THE KEEPING QUALITIES OF GRADE A (CERTIFIED) MILK.

By K. FREEAR, N.D.D., A. T. R. MATTICK, B.Sc. AND R. STENHOUSE WILLIAMS, M.B., B.Sc., ETC.

The National Institute for Research in Dairying,
University College, Reading.

(With 1 Chart.)

IN two previous papers (Freear, Buckley and Stenhouse Williams, 1919; Freear, Mattick and Stenhouse Williams, 1921) accounts were given of the bacteriological condition of the milk from four Grade A (Certified) Farms, and it was shown that the milk from Farm 1 maintained a very high standard of bacteriological purity throughout a long series of examinations. In view of the fact that the keeping qualities of milk are of very great importance both to the industry and to the consumer, these have been studied with milk which was derived from Farm 1.

A paper concerning the keeping qualities of this milk, which was 24 hours old on arrival at the laboratory, has been published already (Freear, Buckley and Stenhouse Williams, 1919).

The present paper is concerned with the results which were found during the period August 18th, 1918–August 24th, 1919, when the milk was 30 hours old on arrival at the laboratory, and was morning's milk, whereas the milk previously discussed was evening's milk.

The milk was cooled at the farm, with water from a deep well, and the temperatures after cooling varied between a maximum of 62° F. and a minimum of 38° F. It was then run into pint bottles which were packed in ventilated boxes and dispatched by rail to the laboratory. No attempt was made to keep the milk cool during the journey with the result that it arrived at temperatures which varied between a maximum of 76° F. and a minimum of 38° F. The results of the study of the bacteriological condition of this milk have already been published, and it has been shown that its general cleanliness was of such a character that it is justifiable to consider its keeping qualities in relation to time and temperature conditions only, its bacteriological condition being regarded as constant (Freear, Mattick and Stenhouse Williams, 1921).

Condition of storage, and method of testing for sweetness.

In order to compare the effects of storage under different conditions, the milk was kept in four different places after its arrival at the laboratory; (1) in the ice chest, (2) in a fairly cool cellar; (3) on a slate slab four feet from

the floor of the laboratory; (4) on the laboratory floor beneath a window facing east, and eight feet from a gas fire. The experiments on the laboratory floor and slab were done in order to try and discover whether or not variations in the keeping qualities of milk could be demonstrated in different parts of the same room, and if so whether they would be of sufficient magnitude to be of practical value.

On its arrival the milk was thoroughly shaken, the caps were removed from the bottles, and samples for bacteriological tests were taken. Each sample was then divided into four parts by pouring through sterile funnels into sterile bottles which were then closed with plugs of sterile cotton wool. These plugs were removed twice daily for the purpose of tasting but no attempt was made to keep either the plugs or the mouths of the bottles sterile.

Table I.

Average periods of sweetness of clean milk when stored in different places.

	Ice chest	Cellar	Slate	Floor
No. of samples	57	57	49	49
Average number of days sweet	14·25	5·7	4·64	5·02
Minimum number of days sweet	2	1·5	1·5	1·0
Maximum number of days sweet	25	15·5	11·5	11·5

Study of periods of sweetness.

Table I shows the periods of sweetness of the samples which have been reckoned from the time of milking. It demonstrates that the average period of sweetness of the samples which were kept in the ice chest was 14¼ days
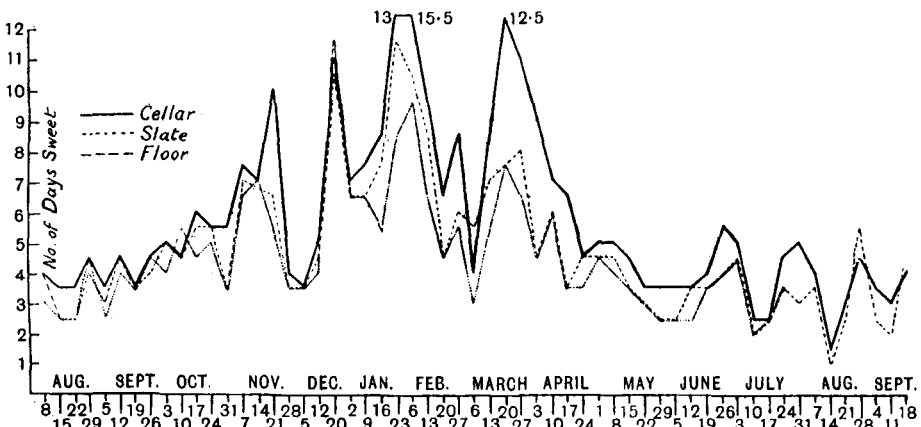

Chart 1. Showing the variation in keeping quality when samples of clean milk were divided into three parts and kept: (1) in a cellar, (2) on the floor of the laboratory, (3) on a slate slab in the laboratory 4 ft. above the floor.

with a minimum of two days, in the cellar 5·7 days with a minimum of 1·5 days, on the laboratory floor five days with a minimum of one day and on the slate in the laboratory 4·64 days with a minimum of 1·5 days. Chart 1 demonstrates the same facts.

It is clear that even under the very varying conditions of cooling, of carriage and of storage on arrival, this milk remained sweet for prolonged periods of time, since no sample was received in a sour condition and only one remained sweet for less than two days. It is interesting to note that samples of milk have been coming from this farm from November 1916 to the present time (Sept. 1921) and on no occasion has a sample been received in a sour condition. The chart further makes clear the phenomenon which is generally described as "seasonal influence," since it demonstrates the effects of temperature, cooling, transit and subsequent storage upon the keeping qualities of the milk.

In order that the facts contained in the chart may be more readily appreciated they have been epitomised in Table II which makes clear the marked influence of variations of temperature, etc. upon the keeping qualities of the milk at different seasons of the year. It will be seen that these were markedly less during the months May–September than they were during the months October–April.

Table II.

Table showing influence of temperature, etc. on keeping qualities at different periods of the year.

| Period | Cellar | | Floor* | | Slate* | |
	No.	Days sweet	No.	Days sweet	No.	Days sweet
May–Sept.	29	3·84	21	3·3	21	3·3
Oct.–April	28	7·62	28	6·22	28	5·6

* Floor and slate samples ceased on July 24th, 1919. Therefore, only 21 samples were examined during the summer period.

If it be granted that the bacteriological condition, and the cleanliness of the utensils used for this milk, were as good as are likely to be found in practice, which we believe to be true, then it is possible to consider other factors which make for sweetness or sourness in milk. Among these may be mentioned the temperatures of cooling and transit and the temperatures of subsequent storage.

The influences of temperatures of cooling and transit may be found from the results obtained with those samples which were subsequently kept in the ice chest, and the influences of the temperatures of storage, in those samples which were kept in the cellar and the laboratory.

Influence of temperatures of cooling and carriage.

The great importance of the temperatures of cooling and carriage on the subsequent keeping qualities of the milk, is shown in Table III.

From Table III it is seen that when the milk was kept in the ice chest those samples which had been cooled to an average temperature of 50° F. and arrived at temperatures between 41° F. and 50° F. remained sweet for an average period of 14·4 days, those which had been cooled to an average temperature of 55° F. and arrived at temperatures between 51°–60° F. re-

mained sweet for 14 days and those which had been cooled to an average temperature of 56° F. and arrived at temperatures which varied between 61°–70° F. remained sweet for 13·5 days. The temperatures of cooling and of carriage, therefore, had an appreciable influence upon the subsequent sweetness of these samples.

Table III.

Influence of temperature and age on arrival on the keeping qualities of samples of milk when stored in the ice chest.

Age in hours when tested	No. of samples	Average temperature of cooling	Average temperature on arrival	No. of days sweet
24	12	50° F.	41°–50° F.	17·5
30	15			14·4
24	14	55° F.	51°–60° F.	16·8
30	17			14·0
24	15	56° F.	61°–70° F.	14·0
30	16			13·5

It is of interest to consider the average periods during which the samples of milk remained sweet in the ice chest when they were 24 hours old on arrival, in comparison with the average periods when the milk was 30 hours old on arrival. This comparison has been made in Table III which shows that those samples which were 24 hours old on arrival, kept sweet in the ice chest for longer periods than those at similar temperatures which were 30 hours old on arrival and that this difference diminishes with the increase of temperature on arrival. Thus when the milk arrived at temperatures between 41°–50° F. the samples which were 24 hours old kept for an average period of .17·5 days, whereas those which were 30 hours old kept for an average period of 14·4 days —a difference of three days. When the temperatures on arrival were between 51°–60° F. the difference was 2·8 days. On the other hand when the milk arrived at temperatures between 61° F. and 70° F. the influence of increased temperature is shown by the fact that the difference was only half a day.

Influence of temperature on delivery and subsequent storage on the keeping qualities.

Table IV brings out the influence of the temperature on delivery and subsequent storage on the keeping qualities of the milk.

The samples which arrived at temperatures lower than 40° F. and above 70° F. are too few in number for discussion. They are included in order to complete the record.

It will be noted that those samples which arrived at temperatures between 61° F. and 70° F. could not be relied upon to keep sweet in the laboratory for a longer period than 2·8 days from the time of milking. At the present time the regulations permit of the sale of this milk when 48 hours old.

If we assume that the milk is 48 hours old when sold to the consumer then there is a margin of only 0·8 day sweetness in the consumer's house, a conclusion arrived at under conditions which were certainly not worse than the

Table IV.

The influence of temperature on arrival and subsequent storage on the period of sweetness of clean milk.

No. of samples	Temp. in °F.	Age in hours	Temp. after cooling °F.	Temp. on delivery °F.	ICE CHEST					CELLAR				
					No. of days sweet	Min. temp. °F.	Max. temp. °F.	Average min. temp. °F.	Average max. temp. °F.	No. of days sweet	Min. temp. °F.	Max. temp. °F.	Average min. temp. °F.	Average max. temp. °F.
1	40 or less	30	44	38	23	33	36	33	34·5	15·5	34	42	37	38·5
15	41 to 50	30·5	50	46	14·4	31	38	33·5	35	7·7	36	51	43·5	45
17	51 to 60	29·7	55	55	14·0	32	42	33·5	35·5	5·0	40	61	52	54
16	61 to 70	30	56	64·5	13·5	33	43	34	36·7	3·6	50	66	58	60
1	73	29	62	73	17	33	39	34	36·5	3·5	61	67	62	65
1	76	28	62	76	14	33	39	34	37	3·5	59	63	59·5	62

No. of samples	Temp. in °F.	Age in hours	Temp. after cooling °F.	Temp. on delivery °F.	LABORATORY SLATE					LABORATORY FLOOR				
					No. of days sweet	Min. temp. °F.	Max. temp. °F.	Average min. temp. °F.	Average max. temp. °F.	No. of days sweet	Min. temp. °F.	Max. temp. °F.	Average min. temp. °F.	Average max. temp. °F.
1	40 or less	30	44	38	9·5	33	62	39	51	10·5	31	53	36	46·5
15	41 to 50	30·5	50	46	5·5	39	71	47	55	6·2	34	57	44·5	51
17	51 to 60	29·7	55	55	4·25	42	72	53·5	59	4·5	39	70·5	51·9	58
16	61 to 70	30	56	64·5	2·8	59	73	61·5	69	3·0	53	76	60	68
1	73	29	62	73	2·5	67	78	67	78	2·5	63	79	62	79
1	76	28	62	76	2·5	57	71	57	71	2·5	57	71	57	71

average. Under the present regulations it does not appear advisable that milk of this age should be delivered to the consumer when it has been allowed to reach temperatures above 60° F.

If it were possible to deliver this milk within 24 hours of milking then the conditions would be altered and the matter would require reconsideration. It is a question for the industry to decide whether they will guarantee that the milk shall be cooled to a temperature of not more than 60° F. and be carried and stored at temperatures which shall not exceed this, with delivery at the end of 48 hours, or whether they will reduce the period of time during which the milk is in transit so as to guarantee its sweetness in the consumer's house. If the former course is taken then it will be necessary to adopt more efficient methods of cooling milk and keeping it cool during transit than exist at present.

If the latter, then the milk should be delivered to the consumer within 24 hours of milking if it is to be guaranteed to keep sweet for a further 24 hours.

The question whether more efficient methods of cooling during the summer months with delayed periods of delivery shall be adopted, or whether the present methods of cooling and transit, but with more rapid delivery, shall continue, is an economic problem which ought to be seriously considered by the industry, and upon which a decision should be reached.

Note.

Any decisions at which Grade A (Certified) Producers may arrive must take into account two fundamental facts. (1) That milk shall not be delivered to the consumer which will go sour before the next delivery. (2) That this milk is subject to official bacteriological examinations at any time before it reaches the consumer.

These two problems have been considered, the first in this paper and the second in the *Journal of Hygiene*, xx. No. 2.

REFERENCES.

FREEAR, K., BUCKLEY, W. and STENHOUSE WILLIAMS, R. *A Study of Two Types of Commercial Milk.* Cambridge University Press, 1919.

FREEAR, K., MATTICK, A. T. R. and STENHOUSE WILLIAMS, R. A Study of the Bacteriological Examination of Grade "A" (Cert.) Milk. *Journ. Hygiene*, xx. 125.