary extract	0.1	0.250 ± 0.03	5.05 ± 0.00	6.212 ± 0.31
		0.3	0.143 ± 0.12	5.09 ± 0.00	6.924 ± 0.50
		0.5	0.107 ± 0.03	5.03 ± 0.00	6.365 ± 0.39
	Dill extract	0.1	0.180 ± 0.09	5.12 ± 0.00	6.663 ± 0.01
		0.3	0.266 ± 0.01	5.06 ± 0.00	6.372 ± 0.52
		0.5	0.180 ± 0.08	5.08 ± 0.00	6.552 ± 0.05
	Coriander extract	0.1	0.179 ± 0.02	5.09 ± 0.00	6.597 ± 0.06
		0.3	0.180 ± 0.06	5.08 ± 0.00	6.500 ± 0.65
		0.5	0.179 ± 0.01	5.09 ± 0.01	6.479 ± 0.12
28.	Control		0.525 ± 0.06	5.04 ± 0.00	6.275 ± 0.22
	Sage extract	0.1	0.450 ± 0.04	5.09 ± 0.01	6.569 ± 0.38
		0.3	0.449 ± 0.12	5.02 ± 0.00	6.513 ± 0.02
		0.5	0.423 ± 0.01	5.07 ± 0.00	6.805 ± 0.25
	Rosemary extract	0.1	0.437 ± 0.03	4.98 ± 0.01	5.960 ± 0.34
		0.3	0.360 ± 0.11	4.99 ± 0.00	6.021 ± 0.32
		0.5	0.393 ± 0.02	4.96 ± 0.00	6.091 ± 0.12
	Dill extract	0.1	0.313 ± 0.01	5.05 ± 0.00	6.179 ± 0.02
		0.3	0.495 ± 0.03	4.98 ± 0.01	6.552 ± 0.31
		0.5	0.400 ± 0.17	5.01 ± 0.00	6.361 ± 0.24
	Coriander extract	0.1	0.358 ± 0.05	5.04 ± 0.00	6.167 ± 0.03
		0.3	0.357 ± 0.11	5.04 ± 0.00	6.538 ± 0.25
		0.5	0.360 ± 0.06	5.04 ± 0.00	6.597 ± 0.15
35.	Control		0.359 ± 0.02	4.72 ± 0.00	5.966 ± 0.25
	Sage extract	0.1	0.428 ± 0.08	4.59 ± 0.01	5.575 ± 0.18
		0.3	0.452 ± 0.05	4.59 ± 0.00	5.585 ± 0.45
		0.5	0.414 ± 0.12	4.64 ± 0.00	5.659 ± 0.28
	Rosemary extract	0.1	0.214 ± 0.01	4.55 ± 0.00	5.225 ± 0.56
		0.3	0.268 ± 0.11	4.55 ± 0.00	5.124 ± 0.09
		0.5	0.267 ± 0.08	4.49 ± 0.00	5.224 ± 0.34
	Dill extract	0.1	0.526 ± 0.11	4.56 ± 0.00	5.378 ± 0.25
		0.3	0.528 ± 0.02	4.56 ± 0.01	5.817 ± 0.16
		0.5	0.438 ± 0.05	4.54 ± 0.00	5.739 ± 0.03
	Coriander extract	0.1	0.522 ± 0.02	4.57 ± 0.00	5.597 ± 0.28
		0.3	0.540 ± 0.08	4.56 ± 0.00	5.994 ± 0.09
		0.5	0.628 ± 0.01	4.56 ± 0.00	5.618 ± 0.11
42.	Control		0.401 ± 0.02	4.59 ± 0.00	5.702 ± 0.32
	Sage extract	0.1	0.403 ± 0.01	4.60 ± 0.01	5.585 ± 0.25
		0.3	0.383 ± 0.05	4.61 ± 0.00	5.634 ± 0.48
		0.5	0.353 ± 0.10	4.67 ± 0.00	5.811 ± 0.15
	Rosemary extract	0.1	0.264 ± 0.01	4.59 ± 0.00	7.739 ± 0.25
		0.3	0.216 ± 0.09	4.60 ± 0.00	7.826 ± 0.02
		0.5	0.243 ± 0.04	4.53 ± 0.00	7.934 ± 0.15
	Dill extract	0.1	0.431 ± 0.06	4.62 ± 0.01	5.235 ± 0.44
		0.3	0.460 ± 0.02	4.56 ± 0.00	5.198 ± 0.32
		0.5	0.459 ± 0.11	4.58 ± 0.00	5.162 ± 0.25
	Coriander extract	0.1	0.414 ± 0.04	4.56 ± 0.00	5.061 ± 0.16
		0.3	0.386 ± 0.18	4.57 ± 0.00	5.943 ± 0.72
		0.5	0.327 ± 0.32	4.62 ± 0.00	5.305 ± 0.24

x: Normal frequency curve; σ : Coefficient of variation

the results of microbiologic analyses carried out on salt solution and standard deviation values belonging to these is presented in Tables 3 and 4, respectively.

The effect of salt concentration is possible. But, it can be easily said that the volatile oil and extracts, forming energy together with salt, lowered the amount of bacteria. Especially, phenolic and terpenoid compounds in composition may have

caused decrease in the number of total bacteria. Coliform group bacteria identified in some samples, at the end of the first week, disappeared at the end of 3rd week and they could not be identified in the subsequent analyses. In addition, in the samples added volatile oil and extract, it was observed that coliform group bacteria observed at the end of first week disappeared more rapidly.

TABLE-3
MICROBIOLOGICAL ANALYSES OF CAPER PICKLING BRINE WITH ESSENTIAL OIL

Day	Range of product	Concentration (%)	Total bacteria log (cfu/mL × 10 ⁴) (G ± σ)	Coliform bacteria log (cfu/mL × 10 ⁴) (G ± σ)	Lactic acid bacteria log (cfu/mL × 10 ⁴) (G ± σ)
7.	Control		0	4.589 ± 0.11	—
	Sage essential oil	0.01	6.946 ± 0.03	4.238 ± 0.24	—
		0.03	6.865 ± 0.18	2.150 ± 2.15	—
		0.05	6.829 ± 0.05	—	—
	Rosemary essential oil	0.01	6.866 ± 0.39	2.000 ± 2.00	—
		0.03	6.922 ± 0.08	—	—
		0.05	6.293 ± 0.05	—	—
	Dill essential oil	0.01	7.180 ± 0.12	—	—
		0.03	6.772 ± 0.07	4.000 ± 0.00	—
		0.05	6.349 ± 0.35	—	—
	Coriander essential oil	0.01	7.126 ± 0.38	—	—
		0.03	6.557 ± 0.56	—	—
		0.05	6.150 ± 0.15	—	—
14.	Control		6.861 ± 0.08	2.000 ± 2.00	—
	Sage essential oil	0.01	5.398 ± 0.00	—	—
		0.03	6.778 ± 0.16	—	—
		0.05	5.732 ± 0.08	—	—
	Rosemary essential oil	0.01	5.287 ± 0.11	—	—
		0.03	5.333 ± 0.13	—	—
		0.05	5.227 ± 0.05	—	—
	Dill essential oil	0.01	5.566 ± 0.05	—	—
		0.03	5.094 ± 0.15	—	—
		0.05	4.906 ± 0.21	—	—
	Coriander essential oil	0.01	6.014 ± 0.03	—	—
		0.03	5.648 ± 0.01	—	—
		0.05	5.475 ± 0.04	—	—
21.	Control		6.748 ± 0.02	—	—
	Sage essential oil	0.01	4.716 ± 0.24	—	—
		0.03	4.150 ± 0.15	—	—
		0.05	4.521 ± 0.52	—	—
	Rosemary essential oil	0.01	—	—	—
		0.03	4.628 ± 0.15	—	—
		0.05	4.772 ± 0.07	—	—
	Dill essential oil	0.01	4.962 ± 0.12	—	—
		0.03	4.978 ± 0.02	—	—
		0.05	—	—	—
	Coriander essential oil	0.01	4.651 ± 0.05	—	—
		0.03	5.318 ± 0.06	—	—
		0.05	5.113 ± 0.03	—	—
28.	Control		6.659 ± 0.55	—	—
	Sage essential oil	0.01	5.066 ± 0.11	—	—
		0.03	2.000 ± 2.00	—	—
		0.05	—	—	—
	Rosemary essential oil	0.01	2.680 ± 2.68	—	—
		0.03	2.35 ± 2.35	—	—
		0.05	—	—	—
	Dill essential oil	0.01	4.151 ± 0.15	—	—
		0.03	—	—	—
		0.05	—	—	—
	Coriander essential oil	0.01	4.000 ± 0.00	—	—
		0.03	2.000 ± 2.00	—	—
		0.05	—	—	—

35.	Control		6.778 ± 0.48	–	–
	Sage essential oil	0.01	5.230 ± 0.15	–	–
		0.03	5.920 ± 0.06	–	–
		0.05	5.395 ± 0.25	–	–
	Rosemary essential oil	0.01	5.057 ± 0.06	–	–
		0.03	4.952 ± 0.05	–	–
		0.05	–	–	–
	Dill essential oil	0.01	5.190 ± 0.01	–	–
		0.03	5.127 ± 0.05	–	–
		0.05	4.772 ± 0.07	–	–
	Coriander essential oil	0.01	5.159 ± 0.05	–	–
		0.03	4.977 ± 0.02	–	–
		0.05	4.962 ± 0.12	–	–
42.	Control		6.394 ± 0.71	–	–
	Sage essential oil	0.01	5.791 ± 0.07	–	–
		0.03	4.900 ± 0.05	–	–
		0.05	5.569 ± 0.06	–	–
	Rosemary essential oil	0.01	5.467 ± 0.05	–	–
		0.03	6.482 ± 0.63	–	–
		0.05	–	–	–
	Dill essential oil	0.01	2.150 ± 2.15	–	–
		0.03	5.025 ± 0.18	–	–
		0.05	4.540 ± 0.06	–	–
	Coriander essential oil	0.01	2.150 ± 2.15	–	–
		0.03	2.540 ± 2.54	–	–
		0.05	2.000 ± 2.00	–	–

G: Logarithmic frequency curvefre; σ : Coefficient of variation; –: Not process

TABLE-4
MICROBIOLOGICAL ANALYSES OF CAPER PICKLING BRINE WITH EXTRACT

Day	Range of product	Concentration (%)	Total bacteria log (cfu/mL × 10 ⁴) (G ± σ)	Coliform bacteria log (cfu/mL × 10 ⁴) (G ± σ)	Lactic acid bacteria log (cfu/mL × 10 ²) (G ± σ)
7.	Control		6.820 ± 0.10	4.589 ± 0.11	–
	Sage extract	0.1	6.976 ± 0.23	–	–
		0.3	6.540 ± 0.24	4.150 ± 0.15	–
		0.5	6.150 ± 0.15	–	–
	Rosemary extract	0.1	6.000 ± 0.00	–	–
		0.3	7.050 ± 0.18	4.150 ± 0.15	–
		0.5	6.588 ± 0.11	–	–
	Dill extract	0.1	6.423 ± 0.42	4.389 ± 0.09	–
		0.3	6.150 ± 0.15	–	–
		0.5	6.472 ± 0.171	–	–
	Coriander extract	0.1	3.000 ± 3.00	–	–
		0.3	6.503 ± 0.14	–	–
		0.5	6.758 ± 0.04	4.000 ± 0.00	–
14.	Control		6.861 ± 0.08	2.000 ± 2.00	–
	Sage extract	0.1	5.264 ± 0.15	–	–
		0.3	4.938 ± 0.46	–	–
		0.5	4.698 ± 0.00	–	–
	Rosemary extract	0.1	6.341 ± 0.00	–	–
		0.3	5.809 ± 0.02	–	–
		0.5	5.240 ± 0.06	–	–
	Dill extract	0.1	5.886 ± 0.07	–	–
		0.3	6.075 ± 0.02	–	–
		0.5	5.690 ± 0.06	–	–
	Coriander extract	0.1	6.748 ± 0.02	–	–
		0.3	6.670 ± 0.02	–	–
		0.5	5.536 ± 0.26	–	–
21.	Control		6.748 ± 0.02	–	–
	Sage extract	0.1	4.929 ± 0.15	–	–
		0.3	4.477 ± 0.00	–	–
		0.5	5.379 ± 0.02	–	–
	Rosemary extract	0.1	5.135 ± 0.09	–	–
		0.3	4.588 ± 0.11	–	–
		0.5	4.451 ± 0.15	–	–
	Dill extract	0.1	4.906 ± 0.21	–	–
		0.3	5.380 ± 0.15	–	–
		0.5	4.724 ± 0.12	–	–

	Coriander extract	0.1	5.734 ± 0.26	—	—
		0.3	5.800 ± 0.05	—	—
		0.5	5.483 ± 0.09	—	—
28.	Control		6.659 ± 0.55	—	—
	Sage extract	0.1	4.000 ± 0.00	—	—
		0.3	4.301 ± 0.00	—	—
		0.5	2.000 ± 2.00	—	—
	Rosemary extract	0.1	2.000 ± 2.00	—	—
		0.3	4.000 ± 0.00	—	—
		0.5	—	—	—
	Dill extract	0.1	5.102 ± 0.10	—	—
		0.3	4.390 ± 0.09	—	—
		0.5	—	—	—
	Coriander extract	0.1	2.389 ± 2.39	—	—
		0.3	—	—	—
		0.5	—	—	—
35.	Control		6.778 ± 0.48	—	—
	Sage extract	0.1	5.167 ± 0.09	—	—
		0.3	5.054 ± 0.15	—	—
		0.5	4.951 ± 0.05	—	—
	Rosemary extract	0.1	4.929 ± 0.15	—	—
		0.3	5.000 ± 0.00	—	—
		0.5	—	—	—
	Dill extract	0.1	5.073 ± 0.07	—	—
		0.3	4.903 ± 0.00	—	—
		0.5	—	—	—
	Coriander extract	0.1	5.079 ± 0.00	—	—
		0.3	4.841 ± 0.06	—	—
		0.5	—	—	—
42.	Control		6.394 ± 0.71	—	—
	Sage extract	0.1	4.350 ± 0.35	—	—
		0.3	2.000 ± 2.00	—	—
		0.5	5.159 ± 0.05	—	—
	Rosemary extract	0.1	4.573 ± 0.27	—	—
		0.3	2.540 ± 2.54	—	—
		0.5	4.301 ± 0.00	—	—
	Dill extract	0.1	5.105 ± 0.15	—	—
		0.3	2.540 ± 0.00	—	—
		0.5	4.301 ± 0.00	—	—
	Coriander extract	0.1	4.171 ± 0.13	—	—
		0.3	5.218 ± 0.37	—	—
		0.5	4.752 ± 0.15	—	—

G: Logarithmic frequency curve; σ: Coefficient of variation; —: Not process

Conclusion

During production of pickle, lactic acid fermentation, among these fermentation events, becomes dominant and lactic acid bacteria is expected to prevail in environment. One of the most important factors determining the course of fermentation is the starting concentration so that fermentation proceeds rapidly in low salt concentrations such as 5-8 % beside the rapid development of fermentation, low salt concentration cause to develop the undesirable microorganisms in the environment. In addition, in higher concentrations such as 10-20 %, fermentation can proceed slowly or cannot occur.

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