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The Manufacture of Ras Cheese from Gamma Irradiated Milk

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ABSTRACT

Cheese milk exposed to gamma irradiation at a dose of 0·5 Mrad was used in the manufacture of Ras cheese. Quality and ripening of cheese made from irradiated milk were compared with those of cheese made from heat-treated milk.

Gamma irradiation of cheese milk reduced the total bacterial count and spore formers by 98·98% and 95·77%, respectively, and eliminated the coliform and pathogenic bacteria. This treatment slightly increased the acid and peroxide values of milk fat, as well as the time required for complete coagulation of milk.

An oxidized flavour in the fresh and 1-month-old gamma-irradiated milk (GIM) cheese disappeared during ripening. At the end of ripening, GIM cheese had a better consistency and increased flavour compared with cheese made from heated milk.

Ras cheese made from GIM differed little in gross chemical composition but contained higher concentrations of soluble nitrogen compounds and of Free Fatty Acids than the control. Irradiation had a stimulating effect on the total, proteolytic and lipolytic bacterial counts during cheese ripening.

INTRODUCTION

Progress of cheese ripening depends on technological treatments applied to milk.

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Pasteurized milk is normally used for making cheese in Egypt. Khalafalla *et al.* (1973) showed that this has drawbacks, including poor renneting, weak curd, slow whey drainage and slow ripening, coupled with the absence of typical flavour. Also, Hofi *et al.* (1970) showed that Ras cheese made from pasteurized milk could take as long as 6 months to mature.

Development of newer and simpler techniques using cheaper equipment has made it possible to consider using ionizing radiation, particularly gamma rays, for sterilizing foods. Practical application of gamma irradiation in dairying is still limited because of the risk of changing its sensory and nutritional qualities (Ibrahim, 1984). However, several investigators have shown that enzymes are relatively resistant to the effect of ionizing radiation (Desrosier, 1963; Saito, 1975). This low sensitivity of enzymes to radiation effects implies little or no interference with the fermentations and chemical reactions that take place during ripening of cheese. Therefore, the present investigation was undertaken to study the effect of gamma irradiation of cheese milk on chemical and bacteriological changes during ripening of Ras cheese.

MATERIALS AND METHODS

Materials

Fresh cow's milk used for gamma irradiation treatment was obtained from the Friesian herd of the ARE USA–NSF project 'Bovine Adaptation to the Sahara' at the Atomic Energy Establishment, Inshas, Cairo, Egypt.

A rennet powder (1:1 000 000) was obtained from L. G. Glad Co., AS, Copenhagen, Denmark.

A starter culture containing *Streptococcus lactis* and *Streptococcus thermophilis* from Chris Hansen Laboratory A/S, Denmark, was used to ripen the cheese milk.

Source of radiation

Irradiation of milk was carried out using Instruction Manual Cobalt-60 Irradiator Type, J-6000/J-6500, at a dose rate 277–278 rad/s, at a level dose of 0·5 Mrad at the National Center of Radiation Research and Technology, Nasr City, Cairo, Egypt.

Cheese making

Fresh cow's milk was divided into two equal parts. The first part was heated at 70°C for 15 s, cooled to 33°C, and made into Ras cheese (control). The second part was exposed to gamma irradiation of 0·5 Mrad from a Cobalt-60 source at a dose rate of 277–278 rad/s (Ibrahim, 1984). All cheese was made as described by Abdel-Tawab (1963), and ripened at 12 ± 2°C for 4 months.

Method of analysis

Analysis of cheese milk

Total Solids, total nitrogen, titratable acidity, fat and ash contents of cheese milk were determined as described by Ling (1963).

Fat was separated from milk by centrifugation with cooling and the fat layer was taken for the determination of both acid and peroxide values according to the methods of the AOCS (1975).

Total count, mould and yeasts, coliform and spore-forming bacteria were determined as described by Marth (1978). Staphylococci, Salmonella and Shigella were determined using the specific media according to the method reported by Collins & Patricia (1976).

Analysis of cheese

Gross chemical composition and nitrogen fractions. Moisture, fat, salt, total nitrogen (TN), titratable acidity, soluble nitrogen (SN) and non-protein nitrogen (NPN) were determined as described by Ling (1963). Amino acid nitrogen (AN) was estimated by Stadhouders' (1959) method.

Determination of free fatty acids. Sodium soaps of the Free Fatty Acids were prepared from cheese samples according to the method of Kuzdzal & Kuzdzal-Savoie (1966). Methyl esters of Free Fatty Acids were prepared as described by Kuzdzal-Savoie & Kuzdzal (1967). Methyl esters were separated in a Pye Unicam Series 104 gas chromatograph (Pye Unicam, Cambridge, Great Britain) with a dual flame ionization detector. Columns 3·6 m long and with a 2 mm inside diameter were used with a 80–100 mesh silanised Chromosorb W carrier coated with 10% polyethylene glycol adipate as a stationary phase. Temperature programming at a rate of 5°C/min was applied in the range 130 to 180°C. The temperature of the injection part was 200°C. Carrier gas flow (He) was adjusted to 35 ml/min. Chart speed was 5 mm/min. Peak areas were calculated by multiplying the peak height by its width at half height. Results were expressed as milligrams per 100 g of cheese.

Bacteriological examination. Cheese samples were analysed bacteriologically for total count, mould and yeast, coliform, spore formers, proteolytic and lipolytic counts according to the method of Marth (1978).

Organoleptic properties. Ras cheese was organoleptically evaluated by the method of Hofi *et al.* (1970) with maximum score points of 10, 50 and 40 for appearance, flavour and body and texture, respectively.

RESULTS AND DISCUSSION

Some properties of cheese milk as affected by gamma irradiation

Table 1 shows the effect of gamma irradiation and heat treatment on some chemical and bacteriological properties of cheese milk.

Studying these results, it can be seen that total count and spore formers were reduced by 98·98% and 95·77%, respectively, when milk was irradiated at a dose of 0·5 Mrad. The corresponding values for the effect of heat treatment were 98·81% and 94·42%. Coliform, mould, yeast, Staphylococci, Salmonella and Shigella were found to be completely

TABLE 1
Effect of Gamma Irradiation (at Dose of 0·5 Mrad) on Some Bacteriological and Chemical Properties of Cheese Milk.

Property	*Raw milk*	*Heated milk*	*Irradiated milk*
Total count	$38{\cdot}6 \times 10^6$	$45{\cdot}9 \times 10^4$	$39{\cdot}4 \times 10^4$
Spore formers	$16{\cdot}3 \times 10^3$	$9{\cdot}1 \times 10^2$	$6{\cdot}9 \times 10^2$
Coliform	87×10^3	—	—
Yeast and mould	$3{\cdot}5 \times 10^2$	—	—
Staphylococci	$67{\cdot}2 \times 10^2$	—	—
Salmonella and Shigella	30	—	—
Total Solids (%)	13·1	13·1	13·1
Fat (%)	4·36	4·37	4·37
Titratable acidity	0·18	0·17	0·17
Total N (%)	0·53	0·53	0·53
Ash (%)	0·72	0·72	0·72
Acid value	0·44	0·46	0·49
Peroxide value	—	—	0·41
Coagulation time (min)	40·6	43·5	43·0

destroyed by both gamma irradiation and heat treatment of cheese milk. The general trend of the results agreed with those of Naguib *et al.* (1973) and Ibrahim (1984).

Neither gamma irradiation nor heat treatment significantly affected Total Solids, fat, titratable acidity, total N, amino acid N or ash contents of cheese milk. However, both treatments led to a slight increase in the acid value of milk fat, particularly with gamma irradiated milk, due to hydrolysis of triglycerides and liberation of Free Fatty Acids. Also, the results indicated that heating of cheese milk at 72 °C for 15 s did not affect the peroxide value while gamma irradiation at a dose of 0·5 Mrad slightly increased the peroxide value, probably due to some oxidation of milk fat. These results agree with those of Ibrahim (1984).

Table 1 also shows that coagulation time of both heat-treated and irradiated milks increased. The similarities between the effect of radiation and of heat treatment on rennet coagulation time could be due to the effect of both treatments on the calcium balance, resulting in a reduction in the available calcium which can function in the action of rennet (Desrosier, 1963).

Some properties of cheese

Gross chemical composition

Table 2 shows the gross chemical composition of irradiated and heat-treated milk cheese, expressed as moisture, fat, salt and titratable acidity. Cheese produced from irradiated milk (CIM) differed from that made from heated milk (CHM) in showing slightly lower moisture, slightly lower salt and slightly higher fat (on a dry basis) contents. Titratable acidities of both cheeses were very similar throughout ripening. These results may be explained on the grounds that heat treatment of milk may affect its coagulability, and softening curd, which, in turn, increases its ability to retain moisture and to adsorb salt during salting, resulting in a slight decrease in the fat concentration. Both heat treatment and irradiation had similar destructive effects on bacterial counts of milk (Table 1), neither treatment affecting either growth or activity of lactic acid bacteria during cheese making and ripening; levels of titratable acidity in both CIM and CHM were therefore similar (Ibrahim, 1984).

Ripening indices

Changes in the soluble nitrogen compounds and Free Fatty Acids were considered as indices of cheese ripening.

TABLE 2
Effect of Gamma Irradiation on the Chemical Composition of Ras Cheese During Ripening

Property	*Ripening period (months)*	*Cheese made of*	
		Heat-treated milk	*Irradiated milk*
	Fresh	41·1	40·2
Moisture (%)	2	38·7	37·8
	4	37·0	35·1
	Fresh	45·2	45·6
Fat (%) (DM)	2	48·0	48·3
	4	48·9	46·6
	Fresh	3·58	3·45
Salt (%) (DM)	2	3·60	3·51
	4	3·64	3·56
	Fresh	0·95	0·93
Acidity (per cent of lactic acid)	2	1·43	1·42
	4	1·79	1·78

DM, Dry matter.

Soluble nitrogen compounds
Figure 1, shows changes in soluble N, non-protein N and amino acid N of CIM, as compared with CHM. The concentrations of soluble nitrogen compounds in fresh CIM (9·62%) were slightly higher than in CHM (8·74%). This may be due to the effect of gamma irradiation on casein and the liberation of soluble nitrogen compounds. Umemato *et al.* (1968) showed that gamma irradiation of casein solution resulted in progressive degradation of proteins and the liberation of tyrosine and non-protein nitrogen.

The soluble nitrogen compounds (SN, NPN and amino acid N) of both CIM or CHM increased gradually during ripening. However, the concentration of protein degradative products remained slightly higher in CIM, compared with CHM, a result that may be explained on the basis that heat treatment and gamma irradiation have different effects on milk enzymes, particularly proteinases, which contribute to proteolysis during cheese ripening. Ismail *et al.* (1975) showed that gamma irradiation

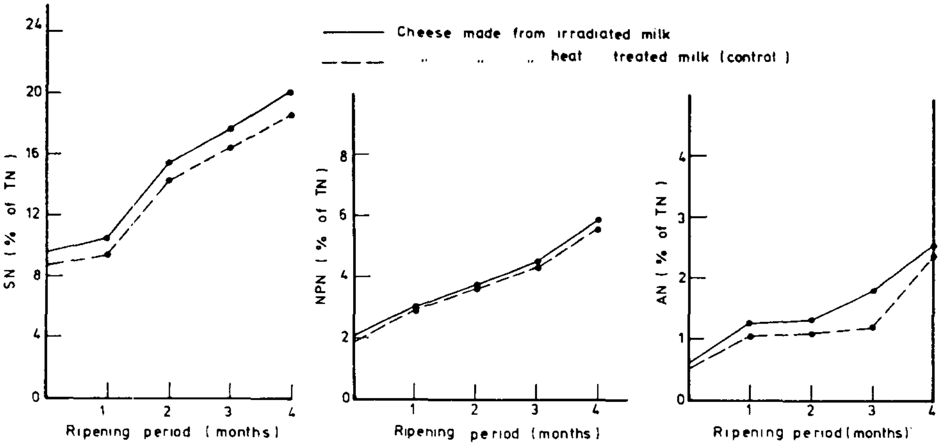

Fig. 1. Effect of gamma irradiation on nitrogen fractions (SN, NPN and AN) of Ras cheese during ripening.

resulted in an increase in the activity of milk proteinase by about 8%, while Chen & Ledford (1971) reported that small amounts of milk proteinases are present in milk after pasteurization and that the presence of residual enzyme activity in pasteurized milk is questionable. In addition, the higher soluble N compounds in the fresh irradiated milk cheese might show some stimulating effect on the growth of lactic acid bacteria which, with their proteinases and peptidases, are considered essential contributors to protein breakdown and the formation of free amino acids during cheese ripening (Desmazeaud & Zevaco, 1979).

Free Fatty Acids

Figure 2 shows the pattern and concentration of Free Fatty Acids extracted from CIM and CHM. Although there may not be great differences in the patterns of individual Free Fatty Acids in two types of cheese, irradiation of milk appears to have increased the tendency to form FFAs during ripening, CIM contains 1·5 times as much FFA as CHM at 4 months (Table 3). This effect may be due to the action of milk lipase during cheese ripening, Ismail *et al.* (1975) having shown that the lipase activity of cow's milk was increased by 0·5 Mrad of gamma irradiation. The rôle played by milk lipase in cheese made from heat-treated milk is less certain, for, whilst many investigators showed that milk lipase was destroyed by pasteurization (Webb *et al.*, 1974), others reported that some milk lipase activity is retained in the cheese or that some reactivation of the lipase may occur (Reiter & Sharpe, 1971).

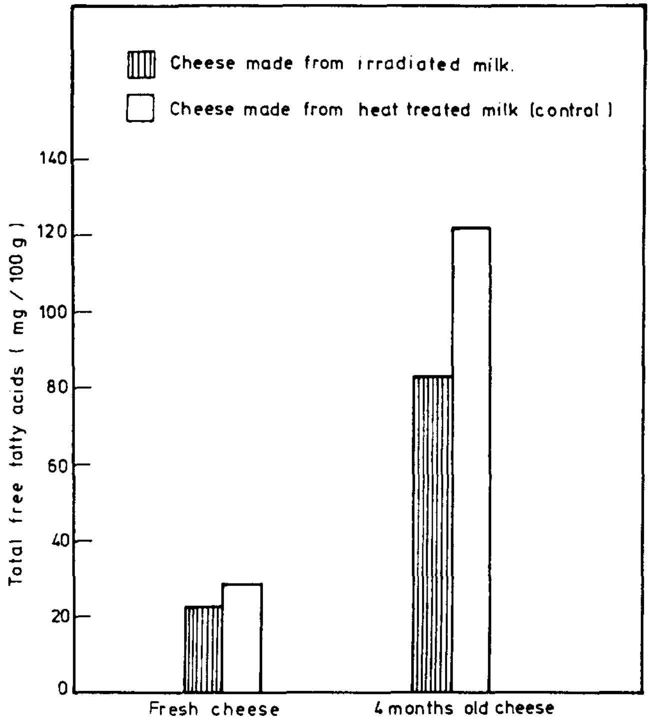

Fig. 2. Effect of gamma irradiation on the Free Fatty Acids of Ras cheese.

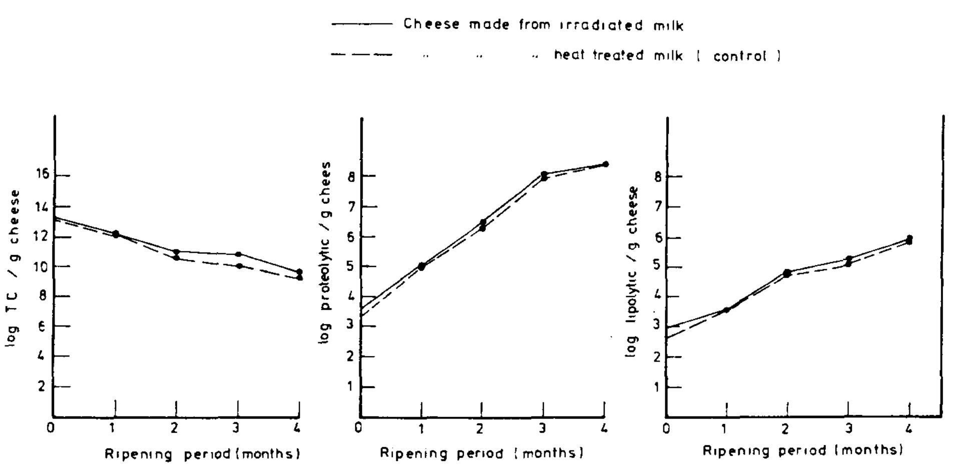

Fig. 3. Effect of gamma irradiation on some bacterial groups of Ras cheese during ripening.

TABLE 3
Effect of Gamma Irradiation on the Free Fatty Acids of Ras Cheese (mg/100 g cheese)

Free fatty acids	*Cheese made from*			
	Heat-treated milk		*Irradiated milk*	
	Fresh	*4 months*	*Fresh*	*4 months*
C_2	0·29	1·22	0·30	1·20
C_3	0·20	0·55	0·30	0·48
C_4	0·37	1·98	0·49	2·21
C_5	Trace	Trace	Trace	Trace
C_5	Trace	Trace	Trace	Trace
C_6	0·38	1·09	0·42	2·06
C_8	0·47	1·31	0·72	2·76
C_{10}	1·14	6·85	1·68	9·78
$C_{10:1}$	0·20	0·50	0·26	0·68
C_{12}	2·14	7·41	2·51	11·83
$C_{12:1}$	0·20	0·48	0·28	0·50
C_{14}	Trace	Trace	Trace	Trace
C_{14}	2·55	12·36	3·21	17·82
$C_{14:1}$	0·56	1·21	0·58	1·62
C_{15}	0·59	1·31	0·43	1·91
C_{16}	0·10	0·20	0·10	0·94
C_{16}	6·39	24·28	7·68	39·66
$C_{16:1}$	0·98	1·18	0·76	2·0 6
C_{17}	Trace	0·62	Trace	0·66
$C_{17:1}$	Trace	0·20	Trace	0·20
$C_{18:0}$	1·07	4·29	1·72	5·96
$C_{18:1}$	4·21	13·92	6·20	16·72
$C_{18:2}$	0·76	1·07	0·92	1·95
$C_{18:3}$	Trace	0·94	Trace	1·02
Total	22·6	83·0	28·6	122

Some bacteriological properties of cheese

The total, proteolytic and lipolytic counts of CIM and CHM are given in Fig. 3. The total count and counts of proteolytic and lipolytic groups of bacteria were very similar in both makes of cheese, indicating that the gamma irradiation did not alter the growth and activity of the cheese flora during ripening. Ibrahim (1984) reported that the growth of lactic acid

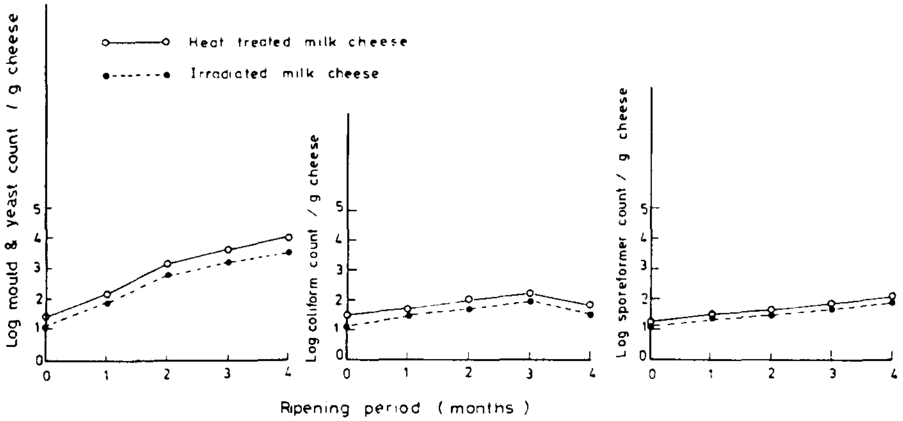

Fig. 4. Effect of gamma irradiation on mould and yeast, coliform and spore formers of Ras cheese.

bacteria in both heated and irradiated milk was found to be nearly the same.

Moulds and yeasts, as well as coliforms, were present in the fresh samples of both irradiated and heat-treated milk cheeses. This could be due to the recontamination of cheese milk with these groups of

TABLE 4
Effect of Gamma Irradiation on the Organoleptic Properties of Ras Cheese During Ripening

Property	*Storage periods (months)*							
	1		*2*		*3*		*4*	
	A	*B*	*A*	*B*	*A*	*B*	*A*	*B*
Appearance (10)	8	8	8	8	8	8	8	8
Body and texture (40)	24	25	25	26	27	28	29	30
Flavour (50)	31	29	35	34	38	38	41	42
Flavour intensity	+	+	+	+	+ +	+ +	+ +	+ + +
Oxidized flavour	—	+	—	+	—	—	—	—
Bitterness and rancidity	—	—	—	—	—	—	—	—
Colour homogeneity	+	+	+	+	+	+	+	+

\+ Flat.
\+ + Medium.
\+ + + Strong.

microorganisms during cheese manufacture as it appears from Table 1 that both gamma irradiation and heat treatment of cheese milk eliminated moulds, yeasts and coliforms. These microorganisms increased in numbers during ripening, attaining lower populations in CIM than in CHM. Gamma irradiation seems to affect the spore formers to a great extent, as observed from Fig. 4.

Organoleptic properties

Quality scores for CIM and CHM are given in Table 4. Gamma irradiation did not affect the appearance of cheese, but enhanced its body and flavour intensity, probably by increasing the concentrations of soluble nitrogen compounds and Free Fatty Acids (Figs 1 and 2). However, an oxidized flavour was detected in fresh and 1-month-old CIM, probably because of oxidation of milk fat by gamma irradiation. This defect disappeared during ripening, whereas taste and odour of CIM from the second month of ripening onwards were organoleptically acceptable and even better than those of CHM of the same age.

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