Supplementing Alfalfa Hay with Succulents

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Introduction

IT IS a common opinion among dairy farmers that the feeding of succulent feeds to dairy cows during the winter is necessary, or at least very helpful, for economical production. The most common succulent feed for dairy cows is silage made from corn, grass, legumes or other crops.

In regions where sugar beets are grown, many farmers feed wet pulp from the sugar factories, or dried pulp that is usually moistened before feeding. In other regions various root crops are used to provide winter succulence. Also wet brewers grains serve the same purpose for dairymen residing near breweries. In some areas, however, particularly where the climate is mild and cows are not confined during the winter, no succulent feeds of any kind are used.

The greatest part of the literature concerning winter succulents for dairy cows has dealt with silage, although some experiment stations have reported work with other succulents. Eckles[1] states that, "the cow seems especially adapted for a feed of this character and cannot do her best unless it makes up part of the ration." He also says that although corn silage is the best method of providing succulents in the corn belt, root crops are entirely satisfactory, particularly where corn cannot be successfully grown.

White and Johnson[2] state that while successful feeders consider succulents in the ration of the dairy cow to be a prime essential, this belief has come about in some sections as a result of watering cows only once or twice daily. But, they point out, this belief does not hold true if a supply of water is constantly before the cows in the barn. White and Johnson found that at prices prevailing in the area, a ration consisting of grain and hay alone produces milk at a lower feed cost than one including succulents. When cows had free access to water in the barn, the inclusion of succulent feeds in the ration did not influence the total roughage dry matter intake.

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* The experiments reported in this publication were conducted at the U. S. Umatilla Field Station at Hermiston, Oregon, on which the Oregon Agricultural Experiment Station is responsible for the livestock projects.

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[1]Dairy Cattle and Milk Production. The Macmillan Co. Revised Edition, p. 466. 1929.

[2]Corn Silage Feeding Investigations. Connecticut Agr. Experiment Station, Bulletin 198, 1934.

Woodward and Dawson[3] found at the Huntley, Montana, Field Station that cows receiving hay and silage produced 1.11 pounds of butterfat daily, calculated to twice a day milking, as compared to 0.86 pounds produced by cows on hay alone. They also quote unpublished data from the Utah Experiment Station that feeding silage with hay increased butterfat production from 0.79 to 0.92 pounds a day.

Very little work has been reported regarding the feeding of Jerusalem artichokes to dairy cows, although several stations have reported using this crop as a feed for hogs. Shoemaker[4] reports that artichokes are used more extensively as a livestock feed in France than in this country.

Plan of Experiment

This experiment was inaugurated at the Umatilla Experiment Station to determine the value of winter succulents in the ration of dairy cows. The rations fed and the cows used for the four years of the experiment were grouped as follows:

	Number of Cows			
	1st year	*2d year*	*3d year*	*4th year*
Group A: Alfalfa hay	....	4	4	....
Group B: Alfalfa hay and concentrates	....	4	6	....
Group C: Alfalfa hay and succulents	8	5	5	10
Group D: Alfalfa hay, concentrates and succulents	8	4	6	9

All cows had access to pastures of fair quality during the summer. Field squash and Jerusalem artichokes were used as the succulent crop during the first three years. Squash was used in the fall and early winter, followed by artichokes until spring. Some beets were fed during the second and third years when weather conditions made it temporarily impossible to dig artichokes. During the fourth year the succulents consisted of Jerusalem artichokes and corn silage.

In all cases the groups were made up so as to have animals of approximately equal productive capacity in the various groups. The majority of the animals had previous production records which were used as a basis for making division into groups. The other cows were assigned to groups on the basis of the records of their dams.

This experiment was planned as a supplement to previous work done at this station[5] in which alfalfa hay had been fed alone and with

[3]Roughage Investigations by the Bureau of Dairy Industry. Paper presented at the annual meeting of the American Dairy Science Association, Burlington, Vermont, June, 1941.

[4]The Jerusalem Artichoke as a Crop Plant. U. S. Department of Agriculture, Technical Bulletin No. 33, 1927.

[5]Feeding Alfalfa Hay Alone and with Concentrates to Dairy Cows. Oregon Experiment Station Bulletin No. 380, 1940.

concentrates to dairy cows. The animals used in the present study included a number of those used in the previous experiment. The remainder were progeny of the original animals. Three of the older cows were part of the foundation stock and were of indefinite breeding. The balance of the herd consisted of animals bred on the station, all of them being grade Jerseys of average productive ability, sired by unproved, registered Jersey bulls.

Methods of Feeding and Handling

Succulent feeds were fed on the basis of the calculated amount of total digestible nutrients they contained. In a given year all cows received the same amount of total digestible nutrients per day—approximately 3.0 pounds—in the form of succulents, regardless of the succulent crop being fed.

The cows were handled as are the majority of the dairy cows in eastern Oregon. They were brought into the barn twice daily and milked by machine. The rest of the time they were kept in a large corral equipped with an open-front shed for protection, or were pastured. Water was available at all times in the corral and pasture, but not in the barn. Minerals were provided in boxes in the corral.

Succulent feeds and concentrates were weighed to individual cows and fed in the barn. Squash and beets were chopped before feeding, while the artichokes were fed whole. It was found that the artichokes were rough enough to force the cows to break them up before swallowing, and as a result, no difficulty with choking was experienced. Artichokes were dug throughout the winter whenever they were required, and were seldom stored for more than ten days. The corn silage, which was of good quality, was put up in temporary silos constructed of wire fencing and processed paper. This method of storage proved a satisfactory substitute for permanent silos.

The concentrate mixture consisted of four parts wheat-mixed feed (mill run), two parts ground barley, and one part ground oats. This mixture was fed at the time of milking according to the following schedule: 1 pound of grain for each 0.1 pound of butterfat above a minimum level of 0.7 pound of butterfat daily, with first-calf heifers being allowed an additional two pounds of grain daily.

Hay was weighed to groups rather than to individuals. During the first year Groups C and D were in separate corrals. In the second and third years, the corral grouping for purposes of hay consumption records was according to whether or not the animal received succulents. Thus, Groups A and B were corralled together and similarly for Groups C and D.

Because the cows that were given concentrates naturally con-

sumed slightly less hay than those restricted to a roughage ration, data previously secured at this station was used in correcting hay consumption according to whether or not the animal had received concentrates. The factor used in making corrections was 3.1 per cent added or subtracted to the average hay consumption of the group.

Data Recorded

Milk and butterfat production data and feed consumption records were kept on a lactation month basis. All data presented are on the basis of a lactation month of 30 days. Milk was weighed at each milking, and butterfat tests were made on two milkings each month by the official Babcock method. Cow weights were taken the first three days of each calendar month, starting with the month before freshening. Breeding records kept included heat periods, service dates, gestation periods, and condition, sex, and weight of calves.

Milk and Butterfat Production

Table 1 gives the production of each group of cows for each year, and the average of the several years, with individual cow production data being given in Table 7 in the Appendix. Butterfat production data is given both on an actual and an age-converted basis, with milk production being shown both as actual and mature equiva-

Table 1. MILK AND BUTTERFAT PRODUCTION BY GROUPS FOR 300-DAY LACTATION

Year	Number of records	Actual milk	Butterfat	Butterfat	Mature equivalent 4-per-cent fat-corrected milk	Mature equivalent butterfat
		Pounds	*Per cent*	*Pounds*	*Pounds*	*Pounds*
Group A:						
Second	4	5,133	5.88	301.7	6,925	317.3
Third	4	5,481	5.60	306.9	7,233	326.5
Average		5,307	5.73	304.3	7,079	321.9
Group B:						
Second	4	6,631	5.92	392.3	8,902	410.3
Third	6	6,093	5.72	348.7	8,222	371.7
Average		6,308	5.80	366.1	8,494	387.2
Group C:						
First	8	4,808	6.05	291.0	6,845	318.0
Second	5	5,590	6.41	358.5	7,898	370.2
Third	5	5,395	5.71	308.1	7,279	330.0
Fourth	10	5,266	5.74	302.3	7,099	323.2
Average		5,216	5.95	310.1	7,201	331.3
Group D:						
First	8	5,985	5.83	349.1	8,415	385.2
Second	4	6,739	5.90	397.8	8,840	405.9
Third	6	6,406	5.73	367.1	8,682	396.5
Fourth	9	5,899	5.87	346.5	8,350	383.0
Average		6,162	5.83	359.4	8,516	390.1

lent 4 per cent fat-corrected milk. Factors used in making age conversions are those given by the U. S. Department of Agriculture, Bureau of Dairy Industry.[6] Factors used in making the 4 per cent fat-correction were taken from a modification of the Gaines formula developed by Perkins[7] of the Ohio Station, who reported factors for converting weights of milk of various fat content to their energy equivalent weight of 4 per cent milk.

The general level of production of cows used in this study is shown in Table 1. The mature equivalent production of 7,000 pounds of 4 per cent fat-corrected milk, and 325 to 330 pounds of butterfat probably represents what can be expected of good-grade herds of cattle fed alfalfa hay throughout the year, with pasture during season. Cows of similar producing capacity fed concentrates, along with alfalfa hay and pasture, can be expected to produce around 8,500 pounds of milk and almost 400 pounds of butterfat. It will be noted in Table 1 that the cows used in this study were high-testing grade Jerseys, with the average test of groups being between 5.73 and 5.95 per cent butterfat.

A comparison of the percentage increase in production of the different groups of cows is given in Table 2. Comparisons are made on the basis of whether the cows received concentrates or succulent feeds. Inasmuch as a considerable number of the same cows were used in different groups from year to year, as shown in Table 7 in

Table 2. COMPARISON OF INCREASE IN PRODUCTION ON DIFFERENT RATIONS

Groups compared	Mature equivalent 4-per-cent fat-corrected milk	Mature equivalent butterfat
	Per cent increase	*Per cent increase*
Increase with concentrate feeding:		
Group B over Group A		
All cows	20.0	20.3
Cows in both groups—different years	24.8	23.0
Group D over Group C		
All cows	18.3	17.7
Cows in both groups—different years	15.5	15.0
Increase with succulent feeding:		
Group C over Group A		
All cows—all years	1.7	2.9
All cows—second and third years	7.2	8.8
Cows in both groups—different years	4.8	5.5
Group D over Group B		
All cows—all years	0.3	0.7
All cows—second and third years	3.0	3.4
Cows in both groups—different years	0.4	2.6

[6]U. S. Department of Agriculture, Bureau of Dairy Industry. Mimeograph 623, Revised.

[7]Journal of Dairy Science, Vol. 20, pp. 129-132, 1937.

the Appendix, a comparison is given of the cows that received different rations during different years.

It will be noted that the cows in Group B, fed concentrates, produced about 20 per cent more fat-corrected milk than did the cows in Group A, fed hay and pasture only. The increase was almost 25 per cent for the same cows maintained in the two groups in different years. Cows in Group D receiving concentrates produced about 18 per cent more than cows in Group C, which received hay and pasture only. The increased production with concentrate feeding compares favorably with the 21 per cent reported by Sherwood and Dean[8] based on earlier four-year production records at the same station.

The difference in production due to succulent feeding was very small. However, as shown in Table 3, the amount of succulents available during the first year of the study was limited to less than one-half of that fed during the second and third years. The comparison of production by groups for the second and third years shows from 3 per cent to 7 per cent greater milk yield with the feeding of succulents. The comparison of production of cows maintained in both groups during different years shows an increase of 0.4 per cent to 4.8 per cent with succulent feeding. It is questionable whether the small increase in production with the feeding of succulents is significant. The economy of such feeding practices will be discussed later.

Palatability of Feeds

The hay fed was, for the most part, alfalfa of good quality and quite palatable so that the animals consumed it without waste. In the few instances in which fair quality hay was offered, the hay that was not consumed was weighed back. The pasture used was largely sweet clover, and while of fairly good quality it did not prove to be very palatable. Alfalfa pasture, when available, was found to be much more palatable and gave better carrying capacity per acre, and although it did increase the danger from bloat, no loss from this cause occurred. One or two cows were treated for bloat with mineral oil drench.

The concentrate mixture proved quite palatable, and most of the cows consumed up to 12 to 14 pounds daily when their production entitled them to receive that much. Squash and artichokes proved very palatable, with little difference observed between them. When either of these were fed, the cows came up to the barn door as soon as they heard the feed buckets rattle and came in on the run when the doors were opened.

[8]Oregon Experiment Station Bulletin 380, 1940.

Corn silage was found somewhat less palatable than either of the other succulent crops mentioned, except when it was of above average quality. Even then the animals would not consume as much corn silage as the other crops; probably because of the higher dry matter content of corn silage. Beets were not particularly relished by any of the cows, and at least two animals refused to eat them at all. The beets fed were a cross between sugar and table beets.

Feed Consumption

Feed consumption data, by years and groups, are given in Table 3. This table shows the pounds of feed consumed and the days on pasture per cow for a 300-day lactation. A study of this table shows that the feeding of succulents did not greatly reduce the amount of hay consumed during the second and third years of the study when the cows were maintained in the four different groups. The succulent feeds were fed at different times during the winter, at about the following rates; 35 pounds of squash, 20 to 25 pounds of artichokes, or 20 pounds of corn silage. The concentrate mixture consisted of 4 parts wheat-mixed feed (mill run), 2 parts ground barley, and 1 part ground oats.

The concentrate mixture was fed at the rate of 1 pound of grain for each 0.1 pound of butterfat above a minimum level of 0.7 pound of butterfat per cow daily. Under this schedule of feeding, the highest producing cows at their peak of production received up to 14 pounds of concentrates daily. It will be noted from Table 3 that the

Table 3. FEED CONSUMPTION PER COW FOR 300-DAY LACTATION

Group and year	Hay	Concentrates	Squash	Artichokes	Beets	Silage	Pasture
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Days*
Group A							
Second	5,287	.....	.....	.....	.....	.....	169
Third	4,819	.....	.....	.....	.....	.....	150
Average	5,053	.....	.....	.....	.....	.....	160
Group B							
Second	4,922	1,743	.....	138	.....	.....	159
Third	5,507	1,592	.....	.....	.....	.....	155
Average	5,273	1,652	.....	55	.....	.....	157
Group C							
First	5,958	.....	949	758	.....	.....	153
Second	5,141	.....	1,829	2,310	75	.....	156
Third	4,885	.....	749	1,732	245	.....	152
Fourth	3,417	.....	.....	1,074	.....	1,978	159
Average	4,713	.....	732	1,322	57	706	155
Group D							
First	5,617	1,497	1,200	703	.....	.....	144
Second	4,720	1,593	814	2,764	56	.....	162
Third	5,091	1,684	708	1,830	204	.....	156
Fourth	3,409	1,591	.....	990	.....	2,214	152
Average	4,631	1,584	633	1,354	54	738	152

average concentrate allowance for a 300-day lactation was between 5 and 5.5 pounds per cow daily.

The cows had access to salt, di-sodium phosphate, and sterilized bone meal in separate boxes under cover in the corrals. Monthly group consumption records of these minerals were obtained. The consumption per cow for a ten month lactation amounted to 4 to 8 pounds of salt, 7 to 12 pounds of di-sodium phosphate, and 1 to 2 pounds of sterilized bone meal. There was a tendency for the higher producing cows in the concentrate groups, and the cows fed succulent feeds, to consume the larger amounts of salt and di-sodium phosphate.

The total digestible nutrients consumed by groups during the different years has been calculated and is shown in Table 4. Also given are the total digestible nutrients consumed per 100 pounds of 4 per cent milk actually produced. In calculating the total digestible nutrients, average analyses of Oregon feedstuffs, as reported by Jones and Morse,[9] were used when available. Other feed analy-

Table 4. CONSUMPTION OF TOTAL DIGESTIBLE NUTRIENTS PER POUND OF FOUR PER CENT FAT-CORRECTED MILK

Group year	Total digestible nutrients					T.D.N. per 100 pounds of 4-per-cent milk
	Hay	Concentrates	Succulents	Pasture*	Total	
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Group A						
Second	2,628	.....	.....	1,690	4,318	65.5
Third	2,395	.....	.....	1,500	3,895	57.3
Average	2,513	.....	.....	1,600	4,113	61.8
Group B						
Second	2,446	1,264	22	1,590	5,322	62.5
Third	2,737	1,154	.....	1,550	5,441	71.2
Average	2,621	1,198	9	1,570	5,398	67.4
Group C						
First	2,961	.....	207	1,530	4,698	74.3
Second	2,554	.....	545	1,560	4,659	61.3
Third	2,428	.....	371	1,520	4,319	63.8
Fourth	1,699	.....	580	1,590	3,869	58.5
Average, 4 years	2,342	.....	430	1,550	4,322	63.7
Average, second and third years	2,491	.....	458	1,540	4,489	62.5
Group D						
First	2,792	1,085	221	1,440	5,538	72.9
Second	2,346	1,155	524	1,620	5,645	65.2
Third	2,530	1,221	380	1,560	5,691	70.8
Fourth	1,694	1,153	615	1,520	4,982	65.7
Average, 4 years	2,302	1,148	433	1,520	5,403	69.0
Average, second and third years	2,438	1,188	452	1,590	5,668	67.9

* Pasture considered to have supplied 10 pounds of total digestible nutrients per cow day.

[9]Oregon Experiment Station Bulletin 398, 1941.

ses and the digestibility coefficients used are those reported by Morrison.[10]

A study of Table 4 shows that it required practically the same amount of total digestible nutrients to produce 100 pounds of 4 per cent milk, whether the cows received winter succulents or not. However, when concentrate feeds were given, it required 5 to 6 pounds more total digestible nutrients per 100 pounds of milk as compared to groups of cows not fed concentrates. It will be recalled that the feeding of concentrates increased production by about 20 per cent. The economy and efficiency of this increased production with concentrate feeding is discussed later. A survey of Table 4 shows that the cows in this herd became more efficient producers during the four years of the experiment, as indicated by the trend to require less total digestible nutrients to produce 100 pounds of 4 per cent milk. This trend was noted in Sherwood and Dean's[11] report of earlier studies with this same herd. This greater efficiency in production is undoubtedly correlated with the improvement of milk producing capacity of the average cow in this herd by the use of good sires.

Weights of Cows

Cow weight data are given in Table 5. The average weight for each group of cows is shown for the period of the experiment by monthly intervals, starting with the month before freshening and continuing through the tenth month of the lactation. Weight data are based on the weights taken during the first three days of each calendar month nearest the lactation month. The gain in weight from the first to the tenth month of the lactation is also shown.

All groups weighed approximately the same before calving and at the start of the lactation. Group D, having a few more first-calf heifers, was the smallest. All groups reached a minimum weight the fourth or fifth month of the lactation. From that time on they gained until at the end of the tenth month the average cow had gained more than forty pounds. Early in the lactation Group A lost more weight than any of the other groups. They dropped from 1,028 pounds the month prior to freshening to a minimum of 835 pounds in the fifth month, a decline of 193 pounds, but a gain slightly over 100 pounds from the fifth to the tenth month. Groups B and C dropped 124 and 128 pounds respectively from the month before freshening until they reached their minimum weight, while Group D lost 102 pounds.

[10]Feeds and Feeding, 20th edition, 1946.
[11]Oregon Experiment Station Bulletin 380, 1940.

Health of Cows

On the whole, the health of all the cows was good. A few cows that received a large concentrate allowance occasionally showed signs of constipation, but this condition was readily corrected by temporarily reducing the concentrate allowance. If wet weather persisted long enough during the winter so that most of the hay consumed for a period of several weeks was wet, some of the cows were troubled with mild dysentery. In this case the younger cows were affected more than the older ones, and cows restricted to a ration of hay alone more than those with a supplement of succulent feeds or concentrates. During the winter it was noticeable that cows of the hay group were in poorer condition than the others, and had rougher coats.

Breeding Record of Herd

The breeding record of all groups, given in Table 6 in the Appendix, was good with no significant difference occurring between the groups. The average number of services per pregnancy was 1.30 for Group A, 1.25 for Group B, 1.28 for Group C, and 1.16 for Group D. One cow of Group C failed to conceive and another cow of the same group did not conceive until the sixth service. These were the only cows to require more than two or three services per pregnancy in the four years of the experiment.

It is the opinion of some dairymen that cows restricted to a diet of alfalfa hay alone will develop breeding trouble, but that has not proved true in this herd. Several cows in the herd restricted to alfalfa hay as the sole ration for four years, and to an all-roughage ration for as long as eight years, have continued to breed normally.

The average length of gestation period was the same for all groups, and the average number of days between calves was approximately the same, ranging from 364 days to 382 days. Calves born to cows in the hay group averaged 68 pounds at birth, slightly more than calves born to cows of the other groups. The hay group, however, contained a total of only ten cows in the two years, and a smaller percentage of them were first-calf heifers, which would account for the slight difference. More bull calves than heifers were born to cows of all four groups, with the total of the four groups being 30 heifers and 43 bull calves, for the 73 cows that were retained in the herd until they had given birth to their next calf. During the third year, two cows aborted from unknown causes. They were non-reactors to the blood test for brucellosis. Table 6, showing the reproductive record of the herd, includes several cows that were removed from the herd for various reasons and are not included in the other tables.

Economics of Feeding Concentrates or Succulents

With the wide variance in the cost of growing or purchasing various feeds in different parts of the county, and with an equally wide difference in the selling price of butterfat, it is difficult to make any definite statements about the economy of the various rations used in this experiment. It is felt that it is better for each dairyman to decide for himself what supplementary feed, if any, is most economical for him to use. In view of the fact that the increased production obtained in these trials checks fairly closely with the findings of other investigators, it is believed that the production here reported may be used by the average dairyman as a basis for making his own calculations regarding the relative economy of the various systems of feeding.

If a dairyman feeding hay only wants to determine the economy of grain feeding to cows of average productive capacity, he can assume that on the average they will produce 20 per cent more butterfat when grain is fed. Knowing the price of grain in his locality, and the price he receives for his milk or butterfat, he can decide if the increased production will pay for the cost of the grain. Similarly a dairyman feeding concentrates to his animals can determine if this is profitable.

Since it requires about the same amount of total digestible nutrients to produce a pound of butterfat with alfalfa hay and succulent feeds as it does with hay alone, it is profitable to feed succulent crops only if the nutrients can be produced as cheaply as in hay. Since the addition of succulent feeds to a hay-concentrate ration does not increase production significantly their provision in the ration is determined by the comparative economy of growing. In places where weather conditions make it difficult to make hay, or where silage may be economically produced, it may be profitable to feed silage and concentrates.

The various succulent crops used in this experiment gave equal results per pound of total digestible nutrients supplied. It follows that if succulent crops are to be used, the one that can be produced or purchased most economically in any given locality should be preferred.

Summary

The experiments reported in this bulletin are based on four years' records of feed consumption, milk and butterfat production, weight changes, and reproduction of the milking herd of 16 to 21 high grade Jersey cows maintained at the Umatilla Branch Experiment Station, Hermiston, Oregon. Records are used for 16 cows the

first year, 17 the second year, 21 the third year, and 19 the fourth year. Feed and milk records cover the first ten 30-day periods following calving.

The primary objective of the study was to determine the value of adding succulent feeds to a winter ration of alfalfa hay only, and alfalfa hay and concentrates. The herd was divided into groups according to the following feeding plan for the study:

Group A—Alfalfa hay, pasture, minerals.
Second year, 4 cows. Third year, 4 cows.

Group B—Alfalfa hay, concentrates, pasture, minerals.
Second year, 4 cows. Third year, 6 cows.

Group C—Alfalfa hay, winter succulents, pasture, minerals.
First year, 8 cows. Second year, 5 cows.
Third year, 5 cows. Fourth year, 10 cows.

Group D—Alfalfa hay, concentrates, winter succulents, pasture, minerals.
First year, 8 cows. Second year, 4 cows.
Third year, 6 cows. Fourth year, 9 cows.

Cows in Group A averaged 7,233 pounds of mature equivalent, 4 per cent fat-corrected milk and 322 pounds of mature equivalent butterfat for the 300-day lactation.

Group B cows averaged 8,494 pounds of mature equivalent, 4 per cent fat-corrected milk and 387 pounds of mature equivalent butterfat. This represents a 20 per cent increase in production with concentrate feeding.

Group C cows averaged 7,201 pounds of milk on a mature equivalent, 4 per cent fat-corrected basis. The mature equivalent butterfat was 331 pounds. The increase in production of Group C over Group A cows, due to the feeding of winter succulents with alfalfa hay, was only about 2 per cent.

Group D cows averaged 8,516 pounds of 4 per cent fat-corrected milk and 390 pounds of butterfat on a mature equivalent basis. This represents about an 18 per cent increase in production over Group C due to concentrate feeding, but in comparison with Group B there was no significant increase due to feeding winter succulents.

The efficiency in utilizing the feed nutrients supplied is indicated by the calculated pounds of total digestible nutrients consumed in producing 100 pounds of milk. This amounted to about 62 pounds for Group A, 67 pounds for Group B, 63 pounds for Group C, and 68 pounds for Group D.

The system of winter feeding to follow in the irrigated regions will depend on the comparative cost of providing nutrients in alfalfa hay, succulent feeds, and a grain mixture and the selling price of milk and butter-

fat. Unless nutrients can be provided more cheaply in succulents than in alfalfa hay it will not pay to feed them. The skillful feeding of 100 pounds of a grain mixture to good cows receiving all the alfalfa hay they will eat will result in the production of about 4 pounds additional butterfat.

In this experiment there was no effect of the ration fed on the weight of the cows, or on their reproductive efficiency. The herd showed a remarkable breeding record during the four years of the study, with 87 cows requiring an average of only 1.24 services per pregnancy and calving again on the average of 369 days, with only one cow failing to breed.

Table 5. COW WEIGHTS BY MONTHS

Month	Group A (8 cows)	Group B (10 cows)	Group C (28 cows)	Group D (28 cows)
—1*	1,028	1,026	1,008	975
1	895	925	914	887
2	861	908	887	882
3	848	902	880	874
4	840	903	881	873
5	835	902	885	880
6	847	911	883	885
7	874	914	894	889
8	885	937	914	899
9	897	941	924	910
10	943	974	955	939
Gain during lactation	48	49	41	52

* Month prior to calving.

Table 6. REPRODUCTIVE RECORD OF HERD

Year and group	Number of cows	Services for pregnancy	Gestation period	Calved again	Weight of calves	Sex of calves		Cows retained until calving
						Heifers	Bulls	
		Numbe.	*Days*	*Days*	*Pounds*	*Number*	*Number*	*Number*
First								
Group C	10	1.27	287	374	61.4	3	6	9
Group D	9	1.22	290	367	64.6	3	5	8
Second								
Group A	6	1.50	283	396	67.0	3	3	6
Group B	5	1.20	279	354	59.0	3	2	5
Group C	6	2.20*	281	379	66.0	4	1	5
Group D	5	1.00	287	363	69.0	1	4	5
Third								
Group A	4	1.00	283	360	70.0	1	3	4
Group B	6	1.30	287	400	58.3	1	5	6
Group C	7	1.00	281	358	61.0	2	4	6
Group D	7	1.00	284	366	59.5	1	4	5
Fourth								
Group C	12	1.00	280	364	58.8	3	3	6
Group D	10	1.30	277	360	55.4	5	3	8
Average or total								
Group A	10	1.30	283	382	68.0	4	6	10
Group B	11	1.25	283	379	58.6	4	7	11
Group C	35	1.28	283	368	61.2	12	14	26
Group D	31	1.16	284	364	62.2	10	16	26

* One cow required six services.

Table 7. Milk and Butterfat Production, 300-day Lactations

Cow number	Age at calving		Carried calf	Milk	Butter-fat	Butter-fat	M. e. 4% f.c.m.†	Mature equiva-lent butter-fat
	Year	*Month*	*Days*	*Pounds*	*Per cent*	*Pounds*	*Pounds*	*Pounds*
Group A								
1	9	0	227	6,000	4.70	282.0	6,789	288.7
1	10	0	217	6,315	4.74	299.5	7,299	313.3
42	4	2	133	4,660	6.11	284.5	6,458	300.0
42	5	5	245	5,048	5.75	290.2	6,468	292.8
26	6	2	106	5,458	6.27	341.9	7,341	341.9
59	3	2	232	4,414	6.76	298.5	7,113	338.6
59	4	2	210	5,649	6.11	345.0	7,830	363.6
65	3	0	231	4,911	5.96	292.8	7,336	336.4
Group B								
3	9	0	214	6,661	5.60	372.9	8,458	381.8
3	10	0	235	6,175	5.21	321.6	7,620	336.4
18	7	0	222	6,725	6.81	458.1	9,550	458.1
18	8	0	50	5,857	6.48	379.2	8,150	383.8
41	4	3	231	6,826	5.60	382.3	8,878	401.1
41	5	2	147	6,433	5.47	352.1	8,007	357.7
56	3	3	230	6,311	5.64	355.7	8,721	400.3
56	4	2	230	7,006	5.47	383.4	9,230	404.1
63	3	2	233	6,082	5.77	350.7	8,768	398.0
63	3	0	230	5,003	6.10	305.0	7,559	350.4
Group C								
1	11	0	233	6,198	4.87	302.2	7,527	323.4
3	8	0	236	5,196	5.57	289.2	6,520	292.6
11	8	0	158	4,596	5.78	265.5	5,907	268.7
11	9	0	229	6,369	5.96	379.6	8,479	388.7
11	10	0	219	4,945	5.67	280.2	6,491	293.1
11	11	0	216	4,691	5.23	245.5	5,922	262.7
17	7	0	210	6,011	5.91	355.1	7,851	355.1
17	8	0	205	5,708	5.59	319.0	7,163	322.8
24	5	2	236	5,267	6.09	320.8	7,037	325.9
24	8	0	219	5,182	5.92	306.8	6,739	310.5
26	5	2	116	5,214	5.91	308.3	6,808	313.2
26	6	5	238	5,871	5.17	303.8	6,928	303.8
26	7	5	209	5,505	5.15	283.5	6,528	284.9
30	4	2	236	6,436	5.53	355.6	8,310	374.8
40	3	4	239	3,962	7.24	286.6	6,561	320.7
40	4	3	0	4,754	7.76	369.0	7,831	387.0
42	3	3	231	4,175	6.08	253.7	6,187	285.9
42	6	5	222	5,243	5.50	288.6	6,422	288.6
49	2	11	222	4,240	6.33	268.5	6,609	311.2
49	3	11	235	5,603	6.79	380.2	8,520	407.2
49	4	11	235	5,287	6.64	351.1	7,525	359.5
49	6	0	237	5,091	6.48	329.9	7,000	329.9
59	2	2	213	4,592	6.27	288.0	7,632	364.0
59	5	2	228	4,910	6.43	315.9	6,784	320.9
65	3	11	185	4,608	6.61	304.7	6,859	326.3
78	2	0	218	5,164	5.55	286.4	8,286	370.6
78	3	0	229	5,657	5.66	320.2	8,158	367.9
84	2	1	210	5,573	5.84	325.6	9,052	416.4
Group D								
1	8	0	227	7,504	4.71	353.2	8,392	357.4
3	11	0	222	5,705	5.41	308.8	7,386	330.4
17	9	1	186	6,499	5.71	371.0	8,361	379.8
18	6	0	207	4,715	7.26	342.4	7,049	342.4
24	6	2	232	5,816	5.63	327.3	7,212	327.3
24	7	2	230	5,336	5.79	308.9	6,790	309.5
30	5	2	231	8,774	5.69	498.8	11,192	506.5
30	6	2	234	9,075	5.53	501.5	11,117	501.5
38	3	3	248	5,961	5.55	331.0	8,330	373.1
38	4	3	221	5,449	5.81	316.8	7,253	332.4
38	5	3	99	6,929	5.44	376.8	8,493	381.7
41	3	3	235	5,768	5.48	316.1	7,964	356.1
41	6	4	228	7,115	5.23	372.4	8,396	372.4
46	5	2	232	6,052	6.38	386.1	8,364	392.3
47	4	1	241	7,018	6.33	444.5	10,000	471.7
47	5	0	222	6,916	6.48	448.3	9,701	457.5
47	6	0	195	7,249	5.99	434.5	9,315	434.5
56	2	3	238	5,562	5.41	301.1	8,413	376.4
56	5	1	205	7,550	5.50	415.1	9,415	422.5
60	1	10*	176	5,300	6.21	318.5	8,804	412.1
63	4	3	168	6,596	6.43	423.8	9,408	444.6
71	3	11	231	6,380	6.05	386.1	8,985	413.5
76	2	0	240	4,887	5.80	283.4	8,031	366.7
79	2	0	224	4,962	6.00	297.6	8,346	385.1
85	2	1	236	4,312	6.35	274.0	7,500	350.4
90	2	0	214	4,733	6.15	291.0	8,145	376.5
91	1	10*	226	4,201	6.57	276.1	7,557	357.2

* Factor for 2-0 years used in making conversions.
† Mature equivalent 4-per-cent fat corrected milk.