COMPOSITION AND NUTRITIVE VALUE OF CHEESE PRODUCED FROM MILK TREATED WITH HYDROGEN PEROXIDE AND CATALASE[1]

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SUMMARY

This study provides information on the nutritional value and wholesomeness of cheese made from milk treated with hydrogen peroxide at 5, 10, and 25 times the anticipated normal practical levels. The milks and their wheys obtained in preparing the cheese samples also were tested. The samples were analyzed for proximate composition and for the vitamins, niacin, thiamine, riboflavin, vitamin B_6, pantothenic acid, folic acid, vitamin B_{12}, vitamin A, and beta-carotene. The amino acids, methionine, cystine, tryptophane, and lysine, also were determined. Biological protein evaluation was done for milk, whey, and cheese by feeding these products to rats to provide 9% protein (dry-weight basis) as the sole source of protein in an otherwise complete ration. Additional rat-feeding tests were done on cheese which furnished 14% protein in the diet. The results indicated no marked changes in the composition or nutritive value of milk treated with 0.1, 0.2, and 0.5% hydrogen peroxide, or of the whey or cheese obtained from that milk.

Various dairy products have been treated with hydrogen peroxide for many years and the literature on this subject has been reviewed recently *(7)*. It has been reported that treatment of milk with low levels of hydrogen peroxide for short periods of time (with subsequent enzymatic removal of residual hydrogen peroxide) enables production of cheese of superior quality *(1, 9)*. The beneficial effects of the peroxide appear to be owing to a selective reduction in the population of certain bacteria.

This study was initiated to provide information on the effect of treatment of milk with hydrogen peroxide on the composition and nutritive value of cheese made from that milk. Analysis for proximate composition, vitamins, and amino acids, and biological protein evaluation (rat-feeding) tests were carried out. The cheese samples were made from raw, pasteurized, and 120° F.–treated milks (no peroxide treatment), and from pasteurized and 120° F. milks processed with 5, 10, and 25 times the anticipated normal practice levels of hydrogen peroxide and for approximately 25 times the anticipated treatment period, considering the temperature employed during treatment. The milks themselves, and the wheys obtained from the making of the cheese samples, also were subjected to analysis and biological protein evaluation. Electrophoretic studies were carried out on proteins obtained from the cheese samples.

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MATERIALS AND METHODS

Preparation of test materials. The facilities of the University of Wisconsin at Babcock Hall were used for the cheese-making and preparation and packaging of samples. All analyses were carried out promptly on samples held under refrigeration. Samples for rat-feeding tests were stored in a freezer.

The milk used in these experiments was taken from the mixed daily supply from 25 herds. The milk received on October 22, 1956, was clarified, cooled, and treated the next morning.

Cheese was made from raw milk, from milk heated to 120° F., and from pasteurized milk. Portions of the 120° F. and pasteurized milks were further subjected to hydrogen-peroxide-catalase treatments. In all cases, the peroxide treatment was carried out at 120° F. The various portions of milk, each of which weighed 480 lb., were handled as follows: One portion of the mixed raw milk was placed in a 60-gal. cheese vat for manufacturing. Approximately 2,000 lb. of milk was heated to 120° F. in a plate-type heater and run into a 300-gal. tank. One portion of this hot milk was immediately cooled from 120 to 88° F., for cheese-making.

The remainder of the 120°-heated milk in the tank was divided into three 480-lb. portions. To one was added 0.1% hydrogen peroxide, to the second 0.2%, and to the third portion, 0.5%. These percentages represent 100% H_2O_2. (For actual amounts of 35% H_2O_2 used to provide these levels of peroxide, see Table 1.) After holding 10 min. under continuous agitation, each portion

TABLE 1

Amounts of hydrogen peroxide and catalase used in 480-lb. vat-lots of milk

Level of peroxide	H_2O_2 required	35% Peroxide used [a]	Catalase used [b]
(%)	*(lb.)*	*(lb.)*	*(ml.)*
0.5	2.40	6.85	44
0.2	0.96	2.74	17
0.1	0.48	1.37	9

[a] The required amount of 35% hydrogen peroxide was mixed with an equal weight of cold water before mixing with the milk.

[b] The required amount of catalase preparation was mixed with five times its volume of cold water before mixing with the milk.

was cooled from 120 to approximately 90° F. and the catalase preparation was added, to destroy the remaining hydrogen peroxide. Each lot of milk was then adjusted to 88° F. for cheese-making.

A second 2,000-lb. portion of the mixed milk was heated in a high temperature, short-time (HTST) pasteurizer to 162° F. for 20 sec., cooled to 110° F., and delivered into a 300-gal. tank, from which one portion was drawn and cooled promptly to 88° F. for cheese-making.

The pasteurized milk remaining in the tank was warmed to 120° F. and divided into three 480-lb. portions. The peroxide treatment of these portions was carried out as just described for the 120° F. milk.

After the pasteurized milk had been divided for the peroxide treatments, an

error in handling made it necessary to discard one of the 480-lb. portions. An equal amount of milk pasteurized by the same method had to be substituted for it. This substitute lot contained a small portion of the milk delivered to the manufacturing laboratory on the day of the experiment. This substitute portion of pasteurized milk was the one treated with 0.2% of hydrogen peroxide.

The hydrogen peroxide used in these experiments was a 35% solution of H_2O_2 designed for use in food processing. The peroxide solution was diluted with an equal weight of cold water before it was added to the milk. The catalase preparation used in these experiments was a stable, buffered solution, at neutral pH, which had been standardized to a potency of 100 Keil Units per cubic centimeter. One Keil unit of catalase is defined as the quantity of catalase required to decompose 1 g. of 100% hydrogen peroxide in 10 min. at 25° C. in an inert atmosphere of CO_2 or N_2. Four times the required theoretical amount of catalase was used to remove all traces of hydrogen peroxide from the milk within 10 min. The catalase preparation was diluted with five times its volume of cold water, then added slowly to the milk, with constant agitation to prevent excessive foaming. The specific amounts used for each concentration of hydrogen peroxide are shown (Table 1). All the peroxide in the treated milk was removed by the catalase before starting cheese-making. The milk was tested for the presence of hydrogen peroxide by adding several drops of a fresh 25% solution of potassium iodide with 2% starch to 5 ml. of milk in a tube. A control tube of identical milk not treated with the hydrogen peroxide was prepared similarly. Complete destruction of hydrogen peroxide was indicated by identical freedom from discoloration in both tubes.

The whey for analysis was removed from each experimental vat just before draining; it was promptly cooled and held at 36° F. To provide whey protein for biological evaluation the following procedure was used:

Unseparated whey removed from the cheese vats at the time of dipping was heated to 200° F. The whey proteins were precipitated by adding to each 100 lb. of the hot whey, 33 ml. of glacial acid diluted with water to 100 ml. The whey-protein precipitate was drained at 70° F. on "Viskon," thoroughly mixed for uniformity, packed in heavily paraffined cottage cheese cartons, fast-frozen at −25° F., and stored at from −10 to −20° F.

All lots of cheese were formed into 5-lb. loaves, wrapped in "Parakote," and held in fiberboard cartons.

The time schedule and method of making the milk into cheese followed procedures which have been described elsewhere *(16)* (Table 2). The time intervals planned for these making procedures required a pH of 6.1 in the curd, at 2.5 hr. after adding rennet to the milk, and a pH of 5.5 at milling, at 4.5 hr. after renneting. When time and acidity measurements did not fit the ideal schedule exactly, then the acidity attained determined the time of dipping or milling. Measurements of pH of curd were made with a Leeds-Northrup portable potentiometer, quinhydrone electrode, and saturated calomel half-cell *(16)*.

Preliminary experiments had shown the desirability of increasing the amount of rennet used in making the cheese from milk treated with these high levels

TABLE 2

Times required for critical stages in the making operation

Milk treatment	Setting[a] to dipping[b]	Dipping to milling[c]	Setting to milling
	hr:min.	hr:min.	hr:min.
Raw milk	2:50	2:30	5:20
Pasteurized			
0.5% H_2O_2	3:08	2:25	5:33
0.2% H_2O_2[d]	3:00	2:16	5:16
0.1% H_2O_2	2:45	2:03	4:48
0% H_2O_2	2:46	1:40	4:26
Heated to 120° F.			
0.5% H_2O_2	3:35	2:10	5:45
0.2% H_2O_2	3:25	2:00	5:25
0.1% H_2O_2	3:21	2:25	5:46
0% H_2O_2	2:45	2:38	5:23

[a] Setting (adding of rennet) occurred when the Marschall rennet test showed ¼-space-change in 15 min.

[b] Dipping (end of running whey) was at pH 6.1.

[c] Milling was at pH 5.5.

[d] This vat-lot of milk was not identical to the others in this series.

of hydrogen peroxide. Therefore, 4 oz. of rennet per 1,000 lb. of milk was used in all lots of milk treated with hydrogen peroxide; 3 oz. per 1,000 lb. was used in the other lots. Under these conditions, milk coagulation was normal.

Development of acidity was slightly slower at first, in vats to which the peroxide had been added. This was especially noticeable in those lots made with 120°–heated milk. This effect might have been prevented by prolonging the period between adding starter and the setting of the vat.

Curd observed at all stages of making was slightly lacking in firmness in those lots which had received 0.5% of hydrogen peroxide. This tendency was not detected in other vat-lots.

For the later feeding of cheese to rats, at a level sufficient to furnish 14% protein in the diet, additional cheese samples were made from pasteurized milk according to the general procedures described above, except that only one level of hydrogen peroxide (0.5%) was used, and the treatment was at 120° for 10 and 30 min. All of the milks were held for an equal period at 120° F. Duplicate sets of samples were made on two separate days and from two different batches of milk.

Analytical methods. The analytical methods employed were, for the most part, well-standardized procedures: moisture *(2)*, ash *(2)*, fat *(2)*, protein *(2)*, carbohydrate (by difference), niacin *(10)*, thiamine *(16)*, riboflavin *(11)*, vitamin B_6 *(1)*, pantothenic acid *(14)*, folic acid *(2)*, vitamin B_{12} *(11)*, vitamin A and beta-carotene *(6)*, methionine, cystine, tryptophane, and lysine *(5)*. For the cheese samples, special methods were used for determining vitamin A and beta-carotene *(2, 6)*, moisture *(13)*, and fat *(12)*. The latter was determined by a modified Babcock test procedure. Hartman *et al. (4)* have demonstrated that cheese requires special treatment for vitamin B_{12} assay; the cheese samples were extracted with acetone and the extracts were then carried through the regular assay procedure.

Biological protein evaluation. Weanling (21-day-old) male albino rats of the Sprague-Dawley strain, weighing 50-60 g., were divided into groups of ten rats each, in such a way that the average weights of all the groups were essentially the same. The animals were housed in individual screen-bottom cages in air-conditioned, temperature-controlled animal quarters; they were supplied with water and test ration ad libitum.

Each sample was incorporated into a semisynthetic rat basal ration as the sole protein source, at such a level as to supply 9.09% protein ($N \times 6.25$) in the finished ration (dry basis). The rations were equalized with respect to fat, ash, carbohydrate, and moisture content, and supplemented with a synthetic vitamin mixture. All of the whey proteins tested contained approximately the following percentages: protein 13, moisture 75, fat 7, ash 0.7, and carbohydrate 4. The casein standard contained 91.3% protein. The final rations for the milk groups contained per 100 g. of solids, 260 g. of moisture; for the whey groups, 60 g., and for the cheese groups, 20 g. In all other respects the rations were identical. The cheese, whey protein, and milk samples were stored frozen. Rations were made up weekly and held in a refrigerator.

The test animals were weighed at weekly intervals through the 6 wk. test period and were fed weighed amounts of test ration. Uneaten rations removed from the cages were collected, combined and, at intervals analyzed for protein and solids content, so as to obtain an accurate estimation of the total food consumption and protein consumption of the animals.

Diet

	(%)
Protein (from sample)	9.09
Corn oil (plus sample fat)	12
Salts I (USP IV) (plus sample ash)	4
Vitamin-glucose mixture[a]	1
Sucrose to	100

[a] Each 100-g. ration provided U.S.P. units: vitamin D, 200, vitamin E, 10.1, vitamin A, 2,000. Milligrams: choline, 100, inositol, 10, niacin, 4, calcium pantothenate, 4, vitamin B_{12}, 0.003, riboflavin, 0.8, thiamine, 0.5, vitamin B_6, 0.5, menadione, 0.5, folic acid, 0.2, and biotin, 0.04; *para*-aminobenzoic acid, 10 grams.

Electrophoretic studies. The electrophoretic studies were carried out at the National Dairy Research Laboratories, Inc., Oakdale, L. I., New York.

Two grams of cheese were weighed out and triturated with ether until the major portion of the fat was removed. The cheese samples were put into solution in sodium cacodylate–sodium chloride buffer (NaCaCO, 02M; NaCl, 0.08M), 0.1 μ, pH 6.63. An excess of disodium dihydrogen versenate was added and the pH was adjusted to 7.3 with 0.1 N NaOH for maximum sequestering of the calcium present. All the protein went into solution, but residual fat caused turbidity. The solutions were ether-extracted at room temperature until sufficiently clear for analysis. The samples were dialyzed against three changes

of buffer for three days at a temperature of 4° C. Analyses were made at a temperature of 1° C. in a Tiselius-type electrophoresis apparatus manufactured by Frank Pearson Associates. Areas of the components were measured by planimeter, and mobilities were calculated from the descending boundaries. Measurements for mobility were made from the intial boundary to the ordinate bisecting the area of a component.

Feeding tests at a 14% protein level. Feeding tests were carried out with newly prepared samples of cheese which had been treated for 10 and 30 min. with 0.5% H_2O_2. The tests were carried out in the same way as the protein evaluation tests, except for the higher level of sample, to furnish a 14% level of protein; the total fat level was 18%.

RESULTS AND DISCUSSION

Analysis. The analytical results on the milk, cheese, and whey samples are presented (Tables 3, 4, and 5). For the most part, the values fall into the ranges one might expect from data available in the literature. However, in the case of certain nutrients, such as folic acid, which are present at rather low levels in relation to the sensitivity of the test methods, the variation in values among the different milk, cheese, and whey samples is somewhat greater than one would expect from normal assay variation. The microbiological assay procedures employed for the amino acid determinations and most of the vitamin assays are ordinarily considered to give results reproducible, on the average, within a range of $\pm$ 10%. For some vitamins, such as folic acid, one expects somewhat greater variation in assay results.

In general, there is no effect of peroxide treatment on levels of nutrients. However, in the case of methionine and lysine, treatment of milk with 0.5% H_2O_2 resulted in a decrease of the levels of these amino acids in cheese produced from this milk, to the extent of 10–25% (dry weight basis). This effect appears to be an indirect one, as it was not noted in the milk and whey samples.

These results substantiate other data which have suggested that, aside from ascorbic acid, the nutrients in milk are rather insensitive to treatment with hydrogen peroxide. Vitamin A in milk has been reported to be relatively stable to peroxide treatment *(14)* and Nambudripad *et al. (10)* found thiamine, riboflavin, niacin, and vitamin B_{12} to be unaffected by addition of 0.03% H_2O_2 (by weight) and by allowing the milk to stand for from 1 to 2 hr. before pasteurizing at 145° F.

Although strong treatment with hydrogen peroxide will produce chemical changes in proteins and amino acids of milk, relatively mild treatment is reported to have little effect *(8, 17)*. This is borne out by the results of the amino acid assays and the electrophoretic studies reported herein.

Protein evaluation. The rats on the protein test were in good health during the experiment and no abnormalities were found on autopsy at termination. Good protein efficiency values (Table 6) were obtained on the various samples and the variation among samples was not unusual for biological tests, with one exception: the protein efficiency ratio for the heat-treated 0.5% peroxide cheese

TABLE 3

Analysis of milk

	Raw	Pasteurized (160° F., 20 sec.) (% H_2O_2)				120° F.–treated (% H_2O_2)			
		0	0.1	0.2	0.5	0	0.1	0.2	0.5
Moisture *(%)*	88.55	88.17	88.65	88.64	88.42	88.70	87.88	88.39	89.79
Ash *(%)*	0.74	0.74	0.74	0.72	0.69	0.73	0.72	0.73	0.72
Fat *(%)*	3.30	3.43	3.32	3.47	3.41	3.26	3.49	3.46	3.10
Protein *(%)*	3.25	3.38	3.32	3.32	3.32	3.19	3.51	3.25	3.25
Carbohydrate *(%)*	4.16	4.28	3.97	3.85	4.16	4.12	4.40	4.17	3.14
Niacin *(mg/100 ml.)*	0.084	0.100	.....	.....	0.084	0.078	.....	.....	0.096
Thiamine *(mg/100 ml.)*	0.044	0.047	.....	.....	0.039	0.036	.....	.....	0.038
Riboflavin *(mg/100 ml.)*	0.16	0.17	.....	.....	0.16	0.17	.....	.....	0.18
Vitamin B_6 *(mg/100 ml.)*	0.075	0.064	0.074	0.076	0.073	0.082	0.074	0.055	0.051
Pantothenic Acid *(mg/100 ml.)*	0.45	0.44	.....	.....	0.45	0.43	.....	.....	0.45
Folic Acid *(µg/100 ml.)*	0.57	0.41	.....	.....	0.46	1.14	.....	.....	0.54
Vitamin B_{12} *(µg/100 ml.)*	0.38	0.34	0.46	0.41	0.43	0.46	0.44	0.37	0.32
Vitamin A *(I.U/100 ml.)*	98.3	91.7	.....	.....	93.3	88.3	.....	.....	95.0
Beta-carotene *(µg/100 ml.)*	25.5	26.0	.....	.....	24.7	26.0	.....	.....	24.5
Methionine *(mg/ml)*	0.75	0.75	.....	.....	0.68	0.78	.....	.....	0.70
Cystine *(mg/ml)*	0.21	0.20	.....	.....	0.19	0.22	.....	.....	0.22
Tryptophane *(mg/ml)*	0.44	0.43	.....	.....	0.40	0.40	.....	.....	0.38
Lysine *(mg/ml)*	2.9	2.9	.....	.....	2.8	2.8	.....	.....	3.0

TABLE 4

Analysis of cheese

	Raw	Pasteurized (160° F., 20 sec.) (% H_2O_2)				120° F.–treated (% H_2O_2)			
		0	0.1	0.2	0.5	0	0.1	0.2	0.5
Moisture *(%)*	38.07	37.69	40.66	40.90	41.24	38.22	39.96	39.75	41.55
Ash *(%)*	4.05	3.65	3.41	3.60	3.68	3.26	3.77	3.56	3.69
Fat *(%)*	32.6	32.4	31.0	30.2	31.0	32.3	31.4	30.8	30.3
Protein *(%)*	27.24	26.09	25.07	26.09	25.33	26.54	24.31	25.46	26.16
Niacin *(mg/100 g.)*	0.080	0.086	.....	.....	0.084	0.092	.....	.....	0.070
Thiamin *(mg/100 g.)*	0.097	0.030	.....	.....	0.020	0.023	.....	.....	0.024
Riboflavin *(mg/100 g.)*	0.48	0.43	.....	.....	0.32	0.38	.....	.....	0.38
Vitamin B_6 *(mg/100 g.)*	0.078	0.077	0.086	0.080	0.091	0.098	0.108	0.102	0.109
Pantothenic Acid *(mg/100 g.)*	0.49	0.51	.....	.....	0.52	0.41	.....	.....	0.43
Folic Acid *(mg./100 g.)*	0.038	0.037	.....	.....	0.044	0.033	.....	.....	0.059
Vitamin B_{12} *(µg/100 g.)*	0.54	0.78	0.74	0.62	0.95	1.33	1.54	0.61	0.58
Vitamin A *(I.U/100 g.)*	1,000	1,050	.....	.....	900	1,000	.....	.....	900
Beta-carotene *(µg/100 g.)*	200	220	.....	.....	190	195	.....	.....	175
Methionine *(mg/g)*	7.07	7.40	.....	.....	5.42	6.73	.....	.....	5.22
Cystine *(mg/g)*	1.00	1.00	.....	.....	0.85	1.02	.....	.....	0.88
Tryptophane *(mg/g)*	2.9	5.0	.....	.....	3.0	3.1	.....	.....	3.0
Lysine *(mg/g)*	25.2	25.0	.....	.....	20.9	23.8	.....	.....	22.0

TABLE 5

Analysis of whey

		Pasteurized (160° F., 20 sec.)				120° F.–treated			
		(% H_2O_2)				*(% H_2O_2)*			
	Raw	0	0.1	0.2	0.5	0	0.1	0.2	0.5
Moisture *(%)*	93.40	93.42	93.46	93.36	93.65	93.46	93.54	93.56	93.45
Ash *(%)*	0.56	0.56	0.58	0.57	0.54	0.54	0.57	0.58	0.56
Fat *(%)*	0.34	0.27	0.26	0.32	0.33	0.33	0.33	0.40	0.37
Protein *(%)*	1.02	0.96	0.96	1.02	1.08	1.02	1.02	1.08	1.08
Carbohydrate *(%)*	4.68	4.79	4.74	4.73	4.40	4.65	4.54	4.38	4.54
Niacin *(mg/100 ml.)*	0.060	0.074	.....	.....	0.120	0.074	.....	.....	0.098
Thiamine *(mg/100 ml.)*	0.049	0.066	.....	.....	0.056	0.043	.....	.....	0.043
Riboflavin *(mg/100 ml.)*	0.13	0.12	.....	.....	0.14	0.13	.....	.....	0.13
Vitamin B_6 *(mg/100 ml.)*	0.059	0.058	0.062	0.031	0.061	0.063	0.058	0.061	0.057
Pantothenic Acid *(mg/100 ml.)*	0.35	0.39	.....	.....	0.37	0.39	.....	.....	0.32
Folic Acid *(μg/100 ml.)*	5.2	2.4	.....	.....	4.4	5.0	.....	.....	4.3
Vitamin B_{12} *(μg/100 ml.)*	0.24	0.24	0.28	0.20	0.24	0.25	0.30	0.18	0.21
Methionine *(mg/ml)*	0.17	0.17	.....	.....	0.17	0.17	.....	.....	0.17
Cystine *(mg/ml)*	0.18	0.19	.....	.....	0.15	0.17	.....	.....	0.18
Tryptophane *(mg/ml)*	0.14	0.15	.....	.....	0.14	0.15	.....	.....	0.13
Lysine *(mg/ml)*	0.83	0.83	.....	.....	0.83	0.82	.....	.....	0.89

sample was 1.82, compared to a value of 2.34 for the control. In a repeat test on this sample (which had been stored in a freezer), a protein efficiency ratio of 2.14 was obtained, with a value of 2.40 for the control. The results as a whole indicate little, if any, change in the nutritional value of cheese protein when the milk from which it is made is treated with peroxide as described.

Electrophoresis. The electrophoretic analyses of proteins of cheeses made from milk treated with various levels of H_2O_2 are shown (Table 7 and Figure 1). The cheese samples were stored in the frozen state for approximately 2 mo., then stored at 40° F. for up to 2 wk. before examining. The four samples which had the longest storage periods *(1,2)* were all low in concentration of beta-casein in the descending patterns, indicating possible storage changes. The descending patterns of the pasteurized series have marked similarity in appearance. Samples 2 and 4, treated, respectively, with the lowest and highest concentration of H_2O_2, show no real differences in their analyses. The control Sample 1 and Sample 3 (0.2% H_2O_2) are both low in beta-casein in the descending pattern. This may be due to the slightly longer storage periods for these samples. The mobility of the alpha-casein complex in the control Sample 1 seems rather low compared to the other pasteurized samples. This difference can not be considered as the result of the peroxide treatment specifically, since Samples 5 (120° F., no H_2O_2) has mobilities similar to the peroxide-treated samples.

In the 120° F. series, no definite changes due to the peroxide treatment were noticed. As in the pasteurized series, the samples with the longest storage periods were low in concentration of beta-casein in the descending patterns. All samples, both pasteurized and 120° F.–treated, showed some dissociation of the alpha-casein complex in the ascending pattern. The degree of dissociation was not related to the strength of the peroxide treatment.

The absence of an effect on electrophoretic patterns, definitely attributable to the peroxide treatments used in these experiments, is what we might expect from electrophoretic studies on peroxide-treated milk reported by Lück and Joubert *(8)*. These workers did observe some changes in the β-lactoglobulin diagrams when skimmilk was treated with 0.25 and 1% H_2O_2 (39%) for from 3 to 5 hr. at room temperature, at which time the catalase was inactivated. After the catalase inactivation, the H_2O_2 level remained constant at from 0.015 to 0.10 *M*. The milk was held for from four to six days after catalase inactivation. Lück and Joubert note that other workers have observed similar effects on the β-lactoglobulin from other treatments, such as radiation with ultraviolet light, or heat treatment.

Feeding tests at a 14% protein level. All rats were in good health during the experiment and no abnormalities were found on autopsy at termination. Analyses of the cheese are given (Table 8) and weight gain and food consumption data also are presented (Table 9). On the average, the animals on the peroxide-treated cheeses gained from 5 to 10% less than the animals on the control cheeses. Statistical analysis showed that variation in feed efficiency among groups was not significantly different (at the 5% level) from variation in feed efficiencies within the groups. There was good correlation between weight gain

TABLE 6

Biological protein evaluation results

(Rat weights are averages for ten rats—in grams)

Milk treatment (% H_2O_2):	Raw	Pasteurized (162° F., 20 sec.)				120° F–treated			
	0.0	0.0	0.1	0.2	0.5	0.0	0.1	0.2	0.5
Milk samples									
Initial weight	53.3	53.6	53.7	52.5	53.2	53.4	52.5	52.3	52.0
6-wk. weight	176.9	185.6	175.6	170.7	173.8	192.9	178.9	185.4	179.5
Food consumption[a]	457.7	132.0	121.9	118.2	120.6	139.5	126.4	133.1	127.5
Protein efficiency[b]	3.04	498.1	479.1	461.2	483.2	514.5	498.0	517.2	489.7
Total gain	123.6	3.00	2.88	2.95	2.94	3.01	2.82	2.97	2.94
Whey protein samples									
Initial weight	52.5	52.7	52.5	52.6	52.7	52.8	52.4	52.3	52.7
6-wk. weight	200.4	206.3	187.0	194.6	183.9	188.0	209.3	189.4	202.2
Total gain	147.9	153.6	134.5	142.0	131.2	135.2	156.9	137.1	149.5
Food consumption[a]	505.9	525.1	474.7	496.8	485.7	490.8	503.3	474.0	488.1
Protein efficiency[b]	3.19	3.19	3.04	3.12	2.92	2.97	3.43	3.16	3.36
Cheese samples									
Initial weight	51.9	52.0	51.3	51.7	52.1	52.5	51.1	52.9	52.9
6-wk. weight	129.6	140.1	140.6	124.4	123.6	136.8	137.4	135.9	111.3
Total gain	77.7	88.1	89.3	72.7	71.5	84.3	86.3	83.0	58.4
Food consumption[a]	361.9	377.5	402.0	352.8	359.7	380.9	378.3	377.6	318.0
Protein efficiency[b]	2.27	2.52	2.42	2.20	2.10	2.34	2.49	2.33	1.82

Casein standards:	A[c]	B[d]		Repeat test on cheese from heat-treated milk	
				H_2O_2	0.5% H_2O_2
Initial weight	52.4	51.8	Initial weight	55.0	54.8
6-wk. weight	145.8	172.3	6-wk. weight	136.8	120.8
Total gain	93.4	120.5	Total gain	81.8	65.2
Food consumption	404.1	443.5	Food consumption	353	323
Protein efficiency	2.33	2.82	Protein efficiency	2.40	2.14

[a] Dry basis.

[b] Grams gain per gram protein consumed.

[c] A = diet moisture content as for whey diet.

[d] B = diet moisture content as for cheese diet.