

Comparison of 2 methods of making kneaded plastic cheese from ewe's milk

SE Kaminarides, V Siaravas, I Potetsianaki

*Laboratory of Dairy Technology, Department of Food Science and Technology,
Agricultural University of Athens, 11855 Athens, Greece*

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Summary — Two methods of making kneaded plastic cheeses from ewe's milk were compared. The first one was the slow acidified curd procedure by biological means, as used in traditional Kasseri cheese, and the second was the rapid acidified curd procedure, by using additional citric acid. Traditional cheese had an 8% higher yield than the chemically acidified one, due to the higher recoveries of milk constituents in cheese (fat, protein, total solids). Differences in pH, ash, Ca, P and NaCl contents of mature cheeses were also observed. In contrast, no significant differences in moisture, fat, protein, soluble-N and quality between the two types of cheese were noted. So, both technologies of kneaded plastic cheese production can be used, but higher yield and mineral retention (Ca and P) were obtained for traditional cheese. The rapid acidified cheese was superior for controlling the acidification process, permeability to NaCl and involved a shorter acidification time of the curd, resulting in potentially better mechanization of the cheesemaking procedure.

kneaded plastic cheese / Kasseri cheese / acidified cheese / ripening

Résumé — *Étude comparative de 2 méthodes de préparation de fromage à pâte filée de lait de brebis. Deux méthodes de préparation de fromage à pâte filée à partir de lait de brebis ont été comparées : la première, dite traditionnelle, était la méthode lente de l'acidification du caillé de façon biologique en cours pour la fabrication du fromage Kasseri, et la seconde, la méthode rapide, consistait en plus à l'utilisation d'acide citrique pour l'acidification du caillé. Les caractéristiques organoleptiques des fromages maturés obtenus étaient presque similaires, mais le rendement des fromages traditionnels était plus élevé de 8% que celui des fromages chimiquement acidifiés. Cette différence était due aux coefficients de rétention des composants du lait (matière grasse, protéines, matière sèche) qui étaient plus élevés pour les fromages traditionnels que pour ceux chimiquement acidifiés. Des différences importantes étaient aussi observées sur les fromages maturés par les 2 technologies, en ce qui concerne les cendres (Ca, P et NaCl) et le pH. En revanche, on n'a pas constaté de différences importantes de l'humidité, de la matière grasse, des protéines et de l'azote soluble. Par conséquent, les 2 technologies de fabrication du fromage à pâte filée peuvent être utilisées. Pour les fromages traditionnels, des rendements plus élevés et une meilleure rétention des éléments inorganiques (Ca et P) étaient*

obtenus. En revanche, les fromages rapidement acidifiés permettent un meilleur contrôle de l'acidification du caillé, une perméabilité au NaCl et une vitesse de fabrication accrues. Les fromages chimiquement acidifiés se prêtent donc mieux à une fabrication mécanisée.

fromage à pâte filée / fromage Kasseri / fromage acidifié / affinage

INTRODUCTION

Kasseri cheese is one of the popular traditional cheeses in Greece made from ewe's milk or from a mixture of ewe and goat's milk. Its technology was introduced to Greece from the Balkans 90 years ago (Davis, 1976). It is a semihard cheese with firm texture, without gas holes, having a mild and pleasant flavour and belongs to the pasta filata group. In production of this type of cheese special features are the following two stages: a) production of a drained and acidified curd (pH 5.2–5.4); and b) processing of the acidified curd in hot water or whey (70–80°C), to give the final homogeneous plastic texture. In the traditional way of Kasseri cheese production, the acidification of curd is done in a biological manner where the lactose is transformed to lactic acid by lactic acid bacteria, the pH is reduced while the dicalcium paracaseinate is transformed to monocalcium paracaseinate until it reaches the pH value of 5.2. Monocalcium paracaseinate is responsible for the ability of the acidified curd to be stretched and plasticized after curd kneading in hot water (Kosikowski, 1977). The acidification time of curd by biological means varies from 8 to 72 h and depends mainly on the quality of milk, the use or not of starters and the ripening temperature of the curd.

Despite the fact that Kasseri cheese is consumed in Greece in remarkable quantities and that large amounts of sheep and goat's milk are used, little research has been done (Kalogridou-Vassiliadou and Manolkidis, 1984). Prospects for the future consumption of this type of cheese seem

promising, due to its good organoleptic characteristics and to the fact that its technology is suitable for mechanization as has already begun in the last 10 years. Mechanization and reduction of the curd acidification time can be achieved exclusively by direct acidification of milk using an acid (common practice in Latin American cheeses), or in combination with the biological acidification that has traditionally been used up to now. The combined acidification procedure (chemical + biological) was selected so as to avoid the drastic changes in cheese characteristics, compared with traditional Kasseri cheese, that are caused by the chemical method alone. Citric acid was preferred mainly for three reasons: i) because of its physicochemical properties (solid, pleasant sour odor, not caustic), so it is easily handled; ii) it has been successfully applied to Mozzarella cheese (Kosikowski, 1977); and iii) smaller amounts are required for the acidification of milk in comparison with acetic and lactic acids. The addition of citric acid to the milk is believed to cause some physicochemical changes in cheese.

The object of this study was to determine differences between Kasseri cheese made by the traditional procedure and an acidified plasticized cheese (thus called, because under current Greek legislation this experimental cheese cannot be classified as Kasseri) made by a rapid combined (chemical + biological) method of curd acidification. The cheeses produced by the two methods were compared for yield, recovery of milk solids, physicochemical changes at different stages of ripening and organoleptic evaluation after ripening.

MATERIALS AND METHODS

Cheesemaking

Six replications of experiments on kneaded plastic cheeses were carried out using both the slow biological acidification procedure (*ie* traditional Kasserri cheese) and the rapid chemical acidification procedure (*ie* a plasticized cheese variety like Kasserri) as outlined in figure 1. The standardized, pasteurized milk was split into two parts.

Experimental planning and sampling

Twenty-four cheese-wheels of about 2 kg each produced from 6 trials (12 for each technology) were examined. One cheese-wheel from each technology and production was used for chemical analyses, and the other for measurement of cheese weight and organoleptic evaluation of ripened cheese.

To study the various physicochemical characteristics and the percentage of recovery of milk constituents in cheese, cylindrical samples of cheeses at 0 (the kneaded curd), 10, 20, 30, 60 and 90 days were taken, using a cork borer. Also, organoleptic evaluation of ripened cheese after 90 days of ripening was performed.

Chemical analyses

In samples of the kneaded curd and cheeses, total nitrogen (TN) and dry matter (DM) were determined according to procedures 25 (IDF, 1964a) and 4 (IDF, 1958) of the International Dairy Federation Standards respectively; fat by the Gerber-Van Gulik method (Schneider, 1954); soluble nitrogen (SN) and pH as described by Kosikowski (1977); ash as specified in AOAC (1975); and calcium, phosphorus and citric acid according to procedures 119A (IDF, 1987), 33B (IDF, 1982) and 34A (IDF, 1964b) of the International Dairy Federation. For the measurement of phosphorus and citric acid a Hitachi U-3200 spectrophotometer (Hitachi, Tokyo, Japan) was used. The standard curves computed were:

$$\mu\text{g phosphorus} = -0.304 + 58.824 A_{820\text{nm}} \quad (r^2 = 0.999)$$

$$\mu\text{g citric acid} = 444 A_{428\text{nm}} \quad (r^2 = 0.995)$$

and the results expressed as a percentage of cheese. For calcium measurement, a Perkin Elmer 380 atomic absorption spectrophotometer (Perkin Elmer, Norwalk, CN) was used.

The results are given as the averages of 18 analyses from six trials.

Organoleptic evaluation

Cheeses were examined for flavour (scale 0–30), texture (scale 0–15) and colour (scale 0–5) by a panel of ten expert judges who had the ability to evaluate Kasserri cheese. Also, the judges were asked to note any defects in flavour (*eg* rancid, acid, bitter, etc) and texture (*eg* crumbly, granular, sandy, hard, etc) and to note any other comments.

Statistical analysis

The statistical significance of the difference of the various characteristics for the cheeses produced using the traditional and rapid technology, was evaluated using the pairwise comparison of *t*-test using G B Stat programme (Friedman and Howard, 1991).

RESULTS AND DISCUSSION

Yield and recovery of milk constituents in cheese

The different process in the acidification of the curd before kneading presents practical interest for the selection of data related to the yield and recovery of milk constituents in cheese derived from the two cheese making methods. So, to collect these data, sheep's milk of known composition was used and the chemical composition of kneaded plastic cheeses produced by the two methods was determined (see table I).

Comparison of conventional and acidified cheeses is shown in table I. The only different parameters are pH, calcium, phos-

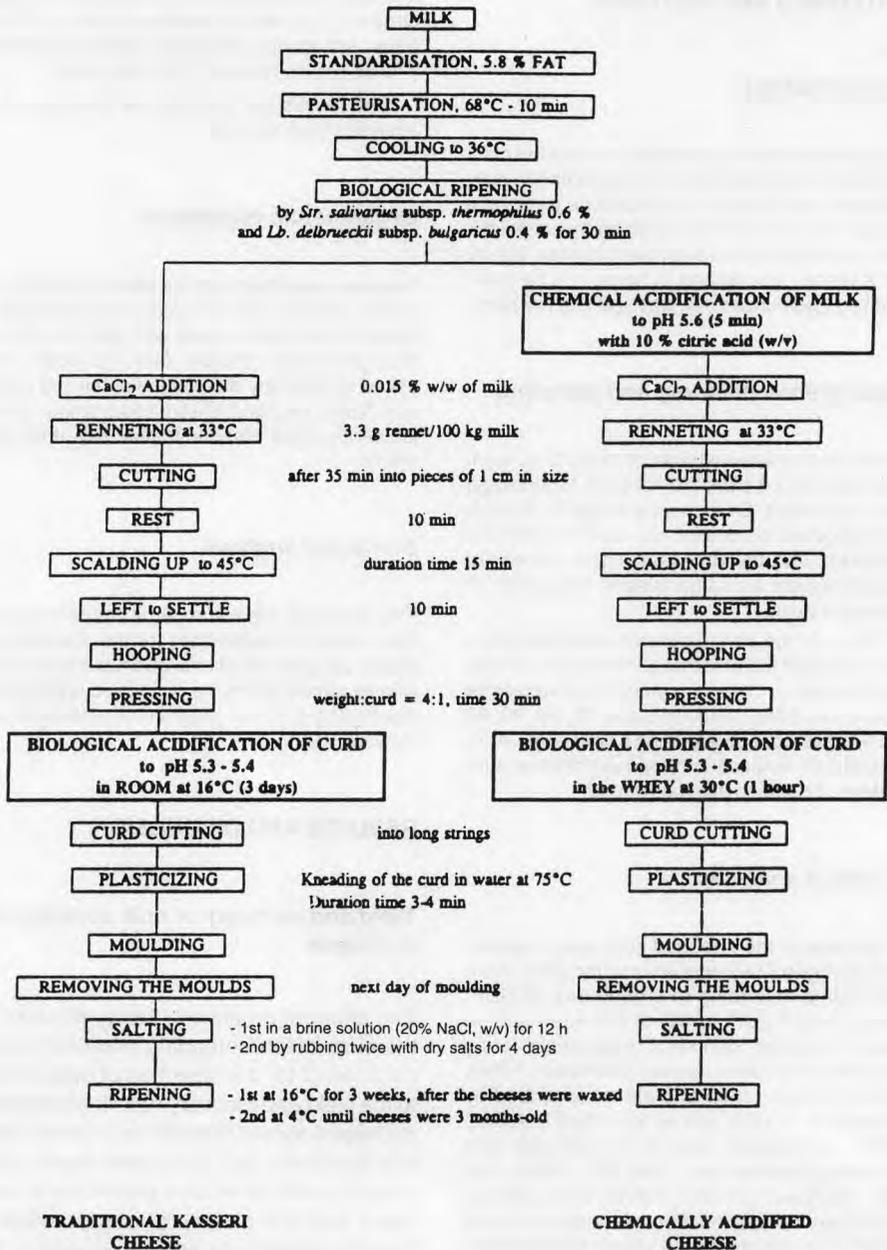


Fig 1. Flow chart for the manufacturing of Kasseri cheese and an acidified plastic cheese variety like Kasseri from sheep milk.
Diagramme de fabrication du fromage Kasseri et du fromage acidifié de type Kasseri à partir du lait de brebis.

Table I. Physicochemical characteristics of milk and ripened plastic cheeses produced by traditional and rapid acidified method.*Caractéristiques physicochimiques du lait et des fromages affinés à pâte filée fabriqués de façon traditionnelle et rapidement acidifiés.*

Physicochemical characteristics of milk and ripe cheeses of 90 days	Milk		90-days-old cheese				Statistical analysis
			Traditional		Acidified		
	\bar{X}	$S_{\bar{x}}$	\bar{X}	$S_{\bar{x}}$	\bar{X}	$S_{\bar{x}}$	
Moisture (%)	83.51 ± 0.40		43.90 ± 0.56		42.75 ± 0.76		NS
Fat (%)	5.80 ± 0.10		23.98 ± 0.62		25.00 ± 0.43		NS
Protein (%) (Total N x 6.38)	5.11 ± 0.06		25.50 ± 0.50		25.66 ± 0.64		NS
Soluble N (%)	0.19 ± 0.01		0.41 ± 0.10		0.46 ± 0.06		NS
Ash (%)	0.84 ± 0.01		4.73 ± 0.21		4.19 ± 0.15		*
Calcium (%)	0.12 ± 0.01		0.68 ± 0.04		0.41 ± 0.02		**
Phosphorous (%)	0.13 ± 0.002		0.54 ± 0.02		0.39 ± 0.02		**
pH	6.54 ± 0.02		5.69 ± 0.01		5.48 ± 0.04		**

\bar{X} = means of 6 trials; $S_{\bar{x}}$ standard error of mean; * significant difference at $P = 0.05$; ** significant difference at $P = 0.01$; and NS = no significant difference.

\bar{X} = moyenne de 6 essais; $S_{\bar{x}}$ erreur standard; * différence significative à $P = 0,05$; ** différence significative à $P = 0,01$; et NS = différence non significative.

phorus (at $P = 0.01$) and ash (at $P = 0.05$). Acidified cheeses had lower ash, Ca, P and pH values, reflecting the effect of acidification of milk on the demineralization of the micelle (Brulé and Lenoir, 1986).

Table II presents a comparison of the two methods on the yield (%) of the curd directly after kneading and following 90 days of subsequent ripening, as well as the total solids, protein, fat and ash recovery in ripened cheese. Results show that the average yield of acidified cheese at the kneading stage of cheese production and during maturation, is lower than that of traditionally made cheese. However, to eliminate the effect of variation in the cheese moisture contents, yields percentages were corrected to 43% moisture. The corrected yield values revealed that the moisture content of cheese did not have an appreciable influence on this parameter. The yield

of ripened cheese adjusted at 43% moisture was found to be 16.1 kg/100 kg milk for the traditional method and 14.8 kg/100 kg milk for the chemical acidification method, meaning a reduction of 8%. This was attributed to losses of various milk constituents (*ie* fat, protein and minerals) to the whey at the draining and plasticizing stages, as well as to curd losses because of the fragility of the acidified gel (Weber, 1986). This is in agreement with lower recovery of total solids, fat, protein and ash in acidified cheese (table II). The lower recovery of fat and total solids in the chemically acidified cheese is in accordance with the findings of Quarne *et al* (1967, 1968) for Mozzarella and Pizza cheese produced by the direct acidification procedure. Fat and total solids recovery for both traditional and acidified cheeses, were lower than for other Greek traditional cheeses made from

Table II. Yield and percentage of conversion of dry matter, fat, protein and ash of sheep's milk of plastic cheeses produced by traditional and rapid acidified method.

Rendement et coefficient de rétention (%) de matière sèche, de matière grasse, de protéine et de cendre de lait de brebis des fromages à pâte filée fabriqués de façon traditionnelle et chimiquement acidifiés.

Yield and percentage recovery	Traditional		Acidified		Statistical analysis
	\bar{X}	$S_{\bar{x}}$	\bar{X}	$S_{\bar{x}}$	
Yield (%)					
– directly after kneading	17.6 ± 0.37		15.5 ± 0.30		**
– at 90-day-old cheese	16.4 ± 0.40		14.7 ± 0.32		**
– corrected to 43% of moisture ¹	16.1 ± 0.28		14.8 ± 0.41		**
Percent recovery ²					
– Total solids	56.8 ± 1.99		51.3 ± 2.38		**
– Fat	68.7 ± 1.65		63.4 ± 2.02		*
– Protein	82.9 ± 1.72		73.8 ± 2.89		*
– Ash	48.0 ± 1.60		23.5 ± 2.64		**

\bar{X} = Means of 6 trials. $S_{\bar{x}}$ standard error of mean; * significant difference at $P = 0.05$; and ** significant difference at $P = 0.01$. ¹ Calculated from the equation $Y_{43\%} = \text{yield of 90-days-old cheese} \times (100 - \text{moisture of cheese}) / 57$. ² Data from ripened cheeses.

\bar{X} Moyenne de 6 essais ; $S_{\bar{x}}$ erreur standard ; * différence significative à $P = 0,05$; ** différence significative à $P = 0,01$. ¹ Calculé à partir de l'équation $Y_{43\%} = \text{rendement du fromage à 90 jours} \times (100 - \text{humidité du fromage}) / 57$. ² Données des fromages affinés.

sheep's milk (Veinoglou *et al*, 1969, 1983; Anifantakis and Kaminarides, 1983). This may be due to losses of fat at the plasticizing stage of pasta filata cheese (Davis, 1976).

Physicochemical changes at ripening

Moisture, fat

The trends in moisture and fat contents during maturation are shown in figure 2. During salting and early curing at 16°C, cheeses lost moisture. Subsequently, when the cheeses were waxed and stored at 4°C, the moisture content diminished slightly as curing continued. The reverse trend was observed for the fat content of cheese because of its concentration. There were

no significant differences ($P > 0.05$) in moisture and fat content between traditional and acidified cheeses.

Proteolysis

The ripening coefficients (SN of the cheese expressed as a percentage of TN) of the cheeses produced by the two methods, were not different ($P < 0.05$). The ripening coefficient of both cheeses increased over the maturation period and more rapidly at the beginning of ripening when cheeses were stored at higher temperature (fig 3). Generally, the rate of proteolysis of this cheese was low, reaching a level of 10% of SN as a percentage of TN in 90-days-old cheese. This was probably attributed to the inactivation of starter and rennet during the kneading of the curd in water at 75°C.

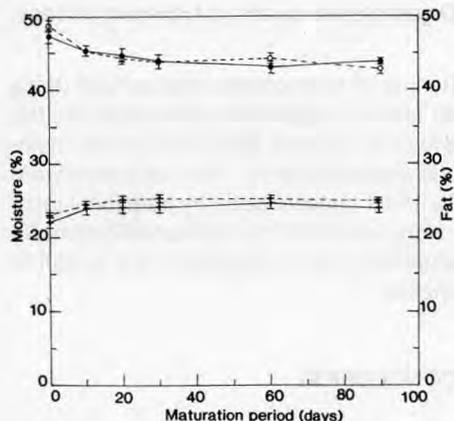


Fig 2. Changes in moisture (●,○) and fat content (+) of kneaded plastic cheeses produced by traditional (—) and rapid acidified (---) manner during maturation. Standard errors of means are indicated by vertical bars.

Changement d'humidité (●,○) et de la matière grasse (+) des fromages à pâte filée fabriqués de façon traditionnelle (—) et rapidement acidifiés (---) durant l'affinage. Les barres indiquent l'écart type de la moyenne.

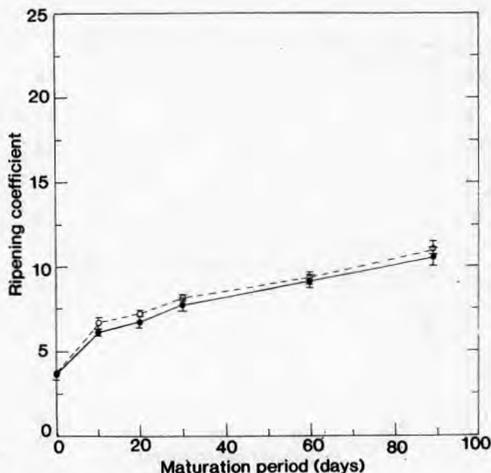


Fig 3. Changes in the ripening coefficient of kneaded plastic cheeses produced by traditional (●—●) and rapid acidified (○—○) means during maturation. Standard errors of means are indicated by vertical bars.

Changement de coefficient de maturation des fromages à pâte filée fabriqués de façon traditionnelle (●—●) et rapidement acidifiés (○—○) durant l'affinage. Les barres indiquent l'écart type de la moyenne.

pH values

Differences in pH of both cheeses were significant ($P < 0.05$) and the average pH of traditional cheese during the 90 days of ripening was higher than that of cheese made by the chemical acidification method (fig 4), mainly due to citric acid. In fact pH increased gradually and reached 5.5 in acidified cheese and 5.7 in traditional cheese after 90 days of maturation. The increase of pH could be due to the salting and protein breakdown in the cheese in combination with thermal processing of the acidified curd.

NaCl

Differences in NaCl content of both cheeses were significant ($P < 0.05$) and showed an increase of salt at the beginning of ripening

which was due to salting (brine and dry salting) during this period of storage (fig 4). It appears that the NaCl content was higher for acidified cheese when compared to that of traditional cheese. This could be attributed to the better diffusion of salt in acidified cheese in the beginning of ripening than in traditionally made cheese, because of the greater permeability of the chemically acidified curd (Weber, 1986).

Citric acid

The mean concentration of citric acid in acidified kneaded curds was 0.35% and after 10 and 90 days of ripening was 0.33% and 0.35% respectively. Consequently, the citric acid was retained almost intact during the maturation of acidified cheese.

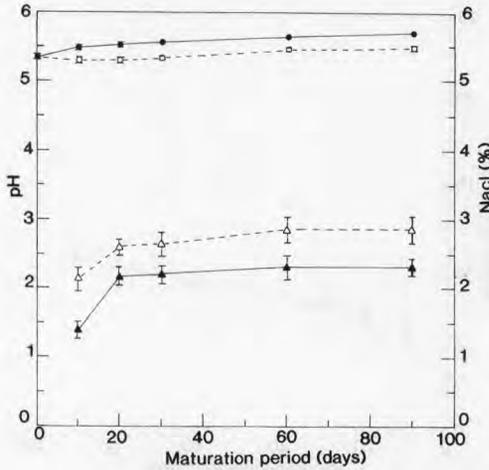


Fig 4. Changes in the pH (●,O) and NaCl content (▲,Δ) of kneaded plastic cheeses produced by traditional (—) and rapid acidified (---) manner during maturation. Standard errors of means are indicated by vertical bars.

Changement du pH (●,O) et de la teneur en NaCl (▲,Δ) des fromages à pâte filée fabriqués de façon traditionnelle (—) et rapidement acidifiés (---) durant l'affinage. Les barres indiquent l'écart type de la moyenne.

Organoleptic quality of ripened cheese

Results of taste panel's assessment (table III) show no significant difference and the quality of cheeses produced by both methods was satisfactory. The total scores were 35.48 for cheese made by traditional technology and 37.37 by rapid acidification. No bitterness was detected in the acidified cheese.

CONCLUSION

The results obtained enable us to draw the following conclusions:

The mature cheeses obtained by both technologies were of good quality and had a similar chemical composition with respect to the moisture, fat, total and soluble proteins as well as organoleptic properties. Both technologies could be applied, each having advantages and disadvantages.

Traditional cheese had a higher yield (due to a higher percentage recovery of milk

Table III. Organoleptic evaluation of ripened kneaded plastic cheeses (90-day-old) produced by traditional and rapid acidified method.

Qualité organoleptique des fromages affinés à pâte filée (90 jours) fabriqués de façon traditionnelle et chimiquement acidifiés.

Organoleptic evaluation	90-day-old cheese				Statistical analysis
	Traditional		Acidified		
	\bar{X}	$S_{\bar{x}}$	\bar{X}	$S_{\bar{x}}$	
Taste (0-30)	20.45 ± 1.58		21.87 ± 1.01		NS
Texture (0-15)	10.87 ± 0.48		11.41 ± 0.41		NS
Colour (0-5)	4.16 ± 0.15		4.08 ± 0.19		NS
Total (0-50)	35.48 ± 2.14		37.37 ± 1.48		NS

\bar{X} Means of 6 cheeses; $S_{\bar{x}}$ standard error of mean; and NS no significant difference at $P = 95\%$.

\bar{X} = moyenne de 6 essais ; $S_{\bar{x}}$ erreur standard ; et NS différence non significative à $P = 95\%$.

constituents in cheese) and higher calcium and phosphorus concentrations.

Acidified cheese had the advantages of greater permeability to NaCl, a lower pH and a reduced acidification process of the curd, resulting in facilitation of the mechanization of the cheesemaking procedure. Moreover, the disadvantage of a lower yield could be decreased if the whey and moulding water were utilized productively (eg production of whey cheese).

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