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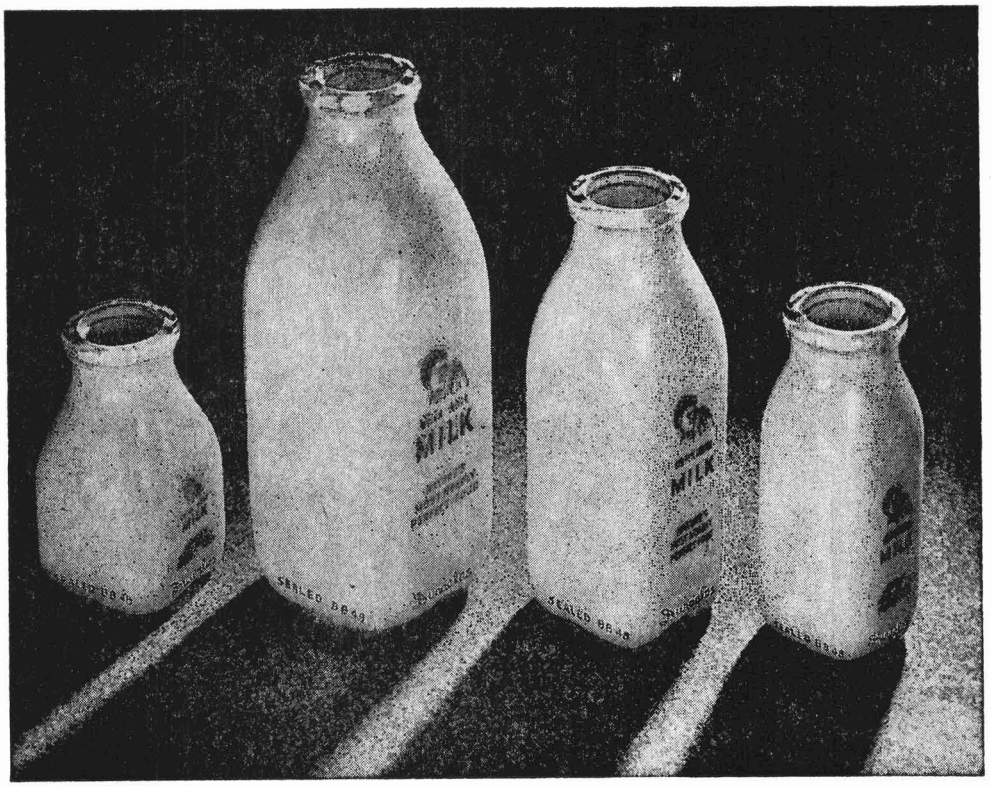

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THE INFLUENCE OF AGE ON BREEDING EFFICIENCY OF DAIRY CATTLE IN ARTIFICIAL INSEMINATION

T. TANABE* AND G. W. SALISBURY
Department of Animal Husbandry, Cornell University, Ithaca, New York

Age, undoubtedly, exerts an influence on breeding efficiency of dairy cattle. Little agreement on the effect of age on fertility exists beyond the general conclusions that the number of services required per conception by heifers is significantly greater than for cows that have calved once or more (2, 3, 8, 10, 11, 13, 14, 15, 20, 21). Also, for cows older than nine or ten years there appears to be a considerable increase in the number of services required per conception (10, 11, 15, 16).

Conflicting results have been reported by others (1, 12), who noted little difference in the number of services required for conception by cows of various ages, including the two-year-old group. Gowen and Dove (9) found a trend of gradual reduction in breeding efficiency with advancing age, starting with heifers under one year of age. Lasley and Bogart (13) in an artificial-breeding project with beef cattle found that the peak of fertility occurred with cows five and six years old, followed by a gradual decline with advancing age.

Starting with yearling bulls which have, in general, the highest fertility index, a gradual, but definite, decline in breeding efficiency of bulls accompanies advancing age when measured by the number of services required per conception (2, 3, 7, 9, 10, 15). Dawson (5) observed a similar declining trend in breeding efficiency of aged bulls between the ages of five and sixteen years.

On the other hand, the New Zealand Dairy Board (16) found that up to ten years of age no significant correlation between age and fertility was evident. Others have found a higher breeding efficiency resulting from the use of young bulls under six years of age, as compared with older bulls, when bred to either cows of all ages (10, 14) or to first-gestation heifers (10, 15).

Although the growing popularity of artificial insemination has greatly

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* The material contained in this report is from a thesis presented by T. Tanabe to the Graduate School of Cornell University, October, 1945, in partial fulfillment of the requirements for the degree of Master of Science in Agriculture.

increased the breeding potentialities of many bulls, little attention has been devoted to the question of age of the mates as a factor in determining the efficiency of the practice.

This study has been undertaken to determine the effect of age of both dam and sire upon the breeding efficiency of dairy cattle in artificial breeding in which there is a preponderance of aged bulls in use. Also, it is now possible under conditions of artificial insemination to determine whether or not reported low fertility of young heifers in natural service is due to physical incompatibility of the mates, or to an inherent lower fertility of young heifers.

EXPERIMENTAL

The data included in this investigation consist of services only to registered Holstein-Friesian cows bred by artificial insemination for which service records were complete and known to be accurate. All grade cows have been sifted out, although complete breeding histories were available, since in most commercial herds it has not been possible to obtain satisfactory records of their date of birth. As a consequence, too frequently their ages have been mere approximations rendering yearly classifications highly inaccurate.

All the services included in this study have been taken from the breeding records of the New York Artificial Breeders' Cooperative from the beginning of the association in June, 1940, until June 30, 1944. Over this period of four years a total of 12,621 services to purebred Holstein-Friesian heifers and cows became available. As summarized in table 1, of this number 8,350 were first services, or services to cows bred for the first time for any single gestation, and 4,271 were second services, or services to cows which had failed to conceive from the first insemination. The number of services to purebred cows represented 22.4 per cent of the total services to the Holstein-Friesian bulls in the period covered.

To determine the age of each cow and bull the date of birth was traced back into the Holstein-Friesian Herd Books through their registration numbers. All cows were grouped in full-year periods, as seen in table 1. From year to year many cows have reappeared, their re-entry depending upon the age at which they were again bred for a later calf. The average age of the 8,350 cows was 4.2 years.

The data were further tabulated and arranged to disclose the breeding efficiency of the 41 bulls during the time they remained in service for the Cooperative. The ages of the bulls ranged from one to twelve years.

The innate fertility of all these bulls, compared with the cows to which they were mated, may be more accurately assessed, since contributory factors of environment and management have been similarized as much as possible for all bulls. On the average, semen samples were drawn from each bull once every seven to ten days. This uniformity in the frequency of collection would tend to minimize the effect noted by Dawson (5) that conception

rate in natural service is an inverse function of the number of previous monthly services.

No discrimination could be made between sterile and fertile cows; therefore, all services to cows, fertile or sterile, were credited or discredited to the respective bulls. Nor was it possible to analyze the data beyond first and second services, since the success of most third services is unknown. Under the present adopted policy, a cow failing to conceive on the first service is entitled to two additional services for the original service charge. Beyond the third service an extra fee is charged. For this reason, after the third service some breeders have resorted to natural breeding or to the disposal of cows which have failed to conceive. Due to this fact there is no reliable way to determine the outcome of the third service. Therefore, third services have been used only as an indication of the success or failure of second services.

When recording the data, the assumption was made that all cows showing no recurrence of estrus during the succeeding five-month period were pregnant unless definitely stated to the contrary. This five-month interval after insemination has been chosen to signify conception since Elliott (6), in studying the results of one local association, found that 95 to 99 per cent of the cows inseminated but returning to service thereafter had already returned during the five months following the last service. Thus, all data in reference to conception rate are based upon the per cent of non-returns during a period of five months after service.

It is recognized that there may be certain confounding factors operative in this study to influence the absolute accuracy of the conception rates reported here. Apparently purebred breeders are somewhat more tolerant of cattle which fail to conceive readily than owners of grade cattle for the actual conception rate for the purebreds considered is about 3 per cent lower than for all cows bred to the Holstein-Friesian bulls during the same period of time. Also, the true effect of age on conception rate may not be shown in these studies for females of the younger ages which failed to conceive were constantly being culled and would not appear in the older age groups. However, it is believed that the sample of cows studied is representative of the cow population in New York and affords an opportunity for establishing a broad generalization regarding their breeding efficiency.

RESULTS

Over-all breeding efficiency. The over-all percentage of conceptions was found to be 48.2 per cent, or equivalent to 2.07 services per conception. In other words, out of 12,621 services to purebred Holstein-Friesian cows 6,538 inseminations were fruitless. This figure of 2.07 services per conception is a reflection of not only the inclusion of barren cows and heifers but of problems peculiar to artificial insemination. These have included the shipment of semen by parcel post and its storage at terminal points until used.

Salisbury *et al.* (17, 18) found that less than 1 per cent to probably no more than 4 per cent of all services during the period covered by this study were made on the day of semen collection.

Another factor that has contributed to the low conception rate of 48.2 per cent comes from inefficiency encountered during the experimental stage of development of each new member-association. This study covers a period of rapid growth during which time the number of member-associations of the New York Artificial Breeders' Cooperative, Inc., increased from 5 to 26.

Influence of age of cow on breeding efficiency. The average percentage of conception, as shown in table 1 was calculated for each age group of cows when bred to bulls of all ages.

TABLE 1

Influence of age of cow on conception rate

Age of cow (years)	First services		Second services		Total services	
	No.	% non-returns	No.	% non-returns	No.	% non-returns
1	1022	44.6	504	38.7	1526	42.7
2	1324	47.4	678	45.1	2002	46.6
3	1478	49.4	742	48.2	2220	49.0
4	1226	53.4	591	47.9	1817	51.6
5	989	49.4	502	49.0	1491	49.3
6	825	50.3	419	51.8	1244	50.8
7	544	48.2	306	51.3	850	49.3
8	405	46.4	217	47.9	622	46.9
9	262	45.4	150	48.7	412	46.6
10	140	49.3	79	53.2	219	50.7
11	89	40.4	54	42.6	143	41.3
12 & over	46	43.5	29	44.8	75	44.0
Totals and percentages	8350	48.69	4271	47.23	12,621	48.20

These summarized figures conclusively establish the fact that in artificial insemination yearling heifers, as a group, require more services per conception than cows of subsequent age groups up through ten years.

It is interesting to compare the curve obtained from first services with that arising from plotting the points of second services. Up to five years of age, the second service conception curve parallels that resulting from first services except at a lower level. Then at this point a complete reversal of the levels of the two curves occurs. Though still running parallel, the second service conception curve now maintains the higher level. In other words, cows under five years of age have a higher conception rate on first service than on second, while in cows over five years of age the percentage of cows conceiving on second service exceeds that from the first.

The results of this study again emphasize a fact observed in other investigations but not always receiving the attention it merits. That is, reproductive functions reach their maximum efficiency after the second or third gestation, maintain this level for a few years, then begin to decline with

advancing age. With the exception of the steep ascent of the ten-year-old group, due to small numbers, a fairly uniform and intelligible breeding efficiency curve is portrayed by plotting the figures in table 1.

Influence of age of sire on breeding efficiency. To study the influence of the age of the sire on breeding efficiency, the rate of conception for bulls of each age was calculated upon services to cows of all ages, as shown in table 2. It is readily seen that in artificial insemination the influence of age of the sire is given no opportunity of following its normal course, since bulls are so rigidly selected and culled for fertility. For this reason the apparent effect of age of the bull in the determination of breeding efficiency is much less marked than the age of the cow, irrespective of this method of grouping, whether by first, second, or total services. Thus, the forms of the two curves obtained by plotting the data in tables 1 and 2 are noticeably different.

TABLE 2

Influence of age of sire on conception rate

Age of bull (years)	First services		Second services		Total services	
	No.	% non-returns	No.	% non-returns	No.	% non-returns
1	222	53.6	115	50.4	337	51.6
2	539	58.1	309	52.8	848	56.1
3	836	50.6	415	48.7	1251	50.0
4	369	49.3	200	46.0	569	48.2
5	456	42.1	263	51.7	719	45.6
6	1009	42.2	515	41.4	1524	41.9
7	1413	49.9	674	46.4	2087	48.8
8	818	51.6	464	48.7	1282	50.5
9	946	48.3	511	45.4	1457	47.3
10	1140	48.4	510	47.8	1650	48.2
11	530	46.0	246	45.9	776	46.0
12	72	43.1	49	57.1	121	48.8
Totals and percentages	8350	48.69	4271	47.23	12,621	48.20

Nevertheless, the points of the age curve for bulls are striking and at variance with the general trend of breeding efficiency found to exist in natural breeding where, starting with yearling bulls, a gradual decline in fertility accompanies advancing age. In this study the only outstanding high figure in the uniform level of breeding efficiency of bulls of varying ages occurs in the two-year-old group: 56.1 per cent, as compared with the average of 48.2 per cent for bulls of all age groups combined. The yearling group, though above the average conception rate, failed to surpass the high level of conceptions of the two-year-old group.

Undoubtedly, the rapid fall in conception rates involving the five-year-old and six-year-old bulls is due to the large number of proved bulls that enter the Cooperative at this age and to the subsequent rigorous culling process which resulted in the bulls in the next age groups being higher than average in fertility.

The data in table 2 may be interpreted as representing a bimodal curve, describing two populations of bulls. The trend of the first four points represents young bulls going into maximum breeding efficiency as two year olds, then waning in fertility with age. The remainder of the curve represents proven bulls which enter the Cooperative at the age of five and six years, unculled for fertility level. Following the disposal of bulls of low fertility the eight-year-old bulls remain a highly selected group which gradually declined in fertility with advancing age.

Influence of age of both dam and sire on breeding efficiency. In this study of 41 bulls the rate of conception varied from 26 to 61 per cent, emphasizing fully the prominent rôle played by the individual bull in determining breeding efficiency. Within any age group, individual variations among bulls have been, in some cases, so great that they have completely overshadowed the difference that might have been due to age.

Out of this study has come no simple regression of conception rate on age of either bulls or cows. It is obvious that the relationship between the age of cows, or bulls, and conception rate in artificial insemination is not a simple linear regression.

At the present time insufficient data on bulls are available to determine the true relationship of age to fertility. It would be desirable to have data on a relatively large number of bulls, all used for several years. Even this might not show the true relationship, for such data would be highly selective and exclusive. That is, continued service in artificial insemination for such long periods would invariably lead to the retention of only bulls of relatively high fertility.

To determine the statistical significance of these data an analysis of covariance (Snedecor, 1940), using both first and second services, was made. In order to eliminate the effect of the number of services upon the efficiency of conception, the number of services for each age of bull and each age of cow was taken as the independent variable, x, and the number of five-month non-returns to service for each of these criteria of classification as the dependent variable, y. From this analysis a highly significant difference between the various ages of both cows and bulls was found; the odds in both cases were greater than 99 : 1 that the effect was not due to chance alone.

It is interesting to note in this connection that an analysis of the unweighted percentages of conception showed no significant differences between ages of cows or ages of bulls. The problem of the analysis of percentages for such data has been discussed by Salisbury *et al.* (17), and by Cochran (4).

The data were not amenable to statistical determination of the interaction between the various ages of bulls and ages of cows. However, when cows and bulls are classified into three-year age groups, a possible interaction seems noticeable. A careful study of the percentages of conception in table 3 indicates that young bulls between the ages of one to three and cows between the ages of four and six possess a higher breeding efficiency than any

other respective group. The highest rate of conception, 54.0 per cent, resulted from the mating of cows and bulls of these two groups.

On the whole the influence of the age of the cow and the age of the sire on breeding efficiency in artificial insemination is very similar to that reported for natural breeding. The lower rate of conception reported for uncalved heifers in natural service has been found equally applicable under conditions of artificial insemination where the incompatability of size and weight is no longer an influencing factor. The characteristic decrease in the level of fertility of cows 10 years of age and over also holds true in artificial insemination. Despite the attempt to retain and use highly fertile

TABLE 3

Influence of age of both dam and sire on conception rate

Age of bull (years)		Age of cows (years)				
		1–3	4–6	7–9	10 & over	All ages
1–3	%	52.1	54.0	51.0	43.1	52.3
	No.	1157	848	359	72	2436
4–6	%	40.9	46.9	46.4	48.1	44.1
	No.	1285	988	435	104	2812
7–9	%	46.7	52.2	46.1	51.1	48.8
	No.	2179	1775	709	163	4826
10–12	%	46.7	48.6	50.1	38.8	47.6
	No.	1127	941	381	98	2547
All Ages	%	46.5	50.6	47.9	46.5	48.2
	No.	5748	4552	1884	437	12621

bulls in artificial insemination, young bulls between the ages of one and three years, maintain highest levels of fertility.

SUMMARY

1. Since the beginning of the New York Artificial Breeders' Cooperative in June, 1940, until June 30, 1944, a total of 12,621 complete, recorded services to registered Holstein-Friesian cows, involving 41 bulls, have accumulated. This number is 22.4 per cent of all matings to Holstein-Friesian bulls.

2. The average number of services required per conception when based on all females, infertile cows included, was 2.07, or a breeding efficiency of 48.2 per cent.

3. The influence of the age of the cow on breeding efficiency reveals a steady increase in the conception rate up to four years of age. Between the ages of five to seven years, inclusive, cows maintain a uniformly high breeding efficiency, which gradually declines with advancing age.

4. Although the full effect of the age of the sire could not be obtained with a group of bulls selected for fertility, young bulls between the ages of one to three years, inclusive, have shown the highest breeding efficiency of all age groups. Within this group the peak in conception rates was found for the two-year-old bulls.

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VARIATION BETWEEN BREEDS IN FEED COST OF MILK PRODUCTION

LYNN COPELAND

Kentucky Agricultural Experiment Station, University of Kentucky, Lexington, Kentucky

INTRODUCTION

In 1943 a program of herd analyses was undertaken by the Dairy Extension Department of the University of Kentucky for all herds finishing a year's work of D.H.I.A. testing. Included in the analysis data sent to each owner are the feed cost figures for producing one pound of butterfat and 100 pounds of milk. Routine examination of these herd-analysis charts seemed to rather consistently show breed differences in the feed cost of producing one pound of butterfat and 100 pounds of milk.

For years, the American Jersey Cattle Club has claimed that one of the attributes of the Jersey breed is economy of butterfat production. Also the Holstein-Friesian Association has advertised the Holstein cow as a low-cost milk producer. Since most of the herds doing D.H.I.A. testing in Kentucky are composed of these two breeds, some interesting comparisons were possible.

PROCEDURE

Feed costs vary over Kentucky, but taking two full associations in the Louisville area for 1945 it was found that eighteen herds composed of either all registered Jerseys, or part registered and part grade Jerseys produced butterfat at a feed cost of $0.34 a pound. Twenty herds of either all registered or part registered and part grade Holsteins in the same two associations produced butterfat with a feed cost of $0.41 a pound. On the other hand, the eighteen Jersey herds had a feed cost of $1.75 for producing 100 pounds of milk, while the twenty Holstein herds produced 100 pounds of milk with a feed cost of $1.49. These results, in herds, all tested in the same three counties, where feed costs and pasture conditions are similar, tend to substantiate the respective claims of the two Breed Associations.

In 1928, Gaines (1) published the final results of his studies showing that the energy yield, that is the gross energy value of the milk, is a better measure of yield than either milk or fat alone. The formula which he published is now well known, but for illustration it is:

$$E' = 0.4M + 15F$$

Where E' is energy value in terms of 4 per cent fat-corrected milk in pounds, M is milk yield in pounds and F is fat yield in pounds. One pound 4 per

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TABLE 1

Kentucky D.H.I.A. cost of production data for the years 1943, 1944, 1945

Breed	Average feed cost per 100 lbs. 4% fat-corrected milk
28—All registered Holstein herds	$1.34
76—All registered Jersey herds	$1.36
41—Part registered and part grade and all grade Holstein herds	$1.50
46—Part registered and part grade and all grade Jersey herds	$1.46
115—All registered herds, including all breeds	$1.35
48—Part registered and part grade herds	$1.47
110—All grade herds	$1.51

cent fat-corrected milk = 340 kilocalories of milk energy. Expressing milk yield in terms of energy value, that is in terms of 4 per cent fat-corrected milk, is a much more reliable measure than is either milk yield or fat yield alone.

The herd analysis chart prepared for each owner shows the total milk yield of the herd, the total fat yield of the herd and the total feed cost for the D.H.I.A. testing year for 365 days. These yields for all herds finishing a year's work during the years 1943 to 1945 inclusive were computed to a 4 per cent F.C.M. basis using the foregoing formula. Then the feed costs of producing 100 pounds of 4 per cent F.C. milk was determined for each herd. The results are shown in table 1.

The Kentucky Agricultural Experiment Station herd is composed of two breeds, registered Jerseys and registered Holsteins. The cattle are all fed the same ration (except for amounts) and handled alike. This gave two breeds fed under exactly the same conditions. The feed cost per pound of butterfat, per 100 pounds of milk, and per 100 pounds of 4 per cent F.C.M. are given in table 2.

As previously stated, feed costs vary over the state. It is recognized that the cheapest milk is made on grass, and the grazing season is longer in the southern part of the state. To eliminate any climatic or geographic errors, all the herds finishing a year's work in 1945 in two full associations operating in the Louisville Milk Shed Area were studied in detail. A few

TABLE 2

Kentucky Agricultural Experiment Station dairy herds (cost of production data)

	Year	Reg. Jerseys	Reg. Holsteins
Average feed cost per 1 lb. butterfat	1944	$0.38	$0.44
Av. feed cost per 100 lbs. milk	1944	$2.00	$1.59
Av. feed cost per 100 lbs. 4% F.C.M.	1944	$1.68	$1.69
Av. feed cost per 1 lb. butterfat	1945	$0.34	$0.39
Av. feed cost per 100 lbs. milk	1945	$1.84	$1.53
Av. feed cost per 100 lbs. 4% F.C.M.	1945	$1.53	$1.55

herds of Guernseys, and a few of mixed breeding were discarded. Only those herds of either all registered Holsteins or part registered and part grade Holsteins, and all registered Jereys, or part registered and part grade Jerseys were used. Table 3 shows the results of this tabulation.

TABLE 3

1945 D.H.I.A. Shelby-Boone-Carroll and Oldham Jefferson Associations	Reg. or reg. and grade Jerseys	Reg. or reg. and grade Holsteins
No. of herds	18	20
Av. fat yield per cow	382.4 lbs.	378.4 lbs.
Av. milk yield per cow	7373 lbs.	10425 lbs.
Av. fat percentage	5.19 %	3.63 %
Av. value of product per cow	$314	$363
Av. feed cost per cow	$129	$150
Av. value of product above feed cost per cow	$185	$213
Av. feed cost per 1 lb. butterfat	$0.34	$0.41
Av. feed cost per 100 lbs. milk	$1.75	$1.49
Av. feed cost per 100 lbs. 4% F.C.M.	$1.49	$1.52
Av. return per $1.00 spent for feed	$2.43	$2.37

DISCUSSION

In all of these tables it was observed that Jerseys consistently showed the lowest feed cost per pound of butterfat, while Holsteins produced 100 pounds of milk with the lowest feed cost. However, on a basis of energy value, as expressed in 4 per cent F.C.M. there was little difference between the respective breeds in feed cost. In the first table, the Holstein breed showed a very slightly lower feed cost per 100 pounds 4 per cent F.C.M. Yet even this small difference might be explained by the fact that the Jersey herds were charged the same amount for pasture, per cow, per month, as were the Holsteins. It is doubtful that a 1,000-pound Jersey on pasture will consume quite as much grass as will, for instance, a 1,500-pound Holstein. The usual charge was $2.00 per cow per month for pasture for a grazing season of from six to seven months.

The last part of table 1 is rather significant, in that it indicates that there is a difference in feed costs between registered herds, and herds of all grade cattle. The feed cost per 100 pounds of 4 per cent F.C.M. was noticeably lower in the purebred herds than in the herds of grade cows. How much of this difference is due to the cows alone and how much to management and feeding is a question. Undoubtedly, the purebred herds were better managed and better fed than the grade herds.

SUMMARY

1. Jersey cows produced butterfat at a lower feed cost per pound than Holsteins.

2. Holstein cows produced milk at a lower feed cost per 100 pounds than Jerseys.

3. On the basis of energy as expressed in 4 per cent F.C.M., there appeared to be no significant difference between breeds in cost of production.

4. Purebred herds apparently produced 4 per cent F.C.M. at a lower feed cost than did grade herds.

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THE EFFECT OF FEEDING COD-LIVER OIL ON THE "OXIDIZED" AND "GOATY" FLAVORS AND VITAMIN C IN MILK

E. S. GUTHRIE[1]

Cornell University, Ithaca, New York

The purpose of this study was to determine the effect of feeding cod-liver oil to cows on the flavor of their milk. It was soon found that the "oxidized" and "goaty" (5) flavors were the only ones of significance, although the flavor of the oil itself was a factor at a certain point of the experiment.

The so-called "oxidized" flavors (1) include "papery," "cardboardy," "oily," "metallic," "fishy," and "tallowy." The "goaty" flavor, likewise, has a name for what it resembles. It is more specific in nature than some of the oxidized flavors. Its origin is caprylic (2) acid.

Inasmuch as vitamin C (4, 6) analyses could be made readily with other studies on ascorbic acid in our laboratories, data were obtained on the vitamin C content of all the samples of milk that were examined in this particular research on flavors. Two experiments involving 10 cows were employed in obtaining the data. The effect of feeding cod-liver oil to the cows in this study was variable. There was an indication in the first experiment that a correlation existed between the feeding of cod-liver oil and the amount of vitamin C in the milk. A second study, therefore, was made which extended over a longer period and in which more cows were included.

FIRST EXPERIMENT (1938–39)

The first experiment involved 4 cows that were in a study which already was under way in the Department of Animal Husbandry. Because of the nature of this study no planned rest periods were provided during the course of the experiment, however a rest from cod-liver-oil feeding of 1 day for cow No. 1 and of 16 days for cow No. 3 was provided.

The grain ration that was fed was composed of the following items: 200 pounds of linseed-oil meal, 400 pounds wheat bran, 400 pounds hominy and corn meal, 370 pounds heavy grain oats, 300 pounds corn distiller's dried grains, 300 pounds cocoanut-oil meal, 20 pounds steamed bone meal, and 10 pounds salt. The grain was fed to these cows according to their milk production. These animals, also, received about 1 pound of timothy hay and 3 pounds of corn silage per 100 pounds body weight. The cod-liver oil was a commercial product sold for animal feeding and was fed in quantities that are mentioned later.

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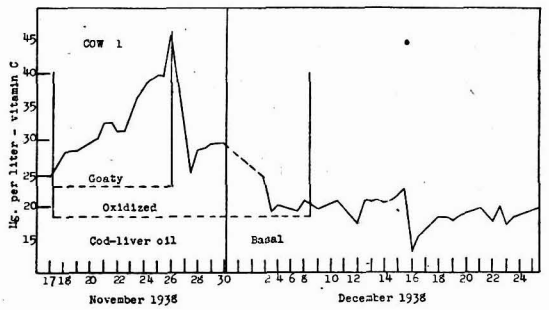

FIG. 1

The oil was administered by drench to cow No. 1 from November 16 to 30 at the rate of 400 ml. once a day. This was at the rate of 0.75 ml. per kilogram weight of cow. Figure 1 shows the record of this cow from November 16 to December 25, 1938. The vitamin C of the fresh milk increased rapidly from 24.85 to 46.38 mg. per liter. At this point the cow was seized by convulsions. She was given a rest of one day and afterwards the dose of cod-liver oil was slightly decreased for the remaining three days of the experiment. The "oxidized" and "goaty" flavors appeared immediately on the rise of the vitamin C. The "goaty" flavor did not appear in the milk after the vitamin C peak was reached. The oxidized flavor, on the other hand, continued to develop in the milk for 12 days after the high point of vitamin C was reached. It, also, should be pointed out that the oxidized flavor did not develop in the milk during the remainder of the basal period. The daily production of milk took a decided drop when the vitamin C content was high, and the milkfat test also decreased from 3.7 to 2.5 per cent.

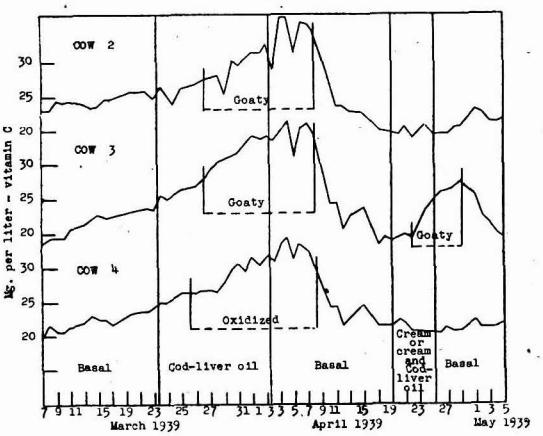

FIG. 2

The data for cows 2, 3, and 4 in this experiment are presented graphically in figure 2. It should be observed that the "goaty" flavor appeared in the milk of cows 2 and 3, two days after the "oxidixed" flavor was recognized in the milk of cow 4, and that both flavors ceased immediately after the peak in vitamin C was reached. At the end of a rest of 16 days, cow 3 was again drenched with cod-liver oil, at the rate of 0.75 ml. per kilogram of body weight. Again the "goaty" flavor appeared on the upward trend of the vitamin C. This time cow 3 was drenched daily for only one week. The other cows were not given cod-liver oil and, as expected, they did not respond with increased vitamin C nor with the production of the "goaty" and "oxidized" flavors.

SECOND EXPERIMENT (1939–40)

The concentrate mixture that was fed in this experiment was made up as follows: 220 pounds of 41 per cent protein soybean-oil meal, 240 pounds 34 per cent protein old process linseed meal, 200 pounds wheat bran, 370 pounds hominy feed and corn meal, 300 pounds ground oats, 300 pounds corn distiller's dried grains, 240 pounds 20 per cent protein cocoanut-oil meal, 100 pounds cane molasses, 20 pounds steamed bone meal, 10 pounds salt. The

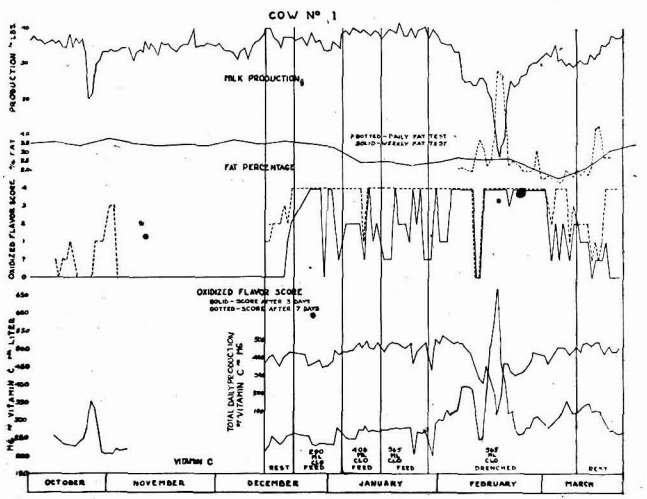

FIG. 3

amount of grain that was fed to each cow depended on the amount of milk that she produced. Each cow received 1 pound hay and 3 pounds silage per 100 pounds body weight. These cows also received dry beet pulp, cottonseed meal, cream, molasses syrup, and cod-liver oil in various proportions.

It was thought that the feeding of the cod-liver oil by mixing it in the feed rather than by drenching would be more satisfactory in handling the

animals and in the functioning of the nervous systems of the cows. The procedure of application was to thoroughly mix it with dried beet pulp. Usually water was added to make it more palatable. The results are shown graphically in figures 3, 4, 5, 6, 7, and 8.

Cows 1 and 2 were drenched a part of the time, when it was found that feeding by mixing with the feed did not give results. The other 4 cows in this experiment received their cod-liver oil only in the feed.

Cow 1 was fed cod-liver oil between October 17 and November 6, when she was dropped from the experiment. On December 22 she was put back for two reasons. First, she was one of the least valuable cows in the herd; and second, she was the cow in the first set that responded most readily when drenched with cod-liver oil. From December 22 to January 5 she received 0.5 ml. cod-liver oil per kilogram body weight. On that date the cod-liver oil was increased to 0.75 ml. per kilogram body weight. Then on January 15 the cod-liver oil was increased to 1 ml. per kilogram body weight and the feeding continued to January 28. At this time the same amount of cod-liver oil was administered by drenching, which was kept up until March 10. The experiment terminated by a rest period that lasted from March 10 to 22.

The drop in the milk production starting with October 26, the rise in vitamin C, and the increase in the oxidized flavor as shown in figure 3 are unexplainable. The most important features of these graphs are the abrupt drops in milk flow and in total production of vitamin C, and the equally abrupt rises in milkfat content of the milk and the vitamin C content of the milk. The oxidized flavors were increased from the mild stage to a maximum in only a few days of feeding, although there was a distinct variation from day to day in the milk that had been stored 7 days. When the cow was drenched from January 28 to March 10, the oxidized flavors were at their worst and then during the final rest period these flavors became less intense. Mention should be made that the fresh milk showed a slightly oily flavor when cow 1 was drenched with the high feeding level of cod-liver oil (1 ml. of oil per kilogram body weight). Only for a period of a few days did this oily flavor appear distinctly as cod-liver oil, and that was immediately after the drop from the peak days of February 16, 17, and 18.

The milk production of cow 1 ranged from 41.5 pounds on January 21 down to 3.3 pounds on February 17. It should be observed that the first decided drop occurred on October 27 when she gave 20.1 pounds of milk. Apparently these two restrictions in milk flow were caused by drenching with cod-liver oil. The solid line showing the weekly-fat-test curve in figure 3 was drawn from the weekly analyses recorded by the Department of Animal Husbandry. The samples were taken on a certain day each week and were not composites for a week. This explanation accounts for the weekly fat test being graphed as 2.6 per cent during the week when on one day the flow of milk dropped to 3.3 pounds and when the fat test of that milk actually was up to 27.5 per cent.

The effect of the administration of the large amount of cod-liver oil to cow 1 was interesting and the way she resisted the shock was astonishing. When she reached the peak of vitamin C, she had a convulsion. She was given one day of rest and then the same amount of cod-liver oil was fed as before, by drenching. Her resistance was shown by the way she pulled back in milk flow, total production of vitamin C, and the daily test of vitamin C. The percentage of milkfat, however, continued to drop until it was down to 1.4 per cent, having gone down from a peak of 27.5 per cent and an average of 3.0 per cent.

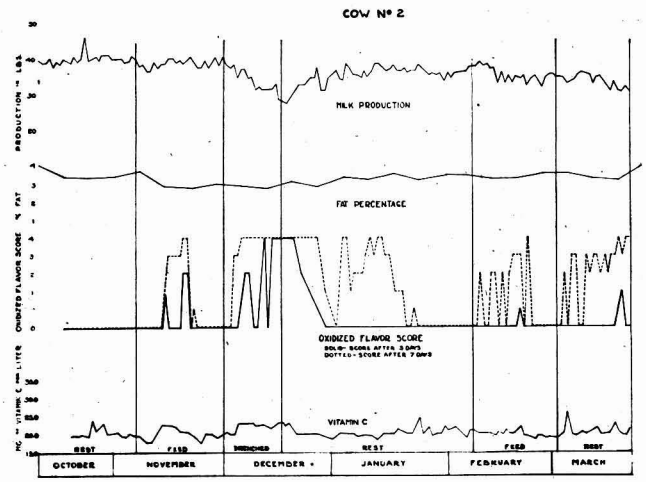

FIG. 4

Cow 2 (figure 4) produced milk that did not become oxidized on either the third or seventh days during the first rest period. When she was fed cod-liver oil from November 6 to 30 at the rate of 0.5 ml. per kilogram body weight, the oxidized flavor appeared and then disappeared. Drenching from November 30 to December 16 at the same rate and then to 0.7 ml. per kilogram body weight until December 16, distinctly increased the oxidized flavor, which disappeared during the rest period from December 16 to February 8. These flavors again appeared during the feeding of cod-liver oil at the rate of 0.5 ml. per kilogram body weight from February 8 to March 2, and remained to the end of the final rest period. There was a short interval of no oxidized flavor, however, extending over the latter part of the last feeding period to a point well in the last rest period. The vitamin C content of the milk remained unchanged, the milkfat test dropped slightly during the cod-liver oil intake periods, and the milk production dropped distinctly at the end of the drenching period.

Cow 3 (figure 5) produced milk that did not become oxidized with the exception of one instance when a question was raised on the sample after

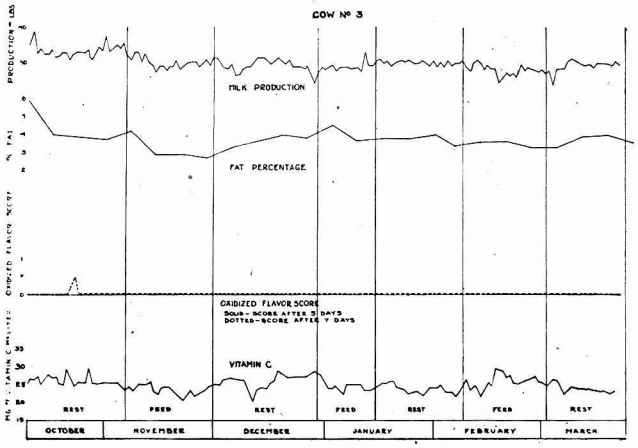

FIG. 5

7-day storage. The percentage of milkfat fell to 2.9 per cent during the first feeding period and then returned to normal. Seemingly this cow had strong resistance, for on all four items in the figure there was little variation.

Cow 4 (figure 6) gave milk that developed the oxidized flavor on 4 days on the 7-day examination. It did not appear on the third day. The percentage of milkfat dropped to the lowest point during the latter part of the first feeding period. The "goaty" flavor appeared at this time. It lasted from November 24 to December 4. This was the only time that the "goaty" flavor appeared in the second experiment. It should be noted that the vitamin C went up when the milk flow dropped on February 24.

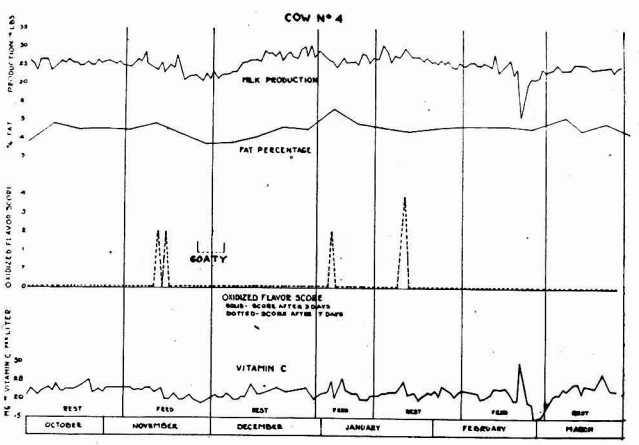

FIG. 6

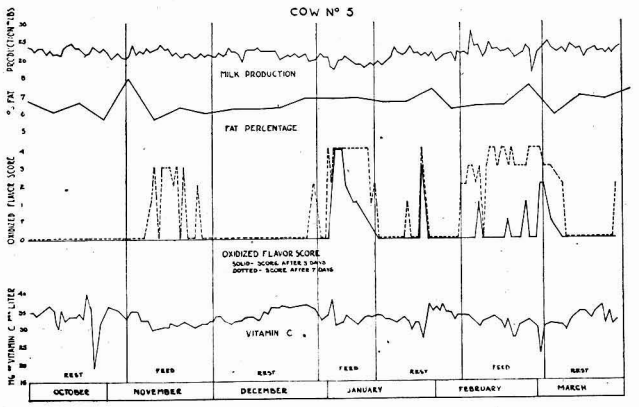

FIG. 7

Cow 5 (figure 7) shows a record of increase in the oxidized flavor during the feeding periods. No explanation is made for the drop in vitamin C on October 28 and March 1.

Cow 6 (figure 8) shows the oxidized flavor in the first rest period. During the other rest periods practically no oxidized flavor was observed, whereas during the codliver oil feeding periods, the oxidized flavor was frequently observed, particularly in the samples stored for seven days.

DISCUSSION OF VITAMIN C RESULTS

Inasmuch as some of the samples, as shown in figures 1 and 3, were extremely high in vitamin C, the question naturally arose as to whether the substance that was titrated as reduced ascorbic acid was all or only in part

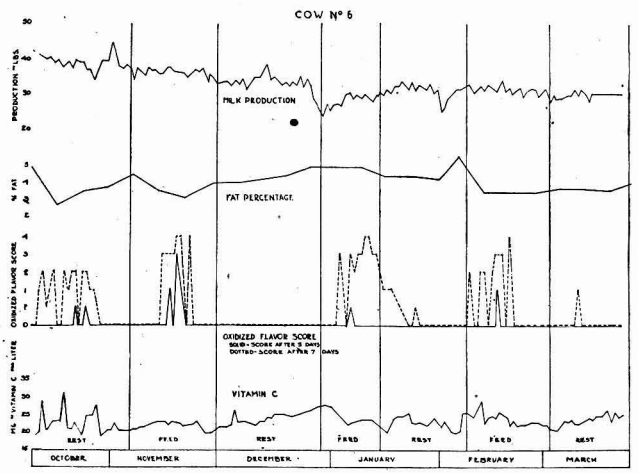

FIG. 8

reduced ascorbic acid. In an attempt to answer this question 23 samples of the milk from cow 1 on February 19 and 20, 1940, were deaerated, placed in ½-pint milk bottles, covered with mineral oil and stored at 0–10° F. The plan was to arrange a guinea-pig-feeding assay for the identification of vitamin C. A more simple and easier means of assay, however, presented itself within a year.

After these 23 samples of milk had been stored for 2 years, specific chemical tests for the identification of ascorbic acid in milk were applied to them. The samples were melted at room temperature during a period of about a day. A 50-ml. portion of the milk then was drawn by pipette from each sample for assay.

A 10-ml. portion of each of the above 50-ml. samples was titrated for

TABLE 1

Vitamin C in the stored milk

Date	Sample	Reduced ascorbic acid in original fresh milk	Reduced ascorbic acid in frozen milk	Cucumber enzyme frozen milk	*E. coli* frozen milk	Cucumber enzyme and *E. coli* frozen milk	Reduced ascorbic acid recovered*, per cent
		Vitamin C—milligrams per liter					
Feb. 19, 1940	1	40.80	34.74	0.67	37.41	22.38	59.82
	2	40.80	37.41	0.67	34.40	25.72	74.77
	3	40.80	34.74	2.00	35.07	23.71	67.61
	4	40.80	32.73	0.67	32.40	29.06	89.69
	5	40.80	43.41	10.43	39.03	32.64	83.63
	6	40.80	37.69	17.50	40.04	33.31	83.19
	7	40.80	39.71	22.88	42.06	33.99	80.81
	8	40.80	37.69	14.13	42.06	34.32	81.60
	9	40.80	39.17	1.34	39.47	30.44	77.12
	10	40.80	38.80	0.67	38.80	30.44	78.45
	11	40.80	43.15	0.67	38.80	32.11	82.75
	12	40.80	38.13	0.67	33.45	30.77	91.98
Feb. 20 1940	13	31.89	25.72	1.34	26.39	23.71	89.84
	14	31.89	29.06	1.34	30.06	28.06	93.34
	15	31.89	25.05	0.67	25.72	23.38	90.90
	16	31.89	27.72	0.67	28.72	26.72	93.04
	17	31.89	34.74	6.68	30.73	24.05	78.26
	18	31.89	30.73	5.34	29.06	24.72	85.06
	19	31.89	29.39	2.67	31.40	25.38	80.86
	20	31.89	26.72	2.67	26.72	22.04	82.49
	21	31.89	30.73	0.67	30.39	16.03	52.74
	22	31.89	30.39	0.67	30.39	17.37	57.16
	23	31.89	29.73	0.67	28.72	16.03	55.81
	Ave.	36.53	33.75	.....	33.53	.....	.....
		Fresh milk plus additional vitamin C					
	1	66.80	.....	0.00	67.47	60.12	89.11
	2	66.47	.....	0.00	67.13	59.45	88.56
	3	66.47	.....	0.00	67.80	59.45	87.68
	4	66.47	.....	0.00	67.47	59.79	88.62

* The reduced ascorbic acid recovered as recorded in column 6 is the percentage of reduced ascorbic acid in column 5 of that in column 4.

reduced ascorbic acid by the Sharp method (6). Another 10-ml. portion was analyzed for total vitamin C by the method of Gunsalus and Hand (3). To the remaining 30 ml. of the sample 0.2 ml. of cucumber concentrate (7) was added. This mixture of milk and cucumber juice was then aerated by shaking occasionally during a period of 15 minutes to convert the reduced ascorbic acid to the reversibly oxidized form. At this point another 10-ml. portion was titrated to ascertain the extent of the activity of the cucumber oxidase. Lastly, 10 ml. of the milk that was treated with the cucumber oxidase was treated with *E. coli* and analyzed for the total vitamin C content by the method of Gunsalus and Hand (3).

A substance that is oxidized by the cucumber oxidase and reduced again by *E. coli* to a compound which reacts instantly with sodium 2–6 dichlorobenzenoneindophenol presumably is ascorbic acid. No naturally occurring substance except ascorbic acid has yet been found that will respond to this test, although some are known which are oxidized by cucumber oxidase. Good recovery of ascorbic acid in milk is 85 to 90 per cent. Table 1 shows the results of the tests.

It should be noted that samples 1–12 were taken from the same milking on February 19, and that samples 13–23 likewise were taken from the same milking on February 20. According to the averages in this table the drop in the amount of reduced ascorbic acid in 2 years was 2.78 milligrams per liter of milk. It would be expected that the average of column 4 would be distinctly higher than column 2. Actually the reverse is true, with only a small difference. Perhaps this limited number of data should not be treated statistically.

The data reported in columns 3 and 6 of table 1 are the most significant. The cucumber oxidase should oxidize all the ascorbic acid. The data in column 3 indicate that samples 3, 5, 6, 7, 8, 17, 18, 19, and 20 have interfering substances, or reductones. The other samples are near blank readings and show, with little doubt, that the substance under inspection was vitamin C. It should be observed that the check samples of fresh milk in column 3 show complete oxidation.

As stated previously, the recovery of vitamin C, was found in column 6, should be as much as 85 to 90 per cent. The fresh milk checks confirm that statement. The recoveries of vitamin C in the 23 stored samples of milk show that 7 conform to that standard and that several others are near that point.

SUMMARY

The milk of each of the 4 cows in the first experiment was free from the oxidized and other off flavors at the beginning of the study. As the feeding of cod-liver oil progressed, the fresh milks lost their characteristic flavors of new milk. They became oily, but not the distinct cod-liver oil flavor. On standing, a "goaty" flavor appeared in the milks of cows 1, 2, and 3, whereas the oxidized flavor developed in the milks of cows 1 and 4.

In the second experiment the milks of cows 3 and 4, with only slight exceptions, did not become oxidized. The milks of the other 4 cows, on the other hand, became oxidized apparently as the result of administering cod-liver oil either in the feed or by drenching. During a period of 41 days of drenching, the first milk from cow 1 showed a slightly oily flavor. It was not typically fishy. Later, however, a very strong oxidixed flavor developed which was of the fishy order. The goaty flavor appeared in this experiment only once. It lasted from November 25 to December 4 in the milk of cow 4. In this experiment, the goaty flavor appeared during the latter part of a feeding period and the first few days of the following rest period. This also was true in the three examples of the previous year. The vitamin C, however, was below average when the milk was "goaty" in this experiment, whereas during the first year this flavor was noticeable when the vitamin C was present in abundance.

The following figures in the first experiment show the increases in reduced ascorbic acid in the milk from the check level when no cod-liver oil was fed, to the average of the three high readings when the amount of the oil was given at the highest level: Cow 1, 111 per cent; cow 2, 31.3 per cent; cow 3, 48.1 per cent; and cow 4, 38.3 per cent. The oil was given by drenching in this experiment.

There was no increase in reduced ascorbic acid in the second experiment when the cod-liver oil was mixed with the feed. In case of cow 2, possibly there was a slight increase during the period of 16 days when she received her cod-liver oil by drenching. Cow 1, on the other hand, responded in the same way that she did the first year, for the reduced ascorbic acid in her milk increased from an average of 25.48 mg. per liter during the 25 days preceding the drenching period to 66.43 mg. per liter on the peak day, or an increase of 163 per cent.

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THE RESULTS OF DEAERATION ON THE OXYGEN, VITAMIN C, AND THE OXIDIZED FLAVORS OF MILK

E. S. GUTHRIE

Department of Dairy Industry, Cornell University, Ithaca, New York

The oxidized flavors of milk and milk products constitute one of the most studied problems in the field of dairy manufactures. This can be verified by observation of the review of literature dealing with the subject of oxidized flavors by Brown and Thurston (1), in which they listed 412 references. Much consumer complaint of pasteurized milk is not made because of the cooked flavor or the so-called "pasteurized flavor," but because of the oxidized flavors, which in the first stages of development may easily be confused with the cooked flavor. These flavors may be described as "papery," "oily," "metallic," "fishy," and "tallowy."

It is known that the oxidized flavors are caused by chemical changes within the milk. Exposure of milk to daylight, under certain conditions, is one factor starting oxidation in the milk. A few metals, particularly copper, constitute a second factor since they act as catalysts in the development of the oxidized flavors. These flavors appear in the milk of at least one-third of the cows in the Cornell University herd before it is 7 days old, even though it is stored in brown-glass bottles for protection from daylight. This milk is pasteurized at 143° F. for 30 minutes, and it is stored at near 35° F. One set of 55 samples of milk from individual cows of the Cornell University herd in June, 1944, after seven days storage, was found to have the following oxidized-flavor scores[1]: 20 samples scored 0, 5 samples scored ?, and 30 samples scored 1 or above. On the 73rd day the results were: 5 samples scored 0, 3 samples scored ?, and 47 samples scored 1 or above. These data indicate that all milks will develop the oxidized flavors when held sufficiently long and in such a manner that there is little or no bacterial spoilage. It is claimed that an enzyme that survives the usual low-temperature pasteurization is a third factor in oxidized flavor development. The presence of air in the milk is a fourth factor. This fourth factor is the one that was under consideration in this study.

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[1] Oxidized flavors scoring system:

−= no oxidized flavor detected.
?= oxidized flavor doubtful.
1= slightly oxidized.
2= distinctly oxidized.
3= strongly oxidized.
4= very strongly oxidized.

When *summarizing*: −= 0, ?= 0.5, 1= 1, 2= 2, etc. Consumer complaints are likely to be made if the score is above 2.

The history of the oxidized flavors in the milk of Cornell University herds during a period of 23 months just prior to the deaeration studies reported in this paper is shown in table 1.

The data that are not recorded in table 1 but from which these monthly figures are taken show a great deal of variation from day to day. During these 23 months samples were taken on 470 days. The range in scores of the milk after a holding period at 35° F. for 3 days was 0 to 4. There were 77

TABLE 1

Oxidized flavors in the Cornell University milk previous to the installation of deaeration equipment

Date		Number daily samples in month	3 days old		7 days old	
Year	Month		Score*	Above 2.00*	Score	Above 2.00
1939	Nov.	23	0.60	0	2.45	11
1939	Dec.	20	0.88	1	2.72	9
1940	Jan.	27	2.04	10	3.63	25
1940	Feb.	14	1.96	4	3.61	13
1940	Mar.	24	2.06	10	3.42	17
1940	Apr.	23	2.78	16	3.86	22
1940	May	21	1.59	6	2.93	16
1940	June	.....	.....	.....	.....	.....
1940	July	25	0.56	0	1.16	0
1940	Aug.	26	1.08	1	3.25	14
1940	Sept.	8	1.11	0	1.87	0
1940	Oct.	17	0.66	0	1.37	0
1940	Nov.	21	0.23	0	0.83	0
1940	Dec.	21	0.55	0	2.55	13
1941	Jan.	26	1.00	0	3.00	19
1941	Feb.	22	0.61	0	2.02	7
1941	Mar.	25	0.85	0	2.60	20
1941	Apr.	18	2.66	10	3.00	9
1941	May	28	1.31	5	3.27	24
1941	June	15	0.08	0	1.32	0
1941	July	.....	.....	.....	.....	.....
1941	Aug.	19	0.19	0	0.97	3
1941	Sept.	7	1.00	0	2.57	4
1941	Oct.	21	1.89	7	3.14	18
1941	Nov.	19	2.06	7	3.21	18
	Total	470	.....	77	.....	262

* See footnote explaining flavor scoring.

samples that scored above 2.00. The range in the 7-day samples also was 0 to 4, with 262 of them scoring above 2.00 (262 consumer complaints).

Apparently the general observation by dairymen that the oxidized flavors are less pronounced in the summer than during the other seasons is true.

One logical way to prevent the development of the oxidized flavors in dairy products is to eliminate the oxygen. When this is done, the other three factors, daylight, certain metals, and the oxidative enzyme, are inactive.

Two deaerating units were employed in this research. A smaller unit

and the first one used is intermittent in operation. Inasmuch as this report deals for the most part with data obtained while using a larger unit, the only reference to this smaller equipment will be found in table 10. The larger unit, which is continuous, has a capacity of 3,000 pounds of milk an hour. The continuous deaeration is accomplished by flashing the milk into a stainless-steel vacuum chamber 18 inches in diameter and 52 inches deep.

The flow of the milk through this continuous deaerating equipment is as follows: From a 300-gallon vat the milk goes through a section of the short-time holding pasteurizer where the temperature is raised to approximately 115° F., which is well above the melting point of the fat. Fluidity of the fat when the milk is highly agitated, as when it is pumped or sprayed, is essential to subsequent satisfactory creaming. Next the milk, in the form of a spray, is drawn into the deaerating chamber in which about 29 inches of vacuum is maintained and where the temperature drops about 10° F. At this time approximately 1 per cent of the milk passes out in the form of vapor which sweeps out the oxygen as it goes. Only approximately 8 gallons of milk are in the deaerator at any one time. The milk, then, is drawn by a positive-action pump from the deaerator and is forced back through the pasteurizer where it is heated to 163° F. for 16 seconds and then cooled. From there it goes to the surge or supply tank that feeds the bottler. Very little air is reincorporated before the milk reaches the bottler.

At present, the milk is not bottled under vacuum. Plans for such a filler, however, have been made. When peacetime measures permit, there will be opportunity for the manufacture of this apparatus and of other refinements in the equipment.

In order to have some knowledge of the oxygen content of milk, determinations were made at various points in the production process. Limited data indicate that there is no oxygen in the milk in the cow's udder.[2] At the time the milk is removed from the udder, it can be assumed that due to atmospheric oxygen, chemical changes immediately start. A study of table 2 will reveal the comparative effect of hand milking and machine milking on the oxygen in the milk.

The data in the upper and lower parts of table 2 were obtained with different makes of milking machines. They were used in 2 different herds.

The amount of oxygen incorporated in the milk of several cows when milked by hand by different milkers can be observed in table 3.

These figures were obtained in one day. They are illustrative of the trials of 6 days. A comparison might be made with the "hand milked" column in table 2.

[2] This statement is made on the basis of only one short test. With the help of Dr. M. G. Fincher, of the Veterinary College, Cornell University; Paul F. Sharp and E. S. Guthrie obtained milk from all four quarters of one cow.

TABLE 2

Comparison of the effect of hand milking and the milking machine on the oxygen content of the milk

Cow	Hand milked	Machine milked	Difference	Hand milked	Machine milked	Difference
	Aug. 6	Aug. 7		Aug. 8	Aug. 9	
1	6.43*	4.48	1.95	6.63	4.70	1.93
2	5.63	5.25	0.38	7.44	5.46	1.98
3	6.76	4.91	1.85	6.97	4.70	1.77
4	5.94	5.04	0.90	5.80	4.83	0.97
5	5.63	4.42	1.21	4.54	4.64	−.10
6	5.76	4.26	1.50	3.57	3.91	−.34
Average	.....	.....	1.29	.....	.....	1.03
	Nov. 14	Nov. 15		Nov. 28	Nov. 29	
1	5.35	4.55	0.80	5.73	4.74	0.99
2	5.78	5.66	0.12	5.18	5.08	0.10
3	5.48	4.49	0.99	5.90	5.27	0.63
4	5.98	4.51	1.47	4.74	3.91	0.83
5	5.30	4.03	1.27	5.02	3.79	1.23
6	5.41	4.09	1.32	5.55	4.27	1.28
Average	.....	.....	0.99	.....	.....	0.84

* The figures are in terms of milligrams of oxygen per liter.

While endeavoring to ascertain how air is incorporated in the milk during the milking process, the results in table 4 were obtained.

The first method was the usual one of driving the stream of milk from the teat directly into the milk in the pail. The second method was to direct the stream against the sides of the pail. Less foam appeared in the latter method, and less oxygen was incorporated.

It seemed advisable to determine the maximum amount of oxygen that could be incorporated in milk under conditions of vigorous agitation in air. Studies on this point were made, one of which is reported in table 5.

A pint of milk from the filler was poured into a quart bottle and shaken in an up-and-down motion 50 times. Then it was poured back into a pint bottle, and after standing about 15 minutes a sample for oxygen analysis was drawn from the bottom. The temperature of the milk was approxi-

TABLE 3

Variations of oxygen in the milk of different cows

Cow	Milker	Comments	Oxygen
			mg./l.
1	1	1 inch foam, very easy milker	6.39
2	2	Easy milker, small streams	7.77
3	3	½ inch foam, easy milker	5.72
4	4	No foam, spray stream	6.75
5	5	No foam, easy milker	6.71
6	5	No foam, easy milker	6.57

TABLE 4

A comparison of methods of hand milking on the oxygen content of milk

Cows	1	2	3
First method	6.55*	6.03	5.05
Second method	4.91	5.64	4.89
Difference	1.64	0.39	0.16

* Milligrams per liter of oxygen.

mately 40° F. These analyses were made on consecutive days in January and February. Each analysis in this table represents an individual sample of milk.

It is important to know how much oxygen is incorporated in milk in the different stages of processing. Table 6 supplies this information.

TABLE 5

Maximum oxygen content of milk

Sample No.	Oxygen mg./l.	Sample No.	Oxygen mg./l.	Sample No.	Oxygen mg./l.	Sample No.	Oxygen mg./l.
1	9.09	7	9.98	13	9.46	19	9.41
2	10.35	8	9.74	14	9.42	20	9.71
3	10.51	9	9.20	15	10.47	21	9.27
4	10.11	10	9.54	16	10.56	22	9.16
5	10.52	11	9.75	17	9.43	23	9.79
6	10.54	12	9.43	18	9.72	.....	.....

The amount of oxygen which may be found in milk before it reaches the deaerator is indicated in tables 5 and 6. With deaeration, when the outfit is working satisfactorily, the oxygen can be and has been reduced to zero point. During the period from January 1, 1942, to June 17, 1944, the analyses of 49 of 362 samples showed that the oxygen was completely eliminated and that many others were near that point. Such data set a bright future for the possible performance of new and improved equipment. This

TABLE 6

*Oxygen content of milk in the different steps in handling**

Stages	Oxygen	Stages	Run 3 oxygen	Run 4 oxygen
	mg./l.		*mg./l.*	*mg./l.*
Patrons' cans	6.09	Raw milk to balance tank	11.9	10.0
Weigh tanks	7.05	Entering exchanger	11.0	9.9
Pump reservoir	7.65	161° F. beginning hold	7.1†	5.9†
Tank cars	9.19	End of hold	6.1†	6.0†
Tank truck	9.68	Leaving cooler	10.2	9.8
		Bottle	11.2	10.4

* Composite of tables 1 and 5 by Sharp, Guthrie and Hand (2).

† Owing to high temperatures, air was lost from the milk as soon as it was liberated to the outside atmosphere.

is especially impressive when it is realized that the daily peak load of this small deaerator was 20,000 bottles of milk, that it now has been in operation for 3½ years, and that a large part of the time it has been operated by two high school boys and other untrained personnel. It should be explained that most of the bottles were the one-half pint size.

Concerning the operation of the deaerator, inquiry often is made about the uniformity of deaeration. The answer to that question is found in table 7.

This operation, of course, was in the continuous flow unit. It was working smoothly and apparently in a normal way. The oxygen content, however, was not sufficiently low. That was the reason for this experiment.

The effect of deaeration on the vitamin C content of the milk was closely observed in this study. One way of determining the results of the removal of the oxygen was to see what happened to the vitamin C content of stored milk during the season when the oxidized flavors were intense. Table 8 shows what took place in one such period in milk that was processed in the continuous flow outfit.

TABLE 7

Variations in the oxygen content of deaerated milk taken at intervals of 15 minutes

Sample	Oxygen	Sample	Oxygen	Sample	Oxygen
	mg./l.		*mg./l.*		*mg./l.*
A	0.87	C	0.87	E	1.50
B	0.95	D	0.65	F	1.06

The oxidized flavors of the same samples of milk that are listed in table 8 are tabulated in table 9.

Table 9 shows that deaeration has much to do with the prevention of the development of the oxidized flavors in milk. These data, it should be recalled, were obtained from milk processed in the commercial-continuous flow outfit.

One of the long-time experiments of this research was that of maintaining the vitamin C and the flavor for one week in the milk that was used in a child-feeding study in the New York State College of Home Economics at Cornell University. The milk was supplied by the Department of Dairy Industry for a period of approximately 20 weeks in each of three consecutive years.

The results of the experiments are shown in table 10. The data of the first year and the grand averages of all three years are presented. The milk was taken from the general supply of the Department, which at that time was practically all produced on the University farms and was a mixture of the milk of the three milkings of each day. It was pasteurized when obtained. After deaeration in the small intermittent-flow unit, the milk

was bottled by the in-bottom method[3] and was held at the usual milk-storage temperatures of 35° to 40° F.

It should be observed that in table 10, the reductions in vitamin C in seven days in the deaerated and undeaerated milks were 0.85 and 10.78 milli-

TABLE 8

Deaeration and vitamin C in milk

Date April 1943	Vitamin C* fresh undeaerated	Age in days	Vitamin C		
			Deaerated		Air re-incorporated§
			In-bottom† filled	Commercially‡ filled	
	mg./l.		*mg./l.*	*mg./l.*	
5	16.31	3	16.24	14.97	13.38
		7	15.51	12.66	6.01
8	18.47	3	16.48	16.48	14.90
		7	14.95	14.63	5.41
12	17.72	3	15.24	14.92	10.80
		7	16.41	13.88	4.73
16	17.14	3	17.04	17.35	17.04
		7	17.96	17.23	11.80
19	18.30	3	16.93	17.57	17.57
		7	17.22	16.27	13.40
22	19.81	3	17.57	18.85	16.61
		7	18.87	17.61	9.75
26	18.04	3	16.67	16.67	13.84
		7	17.39	14.28	5.28
29	20.13	3	18.94	18.01	14.90
		7	16.91	15.99	5.54
Average	18.24	3	16.89	16.85	14.88
		7	16.89	15.32	7.74

* "Fresh undeaerated" is the original milk. It should be understood that about one-half of it, a part of the time, was purchased from outside the Department and held in the raw condition one day, so some of the milk was almost 2 days old when it was processed with the University supply which was 18 hours old or younger, depending on when it was milked.

† "In-bottom filled" has reference to the way that the deaerated milk was put into the bottles. As the milk flowed through a glass tube to the bottom of the bottle, the air was forced up and out of the bottle. Thus only a little oxygen was reincorporated in the milk.

‡ "Commercially filled" has data on the deaerated milk that was bottled under atmospheric conditions where about 2 milligrams of oxygen per liter were reincorporated in the milk.

§ "Air reincorporated" were samples of "commercially filled" cold milk that were thoroughly shaken in order to fill them with oxygen. This milk then was considered to be the check or control sample. It cannot correctly be termed "undeaerated." The samples were obtained in this manner because in the commercially continuous operation it was not possible to take undeaerated and deaerated samples of exactly the same milk. They were more nearly the same when taken in this way.

grams per liter, respectively, and that the deaerated milk was "good" in flavor, whereas the undeaerated milk was "poor." The grand averages for the three years show that the "fresh deaerated," "seven-day deaerated,"

[3] See footnote (†) table 8.

and "seven-day undeaerated" contained 17.79, 16.42, and 7.68 milligrams per liter of vitamin C, respectively, and that the flavor scores were practically the same as those obtained in the first year.

The figures in table 11 are the averages of 250 samples, only one a day, in two and one-half years.

TABLE 9

Deaeration and the oxidized flavors in milk

Date April 1943	Oxygen* fresh deaerated	Age in days	Flavor			
			Deaerated		Air reincorporated**	Fresh undeaerated†
			In-bottom filled**	Commercially filled**		
	mg./l.					
5	0.12	3	– – –‖	– – –	– – –	– – –
		7	? ? ?§	? ? ?	2 2 2	– – –
8	0.00	3	– – –	– – –	– – –	– – –
		7	– – –	? ? ?	2 2 2	– – –
12	0.09	3	– – –	? ? ?	1 1 1	– – –
		7	– – –	2 2 2	3 3 3	– – –
16	0.34	3	– – –	– – –	– – –	– – –
		7	? ? ?	– ? ?	? ? ?	– – –
19	0.16	3	– – –	– – –	– – –	– – –
		7	– – –	? 1 –	? 1 1	– – –
22	0.16	3	– – –	– – –	– – –	– – –
		7	? ? ?	– – –	2 2 2	– – –
26	0.46	3	– ? –	? – ?	1 1 1	– – –
		7	? ? ?	2 2 2	3 3 3	– ? –
29	0.10	3	– – –	– – –	– – –	– – –
		7	? – ?	? – –	3 3 3	– – –
Average	0.18	7	0.29	0.75	2.04	–
Average	.....	7	39 (good)	36 (fair)	31 (poor)	40‡ (excellent)

* "Fresh deaerated" is the original milk immediately after deaeration.

** See footnotes, table 8.

† Same as (*) in table 8.

‡ American Dairy Science Association system of scoring. For convenience, the author has made the following groupings of flavor scores. Excellent 40 or above, without criticism; good 38–39; fair 35–37; poor 30–34; and bad 25–29.

§ The so-called blind system of judging was employed. Each sample was divided in 3 portions, and each portion was poured into a flavoring glass that was numbered on the bottom. Then all 12 flavoring glasses were shuffled. Thus the judge was "blind" so far as the identity of the samples was concerned. Most of the time the decisions were made easily. Occasionally, however, as on April 19, the 7-day sample was confusing, for the score was "? 1 –."

‖ Oxidized flavors system of scoring. See footnote 1.

Under "fresh" in table 11 there were 13 samples that showed an indication of the oxidized flavors. This is not surprising for, as stated in footnote *, table 8, some of the "fresh" milk was about two days old. In the "in-bottom filled" column, 107 samples had oxidized flavors on the seventh day, with 2 so poor that they would not have been accepted by the consumers. Among the "commercially filled" samples, 135 showed the

TABLE 10

Deaeration of the milk by the intermittent method

Fresh deaerated			Seven-day deaerated			Seven-day undeaerated		
Date	Vitamin C*	Score†	Vitamin C	Score	Comments	Vitamin C	Score	Comments
Jan.								
6	17.79	41	15.18	38.5	Slightly old	6.46	32	Oxidized
13	19.05	41	18.87	38.5	" "	9.77	29	"
20	16.85	40	.....	.....	.....	.....	.....	.....
22	16.30	41	15.79	38.5	Slightly old	9.20	32	Oxidized
28	18.45	40	14.85	40.0	.....	6.70	32	"
Feb.								
3	17.67	40	17.89	39.0	Slightly old	6.96	32	Oxidized
10	17.99	40	16.27	40.0	" "	9.37	33	"
16	18.24	40	17.05	39.0	" "	7.05	32	"
23	16.46	40	15.74	39.0	" "	10.11	33	"
Mar.								
1	16.14	41	15.45	37.0	Slightly oxi.	5.64	32	"
8	16.48	41	18.38	40.0	.....	6.13	32	"
15	19.91	41	20.87	40.0	.....	6.11	32	"
22	18.83	41	17.32	40.0	.....	7.15	32	"
29	17.83	41	14.68	40.0	.....	2.39	32	"
Apr.								
5	.....	41	17.78	38.5	Slightly old	6.16	29	"
12	18.81	41	17.91	38.5	" "	7.58	29	"
19	17.91	41	17.25	38.5	" "	5.86	29	"
28	17.94	41	16.80	40.0	.....	6.66	32	"
Ave.	17.79	40.7 (excellent)	16.94	39.12	Good	7.01	31.4	Poor

* Milligrams per liter of vitamin C in terms of reduced ascorbic acid.
† Amer. Dairy Sci. Assn. system of scoring, table 9, footnote (‡).

oxidized flavors on the seventh day. The runs of only 15 days would have caused consumer complaint. It is understood, of course, that not much of this milk is held for seven days by the customers. The last column, which shows the effect of reincorporation of air, had 175 oxidized samples with 85 in the consumer complaint category.

The key to the flavor evaluations, in table 11, is in footnote [1]. In terms of proportion the three-days' readings would be: "In-bottom filled": "commercially filled": "air reincorporated": : 1 : 2.5 : 7. It could be stated,

TABLE 11

A comparison of the vitamin C and oxidized flavors in fresh and processed milks on 250 days during a period of two and one-half years

Fresh		Age	In-bottom filled		Commercially filled		Air reincorporated	
Vit. C	Flavor		Vit. C	Flavor	Vit. C	Flavor	Vit. C	Flavor
mg./l.			*mg./l.*		*mg./l.*		*mg./l.*	
17.19	0.0066	3 days	15.89	0.0372	15.22	0.0892	12.14	0.253
.....	.....	7 days	15.26	0.2526	13.03	0.611	6.08	1.421

therefore, that the intensity of the oxidized flavors in the "commercially filled" samples was 2.5 times that of the "in-bottom filled" samples, and that the intensity of the oxidized flavors in the "air-reincorporated" milks was 7 times greater than that of the "in-bottom filled" milks. Likewise, in the 7-day observation the proportion is: "In-bottom filled": "commercially filled": "air reincorporated": : 1 : 2.5 : 5.5.

The evaluation of deaeration relative to the flavors may be observed in table 12. These judges are recognized critics of the flavors of milk. Their scores, therefore, make a satisfactory summary to the data on flavors.

TABLE 12

*The effect of deaeration of milk on the oxidized flavors**

Exhibited at Vermont Dairy Plant Operators' and Managers' Convention, October 25–26, 1939			
Set I—12 days old	*O. E. Herreid*	*J. A. Newlander*	*E. S. Guthrie*
Check sample	31 oxidized	31 oxidized	28 oxidized
Deaerated sample	39 slightly "off"	39 slightly "off"	38 slightly coppery
Set II—9 days old			
Check sample	33 oxidized	33 oxidized	31 oxidized
Deaerated sample	40 no criticism	40 no criticism	40 no criticism
Exhibited at the Metropolitan Dairy Technological Society, April 16, 1940			
Set I—8 days old	*H. F. Judkins*	*James Bohn*	*E. S. Guthrie*
Check sample	28 or 29 oxidized	28 or 29 oxidized	28 oxidized
Deaerated sample	40 no criticism	40 no criticism	40 no criticism
Exhibited at Massachusetts State College, May 9, 1940			
Set I—6 days old	*H. G. Lindquist*	*M. J. Mack*	*E. S. Guthrie*
Check sample	31 oxidized	31 oxidized	29 oxidized
Deaerated sample	40 no criticism	40 no criticism	40 no criticism
Set II—7 days old			
Check sample	31 oxidized	31 oxidized	29 oxidized
Deaerated sample	40 no criticnsm	40 no criticism	40 no criticism
Set III—29 days old			
Check sample	25 oxidized	28 oxidized	26 oxidized
Deaerated sample	39 slightly old	39 slightly unclean	39 lacked freshness
Exhibited at the University of Tennessee, January 27–29, 1942			
Set I—40 days old	*J. H. Erb*, Ohio State University		*E. S. Guthrie*
Check sample	33 oxidized		31 oxidized
Deaerated sample	39 slightly old		39 lacked freshness

* These data, with the exception of the exhibit at the University of Tennessee, were published in 1940 (3).

SUMMARY

1. The oxygen of milk may vary from 0, or near that point in the udder, to about 11 milligrams per liter in the bottle in undeaerated milk.

2. An intermittent deaerator was used in a series of experiments that extended through 3 periods in 3 years, or a total of 57 weeks. The vitamin C, in the milk in these series of analyses, dropped from 17.9 milligrams per liter in the fresh milk to 16.42 milligrams per liter in the deaerated milk at the end of 7 days, and to 7.68 milligrams per liter in the undeaerated milk during the same period.

3. The flavor of the milk that was deaerated in the intermittent unit was "excellent" when fresh. At the end of 7 days the deaerated milk was "good," whereas the undeaerated milk was "poor" due to the oxidized flavors.

4. A continuous deaerator has been in daily operation by largely unskilled operators for 45 months. Data obtained during the first thirty month's operation are reported. Forty-nine samples out of 362 analyses on as many days, contained no oxygen, and many others were near that point.

5. During the 30 months of the operation of the continuous deaerator the average of 250 analyses of fresh milk was 17.19 milligrams of vitamin C per liter. The "in-bottom filled," the "commercially filled," and the "air reincorporated" samples of 7 days' old milk averaged 15.26, 13.03, and 6.08 milligrams of vitamin C per liter, respectively.

6. The 250 comparisons made during the 30 months of daily operation of the continuous deaerator show that the flavor of the fresh milk, in general, was "excellent," and at the age of 7 days the "in-bottom filled," the "commercially filled," and the "air reincorporated" milks were good, fair, and poor, respectively.

7. The deaerators used in this study were constructed to take the oxygen out of milk in order to prevent the development of the oxidized flavors. The opinions of several reputable judges of milk show that they accomplished the purpose for which they were made. An added advantage of importance is the preservation of substantial amounts of vitamin C.

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RELATION OF THE TEMPERATURE OF SEPARATION AND THE HEAT TREATMENT GIVEN THE SKIM MILK TO THE KEEPING QUALITY OF SPRAY DRIED ICE CREAM MIX

HARRY PYENSON AND P. H. TRACY

Department of Dairy Husbandry, University of Illinois, Urbana, Illinois

Previously reported studies (5, 20, 23) have shown that in so far as whipping ability, body and texture, and flavor are concerned, a very palatable ice cream can be made from fresh reconstituted powdered ice cream mix. A further desirable feature for dried ice cream mix is that there be no appreciable flavor deterioration for several months after manufacture. The most common defect that occurs during storage of the dry mix is the development of an oxidized flavor.

The industry has found that the use of a high preheating temperature before condensing is helpful in retarding the development of an oxidized flavor in powdered milk. Although the composition of milk "agglutinin" has never been reported, it is closely associated with the fat and can be concentrated either in the cream or skim milk depending on the temperature at which the milk is separated (22). In some plants it is a practice to separate milk cold (below 90° F.), while in other plants milk is separated hot (above 120° F.). Since it has been shown that the temperature at which milk is separated is related to the distribution of some of the minor constituents in milk such as "agglutinin" (22), it was thought advisable to study the relation of the temperature of the milk when separated and the forewarming temperature of the skim milk before condensing to the keeping qualities of the dried ice cream mix.

REVIEW OF LITERATURE

Holm, Greenbank, and Deysher (12) found that improved keeping quality of the dried whole milk resulted from forewarming the milk at higher than ordinary preheating temperatures (83° C. for 30 minutes). Jack and Henderson (13) also found that high preheating temperatures were beneficial. Hollender and Tracy (11) found that roller milk powder made from milk heated to 170° F. for 30 minutes was less likely to develop an oxidized flavor during storage than that made from milk heated to a higher (190° F.) or lower (150° F.) temperature for the same length of time. Mattick and coworkers (16) conclude that "increasing the preheating temperature of the milk from 165° F. to 190° F. before spray drying greatly improved the resistance of the powder to the development of tallowy 'off' flavors on storage." They suggest that the protective effect of the high preheating

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temperature is due (a) to production in the milk of antioxidant-active sulphydryl compounds, by the action of heat on the proteins and possibly (b), to the more complete destruction of oxidizing enzymes originally present in the milk or produced therein by the growth of bacteria.

Kende (15) found that the oxidative taint which develops in some milks, particularly at low storage temperatures, could be prevented by heating the milk at 185° F. for 5 minutes. He further states that reducing substances were formed in milk heated to 176–185° F.

Trout (24) recommends that cream to be stored frozen must be pasteurized at least at an exposure of 165° F. for 15 minutes and preferably 185° F. for five minutes. Dahle, Lawhorn ,and Barnhart (4) concluded that a pasteurization temperature of 150° F. for 30 minutes offered no protection during storage if the copper content exceeded 0.6 p.p.m. A flash temperature of 170° F. offered protection in creams having a copper content over 0.75 p.p.m., but under 1.12 p.p.m., while 190° F. flash was only slightly better than 170° F.

Schieb, Stark, and Guthrie (21) have found that high temperature treatment of churning cream aids in producing butter resistant to the development of oxidative taints during storage at 0° F. to −10° F. They found that 165° F. for thirty minutes was necessary, 15 minutes at 165° F. was inefficient, and that cream itself is much more resistant to spoilage when flash-pasteurized at 170–190° F. than when heated to 150° F. for as long as 30 minutes.

There is conflicting evidence in the literature regarding whether the butterfat, fat globule membrane, copper or ascorbic acid are involved in oxidized flavor development. Brown and Thurston (2) have reviewed the various theories of the mechanism of fat oxidation. Since this review Olson and Brown (17, 18) have added some more possible explanations on oxidized flavor development and inhibition. El-Rafey, Richardson, and Henderson (6) have shown that improved keeping quality of butter oil results when the butter is heated to 110° C. to drive off the moisture than when lower temperatures of isolation of the oil are used. They attribute the improved keeping quality to result from the transfer of greater amounts of phospholipid material from the non-oil phase of butter to the oil, presumably because of the denaturing action of heat on the protein of the phospholipid-protein complex. The concentration of reducing substances is also higher in the butter oil made by the "boiling off" process than by the low heat treatment.

Dahle and Josephson (3) found that samples of dry whole milk containing the least lecithin had the best keeping qualities.

EXPERIMENTAL METHODS

The experimental batches were prepared and dried in a commercial plant equipped with a pilot drying unit of 75 pounds per hour capacity.

This plant had practically all stainless steel equipment. All batches of dried ice cream mix within a single run were made from the same lot of milk.

Fresh raw milk was separated at both 55° F. and 130° F. and the cream and skim milk collected to obtain cream and skim milk containing different concentrations of "agglutinin" (22). Theoretically the cream separated at 55° F. should contain most of the "agglutinin" originally present in the milk whereas the 55° F. skim milk should contain a relatively low concentration of "agglutinin." The milk separated at 130° F. should produce skim milk containing most of the "agglutinin" while the cream separated at 130° F. should be relatively low in "agglutinin" (22). Two 5000-pound batches of skim milk separated at the two temperatures (55° and 130° F.) were used. Portions of each batch were forewarmed at 150° F. for 20 minutes and 180° F. for 5 minutes and immediately condensed in a stainless-steel vacuum pan, cooled to 40° F. and stored overnight before use. All the cream was pasteurized at 170° F. for 10 minutes, cooled to 40° F. and stored overnight.

Butter was prepared from 40.5 per cent cream separated at 87° F., pasteurized at 170° F. for 10 minutes, cooled to 40° F. and held four hours before churning. Butter oil was made from the above butter by the decantation method. The butter was melted at 140° F. and held at this temperature overnight. The butter serum was then siphoned from the bottom and the scum removed from the surface. The fat layer was then filtered through cheesecloth.

Ice cream mixes having the composition of 10 per cent butterfat, 10.8 per cent m.s.n.f., 14.5 per cent sugar and 0.3 per cent stabilizer were made in 100-pound batches. The proper amounts of cream, condensed skim, water, sugar and stabilizer were mixed in a small preheater heated to 150° F., homogenized at 1500 pounds pressure and spray-dried at 2000 pounds pressure. Only one-fourth of the sugar was added before drying. When butter or butter oil was used as a source of fat, the desired amount of fat was first mixed with 5 pounds of condensed skim milk and 10 pounds of water, heated to 140° F. and homogenized at 1500 pounds pressure. It was then added to the remainder of the mix and processed as above.

The ice cream mixes were dried on a stainless-steel spray-type drier using a number 64 nozzle with a number 17 core. The air inlet temperature was approximately 310° F. and the outlet temperature 195–200° F.

After drying the mix the remainder of the sugar was added. Powdered vanilla was added at the rate of 3 ounces to 16 pounds of ice cream powder. The powdered mix was then packed in number 2 cans. Three hundred grams (plus or minus 2 grams) of powdered mix was added to each can. The cans were then sealed, nitrogen-packed and stored in a room where the temperature was automatically controlled at 72° F. except during the months when the temperature outdoors was higher than that indoors.

Changes in carbon dioxide and oxygen concentration in the head space were obtained by the manometric procedure of Van Slyke and Sendroy (25).

The copper content of the powdered mixes was determined by the carbamate method of Hetrick and Tracy (10) and the iron content by the 1,10-phenanthroline method of Pyenson and Tracy (19).

The flavor scores were determined on reconstituted ice cream mix by two or more judges within 8 hours after reconstituting. The ice cream score card with a perfect flavor score of 45 was used for scoring the reconstituted ice cream mixes.

Moisture was determined by the toluol distillation method (1).

The fat source and treatment given the ingredients used in making up

TABLE 1

Fat source and treatment of ingredients in ice cream mixes

Batch No.	Fat source	Cream treatment		Skim milk treatment	
		Separation temp.	Past. temp.	Separation temp.	Fore. temp.
		°F.	°F. min.	°F.	°F. min.
23A	Butter oil	.....	.....	55	150 20
23B	Butter oil	.....	.....	55	180 5
23C	Butter oil	.....	.....	130	150 20
23D	Butter oil	.....	.....	130	180 5
23E	Cream	55	170 10	130	150 20
23F	Cream	130	170 10	55	150 20
23G	Cream	130	170 10	130	150 20
23H	Cream	130	170 10	130	180 5
24A	Butter oil	.....	.....	87	150 20
24B	Butter	.....	.....	87	150 20
24C	Cream	87	170 10	87	150 20
24D	Cream	87	170 10	87	180 5

the ice cream mixes before drying are indicated in table 1. The fresh milk was held in large storage tanks before separation. The same source of milk was used for the fat and skim milk. Four batches were made with butter oil as the source of fat and combined with skim milk separated at the two temperatures (55° and 130° F.) (table 1, samples 23A–23D). Four batches were also made with cream pasteurized at 170° F. for 10 minutes at both 55° F. and 130° F. and combined with condensed skim milk forewarmed at 150° F. for 20 minutes or 180° F. for 5 minutes to vary "agglutinin" content and heat treatment of the milk solids.

Batches number 24A–24D were run simultaneously with batches 23A–23H using the same products to permit comparison between different lots of both batches. In these samples butter oil, butter and cream as the source of fat were compared using skim milk separated at 87° F. and forewarmed at 150° F. for 20 minutes before condensing. One batch (24D) was made with condensed skim milk forewarmed at 180° F. for 5 minutes using cream separated at 87° F. as the source of fat.

STORAGE OBSERVATIONS ON DRIED ICE CREAM MIX

Table 2 indicates the changes in carbon dioxide and oxygen in the head space gas and palatability of gas-packed dried ice cream mix on storage for one year at room temperature.

TABLE 2

Changes in carbon dioxide and oxygen in head space gas and palatability of gas-packed dried ice cream mix on storage

Batch No.		Days of storage at room temperature						
		22	52	110	170	210	300	365
23A	% CO_2	0.75	0.31	0.32	0.67	1.02	1.06	1.22
	% oxygen	2.64	2.24	2.07	1.60	0.95	0.53	0.41
	Flavor	38*	36*	35*	35*	35*	35*	34*
23B	% CO_2	0.42	0.28	0.33	0.80	0.50	0.54	0.23
	% oxygen	2.93	3.00	2.56	2.33	2.25	1.44	1.43
	Flavor	40.5	40	39.5	39	38†	38.5	38
23C	% CO_2	0.71	0.38	0.91	0.87	0.61	0.52	0.81
	% oxygen	2.27	3.49	1.86	2.33	1.78	0.85	0.51
	Flavor	40.5	40	38*	37*	38	37*	36.5*
23D	% CO_2	0.91	0.38	0.57	0.65	0.81	0.61	0.63
	% oxygen	2.91	3.00	1.78	2.16	1.86	1.11	0.87
	Flavor	40.5	39.5	39.5	39	39	38.5	38.5
23E	% CO_2	0.53	0.66	0.48	0.81	1.06	1.01	1.23
	% oxygen	2.57	2.54	2.33	2.04	1.69	1.11	0.59
	Flavor	40.5	39.5	36†	36†	36.5*	35.5*	35*
23F	% CO_2	0.74	0.55	0.84	1.16	0.93	1.50	0.95
	% oxygen	3.49	3.04	2.19	1.80	1.63	0.93	0.74
	Flavor	40.5	38	34.5†	35†	35*	35*	35.5*
23G	% CO_2	0.75	1.07	0.72	0.73	1.13	1.21	1.05
	% oxygen	2.56	2.88	3.00	2.36	1.55	1.10	1.03
	Flavor	40.5	37.5*	37.5	34.5*	37*	35*	36.5*
23H	% CO_2	0.53	0.29	0.44	0.49	0.46	0.62	0.87
	% oxygen	3.87	2.91	2.47	2.43	2.31	1.22	1.97
	Flavor	40.5	40	39.5	39	39	39	38.5
24A	% CO_2	0.94	0.00	0.53	0.41	0.82	1.03	0.97
	% oxygen	2.22	2.39	1.82	0.65	0.76	0.33	0.65
	Flavor	40.5	38*	37*	34.5*	36*	35.5*	34.5*
24B	% CO_2	0.72	0.15	0.36	0.63	0.84	0.94	0.93
	% oxygen	2.55	2.40	2.03	1.53	1.45	0.82	0.71
	Flavor	40.5	40	37*	35*	36*	35*	35*
24C	% CO_2	1.08	0.81	0.92	1.13	1.30	1.59	1.33
	% oxygen	2.76	2.72	2.36	1.63	1.35	0.72	0.45
	Flavor	39	38.5*	36†	34.5*	35*	34.5*	34.5*
24D	% CO_2	0.69	0.76	0.56	0.48	1.11	1.10	0.95
	% oxygen	2.70	3.16	2.40	0.42	1.86	1.09	0.81
	Flavor	39	39.5	39	38.5	38	37.5	38

* Oxidized.
† Metallic.

The carbon dioxide content of the head space gas varied throughout the storage period. A relatively large amount of carbon dioxide developed and remained throughout the intervals of analysis. Oxygen concentration in the headspace gas gradually became lower as the storage period advanced.

At 22 days of storage, the oxygen values varied from 2.27 per cent to 3.87 per cent. At the end of one year the oxygen values decreased more than 50 per cent. In most cases more than two-thirds of the oxygen in the headspace was absorbed during the year of storage.

The flavor scores in table 2 indicate that, in general, the powder became less palatable as the storage period advanced. The initial oxygen content of the headspace gas was lowest in those cans containing powder made with butter oil as a source of fat. Nevertheless the keeping qualities of these mixes were no better than those made with cream. There was slightly more rapid oxygen absorption, more carbon dioxide evolution and more oxidized flavor development in mixes made from the condensed skim milk forewarmed at 150° F. than in those mixes that had the condensed skim milk forewarmed at 180° F. When the skim milk was forewarmed at 180° F. for 5 minutes,

TABLE 3

The moisture, iron and copper content of spray dried ice cream mix

Batch No.	Moisture	Iron	Copper
	%	*p.p.m.*	*p.p.m.*
23A	0.8	4.4	0.65
23B	1.0	3.3	0.58
23C	0.8	3.6	0.93
23D	1.0	3.7	0.55
23E	1.1	3.6	0.53
23F	1.4	3.9	0.53
23G	1.2	3.8	0.65
23H	0.8	3.4	0.65
24A	0.8	3.6	0.60
24B	1.6	3.2	0.68
24C	0.8	4.0	0.70
24D	1.5	3.4	0.65

the reconstituted dried mix developed a flavor designated as stale or lacking in freshness, but the typical oxidized flavor was not apparent.

Higher flavor scores occurred in the reconstituted ice cream mixes when the skim milk was forewarmed at 180° F. for 5 minutes. In every case, regardless of the source of fat, forewarming the skim milk before condensing to a high temperature prevented the development of oxidized flavor during the storage period (12 months). The temperature at which the milk was separated did not affect the keeping quality or oxidized flavor development. From table 2 it can be seen that batches 23B, 23D, 23H and 24D which were made from skim milk forewarmed at 180° F. developed no oxidized flavor and were almost as palatable at the end of the storage period of 12 months as they were at the beginning of the experiment.

From the results summarized in table 2 and from the above discussion, it can be seen that high forewarming treatment on the skim milk used as a source of solids is beneficial in prolonging the keeping quality of dried ice cream mix. This phenomenon may be associated with the liberation of the

sulfhydryl groups on high forewarming treatment. Some heat labile sulphides are liberated at the high forewarming temperature used in this study (6, 7, 8, 14). The temperature of separation of the cream and the source of fat, whether butter oil, butter or cream, made little difference on palatability. Further work is now in progress to secure information on the relation of the heat treatment given the butter fat to the keeping quality of spray dried ice cream mix.

THE MOISTURE, IRON AND COPPER CONTENT OF SPRAY DRIED ICE CREAM MIX

A summary of the moisture, iron and copper content of the mixes reported in this investigation are given in table 3. The moisture in all the dried mixes was 1.6 per cent or less. The iron varied in the various batches from 3.2 to 4.4 parts per million and the copper varied from 0.55 to 0.93 parts per million.

SUMMARY

Twelve batches of dried ice cream mix were made from the same lot of milk. The milk was separated at various temperatures to secure cream and skim milk containing various amounts of "agglutinin." The skim milk was forewarmed at both low and high temperatures and condensed in a stainless steel vacuum pan. Some of the cream was made into butter and butter oil. Dried ice cream mixes were made from these ingredients so that the relation of the heat treatment given the serum solids to the keeping quality could be studied.

The carbon dioxide content of the headspace gas varied throughout the storage period. Oxygen concentration gradually became lower as the storage period advanced. There was a tendency toward more rapid oxygen absorption, more carbon dioxide evolved, and more oxidized flavor development in mixes that had the condensed skim milk forewarmed to 150° F. for 20 minutes than in those mixes that had the condensed skim milk forewarmed at 180° F. for 5 minutes. There seemed to be no significant differences in oxidized flavor development when the mixes were prepared from concentrated skim milk made from skim milk separated at 55° or 130° F. Whether the fat used was in the form of cream, butter or butter oil was not a factor influencing the keeping quality of the dried ice cream mix. All the batches became oxidized which contained butter oil, butter or cream which were made with skim milk forewarmed at 150° F. for 20 minutes. After one year dried mixes made from skim milk forewarmed at 180° F. for 5 minutes had not developed an oxidized flavor and were still highly palatable.

High forewarming temperature on the skim milk before condensing is beneficial in prolonging the keeping qualities of dried ice cream mixes and the retardation of oxidized flavor development.

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CAROTENE UTILIZATION IN THE NEWBORN CALF

A. A. SPIELMAN, J. K. LOOSLI, J. W. THOMAS, C. L. NORTON, AND K. L. TURK
Department of Animal Husbandry, Cornell University

Mature bovine obtain their vitamin A requirements from the metabolic conversion of carotene because usual rations do not contain preformed vitamin A. On the other hand, the newborn calf normally receives considerable amounts of vitamin A and carotene from colostrum. Sutton (12) reports that calves receive about 53 milligrams of carotene when fed colostrum during the first seven days. If it is utilized, this carotene is an important source of vitamin A. However, little is known regarding the ability of the newborn calf to utilize carotene. Suggestions that the newborn calf is unable to utilize carotene (9), or that the young calf converts carotene more efficiently or more rapidly than older animals (7) have been made, although few data have been presented. Therefore, it is important to know if the newborn calf utilizes carotene and the age at which conversion is sufficient to provide the full requirement of vitamin A.

The study, reported herein, was undertaken to obtain more specific information on this problem.

EXPERIMENTAL

Male calves of the Holstein, Guernsey, and Jersey breeds were used. Because of the high vitamin A and carotene content of colostrum, the calves were fed fresh skim milk or reconstituted skim milk from birth. A low-carotene ration composed of ground oats, ground barley, wheat bran, linseed oil meal, dicalcium phosphate, and salt was fed *ad libitum*. Dried beet pulp was included in the ration as the sole source of roughage. In order to minimize the possibility of vitamin deficiencies other than vitamin A, each calf received daily a capsule[1] containing 1000 U.S.P. units of vitamin D, 250 milligrams of ascorbic acid, 50 milligrams of alpha-tocopherol, 10 milligrams each of thiamine, riboflavin and pyridoxine, 100 milligrams of niacin, 50 milligrams of calcium pantothenate and 1000 milligrams of choline chloride.

Various materials were used to supply carotene. During the early phases of the study, solutions containing one gram of crystalline carotene[2] dispersed in 100 ml. of peanut oil or 500 ml. of lard were used. Alfalfa leaf meal containing 12.8 mg. of carotene per 100 grams was also used. A commercial concentrate[3] containing 33 mg. of carotene per gram derived from vegetable sources and dispersed in cottonseed oil was used during the latter part of the experiment. The calves were weighed at weekly intervals, and the carotene intakes were adjusted according to body weight.

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[1] Generously supplied by Hoffmann-La Roche, Inc., Nutley, N. J.

[2] 90% Beta-carotene. General Biochemicals, Chagrin Falls, Ohio.

[3] Carotene in oil, Type 288. General Biochemicals, Chagrin Falls, Ohio.

The calves were housed in individual stalls in a separate barn that was provided with artificial heat in cold weather to avoid the complicating effects of extremes in temperatures.

Plasma carotene and vitamin A were determined at birth and at least twice weekly thereafter using the method of Kimble (8). Ophthalmoscopic examination of the eyes were made at frequent intervals. All calves were slaughtered at 60 days of age and a careful examination made of the various organs for gross pathological conditions. Analyses of the livers were made according to the extraction procedure of Davies (3) to determine the storage of carotene and vitamin A. Similar examinations and analyses were made of all calves that died during the course of the experiment.

During the early phases of this study a transfusion of about 500 ml. of the dam's blood was given to each calf at birth. In some cases an additional 250 ml. of plasma or blood was injected subcutaneously. This practice was recommended by Smith and Little (11) as an effective means of providing the protective immune bodies normally supplied by colostrum. This procedure proved to be impractical and unsatisfactory as a prophylactic measure and was replaced by the oral administration of 4 to 8 grams of sulfathalidine daily for the first 7 to 10 days.

RESULTS AND DISCUSSION

A summary of the sources and levels of carotene fed and the results obtained with the first 11 calves is shown in table 1. All of the calves except No. 1 failed to gain in weight and died at about seven days of age, regardless of the source of carotene or the amount fed. Post-mortem examinations indicated that death resulted from severe enteritis and/or septicemia and pneumonia. Insignificant amounts of carotene and vitamin A were found in the livers.

The blood-plasma levels of carotene and vitamin A for these calves are presented in figure 1. It will be noted from these data that without exception the plasma vitamin A did not show any appreciable increase. Although somewhat more variable, the plasma-carotene data seemed to indicate poor absorption of carotene. As shown in table 2, acute scours occurred in these calves shortly after birth and generally persisted until death. Since Adlersberg and Sobotka (1) demonstrated that humans with active sprue were unable to absorb fat-soluble vitamins, it seemed likely that the early onset of scours was at least partially responsible for the poor carotene absorption and low plasma vitamin A. Later it was found that even in older calves chronic scours decreases the absorption of carotene as exemplified in figure 2. A similar effect of scours on the absorption of vitamin A was also observed. Sutton and Kaeser (12) recently reported a simultaneous drop in blood plasma carotene and vitamin A in calves that had diarrhea, indicating poor absorption.

TABLE 1

Summary of experimental procedure and results obtained with calves developing scours shortly after birth

Number	Breed	Carotene		Birth wt.	Change in weight*	Age at death	Necropsy	Liver storage	
		Source	Daily intake					Carotene	Vitamin A
			mg./100 lbs.	*lbs.*	*lbs.*	*Days*		*γ/gm.*	*γ/gm.*
1	H	Carotene in peanut oil	12	100	+5	19	Enteritis, septicemia, kidney degeneration, liver necrosis	1.0	0.0
2	G	Carotene in peanut oil	18	65	+2	9	Enteritis, pneumonia	0.0	0.0
3	H	Carotene in peanut oil	36	77	−3	11	Enteritis, septicemia	0.25	0.02
4	H	Carotene in lard	75	88	−10	4	Enteritis, pneumonia	0.38	0.02
5	J	Carotene in lard	165	66	−6	5	Enteritis, pneumonia	0.96	0.01
6	H	Alfalfa leaf meal	60	85	−5	3	Enteritis, pneumonia	0.04	0.0
7	G	Alfalfa leaf meal	60	64	−4	3	Enteritis, pneumonia	0.07	0.0
8	G	Alfalfa leaf meal	60	79	−10	9	Enteritis, pneumonia	0.10	0.01
9	H	Concentrate	5	92	0	8	Enteritis, septicemia	1.63	1.31
10	G	Concentrate	5	75	−4	5	Enteritis, pneumonia	0.64	0.0
11	H	Concentrate	8	98	−10	7	Enteritis, septicemia	0.12	0.28

* From birth until death.

While the exact cause of the early onset of diarrhea could not be ascertained, several factors were involved. These calves did not receive the natural protective immune bodies normally supplied in colostrum. Thus, favorable conditions existed for the development of infection and scours. The large amount of vitamin A, *per se,* which the newborn calf usually receives in colostrum may play an important rôle in the prevention of scours and infection. In fact, it was found (10) that calves died when the blood plasma vitamin A and carotene failed to increase following the ingestion of colostrum. The presence of both the immune bodies and the vitamin A in colostrum may be necessary to provide the greatest protection against scours and infection. Additional information on this problem is being accumulated by feeding skimmed colostrum, with and without large amounts of supplemental vitamin A.

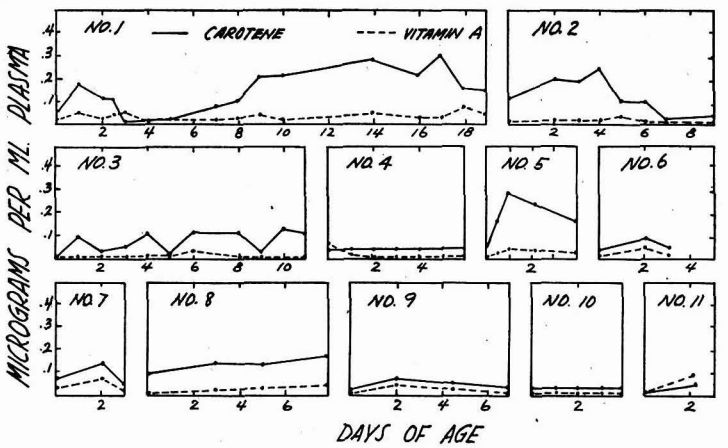

FIG. 1. Plasma carotene and vitamin A of the calves that developed scours shortly after birth.

The sources of carotene fed may have contributed to the poor absorption and utilization since difficulty was experienced in preparing a concentrated solution of carotene in oil suitable for the tests. It is believed that the large amounts of oil fed may have been responsible for scours in certain cases. Alfalfa leaf meal did not prove very satisfactory, probably due to the newborn calf's inability to efficiently digest fibrous feeds. Ward *et al* (13) found that carotene fed as a commercial concentrate in oil was more available to young calves than the carotene in alfalfa hay or other feedstuffs. This does not appear to be the case with older bovine, as Hauge *et al.* (5, 6) found that the mature dairy cow can utilize the carotene in alfalfa hay as readily as isolated carotene for the production of butterfat of high vitamin A value. Furthermore, Guilbert *et al.* (4) found that the minimum carotene requirements to prevent night blindness in cattle, sheep, and swine were

TABLE 2

The incidence and duration of scours of the calves listed in Table 1

No.	Breed	Carotene supplement	Daily intake	Day of age																		
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
			mg./100 lbs.																			
1	H	Carotene in peanut oil	12		+	+									+	+	+	+	+	+	+	+	Died
2	G	Carotene in peanut oil	18		+	+	+	+	+	+	+	+	Died										
3	H	Carotene in peanut oil	36						+	+	+	+	+	+	Died								
4	H	Carotene in lard	75	+	+	+	+	Died															
5	J	Carotene in lard	165		+	+	+	+	Died														
6	H	Alfalfa leaf meal	60	+	+	+	Died																
7	G	Alfalfa leaf meal	60	+	+	+	Died																
8	G	Alfalfa leaf meal	60		+	+		+		+	+	+	Died										
9	H	Concentrate	5			+	+	+	+	+	+	Died											
10	G	Concentrate	5			+	+	+	Died														
11	H	Concentrate	8			+	+	+	+	+	Died												

+ = Scours.

practically the same when the carotene was furnished by alfalfa or by crystalline carotene dissolved in cottonseed oil. Balance studies with newborn calves should contribute more evidence regarding the relative availability of carotene from different sources. The provitamin A activity of the several carotenoids present in alfalfa is as yet unsettled and may play an important rôle in this problem.

No information is available regarding the possible function of the tocopherols in carotene absorption and utilization by the newborn calf. It should be pointed out that every calf in this study received daily 50 milligrams of alpha-tocopherol in addition to that supplied by the alfalfa leaf meal or the cottonseed oil.

Little information regarding the ability of the newborn calf to utilize carotene was obtained from the foregoing calves and procedure, because of early infection and death. Therefore, further studies were undertaken. The commercial carotene concentrate, standardized to contain 33 mg. of carotene per gram, was used exclusively. Four to eight grams of sulfathalidine per day were administered orally to each calf during the first week. By following this procedure it was possible to reduce the incidence of early scours and to obtain a satisfactory survival rate as shown in tables 3 and 4.

The incidence and duration of scours in the individual calves receiving the commercial carotene concentrate and sulfathalidine are presented in table 3. It will be noted that without exception scours did not occur during the first five days following birth. It is likely that the more or less chronic scours observed in calf No. 12 was due to vitamin A deficiency as indicated by the low level of plasma vitamin A (figure 2). The presence of papilledema at 30 to 40 days of age was additional evidence of inadequate plasma vitamin A. Yellow, oil-like material was frequently observed in the feces from calf No. 15, due probably to the ingestion of excessive amounts of the carotene concentrate. This condition may have contributed to the manifestation of mild diarrhea by this calf throughout the experimental period.

As noted in table 4, four Holstein, one Jersey, and two Guernsey male calves receiving no colostrum were raised from birth to 60 days of age on a diet in which carotene was the only source of vitamin A. With the exception of calf No. 12, which received only 2 mg. of carotene per 100 lbs. of body weight, the calves made satisfactory growth gains and exhibited no symptoms of vitamin A deficiency.

The blood plasma carotene and vitamin A levels of these calves from birth to 60 days of age are shown in table 5. The data on calves number 12, 13, and 18 were selected as typical and presented in graphic form in figure 2. As shown by these data, the calves were able to absorb and utilize carotene when scours were prevented during the first week. Immediate conversion of carotene into vitamin A was efficient enough to cause a marked rise in the plasma level of vitamin A. At one day to two days of age the

TABLE 3

The incidence and duration of scours in the calves receiving sulfathalidine and the commercial carotene concentrate

No.	Breed	Carotene supplement	Daily intake	Day of Age																										
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
			mg./100 lbs.																												
12	H	Concentrate	2						+	+	+		+	+	+	+		+		+	+	+			+			+		+		+
13	H	Concentrate	15																												
14	H	Concentrate	30																			+						+				
15	H	Concentrate	130						+		+	+	+	+		+	+		+	+		+		+	+			+	+		+	
16	J	Concentrate	66																											+		
17	G	Concentrate	40							+				+																		
18	G	Concentrate	10											+	+	+	+					+	+	+	+			+	+	+	+	

+ = Scours.

TABLE 4

Summary of experimental procedure and results indicating carotene utilization

Number	Breed	Carotene		Birth Wt.	Weight gain*	% of normal gain	Age when killed	Necropsy	Liver storage	
		Source	Daily intake						Carotene	Vitamin A
			mg./100 lbs.	*lbs.*	*lbs.*		*days*		γ/*gm.*	γ/*gm.*
12	H	Concentrate	2	97	18	26	60	Papilledema at 30–40 days old	0.57	0.01
13	H	Concentrate	15	92	72	103	60	Normal	1.27	1.46
14	H	Concentrate	30	97	71	101	60	Normal	1.53	2.21
15	H	Concentrate	130	102	74	106	60	Normal	.....	.....
16	J	Concentrate	66	48	41	100	60	Normal	.....	.....
17	G	Concentrate	40	75	37	88	60	Normal	5.05	1.47
18	G	Concentrate	10	65	32	79	60	Normal	1.35	1.50

* From birth to 60 days of age.

TABLE 5

Carotene and vitamin A content of blood plasma of calves utilizing carotene from birth to 60 days of age

Days of age	No. 12		No. 13		No. 14		No. 15		No. 16		No. 17		No. 18	
	Car.	Vit. A	Car.	Vit. A	Car.	Vit. A	Car.	Vit. A	Car.	Vit. A	Car.	Vit. A	Car.	Vit. A
	γ/ml.	γ/ml.	γ/ml.	γ/ml.	γ/ml.	γ/ml.	γ/ml.	γ/ml.	γ/ml.	γ/ml.	γ/ml.	γ/ml.	γ/ml.	γ/ml.
Birth	0.01	0.03	0.02	0.02	0.01	0.01	0.02	0.03	0.05	0.01	0.09	0.02	0.06	0.03
1– 2	0.08	0.09	0.20	0.12	0.30	0.10	0.48	0.11	0.49	0.10	0.31	0.11	0.27	0.07
3– 7	0.11	0.09	0.25	0.12	0.70	0.15	1.23	0.18	0.75	0.16	0.52	0.09	0.50	0.11
8–14	0.09	0.05	0.29	0.15	0.80	0.16	0.92	0.25	1.51	0.31	0.56	0.07	0.49	0.13
15–21	0.08	0.04	0.30	0.10	0.83	0.30	0.94	0.18	1.80	0.32	0.74	0.08	0.45	0.10
22–28	0.09	0.03	0.28	0.08	1.05	0.28	0.70	0.06	1.46	0.25	0.64	0.05	0.33	0.06
29–35	0.15	0.07	0.30	0.10	0.90	0.20	1.14	0.21	1.23	0.23	0.60	0.04	0.35	0.05
36–42	0.20	0.10	0.26	0.10	0.88	0.18	1.24	0.27	0.78	0.18	0.64	0.06	0.51	0.07
43–49	0.12	0.08	0.30	0.13	0.92	0.20	1.11	0.19	1.25	0.21	0.76	0.07	0.68	0.11
50–60	0.10	0.06	0.30	0.11	0.85	0.18	1.08	0.21	1.32	0.25	0.96	0.07	0.51	0.12

plasma vitamin A levels were equal to or above the 0.1 microgram per ml. level which has been suggested (2) as the minimum below which deficiency symptoms occur. Additional evidence of the utilization of carotene was provided by the presence of appreciable amounts of vitamin A in the livers of the calves sacrificed at 60 days of age (table 4).

In view of the present paucity of knowledge regarding the complex factors involved in the physiological rôle of colostrum, experiments using the no-colostrum technique are not without reproach. While this technique is advantageous experimentally, caution should be practiced in drawing conclusions which may, of necessity, be revised as additional information is obtained.

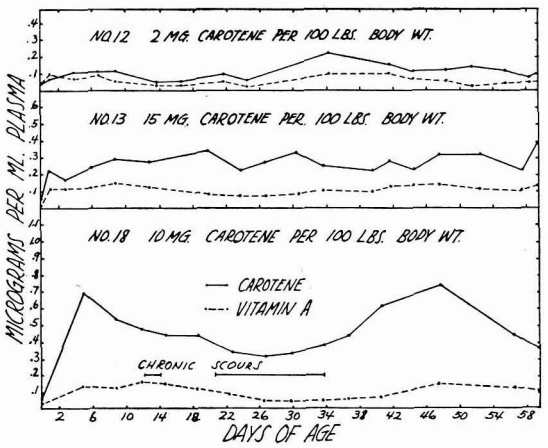

FIG. 2. Plasma carotene and vitamin A of three calves selected as typical of the calves utilizing carotene from birth to 60 days of age.

SUMMARY

Experiments were conducted with 18 newborn dairy calves to study carotene utilization. Holstein, Guernsey, and Jersey male calves were fed a skim milk–low carotene ration from birth without having received colostrum. Crystalline carotene in peanut oil or lard, alfalfa leaf meal and a commercial carotene concentrate were used as sources of carotene. Blood plasma levels and liver storage of carotene and vitamin A, growth and general well-being were used as criteria of carotene utilization.

The onset of infection and scours shortly after birth reduced the absorption and utilization of carotene regardless of the amounts fed.

Alfalfa leaf meal and laboratory preparations of crystalline carotene in peanut oil or lard were unsatisfactory as sources of carotene for the newborn calf.

Satisfactory prevention and control of scours was obtained in most cases by oral administration of 4 to 8 grams of sulfathalidine daily for the first week.

When scours were controlled, newborn calves were able to utilize the carotene in a commercial concentrate at a rate sufficient to provide for satisfactory growth and some storage in vitamin A in the liver.

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ABSTRACTS OF LITERATURE

BOOK REVIEWS

149. Piping Handbook, Fourth Edition. SABIN CROCKER, M.E., Senior Engineer, Engineering Division, Detroit Edison Co. McGraw-Hill Book Company, Inc., New York. 1945.

The author, a member of the American Society of Mechanical Engineers, and of several testing and standardization organizations concerned with piping, first published this handbook in 1930. The work was undertaken because of the growing need for an authoritative reference source in the highly specialized field of piping systems in connection with modern power plants, distribution systems, and in industrial operations. It is the endeavor of the author to make this handbook self-contained, insofar as practicable, for the benefit of those who have to deal with design problems without ready access to a reference library.

In the Fourth Edition, the scope of Piping Handbook has been extended to include chapters on "Gas Piping," "Refrigeration Piping," "Hydraulic Power Transmission Piping," and "Corrosion," which also covers the subject of protective coatings. Other chapters have been augmented and still others revamped. In much of this preparation some forty-odd collaborators, experts in the various fields of piping applications involved, have assisted the author in the chapter content. Much fundamental material has been incorporated for mathematical solution of fluid flow, together with graphic methods. Material of this sort which is too cumbersome for handbook inclusion is referred to original source. The 1350 pages contain many tables, charts, diagrams, drawings and a few photographic reproductions of special equipment. The chapter listing furnishes an insight of subject matter.

I. Definitions, Formulas, and Tables; II. Fluids—Properties of Fluids; III. Metallurgy of Piping Materials; IV. Pipes, Valves, and Fittings; V. Heat Insulation; VI. Hangers and Supports; VII. Expansion and Flexibility; VIII. Steam Power—Plant Piping; IX. Building Heating Systems; X. Plumbing Systems; XI. Underground Steam Piping; XII. Water-Supply Piping; XIII. Fire-Protection Piping; XIV. Oil Piping; XV. Gas Piping; XVI. Refrigeration Piping; XVII. Corrosion; XVIII. Hydraulic Power Transmission Piping. L.M.D.

150. Industrial Oil and Fat Products. ALTON E. BAILEY, Senior Chemical Technologist, Southern Regional Research Laboratory, U. S. Dept. of Agr., New Orleans, Louisiana. Inter-science Publishers, Inc., New York, N. Y. 1945.

A notable contribution to the field of oil and fat technology, containing

much material published for the first time, suitable as a text or a reference and even a handbook on the subject. The book is divided into four sections: A. The Nature of Fats and Oils. In this section the main subjects are, I. The Structure and Composition of Fats and Oils, II. Reactions of Fats and Fatty Acids, III. Physical Properties of Fats and Fatty Acids, IV. Rôle of Fats in the Diet of Man. B. Raw Materials for Oil and Fat Products, V. Sources, Utilization, and Classification of Oils and Fats, VI. Production and Consumption of Primary Fats and Oils, VII. Composition and Characteristics of the Individual Fats and Oils. C. Industrial Utilization of Fats and Oils, VIII. Cooking and Salad Oils; Salad Dressings, IX. Plastic Shortening Agents, X. Butter and Margarine, XI. Bakery Products and Confections, XII. Soap and the Other Surface-Active Materials, XIII. Paints, Varnishes, and Related Products, XIV. Miscellaneous Oil and Fat Products. D. Unit Processes in Oil and Fat Technology, XV. Extraction of Fats and Oils, XVI. Refining and Bleaching, XVII. Deodorization, XVIII. Hydrogenation, XIX. Soapmaking, XX. Fractionation of Fats and Fatty Acids, XXI. Flat Splitting, Esterification, and Interesterification, XXII. Polymerization, and Emulsification. 710 pages, 921 footnote references, 163 tables, and 111 figures comprising graphs, line drawings, flow diagrams and photographic reproductions. L.M.D.

CONCENTRATED AND DRIED MILK: BY-PRODUCTS

151. Fat Problems in Dairy Products. Lt. Robert J. Remaley, QMC Laboratory, Chicago, Ill. Natl. Butter & Cheese Jour., *37*, No. 3: 36. March, 1946.

Examination of dry whole milk showed that oxidized flavor may be largely overcome by limiting oxygen to 3% of the gases in the container and by limiting copper to 1.5 ppm. and iron to 10 ppm. Shorter time and lower temperatures of preheating eliminated heated flavor and inhibited stale flavor. Oxidized effects were increased by such reductions. Trials with several antioxidants indicated no significant advantages over gas packaging.

Dry ice cream mix presents problems of quality preservation similar to those of dry whole milk; its keeping properties are not as good.

Good butter oil can be made from butter containing high free fatty acids, or protein decomposition or any physical defect; it cannot be made if the butter is tallowy, metallic, fishy or excessively oily. High heat applied before centrifuging butter or cream improves keeping properties of the oil; extreme heating (240° F.) after centrifuging causes oxidation. Recombined milk made with butter, butter oil or vegetable oil may be more satisfactory than reconstituted dry whole milk. W.V.P.

ICE CREAM

152. Frozen Fruit Purees in Ice Cream. DONALD K. TRESSLER. Ice Cream Field *47*, No. L: 32, 60. Jan., 1945.

Various products in which purees can be used are listed and it is stated that crushed and pureed fruits hold their flavor and color better than fruits not crushed before freezing. The addition of sugar helps to preserve the flavor and color as well as retard oxidation and hence for many purposes is desirable. Protective colloids, such as pectin or gelatin are sometimes beneficial as is the case with "Velva Fruit" and products used in ribbon ice cream. Deaération of purees is advisable before freezing.

The following formula and procedure is recommended for making pectinized puree from Elberta or other varieties of peaches which brown easily.

Ground peaches 100 lbs., granulated sugar 50 lbs., enzyme converted corn sirup (43° Bé.) 60 lbs., pectin 2.5 lbs., citric acid 1.25 lbs., and water 20 lbs. Stir pectin into 15 lbs. of the corn sirup previously heated to 160° F., then stir this suspension into boiling water. Keep the mixture hot until a smooth sirup results and then add balance of enzyme-converted corn sirup. Peel peaches by scalding in boiling water, steaming for about a minute or dipping in hot lye solution. Sprinkle halved peaches with sugar and citric acid solution before grinding and as fruit comes from grinder, stir immediately into pectin-corn sirup solution maintained at 175° F. Then cool and freeze.

It is stated that the Hale Haven, South Haven, Veefreeze, and J. H. Hale varieties of peaches give especially good pectinized purees and that the following varieties give good purees; Elberta, Ideal, Massasort, Marigold, Vedette, Veteran, Viceroy, Eclipse, Oriole, Rio Oso Gem and Sunbeam. The author states "Pectinized nectarine and apricot purees may be prepared according to the procedure described for peaches. Mixture of peach and nectarine purees and peach and apricot purees are even more inviting than the straight product."

Recipes are also given for pectinized purees of raspberry, boysenberry, loganberry, youngberry, blackberry and blueberry and it is stated that pineapple, grape, plum, cherry and orange marmalade make excellent purees for use in ribbon ice cream.

Directions for making Velva Fruit are also given. W.C.C.

153. Will Vitamined Ice Cream Be "Atomic Bomb" to the Industry? GEORGE BRICKER. Ice Cream Field, *47*, No. 1: 14, 46. Jan., 1946.

It is the author's opinion that vitamined ice cream will rapidly spread until it eventually becomes a standard of quality throughout the nation. He states that there is no great expense or difficulty in adding vitamins to ice cream mix. A listing of the vitamin content of Ardens' Ice Cream is

taken from their label. C. W. Crawford, U. S. Food and Drug Adm., is quoted as stating that under present Federal regulations vitamins may be added to ice cream if the product is properly labeled.

It is stated that there is a sharp division of opinion regarding the use of vitamins in ice cream. Fred Yoars, President, National Association of Retail Ice Cream Manufacturers, is quoted as saying that "Enriching ice cream is much simpler and far more practical than it sounds. Alert and progressive ice cream manufacturers can and will capitalize on it to the benefit of the public and themselves alike."

C. W. England, Director of Research, Highs Dairy Products, Washington, D. C., is quoted as follows: "Vitamins are now being added to bread, candy, and various other foods, and we might as well be realistic about the future of vitamins in ice cream."

P. H. Tracy, University of Illinois, stresses ice cream quality and advocates new products, particularly new sweetening agents and vitamins in producing ice cream. A. D. Burke, Dairy Dept., Alabama Polytechnic Institute, sees no objection to added vitamins but warns against over enthusiasm on the use of vitamins.

Strong opposition to adding vitamins to ice cream cones from Harold Gasser, Bard's Dairy Stores Co., Pittsburgh, who states "To add 'medicine' artificially—is too much."

G. Vergil Rector, Fairmont Creamery Company, Omaha, Neb., is not in favor of adding vitamins to ice cream. He states "Plenty has been said and is being said today about ice cream as a food without having to lay undue emphasis on reinforced vitamins."

Frank Leggett, Barber Brothers and Leggett, Evanston, Ill., concurs with the opposition and states "Our contention is that the consumer values ice cream according to its quality as manifest to him in appearance, body and flavor."

C. D. Dahle, Dairy Manufacturing Dept., Pennsylvania State College, is not enthusiastic about the addition of vitamins to ice cream. He states, "A good diet will supply anyone their vitamin needs. Those who are not able to get adequate diets probably are not the ones who will buy ice cream in the first place, and will not buy it in the second place for its vitamin content." W.C.C.

154. **Low Temperatures on the Highways.** M. V. STAGG, Williams Oil-O-Matic Division, Eureka Williams Corp., Bloomington, Illinois. Refrig. Engin., *51,* No. 3: 231. March, 1946.

Truck refrigeration fills in that all-important gap between production or processing of perishables and their arrival at retail outlets. Desirable features of truck refrigeration include low weight, dependability, easy accessibility for adjustment and maintenance, and compactness of unit for

minimum loss of pay load space. Factors determining the type of truck refrigeration requirements cover a wide range, some of the most important being, distance of haul, temperature needs varying with product handled, whether or not the haul will be a long-sealed up run or broken by frequent retail stops. Out of the widely varying requirements of the truck refrigeration field, certain systems have evolved. These include: 1. Ice bunker system; 2. Circulating brine system; 3. Dry ice system; 4. Gasoline-powered direct cooling system (with fin plate or blower coils); 5. Truck engine-powered system in two types: direct mechanical connections, and truck-generated electric power used to drive refrigeration equipment by electric motor; 6. Eutectic (synthetic brine) or holdover plates, commonly found in two types of installations: (a) electric-driven condensing unit for plug-in at garage, and (b) garage-mounted condensing unit with make-and-break refrigerant lines. The author feels that the ice bunker system, the circulating brine system, and the dry ice system are identified with the past of truck refrigeration. Ice and dry ice are expensive because of their depletion and brine because of its destructive action. Mechanical refrigeration allows for temperature flexibility and will meet the demands for low-temperature long hauls of frozen foods. Insulation should be employed generously, especially for truck bodies to be used for low-temperature transportation. Interior body design must allow for unrestricted air circulation. All refrigeration piping and cooling units should be fully protected against damage from loading and unloading and from travel vibration. Compressor design must provide for ruggedness and dependability under all factors of highway travel, and especially have a positive lubricating system, preferably of pressure type. L.M.D.

155. Ascorbic Acid Improved Frozen Peach Pack. J. G. Woodroof, R. C. Cecil, Ida Atkinson, and Ethyl Shelor. Food Freezing, *1*, No. 4: 123. Feb., 1946.

The authors studied five varieties of peaches using ascorbic acid to prevent browning of the cut fruit in its preparation for packaging. Several factors enter the problem, such as, whether the fruit is sliced, halved, or pureed; how the peaches are peeled, sliced, mixed with sugar; method of packaging; and whether or not dextrose is to be used for sweetening. While each variety of peach may require different treatment, the following general procedure is advocated. (1) Speed in handling from field box to final container for prepared fruit, (2) Each slice should be coated with sugar or syrup and packed "solid" with no air cavities in the containers, (3) Peeled peaches should be dipped in acid both to neutralize traces of lye and form an acid medium for peach slices, (4) 0.05 per cent ascorbic acid plus 0.10 per cent citric acid to retain color of the fruit, even bleaching it. Low acid varieties of peaches are greatly improved in flavor by the use of either citric

or phosphoric acid, especially when used in ice cream. The ascorbic acid prevents oxidation of the thawed fruit besides protecting it in freezer storage. L.M.D.

MILK

156. Three-Day-a-Week Delivery. T. KLINE HAMILTON, Diamond Milk Products Inc., Columbus, Ohio. Internatl. Assoc. Milk Dealers Bul., *38*, No. 3: 71–75. Feb., 1946.

Three-day-a-week delivery, started in Columbus in October, 1943, has the following benefits: 1. All the proven benefits of EOD and daylight delivery are retained; 2. Housewife likes the service; 3. No Sunday work and six-day plant operation eliminates plant relief system; 4. Fifty-two less delivery days; 5. No Sunday work builds employee and consumer goodwill; 6. Through care delivery loads have been leveled over the week compared with other systems as shown in average daily delivery for the week. The last column is the average of corresponding days on each route.

	Seven-day delivery 1940	*Six-day delivery 1941*	*EOD delivery 1942*	*Three-day delivery 1943–1945*	
Monday	96%	121%	99%	102%	99%
Tuesday	96%	102%	94%	96%	
Wednesday	100%	100%	97%	96%	95%
Thursday	99%	99%	99%	94%	
Friday	97%	99%	101%	107%	
Saturday	99%	179%	107%	105%	106%
Sunday	113%	0%	103%	0%	
Average	100%	100%	100%	100%	

7. The square bottle has saved space and keeping quality has been no problem —consumption is increased; 8. This improved delivery system promises to help keep delivery costs in bounds and at the same time give the customer good service, the farmer a good market, and labor a high level of employment and good wages. E.F.G.

157. Whiting Finds "Homogenized Vitamin D Milk" Big Sales Success. ROBERT A. BURNS, Whiting Milk Co., Boston Mass. Internatl. Assoc. Milk Dealers Bul., *38*, No. 3: 86–92. Feb., 1946.

Starting with retail routes and later extending the product to wholesale routes, this concern has developed homogenized Vitamin D milk into a substantial part of its sale volume. Sample advertising copy is shown. E.F.G.

158. How to Hold or Improve Volume on Premium Milk When Wartime Sellers Market Fades. ANTHONY HEBNER, Adohr Milk Farms, Los Angeles, Calif. Internatl. Assoc. Milk Dealers Bul., *38*, No. 3: 82–85. Feb., 1946.

The first requisite is to have a milk well worth the premium. A well-

schooled sales organization and aggressive advertising can sell such milk. Approximately half the volume of this concern over the years has been premium milk. Customers can be more easily shifted to such milks on a falling market and seldom change back. E.F.G.

159. **Three-Day-a-Week Delivery.** ARIEL C. MERRILL, Clover Leaf Dairy, Salt Lake City, Utah. Internatl. Assoc. Milk Dealers Bul., *38*, No. 3: 76–81. Feb., 1946.

Three-day-a-week delivery, used in Salt Lake City for three years, is probably the most efficient delivery system tried to date. Our experience indicates that the milk retains its fresh, sweet flavor satisfactorily. Consumer acceptance is as good as EOD delivery. All drivers have Sunday off and no relief drivers are necessary. A calendar with alternate bold-faced and light-faced type is suggested as an aid to the housewife in keeping her delivery days straight. The cost of delivery has been 0.3 cents less per unit with the three-day-a-week plan than with the nearest in economy, the six-day-a-week plan. However, many things will influence the cost in a particular situation and the ability of a distributor to adopt and maintain the three-day-a-week plan. E.F.G.

MISCELLANEOUS

160. **Tomorrow's Packages**—regenerated cellulose film. D. E. DREW, Supervisor, Packaging Engineering, Section Cellophane Division E. I. duPont de Nemours & Co., Inc., Wilmington, Delaware. Food Freezing, *1*, No. 3: 101. Jan., 1946.

Third in a series of technical discussions of a packaging series. The basic properties of transparent regenerated cellulose film are listed and each discussed briefly. Properties which render cellophane an indispensable adjunct to quick-frozen foods are: Moisture Proofness, Airproofness, Strength, Flexibility, Liquid Resistance, Grease Resistance, Odor Resistance, Temperature Stability, Sealing, Printability, Coverage, and Transparency. Available in (1) Sheets of printed or unprinted cellophane for direct wraps; (2) Rolls for automatic wrapping of cartons, trays, or directly on the product; (3) Sheets, spot-glued or laminated to cartons for inner protective layer or as an outside covering; (4) Bags of all sizes, from small units for home consumption to large bags for 40-lb. bulk packs. Bags may be laminated with paper, foils, carton stock or with other types of plastic films. L.M.D.

161. **Notes on Cooling Towers and Evaporative Condensors.** S. I. ROTTMAYER, SAMUEL R. LEWIS AND ASSOCIATES., Chicago, Illinois. Refrig. Engin., *51*, No. 3: 220. March, 1946.

Water cooling towers are classified in four general groups:

1. The Atmospheric Type, which depends on wind motion for operation.
2. The Natural Draft Type, employing stock or thermal action for production of air movement through the tower.
3. The Mechanical Draft Type, employing forced or induced draft fans for aerating air movement through the tower. The humidfying air washer is a modification of an induced draft cooling tower.
4. The Evaporative Condenser, which is a combination of a refrigerating condenser and a mechanical draft cooling tower.

Each type of cooling tower is described as to constructional and operational details. General information is imparted concerning problems arising from municipal regulations, corrosion, algae growth, and water basins. Cost estimates per ton of refrigerating plant capacity are included.

L.M.D.

162. Plans and Calculations for Three Typical Locker Plants. J. A. SMITH, Frigidaire Division, General Motors Corp., Dayton, Ohio. Refrig. Engin., *51,* No. 3: 215. March, 1946.

Practical floor layouts are suggested for frozen food locker plants with 120,355 and 1008 lockers. Methods are outlined for figuring refrigeration loads and selecting the proper condensing units and evaporators for them. Plan "A"—120 lockers provides for a small frozen food locker plant as an adjunct to a grocery or meat market and provides for only a limited amount of processing, while the Plans "B" and "C" provide for complete processing, including facilities for fowl, vegetables and fruits. Products loads are calculated on the bases of pounds per locker per day. Plate freezers and forced-air room refrigerating units are employed. L.M.D.

163. Need of Technological Supervision in the Food Industry. With Special Reference to the Selection, Preparation and Freezing of Fruits and Vegetables. Part II. H. C. DIEHL, Director and Secretary, The Refrigeration Research Foundations, Inc., Berkeley, California. Refrig. Engin., *51,* No. 3: 223. March, 1946.

The first half of the paper was published in the February issue of Refrigerating Engineering. This paper (Part II) discusses the value of pre-cooling harvested produce before it is processed for freezing, and the importance of bacterial control in all parts of the frozen food plant. A detailed list of 45 bibliography items furnishes a valuable source of information for those interested in the technological phases of food freezing. Following the bibliography is the reported discussion of the paper by several experts in the field of food freezing. Emphasis was placed upon the importance of considering all phases of the frozen fruit or vegetable from field production to consumer information on proper utilization of the products, it being conceded that satisfactory refrigeration applications are entirely

adequate, but that much research needs to be entered into in order to improve physical and nutritive qualities of the frozen foods. L.M.D.

164. Research and Quality Control of Pre-cooked Frozen Foods. BARBARA L. HUTCHINGS AND CLIFFORD F. EVERS, The Bird's Eye Snider Laboratories. Refrig. Engin., *51,* No. 1: 26. Jan., 1946.

Pre-cooked frozen foods have provoked great interest in their potentialities in the last several years. Here is a possibility of better food and less waste—but—such products will continue to be expensive food items. The authors emphasize the necessity for the chemist, bacteriologist, cook, mechanical engineer, packing expert and plant manager to work together in solving the many additional problems entering the production picture of pre-cooked frozen foods as contrasted to the freezing of fresh foods.

These problems, in the main, resolve themselves into protective sanitation against contamination from *Staphylococcus aureus* and other food-poisoning bacteria; mold and yeast contamination; enzyme inactivation, especially that of lipase, because of the many fatty foods, sauces and gravies; flavor control, particularly in connection with spices where it has been found that the oils of spices rather than dry spices reduce variability in flavor; the colloidal state of many cooked foods presents the problem of "weeping" control; color; physical attributes of slicing, dicing, stringing, etc.; production equipment design and operating; packaging requirements will be at the maximum of protective qualities; probably requirement of lower storage temperatures for prolonged storage; and consumer education in proper preparation. This latter consideration is one which can do much to promote the consumer acceptance of pre-cooked frozen foods but it calls for painstaking attention on the part of companies entering this field.

L.M.D.

165. Home Freezers During Power Outage. EARL C. MCCRACKEN, LENORE E. SATER, AND KATHERINE B. BAILEY, Bureau of Human Nutrition and Home Economics, U.S.D.A., Washington, D. C. Refrig. Engin., *51,* No. 2: 117. Feb., 1946.

The ability of the home freezer to maintain refrigeration or safe-keeping temperature during an extended period of nonoperation is an important aspect of the frozen food storage problem. It is the concern of the owner-operator, the utility company, and the dealer-service man. The frozen food, if possible, must not warm up to a temperature above that of its crystallization stage which generally lies between 25° and 31° F. in order to retain its palatability which would be greatly reduced by partial decrystallization and subsequent refreezing. In no case should the warm up go beyond 40° F., for the consensus is that no frozen food should be eaten if it has reached 50° F. after having passed through the slow temperature

change occurring in a freezer during a power outage. The question resolves itself into how soon it will take the first package in the freezer to reach the limiting temperature. Factors entering into this are efficiency of insulation, size of food load in the freezer, and whether or not the freezer has eutectic plates.

The most vulernable packages are those in the top layer. The shortest time to reach 32° F. with full load was 44 hours and with one-fourth load, 33 hours. The shortest time to reach 40° F. under the same load conditions were 84 and 47 hours, respectively. Packages in the freezing compartment warm more rapidly than those in the storage compartment, because of nearness to the warm machinery. Indications are that more insulation should be supplied in top and lids, and between freezing compartment and compressor.

The authors recommend the development of an alarm device which would warn of temperature reaching the safety limit and which would be independent of the electric power circuit. This would serve to warn of trouble whether it arise from overloading, power failure (blown fuse), equipment failure, or evident general power outage. L.M.D.

166. **The Moisture Losses in Stored Frozen Meats Vary with Packaging Material, Wrapping Method.** NANCY K. MASTERMAN AND KARL WINSOR. Ithaca, N. Y. Food Freezing, *1*, No. 4: 140. Feb., 1946.

Two methods of wrapping meat or variations of these methods are in general use in locker plants, the butcher's wrap and the drugstore or confectioner's wrap. Comparisons were made between both methods of wrapping on pork chops and ground beef, using in one set of observations locker paper and in the other cellophane, both with outer wrap of butcher's paper, frozen and stored for six months. Weighings were made each month in the locker room. In no case was there a loss in weight in the cellophane packages wrapped by either method, while the locker paper packages developed losses in weight varying from 0.88 per cent in chops wrapped with the butcher style to 3.74 per cent in ground beef in the drugstore wrap. In fact, there was a small gain in weight in the cellophane-wrapped packages, indicating a one-way vapor transfer. The cellophane-wrapped meats presented a glazed fresh appearance while the locker-paper wrapped products were unglazed and dehydrated. The greater number of layers of paper in the butcher wrap gave greater protection when locker paper was used than did the one-layer drugstore wrap. The latter wrap results in a flatter package which, when cellophane is used, is most desirable, but the cost is about twice that of locker paper. This leaves it up to the locker plant operator to decide which method will result in the greatest patron satisfaction. L.M.D.

167. **The Preservation of Foods by Freezing.** CLARENCE BIRDSEYE. Refrig. Engin, *51,* No. 2: Refrig. Engin. Application Data 22. Feb., 1946.

An eight-page résumé of the frozen foods industry touching upon its history, theory of freezing, freezing methods, processing, packaging, storage and transportation, retailing, and the possible developments of frozen food locker plants, together with institutional and farm and home refrigeration.

L.M.D.

168. **Tomorrow's Packages. Economical Carton Varieties.** THOMAS F. CASS, JR., Sales Research Manager, Container Corp. of America. Food Freezing, *1,* No. 4: 126. Feb., 1946.

The basic requirements for a frozen foods container are: economy, structural strength, merchandising appeal and functional protection to maintain the quality of the packaged food. Two general types of cartons are in use, the tuck end and the top opening. Adaptability to automatic filling is also a consideration. In all cases vapor-moisture proofness must be assured. One method for meeting this need is with laminated boards. Wet-proofness is highly desirable and is now being provided by carton stocks in the manufacture of which special resins are combined with the pulp, and special surface treatments of the board to produce water resistance without using wax surface coatings. Wet-proofness does not provide moisture-vapor transmission protection. This requires thermoplastic laminating or other accessory materials. Descriptions are given of the newest styles of cartons such as the "Placepak," a knocked-down top-opening carton that can be set up with a one hand motion, the cover remaining in upright position; the "Sealok," an end-opening laminated board stock that requires no inner or outer wrap and is sealed after filling; however, it cannot be used for liquid-containing products, unless an inner product container is used; metal-topped and -bottomed fiber cans; a three-piece carton to be set up on production line with special forming and sealing equipment; the Dacca Vapor-Pak, a carton completely processed in the packers plant, which provides a single unit package completely moisture-vapor proofed with thermoplastic inside and out and finally is hermetically sealed; the Vapocan, an adaptation of the Dacca Vapor-Pak, has been developed for home use and locker plants and is a single unit, straight-sided, thermoplastic coated inside and out, provided with a friction plug lid for easy opening and closing. This latter packaging unit is ideal for home freezer use, for it will handle fruits in syrup and fruit juices as well as other frozen products. The top-opening container with accessory protective wrapper must be used for bulky products and large pieces of poultry, meats and fish. The Vapocan adapts itself to serve as a container for liquid type pre-cooked foods frozen in the home.

L.M.D.

169. **Need of Technological Supervision in the Food Industry.** With Special Reference to the Selection, Preparation and Freezing of Fruits and Vegetables. H. C. DIEHL, Director and Secretary, the Refrigeration Research Foundation, Inc., Berkeley, California. Refrig. Engin., *51*, No. 2: 123. Feb., 1946.

The necessity for establishing common quality standards for frozen foods becomes more clearly apparent as the industry emerges from wartime conditions to those of a peacetime competitive character. Raw materials must possess the best quality that can be obtained within economic limits, for no frozen food can be better in quality than the raw material of its origin. A plea is made for increased emphasis on basic research into quality items of raw product, such as variety or type, nutritional values, composition, stage of maturity for harvesting, protection of desirable constituents during harvesting and transport to the processing line. Processing, freezing, packaging, storage, distribution and proper preparation by the consumer have received much attention. The author points out that these aspects of the industry have far outstripped the other which requires a much greater devotion of time, basic research being a slower process, and in this case one which has been either slighted or lost to sight, because the rush to develop volume business demands expenditure of funds in promotional channels.

Now is the time to devote a greater portion of the industry's operational capital to the biological properties of its numerous raw materials. The author decries the universal belief that "quick freezing" is in itself the answer to the quality problem of frozen foods, rather it is the industrial tool which renders possible the preservation of quality carefully nurtured in the raw materials. Basic research is needed (already underway at the University of Texas) to establish thermal characteristics of refrigerated foods which will provide more accurate data than at present available to enable engineers to design industrial plants that will be as economical and efficient as possible. Even the interdependence of the geneticist and the engineer is brought to light, the one to develop varieties to possess desired characters as ideally as possible, and the other to accommodate flow sheet and design application to special needs of the raw material. In many cases the refrigeration engineer will find his services extending to the field to provide chilling protection before the food reaches the plant in order to protect quality values. L.M.D.

170. **Milk Freezing for Commercial Use.** JOHN E. NICHOLAS, Professor of Agricultural Engineering, School of Agriculture, Pennsylvania State College. Food Freezing, *1*, No. 4: 130. Feb., 1946.

In large quantity production of certain types of frozen foods where the individual unit is small, it is more advantageous to freeze in bulk and

package afterward, the opposite of the usual locker plant method of packaging first and then freezing. The rapidity of the complete freezing operation, pre-cooling, crystallization, and then sub-cooling is a matter of minutes in air blast bulk freezing as contrasted to hours in pre-packaged one surface plate contact freezing. Two sets of time-temperature graphs are shown to illustrate the fast freezing of bulk commodities, one layer thick on screen trays in 600–800 ft./min. velocity air blast. Complete freezing from an initial temperature of 80° F. to 0° F. was accomplished in from 7 to 11.5 minutes with air blast temperatures varying from –15.9° F. to –13.3° F. The factor of desiccation is variable, being nil or even increased moisture where steam blanching is practiced with carrots, peas, broccoli, etc., to high loss (as much as 25.0 per cent with some leafy vegetables) of moisture. Prepacking and moisture sealing should be followed even in air blast freezing of such products. An outstanding advantage of the bulk freezing is the packing of the product into large bulk containers to be placed in low-temperature storage, pending packaging after the rush of handling peak production is over. This type of operation should provide opportunity for exceptionally large-scale freezing operations. L.M.D.

171. **Tomorrow's Package—rubber hydrochloride film returns.** A. B. CLUNAN, Manager of Packaging Sales, Pliofilm Dept., The Goodyear Tire and Rubber Company. Food Freezing, *1*, No. 5: 176. March, 1946.

Many commercial films have sacrificed moisture-transmission rate when the materials were processed to remain flexible at low tempratures. A new film, FF Pliofilm, just going into production, has been developed. Research laboratories show that the new film remains flexible at –20° F., and shows an almost zero value for its moisture-transmission rate. It possesses the heat-sealing qualities of the conventional Pliofilm and, in addition can be sealed against a frozen product. Rubber-hydrochloride film is to be supplied in rolls which will be 24 inches wide by 100 feet or 200 feet long. Properties of the new film are: (1) Imperviousness to dilute acids, air, alkali, brine, grease, heat and cold, (2) Dimensionally stable throughout the humidity range, (3) Great tensile strength and resistance to punctures, (4) Non-explosive and not readily flammable, (5) Prints easily, (6) Closes by heat sealing, sewing or adhesives. L.M.D.

ERRATA

Vol. XXIX, No. 4, page A55. Abstract No. 106.

The fifth sentence of this abstract should read: Cheese from milk pasteurized at 143° F. for 30 minutes or 162° F. for 15 seconds did not give values greater than 5 units, regardless of the age of the cheese.

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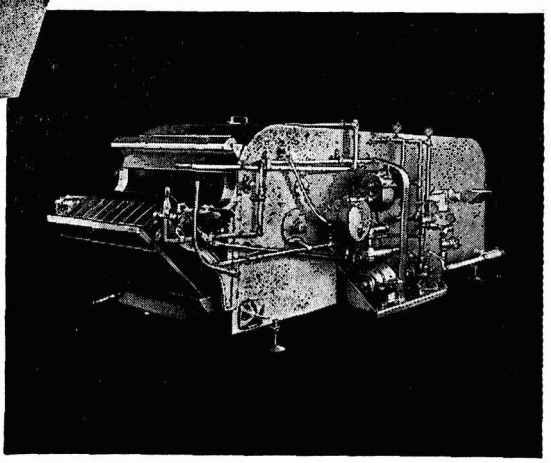

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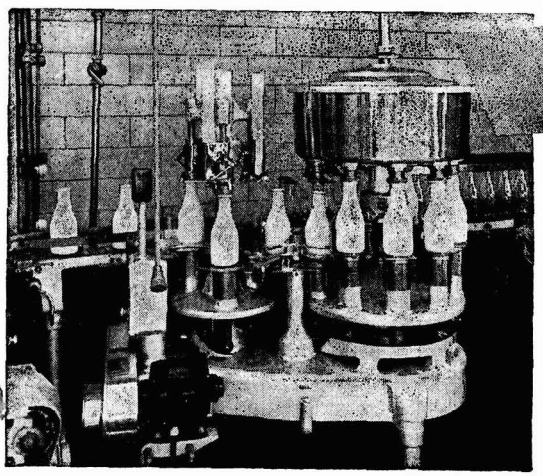

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