VARIATION IN THE FREEZING POINT OF GENUINE FARM MILKS IN QUEENSLAND

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SUMMARY

An average freezing point value of —0·548°C was determined for 1,775 herd and individual cows' milks examined over a period of 18 months. The individual cows' milks varied from —0·509°C to —0·578°C, while bulked morning and evening herd milks ranged from —0·536° to —0·560°C.

Variations in freezing points occurred with season of the year, morning and evening milkings, stage of lactation, and breed of cow. A trend for individual cows to give similar results at a particular milking was observed.

I. INTRODUCTION

The freezing point of cow's milk is of practical importance as it is the least variable property and provides the most accurate means of detecting added water. Henderson and Meston (1914) reported that in southern Queensland the average freezing point of bulk herd milk determined by the Winter method was —0·550°C. Where their evaluation of Winter's table has been taken too literally, the assumption has been made that the freezing point of pure milk is constant and the correct value is —0·550°C. Reports from overseas list varying ranges of freezing-point depressions for both herd and individual cows' milk. More recent observations in Australia and overseas suggest that variations do occur; but it is generally agreed that the freezing point of genuine milk, as shown by the vast numbers of experiments employing both the Winter and the Hortvet methods, is not lower than —0·530°C.

Hillman, Provan, and Steane (1950) have shown cases of abnormal differences in the freezing-point depression from one herd. Aschaffenburg and Rowland (1950) also demonstrated that exceptions do occur. They searched for a cause and suggested an explanation.

Where abnormal freezing-point results have been obtained in North Queensland, follow-up work has shown that authentic samples from at least one farm gave abnormally high freezing-point results. There are some instances where doubts have been cast on the infallibility of the test and it would appear that cases arise which require a thorough knowledge of freezing-point variations and consideration of all available evidence. In order to provide basic information on how much variation is to be expected in normal milk in Queensland, trials were carried out on milk from five herds.

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II. MATERIALS AND METHODS

Five Atherton Tableland herds were selected for the trials. They were maintained under the general district system of being mainly dependent on pasture grazing (paspalum and kikuyu grass with smaller amounts of guinea grass), with some supplementary feeding during the dry season from August to December, and were representative of the wide variations in district practices. They were comprised of cows of the predominant Australian Illawarra Shorthorn (A.I.S.) breed, as well as of Jersey and Friesian breeds. Briefly, the herds and their nutritional status were:—

Herd No. 1: An A.I.S. grade herd usually maintained at a fair level of feeding.

Herd No. 2: A well-fed purebred A.I.S. commercial dairy herd.

Herd No. 3: A poorly fed mixed Jersey–A.I.S. grade herd.

Herd No. 4: A well-fed purebred Jersey and grade Friesian herd.

Herd No. 5: A poorly fed mixed Jersey–A.I.S. grade herd.

Unlike the cows in the experiment of Aschaffenburg and Rowland (1950), these animals had access to drinking water at all times during pasture grazing and it was also noted that most cows consumed some water while in the yard immediately prior to milking. Details of supplementary feeding were recorded, but due to irregularities in practices they could not be correlated with other results. Individual cow and herd milk samples were examined for a period of 12 months and the samples from Herds 1, 3 and 5 were continued for a further four months during the dry spring and early summer months. During this extended period there was no supplementary feeding; this should enable a true picture of freezing-point variation under the most extreme feeding conditions experienced on Tableland farms to be gained.

The farms with Herds 1 to 3 were each visited one day weekly and samples of the morning and the evening herd milks were obtained. Farms with herds 4 and 5 were visited once monthly, when samples were obtained for the morning and the evening milkings of the individual cows. On the days that sampling was carried out on the farm, samples of bulked morning and evening milk from the respective herds were obtained at the factory. All samples were subjected to fat, solids-not-fat and freezing-point determinations in the laboratory.

Basic precautions were taken to ensure by means of personal observations that no extraneous water even in trace amounts gained access to the milk during milking.

The freezing points were determined by the Winter method, which is the technique prescribed for official analysis by Regulation 86 of the Queensland Health Department's Food and Drug Regulations and it is the method employed by the Queensland Department of Agriculture and Stock.

III. RESULTS

(a) Herd Milks

In the weekly sample group of three herds, freezing points were determined on 365 samples during the period July 1960 to October 1961.

Table 1 shows the average freezing points of the milk of these herds for both morning and evening samples.

TABLE 1

AVERAGE FREEZING POINTS OF THE HERD MORNING AND EVENING SAMPLES

Herd No.	Milking	No. of Samples	Average Freezing Point (−°C)
1	a.m.	63	·547
1	p.m.	62	·550
2	a.m.	57	·546
2	p.m.	57	·548
3	a.m.	63	·547
3	p.m.	63	·547

The recorded freezing-point depressions ranged from —0·527° to —0·570°C. Table 2 shows their distribution. It is noted that three samples from Herd 2 recorded results above —0·531°, viz. —0·527° and —0·529° for evening milks and —0·530° for a morning milk.

TABLE 2

DISTRIBUTION OF FREEZING-POINT DEPRESSIONS OF HERD MILKS

Freezing Point (−°C)	Herd No. 1		Herd No. 2		Herd No. 3		Total
	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.	
<0·531			1	2			3
0·531 to 0·535	2	1	3	4		5	15
0·536 to 0·540	5	4	4	1	6	7	27
0·541 to 0·545	18	14	17	11	16	13	89
0·546 to 0·550	23	21	23	16	24	19	126
0·551 to 0·555	11	18	8	14	15	13	79
0·556 to 0·560	4	2	0	8	2	6	22
0·561 to 0·565		1	1	1			3
>0·565		1					1

A total of 254 samples of bulked morning and evening milks from each herd was taken at the factory for days on which the milkings were supervised on the farm. The freezing points ranged from —0·536° to —0·560° with 6·7 per cent. below —0·540°. The percentage distribution is shown in Figure 1.

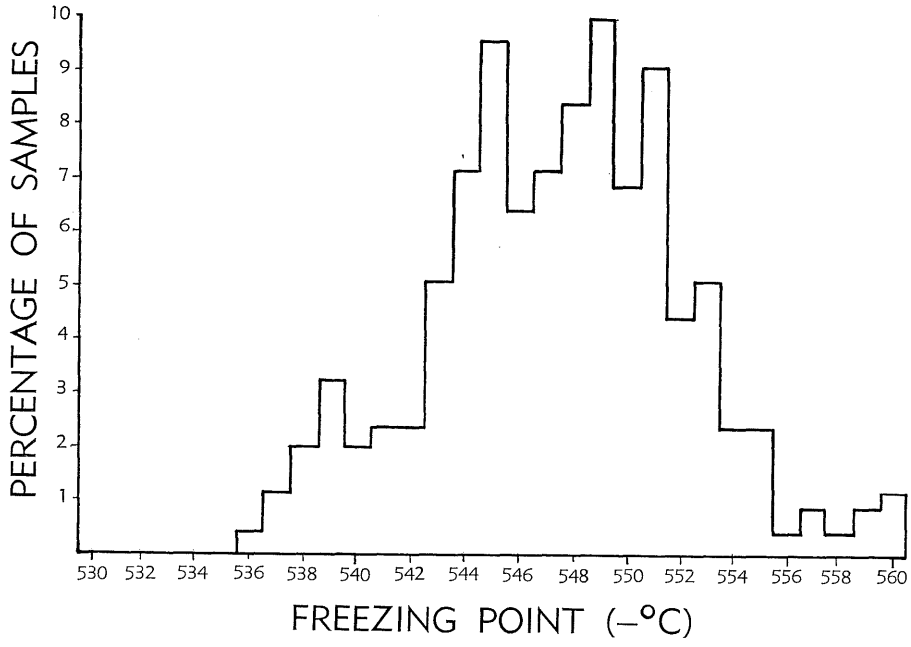

Fig. 1.—Percentage distribution of freezing-point values for bulked herd milks.

Fifteen of the 17 samples which gave results above —0·540° were obtained during the months of July and August, a period which corresponds with the period of the year when the average freezing point is at its highest.

Two results of —0·538° were obtained for samples from Herds 2 and 3 during the months of April and March, respectively. During this period, Herd 3 had experienced a sickness which caused production to decline from 60 gal to below 30 gal daily; but there was no apparent reason for the high result in the milk of Herd 2.

(b) Individual Cow Milks

Freezing-point depressions for 1,156 genuine individual cow samples ranged from —0·510° to —0·578°. The distribution is shown in Table 3.

TABLE 3

DISTRIBUTION OF FREEZING-POINT DEPRESSIONS OF INDIVIDUAL COWS' MILK

Freezing Point (−°C)	Morning Samples	Evening Samples	Total Samples
0·509 to 0·510		2	2
0·511 ,, 0·512			
0·513 ,, 0·514	1		1
0·515 ,, 0·516			
0·517 ,, 0·518			
0·519 ,, 0·520		3	3
0·521 ,, 0·522		1	1
0·523 ,, 0·524	2	1	3
0·525 ,, 0·526		4	4
0·527 ,, 0·528	4	3	7
0·529 ,, 0·530	7	11	18
0·531 ,, 0·532	13	9	22
0·533 ,, 0·534	4	12	16
0·535 ,, 0·536	11	4	15
0·537 ,, 0·538	25	11	36
0·539 ,, 0·540	34	36	70
0·541 ,, 0·542	32	33	65
0·543 ,, 0·544	36	18	54
0·545 ,, 0·546	57	43	100
0·547 ,, 0·548	78	64	142
0·549 ,, 0·550	72	56	128
0·551 ,, 0·552	52	61	113
0·553 ,, 0·554	35	52	87
0·555 ,, 0·556	52	59	102
0·557 ,, 0·558	51	31	82
0·559 ,, 0·560	9	36	45
0·561 ,, 0·562	4	8	12
0·563 ,, 0·564	7	4	11
0·565 ,, 0·566	1		1
0·567 ,, 0·568	2	5	7
0·569 ,, 0·570	2	2	4
0·571 ,, 0·572		3	3
0·573 ,, 0·574			
0·575 ,, 0·576		1	1
0·577 ,, 0·578		1	1

Analysis shows that 570 (49·3 per cent.) of the samples fall in the range −0·545° to −0·554°, while 96·2 per cent. of the samples fall in the range −0·531° to −0·570°.

Seasonal Effect.—The average freezing-point depression of individual cow milks was below −0·550° during the period December to May, but during the remainder of the year remained above this figure. It rose to a maximum of −0·541° during July and August, which are the coldest months of the year, and gradually decreased during the dry spring months.

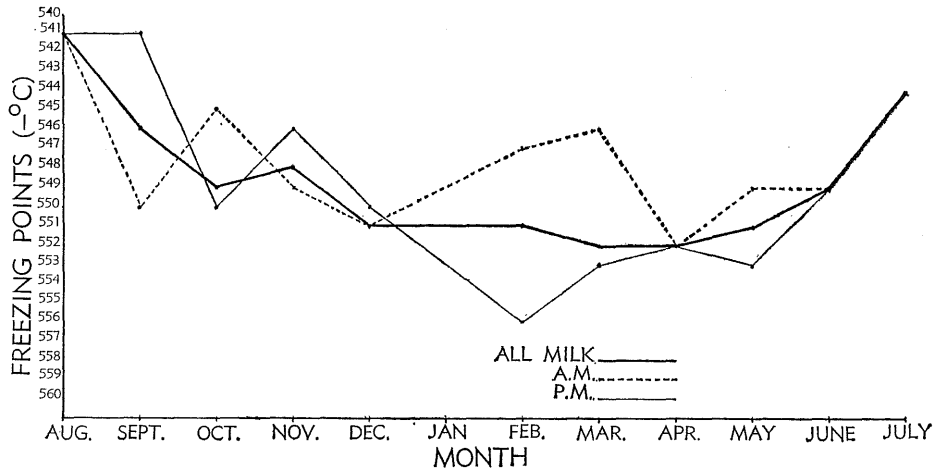

Fig. 2.—Monthly mean freezing points for individual cow milks.

Morning and Evening Milkings.—A comparison of the monthly average freezing point depressions for morning and evening milk is shown in Table 4 and Figure 2.

TABLE 4

PERCENTAGE OF INDIVIDUAL COWS' MILKS WITH MAXIMUM FREEZING-POINT DEPRESSIONS FOR MORNING AND EVENING MILKINGS

Month	Percentage of Cows Recording Maximum Freezing-Point Depressions for	
	a.m. Milk	p.m. Milk
August	50·0	50·0
September	31·2	68·8
October	72·7	27·3
November	54·9	46·0
December	32·2	67·8
January	86·0	14·0
February	88·2	11·8
March	78·8	21·2
April	71·4	28·6
May	81·3	18·7
June	57·0	43·0
July	48·0	52·0

The freezing-point differences between the two consecutive milkings are quite irregular. The freezing point of the morning milk was sometimes higher, sometimes lower, than that of the corresponding evening milk. However, during the summer and autumn months, the evening average remained at the lower level. During this period there was a marked tendency towards higher freezing points for morning milk of individual cows. While the extent of the difference between milkings varied with each herd, the trend was the same for each month except

October and November. During these two months 95 and 74 per cent. respectively of the individual cows of Herd 4 had higher freezing points for morning milk than for evening milk, while the corresponding results for Herd 5 were 43 and 35 per cent.

Effect of Breed.—In Herd 4, Friesian cows were compared with Jerseys, and in Herd 5, A.I.S. cows were compared with Jerseys. In order to reduce variations from other sources, six cows of each breed were selected from each herd and results were obtained for the complete lactation period of each cow. They are summarized in Tables 5 and 6.

For each comparison all conditions were the same and the comparisons were made against cows within the same month of lactation during the same month of the year. The average freezing-point results are compared for each breed and a difference of 0·002°C is significant at the 5 per cent. level.

Stage of Lactation.—The average freezing-point depressions of individual cow milks from Herds 4 and 5 are shown in Figure 3. Abnormal results were obtained for samples during the 13th and 14th months of lactation for two cows but they were excluded because of the abnormally long lactations. A general decrease in the average freezing-point value after the fifth month of lactation will be noted.

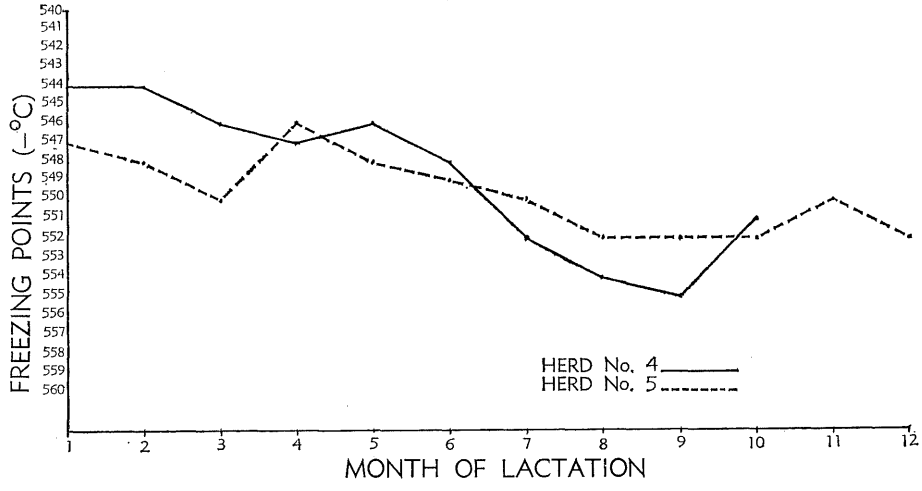

Fig. 3.—Effect of stage of lactation on average freezing-point values in two herds.

Solids-not-fat.—Solids-not-fat results were obtained for all samples which were examined for freezing point. The results showed a large variation in the solids-not-fat level with the breed of cow and level of feeding. This could give misleading results in correlation with the freezing points, particularly in the case of individual cows.

TABLE 5

COMPARISON OF FREEZING POINTS OF MILK OF FRIESIAN AND JERSEY COWS IN HERD 4

Cow No.	Milking	Av. F.P. (−O°C)	Standard Deviation	Cow No.	Milking	Av. F.P. (−O°C)	Standard Deviation
	Friesian				Jersey		
1	a.m.	·545	·0100	1 ..	a.m.	·548	·0018
1	p.m.	·554	·0120	1 ..	p.m.	·551	·0029
2	a.m.	·542	·0056	2 ..	a.m.	·551	·0016
2	p.m.	·550	·0120	2 ..	p.m.	·554	·0090
3	a.m.	·546	·0028	3 ..	a.m.	·546	·0098
3	p.m.	·545	·0012	3 ..	p.m.	·547	·0098
4	a.m.	·545	·0022	4 ..	a.m.	·547	·0085
4	p.m.	·554	·0133	4	p.m.	·551	·0054
5	a.m.	·545	·0074	5 ..	a.m.	·549	·0027
5	p.m.	·553	·0040	6 ..	p.m.	·552	·0021
6	a.m.	·547	·0020	6 ..	a.m.	·550	·0072
6	p.m.	·550	·0015	6 ..	p.m.	·555	·0030
	a.m.	Av. −0·545°C			a.m.	Av. −0·549°C	
	p.m.	Av. −0·551° C			p.m.	Av. −0·552°C	
		Av. −0·548°C				Av. −0·550°C.	

TABLE 6

COMPARISON OF FREEZING POINTS OF MILK OF A.I.S. AND JERSEY COWS IN HERD 5

Cow No.	Milking	Av. F. P. (−O°C)	Standard Deviation	Cow No.	Milking	Av. F.P. (−O°C)	Standard Deviation
		A.I.S.				Jersey	
1	a.m.	·546	·0092	L1 ..	a.m.	·551	·0041
1	p.m.	·546	·0064	L1 ..	p.m.	·551	·0064
2	a.m.	·547	·0062	L2 ..	a.m.	·549	·0021
2	p.m.	·546	·0061	L2	p.m.	·542	·0015
3	a.m.	·546	·0042	L3 ..	a.m.	·546	·0011
3	p.m.	·541	·0067	L3 ..	p.m.	·546	·0019
4	a.m.	·547	·008	L4 ..	a.m.	·550	·0021
4	p.m.	·551	·0062	L4 ..	p.m.	·550	·0015
5	a.m.	·551	·0063	L5 ..	a.m.	·550	·004
5	p.m.	·549	·0077	L5 ..	p.m.	·547	·0012
6	a.m.	·547	·0044	L6 ..	a.m.	·549	·0018
6	p.m.	·549	·012	L6 ..	p.m.	·550	·0053
	a.m.	Av. −0·547°C			a.m.	Av. −0·550°C	
	p.m.	Av. −0·547°C			p.m.	Av. −0·549°C	
		Av. −0·547°C.				Av. −0·549° C.	

The extreme values for freezing point with the corresponding solids-not-fat for herd milks are tabulated in Table 7, and mean results for individual cows' milks in Table 8.

TABLE 7

EXTREME VALUES FOR FREEZING POINT AND SOLIDS-NOT-FAT IN HERD MILKS

Freezing Point (−°C)		Solids-Not-Fat (%)	
Max. a.m. 0·530	p.m. 0·546	a.m. 8·5	p.m. 8·6
Min. a.m. 0·561	p.m. 0·558	a.m. 8·7	p.m. 8·8
a.m. 0·545	Max. p.m. 0·527	a.m. 8·7	p.m. 8·5
a.m. 0·550	Min. p.m. 0·570	a.m. 9·0	p.m. 9·9
a.m. 0·546	p.m. 0·541	Max. a.m. 9·2	p.m. 9·1
a.m. 0·546	p.m. 0·550	Min. a.m. 7·8	p.m. 7·9
a.m. 0·542	p.m. 0·549	a.m. 9·0	Max. p.m. 9·3
a.m. 0·546	p.m. 0·550	a.m. 7·8	Min. p.m. 7·9

TABLE 8

MEAN VALUES FOR FREEZING POINT AND SOLIDS–NOT–FAT IN INDIVIDUAL COW MILKS

	Freezing Point (−°C)	Solids-Not-Fat (%)
a.m. milk	0·547	8·5
p.m. milk	0·548	8·6
All milk	0·548°C.	

The standard deviations of freezing-point depression and solids-not-fat content were determined for all individual cows' milks. The standard deviations of freezing points were found to be 0·0074 and 0·0087 and the coefficients of variation 1·35 and 1·59 for morning milk and evening milk respectively. The standard deviations of solids-not-fat (0·384 and 0·401) showed a wider variation, with coefficients of variation of 4·52 and 4·66 for morning milk and evening milk respectively.

IV. DISCUSSION

The freezing points of separate morning and evening herd milks ranged from −0·527° to −0·570°. Fewer than 0·2 per cent. of samples were below −0·565°, but more important, only 0·55 per cent. gave results above −0·530°C. It is the practice of North Queensland factories to accept refrigerated milk supplies comprising both evening and morning milk. The freezing points of the respective bulked herd milks as delivered to the factory were within a range of −0·536° to −0·560°, with 6·7 per cent. above −0·540°.

As expected, the individual cow samples varied through a much wider range from —0·509° to —0·577°, with 2·6 per cent. of the results being above —0·530°. It can be seen that occasions do arise when there is a tendency for a high percentage of cows in a herd to give either high or low freezing point results at a particular milking. During February, 88·2 per cent. of the cows from two herds gave lower results for the evening milking, while 68·8 per cent. of the cows gave higher results for the evening milking during September. When results of samples of herd milk for a single milking are considered, the effect of bulking should not be over-estimated. However, when samples are received from bulk herd milk comprising two successive milkings, it is unlikely that the freezing-point depression would be above —0·535°.

There is a significant change in the average freezing point with season of of the year. The tendency was towards high freezing-point results during the colder months. It is during these months that supplies to factories are low and cases of deliberate adulteration are most likely to occur. Laboratory quality control records of farm supplies to factories over the past three years show that over 90 per cent. of the cases of added water occur during the period June to October. Unfortunately, in such cases the calculated percentage of added water is probably exaggerated and there is no reliable approximation unless a tolerance is applied and the result reported as "minimum percentage of added water."

No correlation could be found between morning and evening results except a general tendency towards higher freezing point for morning milk during the summer and autumn months.

Aschaffenburg and Veinoglou (1944) have shown low correlations between solids-not-fat content and freezing-point depression. Solids-not-fat results were obtained for all samples, but as the work included extreme variations due to level of feeding, season and breed, correlation of these results was not attempted. However, it was interesting to note that there were slight but significant differences between the freezing points of Jersey, Friesian, and A.I.S. milk. As with the solids-not-fat content, the freezing point was less variable for the Jersey breed than for either the Friesian or A.I.S. breeds. This was noted in both the well-fed and the poorly fed herds.

There was a general decrease in the average freezing-point value as lactation progressed. Although the seasonal effect could influence this section of the experiment, the trend after the fifth month is significant when it is considered that some 40 per cent. of the samples for the seventh, eighth and ninth months of lactation were taken during the winter months when the average freezing point of individual cows' milk was at its highest.

It is apparent that the average value obtained is dependent upon the design of the experiment. Some of the unusual average values reported in the literature have been based on insufficient samples over too short a period and have been

influenced by environmental factors. The average freezing-point values obtained for herd milks and also individual cows' milks were both —0·548°. This shows good agreement with a number of overseas findings and is, in fact, the same as the average determined for 75 samples by Hortvet (1921). Although variations in freezing points were observed, a thorough knowledge of the freezing-point test and its limitations provides the most useful tool for determining added water in milk.

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