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Ripening Changes and Quality of Recombined Milk Blue Cheese as Affected by Mould Strain and Salting Method

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ABSTRACT

Blue cheese was made from recombined milk using two strains of P. roqueforti*; namely, 6829 Wiesby and IMI 173224. The resultant cheeses were either dry-salted or brined and ripened for three months. A control cheese was also made from cow's milk by the traditional method. Results showed that neither the type of* P. roqueforti *strain nor the salting method had any marked effect on the gross chemical composition of the blue cheese.*

Blue cheeses ripened with P. roqueforti *strain 6829 Wiesby contained higher levels of water-soluble nitrogen, 12% TCA-soluble nitrogen, 5% PTA-soluble nitrogen, soluble tyrosine and tryptophan, free volatile fatty acids and carbonyl compounds than those ripened with the IMI 173224* P. roqueforti *strain. The formation of these compounds in dry-salted blue cheese was also higher than that salted in brine.*

The organoleptic properties of dry-salted blue cheese made from recombined milk and ripened with P. roqueforti *strain 6829 Wiesby were comparable to those of control cheeses after three months.*

INTRODUCTION

In France, Roquefort cheese is usually made from raw sheep's milk which contains high levels of total solids and short chain fatty acids (Scott, 1981). In different countries, blue cheese is made from pasteurized cow's or goat's milk or their mixtures. Also, buffalo's milk may be used in the manufacture of blue cheese. The unique flavour of the blue cheese is due mainly to the short

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chain fatty acids, methyl ketones, and other compounds which contribute to the peppery taste (Kinsella & Hwang, 1976).

Recombined milk has been used in the manufacture of different varieties of cheeses, such as Cheddar, Mozzarella, Cottage, Dutch-type cheese, Gouda, Edam, White cheese, Fetta, Queso Blanco and Camembert cheeses (Lablée, 1970; Peters & Knoop, 1975; Flangan *et al.*, 1978; Kosikowski, 1978).

However, very little research has been done on the possibility of introducing recombined milk in the manufacture of blue cheese and its effect on ripening changes. Therefore, the present study was devoted to investigating the effects of *P. roqueforti* strain and salting method on the ripening changes and quality of blue cheese made from recombined milk.

MATERIALS AND METHODS

Materials

Fresh cow's milk, low heat non-fat dry milk fortified with vitamins A and D, produced in 1984 in the USA and anhydrous milk fat were obtained from Misr Milk and Food Company, Mansoura, Egypt. A rennet powder (1:100 000) was obtained from L. C. Glad Company A/S, Copenhagen, Denmark. A 'lactic ferment' freeze-dried mixed culture consisting of *S. lactis*, *S. cremoris* and *S. diacetylactis* was obtained from Chr. Hansen Laboratory, Copenhagen, Denmark. This culture was activated before being used in the manufacture of blue cheese. *P. roqueforti* strain 6829 was obtained from Laboratorium Wiesby, GmbH & Company, Federal Republic of Germany. *P. roqueforti* strain IMI 173224 was obtained from the Commonwealth Mycological Institute, Surrey, TW93, UK.

Blue cheese making and methods of analysis

Experimental blue cheeses were manufactured at the Dairy Factory of El-Mansoura, belonging to Misr Milk and Food Company, Egypt, as described by Scott (1981). Control cheese was made from pasteurized cow's milk containing 4% and 8·5% SNF. The pasteurized milk was tempered at 30°C and inoculated with 2% of starter and 1% of Danish blue mould. The cheese making procedure was completed and the resultant cheese was brined (18% brine solution) for two days.

Experimental blue cheese was made from pasteurized recombined milk containing 4% fat and 8·5% SNF. Recombined milk was divided into two equal parts. The first part was inoculated with *P. roqueforti* 6829. The resultant cheese was divided into two portions; the first portion was brined

and the second portion was rubbed with 200 g dry salt for six successive days. The second part of recombined milk was inoculated with the second strain of *P. roqueforti* IMI 173224 and was treated as in the first part. All treatments were carried out in triplicate. The resultant cheese from each treatment was ripened at 10°C and 95% relative humidity for three months.

Samples of blue cheese were taken after salting and monthly during ripening.

Organoleptic properties of blue cheese were evaluated as described by Spreer (1978) with maximum score points of 4·5, 3·5, 2 and 10 for external appearance, internal appearance, odour and taste, respectively.

Cheese samples were analysed for moisture, fat, salt, pH, total nitrogen (TN), water-soluble nitrogen (WSN), 12% trichloroacetic acid-soluble nitrogen (NPN) as described by Ling (1963). 5% Phosphotungstic acid (PTA)-soluble nitrogen (PTA) was determined as reported by Stadhouders (1959). Tyrosine and tryptophan were determined by the method of Lin *et al.* (1982). Total volatile fatty acids (TVFA) were estimated by the method of Kosikowski (1978). Total carbonyl 2, 4-dinitrophenylhydrazone derivatives (DNPH) were prepared according to the method described by Bassett & Harper (1958). Resultant 2,4-DNPH derivatives were dissolved in hexane and their concentrations were determined by measuring the absorbancy of the solutions at 340 nm. The reading was converted to micromoles using a molar extinction coefficient of 22 500 (Schwartz & Parks, 1963).

RESULTS AND DISCUSSION

Gross chemical composition of blue cheese

The changes in the chemical composition of blue cheese made from recombined milk using different *P. roqueforti* strains and different salting methods are shown in Table 1.

Blue cheese made from fresh cow's milk had a higher moisture content than that made from recombined milk. Moreover, the brine-salted blue cheese had a lower moisture content than the dry-salted one. The type of *P. roqueforti* strain showed no marked effect on the moisture content of cheese after salting or during ripening. The moisture contents of both control and experimental cheeses decreased during ripening.

The fat contents of all blue cheeses gradually decreased during ripening. Neither *P. roqueforti* strain nor salting methods greatly affected the fat contents of blue cheeses. However, control blue cheese had a slightly higher fat content than recombined milk blue cheese using both types of *P. roqueforti* strains and salting methods. This might be due to the partial loss

TABLE 1
Gross Chemical Composition of Blue Cheese as Affected by *P. roqueforti* Strain and Salting Methods during Ripening

Property (%)	*Ripening period (months)*	*Control cheese*	*Cheese ripened with*			
			P. roqueforti *6829*		P. roqueforti *IMI 173224*	
			Brine salted	*Dry salted*	*Brine salted*	*Dry salted*
Moisture	F	49·21	45·16	48·31	45·22	47·05
	1	42·90	41·35	43·22	41·98	43·23
	2	38.15	36·69	37·88	34·94	40·34
	3	35·56	32·14	34·28	31·66	33·56
Fat (dry matter)	F	64·97	58·35	60·94	56·58	58·85
	1	61·29	59·68	60·23	56·88	59·01
	2	60·63	58·44	57·79	55·79	60·01
	3	58·97	53·24	54·93	54·18	54·18
Salt (dry matter)	F	5·71	5·29	4·84	5·84	5·48
	1	6·48	5·97	5·81	5·69	5·29
	2	7·44	7·11	5·96	6·61	6·70
	3	7·60	7·30	6·54	7·98	6·17
pH	F	5·07	5·27	5·32	5·02	5·72
	1	5·94	5·63	5·83	5·53	5·52
	2	6·03	5·66	5·97	5·71	5·88
	3	6·14	5·90	5·91	5·82	6·10

F = After salting.

of fat in the whey when blue cheeses were made from recombined milk. The decrease in fat during cheese ripening may be also due to the extensive lipolysis caused by the examined strain. El-Gendy *et al.* (1966) showed a continuous gradual decrease in the fat content of blue cheese during ripening.

Table 1 also shows that salt contents of all blue cheeses, ripened with both strains of *P. roqueforti* and salted by both methods, increased continuously during ripening. However, cheese made from recombined milk had a slightly lower salt level than the control.

The salt content in brined blue cheeses was higher than that of dry-salted cheeses and it increased gradually during ripening. The increase in NaCl content in brined blue cheeses may be due to the increased incorporation of the salt with water during salting. So, it may be concluded that neither the type of *P. roqueforti* strain nor the salting method affected the salt content of blue cheeses.

The pHs of cheeses using the dry salting method were higher than both control cheese and brined cheese. *P. roqueforti* strains showed a slight effect on the pH value of recombined milk cheese using both salting methods. The pH values of all blue cheeses gradually increased during ripening for 3 months.

The pH increased faster in the dry salted blue cheese (using both strains of *P. roqueforti*) than in brined blue cheese.

Rabie (1980) found that the pH of Edelpilzkäse gradually increased during ripening, reaching a maximum value of 5·95 at the end of cheese ripening.

The obtained results for matured blue cheese agree with those obtained by Rabie (1980) and Godinho & Fox (1982).

Ripening indices

Formation of soluble nitrogenous compounds

Proteolyses as measured by the formation of water-soluble N, 12% TCA-soluble N and 5% PTA-soluble N were considered as indices for testing the breakdown of casein.

Changes in WSN

Figure 1 shows the changes in the WSN-contents of recombined milk blue cheeses ripened with *P. roqueforti* 6829 and *P. roqueforti* 173224 using two salting methods.

The results show that recombined milk blue cheese ripened with *P. roqueforti* strain 6289 had a higher level of WSN than that ripened with *P. roqueforti* strain 173224, indicating that the former strain was more strongly proteolytic than the latter.

Moreover, proteolyses occurring in dry-salted recombined milk cheeses ripened with both strains were higher than those of brined blue cheese (Godinho & Fox, 1982).

Changes in 12% TCA soluble N (NPN)

Figure 2 shows the changes in 12% TCA-soluble N (NPN) of recombined milk blue cheese using different *P. roqueforti* strains and salted by two methods. Results indicate that the formation of NPN with *P. roqueforti* 6829 was higher than *P. roqueforti* IMI 173224 in blue cheese using both salting methods. However, the rate of proteolysis of both strains was slightly lower than the control.

Changes in 5% PTA-soluble N (AN)

Figure 3 shows the changes in 5% PTA soluble N (AN) of recombined milk

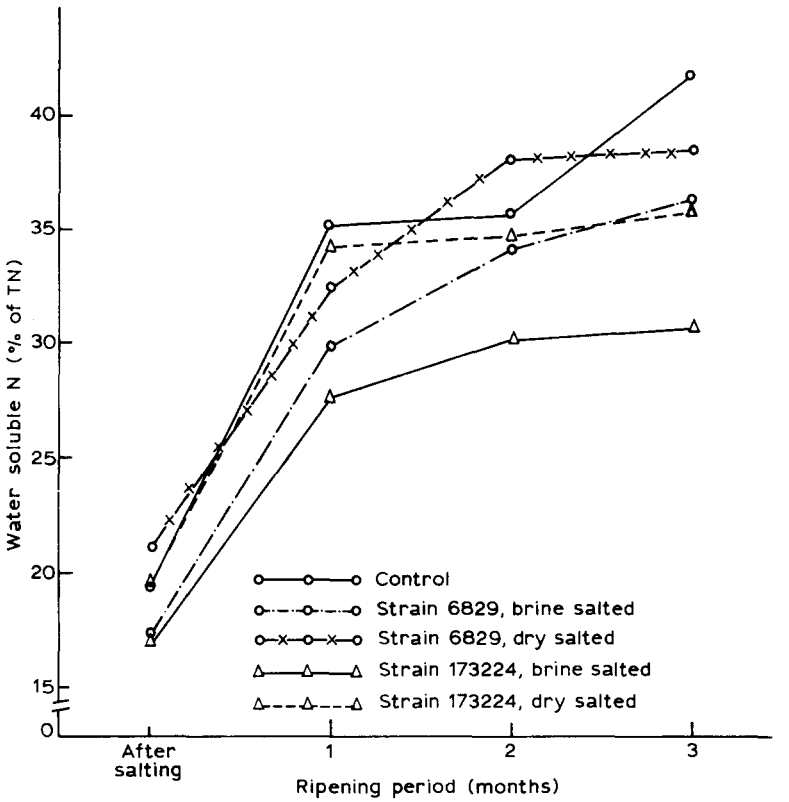

Fig. 1. Changes in water-soluble (% of TN) of recombined milk blue cheese ripened with different *P. roqueforti* strains during maturation.

blue cheese using two strains of *P. roqueforti* and two salting methods.

These results show that the rate of protein breakdown in recombined milk blue cheese using *P. roqueforti* 6829 was higher than that of *P. roqueforti* IMI 173224 in both salting methods.

The dry salting method resulted in higher proteolysis in cheese with both *P. roqueforti* strains than brine salting and this may be due to the irregular salt diffusion in dry salted blue cheese which led to more proteolysis in the centre of the cheese than in the rind. Godinho & Fox (1982) observed a similar trend. Also, the higher salt concentration in the case of brined blue cheese, using both strains, may inhibit the growth of *P. roqueforti* to some extent.

The higher values of SN and NPN could be attributed to the strong effect of endopeptidases produced by *P. roqueforti.* However, the present results were lower than those obtained for French blue cheese and Edelpilzkäse by Gripon & Le Bars (1978) and Rabie (1980), respectively.

The increased rate of 5% PTA-soluble N could be attributed to the action

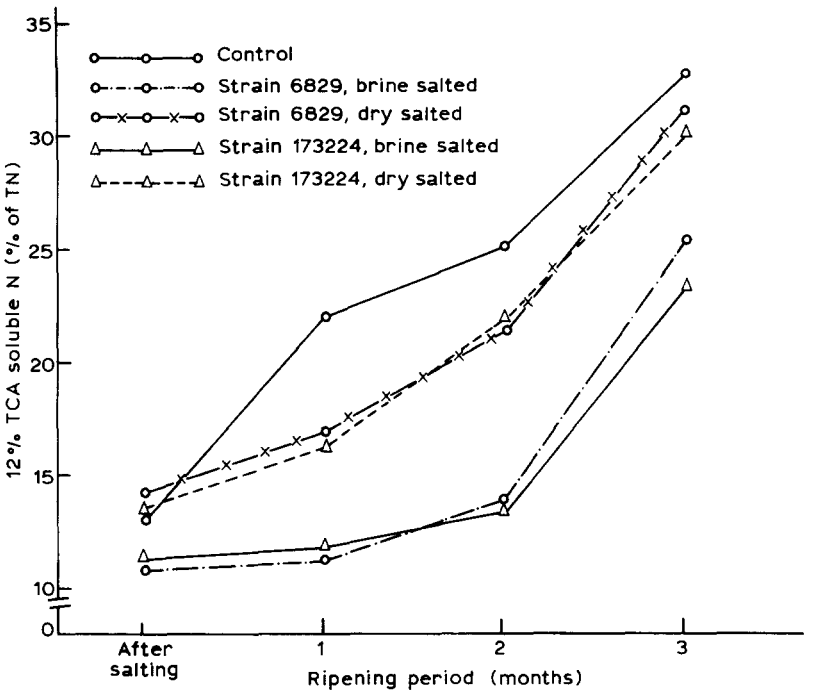

Fig. 2. Changes in 12% TCA-soluble N (% of TN) of recombined milk blue cheese ripened with different *P. roqueforti* strains during maturation.

of exopeptidases produced by *P. roqueforti.* The results for ripened blue cheese agree with those obtained for Edelpilzkäse by Hänni (1967) and Rabie (1980).

Soluble tyrosine and tryptophan

Figures 4 and 5 represent the changes in soluble tyrosine and tryptophan contents of recombined milk blue cheese ripened with different *P. roqueforti* strains and salted by two methods.

The soluble tyrosine and tryptophan in recombined milk blue cheese ripened with *P. roqueforti* 6829 were higher than that of *P. roqueforti* 173224 after salting and during ripening for 3 months in both salting methods. Dry salted blue cheese contained higher concentrations of soluble tyrosine and tryptophan with both *P. roqueforti* strains than brined blue cheese. This may be due to the irregular salt diffusion in dry salted blue cheese which leads to more proteolysis in the centre of the cheese than in the rind (Godinho & Fox, 1982). The higher salt content in the case of brined blue cheese ripened with both strains may inhibit the growth of *P. roqueforti* to some extent leading to irregular distribution of mould throughout the cheese.

The increased accumulation of amino acids in recombined milk blue

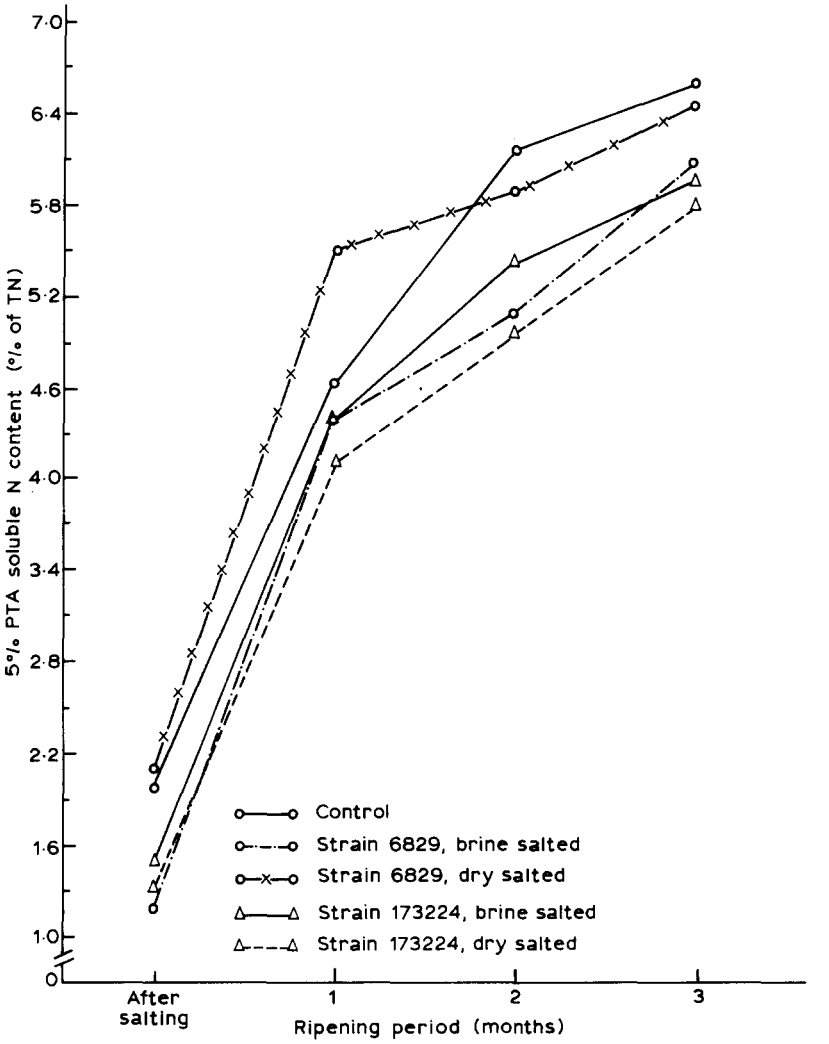

Fig. 3. Changes in 5% PTA-soluble N (% of TN) content of recombined milk blue cheese ripened with different *P. roqueforti* strains during maturation.

cheese could be attributed to the action of exopeptidase produced by *P. roqueforti*. The results for tyrosine and tryptophan are in accordance with Lin *et al.* (1982) and Montasser (1986).

Changes in total volatile fatty acid

Figure 6 shows the changes in total volatile fatty acids of recombined milk blue cheese made using two strains of *P. roqueforti* and two salting methods. It may be observed that the free volatile fatty acids increased gradually during ripening of all blue cheeses. Moreover, the concentration of volatile

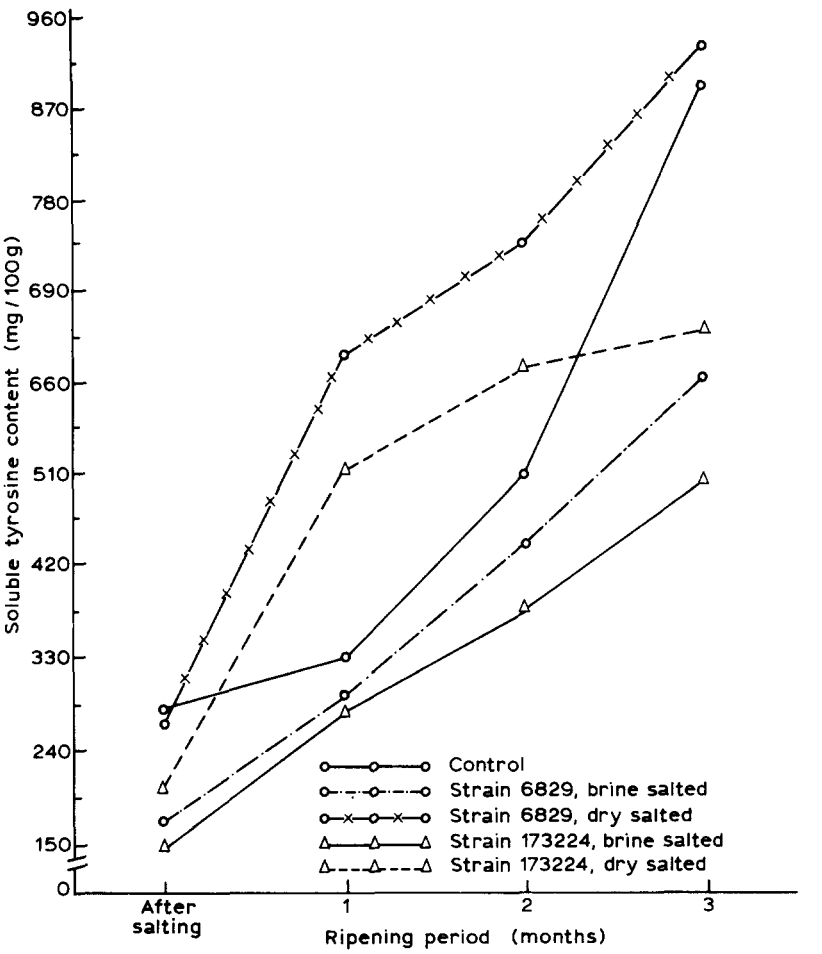

Fig. 4. Changes in soluble tyrosine of recombined milk blue cheese ripened with different *P. roqueforti* strains during maturation.

fatty acids produced by *P. roqueforti* strain 6829 was higher than that produced by *P. roqueforti* IMI 173224 in recombined milk blue cheese using the two salting methods during ripening, but it was slightly higher than the control. This indicates that the lipolytic action of the former strain was higher than the latter.

These results confirm that *P. roqueforti* strain 6829 is quite suitable for the production of blue cheese because of its higher lipolytic activity.

The increase in the concentration of volatile fatty acids during ripening may be attributed to the lipases produced by *P. roqueforti* (Imamura & Kataoka, 1963; Poznanski *et al.*, 1966; Schormüller, 1968). They reported that *P. roqueforti* produces two types of lipases. The acid lipase liberates low molecular weight fatty acids from C_4, C_6 to C_8 acids. A similar trend was

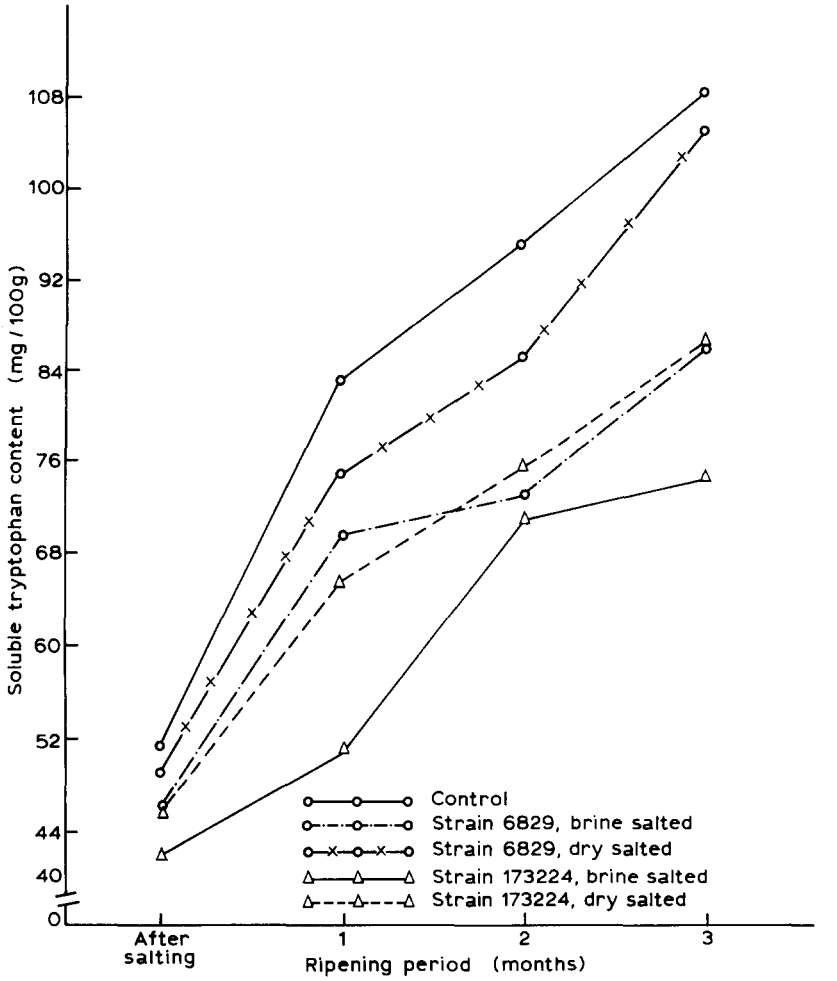

Fig. 5. Changes in tryptophan of recombined milk blue cheese ripened with different *P. roqueforti* strains during maturation.

observed by Montasser (1986) in blue cheese made by the conventional method.

Changes in carbonyl compounds

Figure 7 shows the changes in total carbonyl compounds of recombined milk blue cheese salted by two salting methods and ripened with *P. roqueforti* strain 6829 Wiesby and IMI 173224 during ripening for three months.

It is evident that all experimental blue cheeses had higher levels of total carbonyl compounds than the control blue cheese after salting and the second and the third month of cheese ripening.

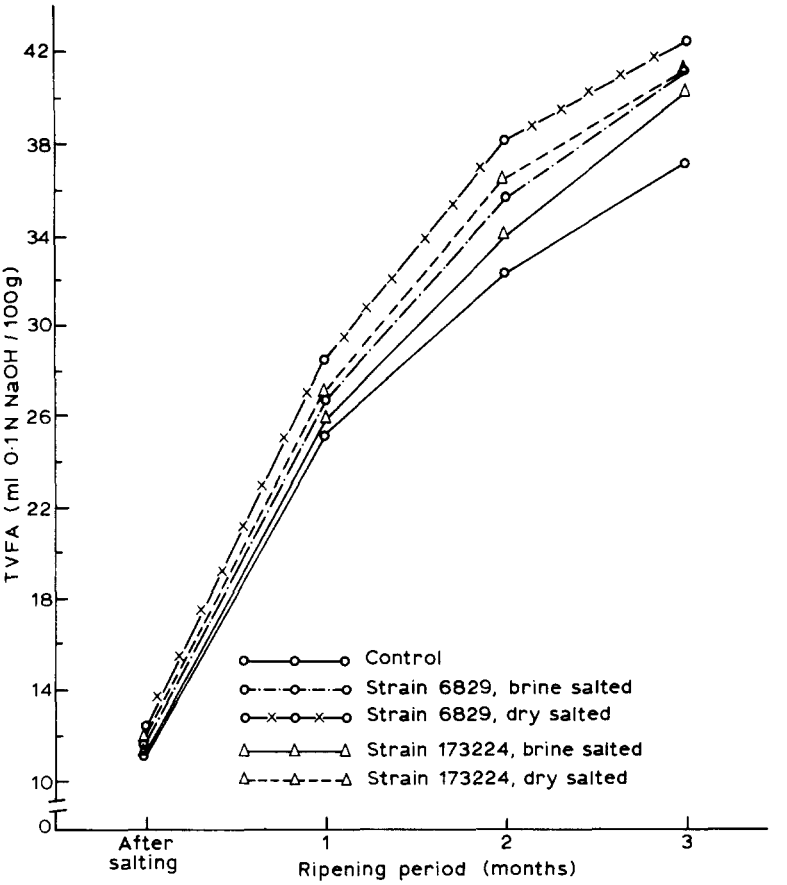

Fig. 6. Changes in total volatile fatty acids of recombined milk blue cheese ripened with different *P. roqueforti* strains during maturation.

On the other hand, the concentration of total carbonyl compounds produced by *P. roqueforti* strain 6829 Wiesby was higher than that produced by *P. roqueforti* strain IMI 173224 after salting and during cheese ripening.

Moreover, results obtained also clearly indicate that the levels of carbonyl compounds produced by *P. roqueforti* strain IMI 173224 with the brine salting method approached the levels of carbonyl compounds of control blue cheese after salting and two and three months, respectively.

In addition, the production of total carbonyl compounds in all blue cheeses considerably increased during the various stages of cheese ripening. The obtained results agree with the values reported by Schwartz & Parks (1963), Schwartz *et al.*, (1963), Dartey & Kinsella (1971) and Jolly & Kosikowski (1975) but were higher than those found by Godinho & Fox (1982).

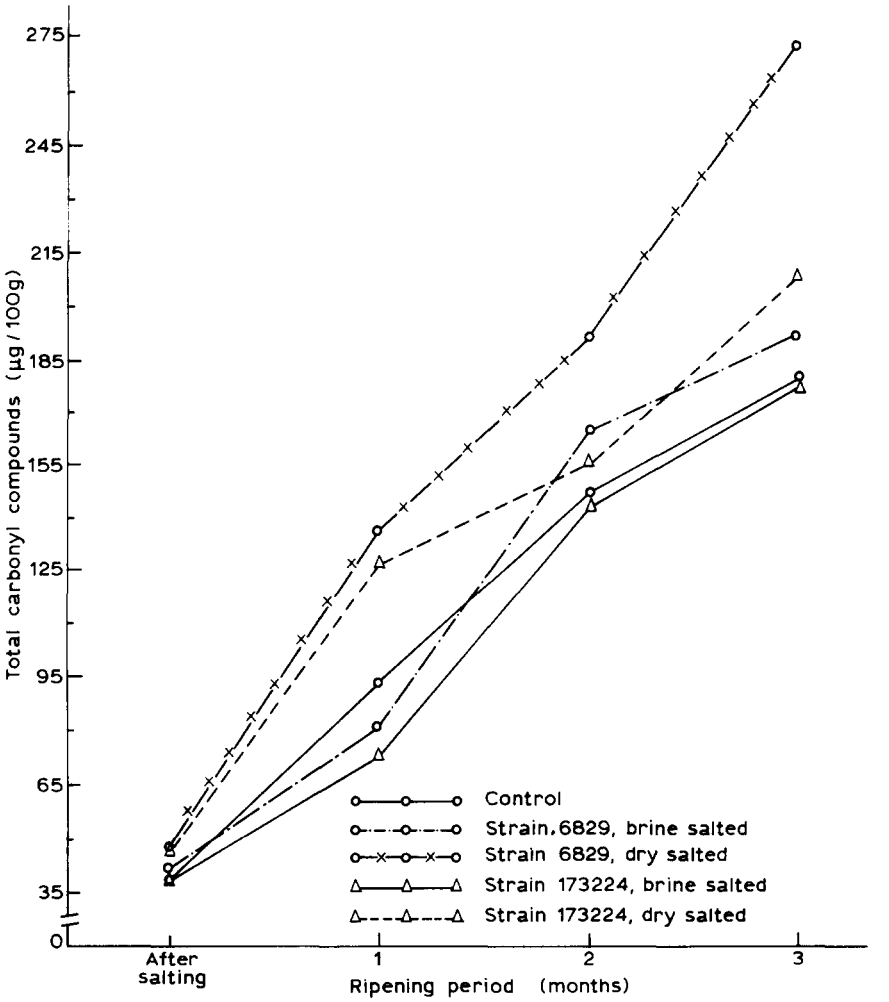

Fig. 7. Changes in total carbonyl compounds of recombined milk blue cheese ripened with different *P. roqueforti* strains during maturation.

Thus, the present results indicate that the type of *P. roqueforti* and salting method appear to have a strong influence on proteolysis and lipolysis as indicated by the formation of free volatile fatty acids and production of carbonyl compounds. Application of the dry salting method and inoculation of blue cheese milk with *P. roqueforti* strain 6829 Wiesby is recommended because it yielded a blue cheese with better visual appearance and better rind development with less surface mould growth and typical blue cheese flavour.

Organoleptic assessment of cheese

Organoleptic evaluation of the cheese at different stages of ripening revealed

TABLE 2
Changes in Organoleptic Properties of Recombined Milk Blue Cheese Ripened with Different Strains of *P. roqueforti* using Two Salting Methods

Ripening period (months)	*Items of score*	*Control blue cheese*	*Blue cheese ripened with*			
			P. roqueforti *6829*		P. roqueforti *IMI 173224*	
			Brine salted	*Dry salted*	*Brine salted*	*Dry salted*
	External appearance	4·5	4·2	4·3	4·0	4·2
	Internal appearance	2·4	2·3	2·4	2·2	2·2
1	Odour	0·8	0·7	0·8	0·7	0·7
	Taste	8·0	7·8	7·9	7·5	7·9
	Total	15·7	15·0	15·4	14·4	15·0
	External appearance	4·3	4·0	4·2	3·8	4·0
	Internal appearance	3·0	2·6	2·9	2·5	2·7
2	Odour	1·4	1·3	1·5	1·1	1·4
	Taste	9·0	8·8	9·2	8·6	9·0
	Total	17·7	16·7	17·8	16·0	17·1
	External appearance	3·9	3·7	3·9	3·6	3·7
	Internal appearance	3·4	3·2	3·4	3·0	3·2
3	Odour	1·7	1·5	1·9	1·3	1·7
	Taste	9·4	9·2	9·5	9·1	9·2
	Total	18·4	17·6	18·7	17·0	17·8

a significant effect of strain types on the flavour (Table 2), body and texture of recombined milk blue cheese. However, blue cheese ripened with *P. roqueforti* 6829 developed a typical blue cheese flavour and more acceptable body and texture characteristics compared with cheese made with *P. roqueforti* IMI 173224.

Blue cheese made using *P. roqueforti* strain 173224 also showed satisfactory blue cheese flavour. However, the distribution of *P. roqueforti* 6829 Wiesby in blue cheese was better than the other strain. The results may be attributed to higher levels of soluble nitrogenous compounds, amino acids and total volatile fatty acids and carbonyl compounds.

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