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Use of Salt-Tolerant Lactic Acid Bacteria for Manufacture of White Pickled Cheese (Domiati) Ripened Without Salted Whey in Sealed Polyethylene Pouches

S. M. EL–GENDY*, H. ABDEL–GALIL, Y. SHAHIN and F. Z. HEGAZI

Department of Food Science, University of Assiut, Assiut, Egypt

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ABSTRACT

White pickled cheeses of the Domiati type were made from a 1:1 mixture of raw cows' and buffaloes' milk (5.5% fat) with and without heating momentarily to 72°C. To cheese milk were added: (*a*) 6.5% salt + 2% *Lactobacillus casei* subsp. *pseudoplantarum* 333C starter, (*b*) 9% salt + 2% *Lactobacillus casei* starter, (*c*) 9% salt + 2% *Pediococcus* sp. 452 starter, (*d*) 9% salt + 2% *Leuconostoc paramesenteroides* II47 starter; control cheeses were made from raw milk with either 6.5 or 9% salt. Finished cheeses were sealed in polyethylene pouches without salted whey and ripened at ambient temperature (10-25°C) for up to 5 months. Pouch-cheeses ripened without salted whey were generally attractive, uniform creamy in color, had a firm body, waxy buttery smooth texture and a pleasant flavor. Milk with 6.5% salt appeared to be preferable to milk with 9% salt for making the cheese. The highest organoleptic scores were achieved by cheese made from milk heated momentarily to 72°C and which received 6.5% salt and 2% *L. casei* starter. Inoculation of both raw and heated milk containing 9% salt with either *L. casei* subsp. *pseudoplantarum* 333C, *Pediococcus* sp. 452 or *L. paramesenteroides* II47 improved cheese flavor. Limburger cheese flavor was occasionally and yeasty flavor most frequently encountered. All cheeses had high DM, fat, total and soluble N, and amino acid N, with only little loss of their nutritive constituents when compared with reported values for cheese ripened in the normal way. Increasing the salt percentage in cheese milk reduced the total protein recovered in cheese. None of the cheese components examined seemed to be associated with high flavor scores. No correlation could be established between the number and types of lactic acid bacteria found and flavor intensity.

Most of the white pickled cheese of the Domiati type marketed in Egypt is produced from salted raw milk in small private dairy plants. Because of use of raw milk, lack of installations (for pasteurization of milk and sterilization of equipment) and use of large amounts of salt (up to 12%) to suppress coliform bacteria, the resultant cheese is variable in quality. This cheese, however, is not hazardous to public health because of the high percentage of salt used and the long ripening period which sometimes is 6 months, during which pathogens usually die. The quality of the resultant cheese depends largely on the quality of raw milk used. If the milk from the beginning is of low bacterial count and initially contains desirable lactic acid bacteria, a cheese of good quality would be expected; but in several instances the cheese has unpleasant flavor, is of poor body and texture and has off-flavors. Moreover, the conventional ripening process of the finished cheese under salted whey in tinplate cans usually leads to a loss of fat and soluble nitrogen in the salted whey during a long ripening period. The cans filled with cheese and salted whey are also not economical as they can be punctured and cost much in storage and transport.

In this work, the organoleptic properties, chemical composition and microbial flora of cheese as affected by type of starter culture used, percentage of salt added to milk and ripening without salted whey were studied.

MATERIALS AND METHODS

Milk used in these experiments was a 1:1 mixture of cows' and buffaloes' milk (5.5% fat) obtained from the faculty herd. Raw milk and milk heated momentarily to 72°C received the following treatments: (*a*) addition of 6.5% salt and 2% *Lactobacillus casei* subsp. *pseudoplantarum* 333C starter, (*b*) 9% salt and 2% of the same *L. casei* starter, (*c*) 9% salt and 2% *Pediococcus* sp. 452 starter, (*d*) 9% salt and 2% *Leuconostoc paramensenteroides* II47 starter. Raw milk with either 6.5 or 9% salt (according to treatment) but without inoculation with starter was used to produce the control cheeses. Three 10-kg portions of milk were used to manufacture the different batches of cheese in each treatment. Starter cultures were isolated from 9 to 12% salted raw milk incubated at 30°C for 4-21 d (*7*). Two trials involved making cheese by the standard make procedure.

Ripening of the finished cheese was carried out without salted whey according to Hegazi (*12*) by sealing the cheeses in polyethylene pouches in place of tinplate cans and storing cheeses at ambient temperature (10-25°C) for up to 5 months.

Organoleptic assessment, chemical and bacteriological analyses of cheeses were done at 5 months of age, using two samples per variable for each analysis.

Organoleptic assessment

Scores were given according to the following schedule: general appearance 10, body and texture 30 and flavor 60.

Chemical analysis

Titratable acidity, moisture and soluble nitrogen content of cheese were determined by methods of the A.O.A.C. (*3*); total nitrogen by the semi-

TABLE 1. *Organoleptic assessment of Domiati cheese (5-months-old) made with salt-tolerant starters in different treatments and ripened without salted whey in sealed polyethylene pouches (average of 2 trials).*

Starter	Treatment	General appearance (10)[a]	Body and texture (30)[a]	Flavor (60)[a]	Total (100)[a]
	raw with 6.5% salt	9.0	28.0	54.0	91.0
	raw with 6.5% salt + starter	8.5	26.5	50.0	85.0
	heated[b] with 6.5% salt + starter	10.0	30.0	57.0	97.0
L. casei subsp. *pseudoplantarum* 333C	raw with 9.0% salt	8.5	26.5	46.5	81.5
	raw with 9.0% salt + starter	9.5	28.5	54.0	92.0
	heated with 9.0% salt + starter	10.0	29.0	49.5	88.5
	raw with 9.0% salt	9.0	29.0	43.5	81.5
Pediococcus sp. 452	raw with 9.0% salt + starter	9.0	29.0	54.0	92.0
	heated with 9.0% salt + starter	9.0	29.5	49.5	88.0
	raw with 9.0% salt	8.5	28.0	37.5	74.0
Leuconostoc paramesenteroides II47	raw with 9.0% salt + starter	9.5	29.0	48.0	86.5
	heated with 9.0% salt + starter	9.0	29.0	51.0	89.0

[a]Maximum possible score/
[b]Heated momentarily to 72°C.

micro Kjeldahl method (*19*) and amino acid nitrogen by the method adopted by Nassib (*16*). Determination of fat was carried out according to Ling (*13*). The pH of cheese was measured electrometrically by the B.S.I's method (*4*).

Bacteriological analysis

The methods adopted were mentioned elsewhere (*7*), except that a 10-g portion of cheese was used for each analysis.

RESULTS AND DISCUSSION

Ripening without salted whey in sealed polyethylene pouches had a favorable effect on formation of flavor, consistency and appearance of cheese. Results of the organoleptic assessment of cheeses from different treatments are in Table 1. The cheeses were generally attractive, uniformly creamy in color, had a firm body, waxy buttery smooth texture and a pleasant flavor. Flavor scores averaged 54, 50, 49 and 46 for cheeses made from 6.5% salted milk with *L. casei* starter and in cheeses made from 9% salted milk with either *L. casei, Pediococcus* or *L. paramesenteroides,* respectively. Addition of 6.5% salt to cheesemilk appeared to be preferable to 9% salt. The highest organoleptic scores were obtained with cheese made from milk heated momentarily to 72°C and that received 6.5% salt and 2% *L. casei* starter. Addition of either *L. casei, Pediococcus* sp. or *L. paramesenteroides* to both raw and pasteurized milk containing 9% salt improved Domiati cheese flavor. In any event, salt added to raw milk should not exceed 9% since this amount has been found to be quite enough to suppress *Enterobacter aerogenes,* the most salt-tolerant gas-forming organisms in milk, without giving cheese too salty to be palatable (*1*). Some of the cheeses manufactured from 9% salted raw milk scored lowest for flavor.

Raw milk cheese occasionally had a typical Limburger cheese flavor probably due to the activity of arthrobacters, coryneforms and similar organisms which may occur on the cheese surface (*2,6*). Yeasty flavor also was frequently encountered in both raw and pasteurized milk cheese. These defects, however, could be overcome by packing of cheese in hermetically sealed containers (*12*).

In large dairy plants where pasteurization facilities are available, manufacture of cheese from heated milk with 6.5% salt and 2% *L. casei* is most applicable. In small private dairy plants, under primitive conditions, inoculation of 9% salted raw cheese milk with 2% *L. casei* is recommended.

The composition of cheese from various treatments is given in Table 2. All cheeses had high DM, total and soluble N and amino acid nitrogen compared with values obtained by other investigators (*17,18*) for white pickled cheese ripened in the normal way in a brine solution. Mahmoud and Kosikowski (*14*) also found the fat, protein and TS to be higher in pouched than in brined cheese.

Cheeses produced from 9% salted milk generally retained more moisture than did cheese from 6.5% salted milk and the total protein recovery was reduced. The high DM and low protein contents were related to the high fat and high salt content of milk, respectively. Dariani et al.

TABLE 2. *Composition of Domiati cheese (5-months-old) made with salt tolerant starters in different treatments and ripened without salt whey in sealed polyethylene pouches (average of 2 trials).*

Starter	Treatment	pH	Acidity (%)	Moisture (%)	Fat (%)	T.N. (%)	S.N. (%)	Amino N (mg/100 g)
	raw with 6.5% salt	5.4	1.58	42.74	31.5	4.43	1.50	291
	raw with 6.5% salt + starter	5.0	1.43	46.16	28.0	4.20	1.29	266
	heated with 6.5% salt + starter	5.4	1.41	45.48	29.5	3.50	0.96	84
L. casei subsp. *pseudoplantarum* 333C	raw with 9.0% salt	4.4	1.51	44.41	28.5	3.09	1.31	298
	raw with 9.0% salt + starter	4.3	1.32	46.49	30.0	2.65	1.18	154
	heated with 9.0 salt + starter	4.2	1.15	45.66	26.0	2.78	1.27	241
	raw with 9.0% salt	4.7	1.57	45.16	29.5	3.30	1.40	154
Pediococcus sp. 452	raw with 9.0% salt + starter	4.9	1.66	48.80	27.0	2.88	1.26	245
	heated with 9.0% salt + starter	5.1	1.46	46.49	28.5	2.87	1.26	211
	raw with 9.0% salt	5.1	1.59	46.94	29.5	3.42	1.08	221
Leuconostoc paramesenteroides II 47	raw with 9.0% salt + starter	4.7	1.43	51.64	26.0	2.97	1.25	166
	heated with 9.0% salt + starter	4.1	1.34	50.55	28.0	3.10	1.16	161

(5) salted pasteurized (145°F for 30 min) cheese milk at 5 or 7%, and found that increasing the salt from 5 to 7% reduced protein recovery in all cheeses, which is in consistent with the results obtained here by raising the salt from 6.5 to 9%.

Raw-milk cheese showed an increased moisture content and generally a decreased acidity when the milk was inoculated with starter. In this connection, El-Koussy et al. (*10*) reported that addition of starter to cheese milk did not significantly affect the cheese moisture or acidity. Nagmoush et al. (*15*), using 0.1 or 3% of a 1:1 *Streptococcus lactis*/*Lactobacillus bulgaricus* starter, also found no apparent effect on cheese composition or quality, whereas Farhat and Mahran (*11*) obtained Domiati cheese that was too soft when they used ≥2% *S. lactis* starter.

Cheeses made from raw milk or 6.5% salted milk generally showed higher development of acidity than those made from heated milk or 9.0% salted milk. El-Koussy et al. (*9*) noted that heating and high salt concentrations each decreased the rate of increase of acidity in fresh cheese and in cheese during storage. Heated-milk cheeses also generally had higher moisture, but lower total and soluble N contents than did raw-milk cheeses. An increase in the moisture content with increasing the heating temperature of cheese milk was reported by El-Koussy et al. (*8*). Cheeses made from heated milk with 6.5% salt contained 28% of their total N (vs. 35.8% for the control cheese) in the soluble form, whereas this percentage was higher in cheeses from heated milk with 9% salt than in control cheeses. The amino N content was often lower in the cheeses from different treatments than in the raw-milk cheese without starter. Findings of Saleem and Abd-El-Salam (*20*) that 3-month-old cheese made from flash-heated to 70°C had a higher soluble N content and soluble N/total N ratio than did raw-milk cheeses are not in full agreement with our results.

None of cheese constituents determined seemed to be associated with high flavor scores; the acidity, moisture, fat and soluble nitrogen contents of the cheeses showed no definite effect.

The microbial flora of cheeses from different treatments consisted mainly of lactic acid bacteria. Only the aerobic plate count is given in Table 3. Cheese which achieved the highest flavor scores and was manufactured from heated milk containing 6.5% salt inoculated with 2% *L. casei* starter had 0.2 to 1.1 million lactic acid bacteria/g; the values were 0.038 to 5.7 million when 9% salt was used. The flavor intensity in cheese appears not to be correlated with the level of lactobacilli present at the time of testing. *L. casei* was the most widely distributed of the species, nearly always present in treatments of trial II, predominating in most of the cheeses, irrespective of salt concentration and type of starter used. Most of the cheeses in trial I, which had been made from milk inoculated with *L. casei*, failed to show its presence at the time of testing. *Pediococcus* sp. was the third in frequency of distribution after the yeasts, whilst leuconostocs were not encountered. *L. plantarum* was also isolated in these experiments, but with lower fre-

TABLE 3. *Aerobic plate count of Domiati cheese (5-month-old) made with salt-tolerant starters in different treatments and ripened without salted whey in sealed polyethylene pouches (average of 2 trials).*

Starter	Treatment	Count/g
L. casei subsp. *pseudoplantarum* 333C	raw with 6.5% salt	7.6×10^5
	raw with 6.5% salt + starter	1.3×10^6
	heated with 6.5% salt + starter	1.4×10^6
	raw with 9.0% salt	9.9×10^5
	raw with 9.0% salt + starter	3.2×10^6
	heated with 9.0% salt + starter	2.9×10^6
Pediococcus sp 452	raw with 9.0% salt	2.5×10^6
	raw with 9.0% salt + starter	1.8×10^6
	heated with 9.0% salt + starter	8.9×10^5
Leuconostoc paramesenteroides II47	raw with 9.0% salt	1.1×10^5
	raw with 9.0% salt + starter	1.6×10^5
	heated with 9.0% salt + starter	1.4×10^6

quency than the other two lactic acid organisms, whereas yeasts occurred most frequently.

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