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H. Choy. 29/11/48.

MEASUREMENT OF DRY MATTER INTAKE  
OF DRY JERSEY COWS  
ON HAY AND SILAGE ALONE AND IN COMBINATION.

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MEASUREMENT OF DRY MATTER INTAKE OF DRY JERSEY COWS  
ON HAY AND SILAGE ALONE AND IN COMBINATION.

Section II

INTRODUCTION.

In the provision of an adequate supply of nutrients to dairy cows, primary consideration must be given to the capacity or appetite of the animals for the food offered. This is due to the fact that appetite, measured in terms of dry matter intake per day, limits the quantity of food (dry matter) that a cow consumes.

In feeding bulky roughages to dairy cows, appetite is an important factor to be considered. Bulky roughage such as hay has a low nutrient content whereas silage is both low in nutrients and dry matter, when compared with concentrated foods. (Table I).

Table I. Dry matter and nutrients content of hay, silage and meat meal (1)

Feed	Dry Matter (%)	Digestible Crude Protein (%)	Starch Equivalent (%)
Poor Meadow Hay	85.7	3.4	22.0
Good	85.7	5.4	37.0
second quality Grass silage	24.5	2.4	12.6
first quality	21.0	2.7	12.8
Pure meat meal	89.2	67.2	91.0

The successful use of roughage as a source of nutrient supply for dairy cattle depends largely on the amount that can be consumed by the animals. Appetite places a limit to this amount.

When roughage is fed to dairy cows along with some concentrated foods for production, such as in England, Denmark and United States or when it is fed alone for maintenance purposes, appetite may present no problem. In the first case, the nutritive requirement of the cows is assured by supplementing with highly digestible concentrates; in the second case, the nutritive requirement of an animal is relatively low.

When roughage is fed ad lib. to dairy cows as a sole ration for production, however, appetite, by limiting the amount of roughage eaten and hence the nutrient intake of the cows, may become a limiting factor in production. This is



especially the case with high producers or cows at the peak of their production and especially so when roughage of poor quality is fed.

The following evidence may be quoted.

Graves et al (2) in analysing the results of feeding Holstein cows exclusively on alfalfa hay suggested that the inability of the animals to consume large amounts of hay early in the lactation period may be an important factor in preventing cows from reaching their maximum production.

Bartlett (3) comparing the use of bulky foods with concentrated foods for "steaming up" of cows, found that the cows steamed up on bulky foods yielded about 4 lb. of milk per day less than those steamed up on concentrated foods.

Autrey et al (4) comparing the efficiency of hay and silage ration with a ration containing limited grain and a ration of full grain, for milk production reported the average daily production of fat-corrected milk was:

30.3 lb. for the cows on hay and silage

34.3 lb. on hay and silage with limited grain

37.2 lb. on full grain ration.

Sherwood and Dean (5) feeding Alfalfa hay alone and with concentrates to Jersey and Guernsey cows found that the hay and concentrate-fed cows averaged per lactation 5,358 lb. of milk containing 294.0 lb. of butterfat, while the hay-fed cows only averaged 4,192 lb. of milk with 236.3 lb. of butterfat.

Graves et al (6) compared the use of Alfalfa hay and pasture, with a full grain ration for milk production and found that the cows on Alfalfa hay and pasture only yielded 69.75 per cent as much milk as the animals on full grain ration.

Bartlett (3) in an experiment conducted with 12 dairy cows to determine the effect of feeding the same amount of nutrients in differing bulk, reported that one important limiting factor in milk production was the inability of the cow to consume sufficient nutrients in the form of foods low in starch equivalent.

Under a pure grassland system in New Zealand, hay and silage have been used very extensively for feeding dairy cows. During periods of insufficient growth of pasture such as late winter and dry summer, cows live chiefly on hay and/or silage with little pasture available. Hence the determination of the amounts of hay, silage, or both a dairy cow will eat is not only a matter of academic interest but of practical importance.

Section II.

OBJECTS OF THE EXPERIMENT.

Chiefly, the purpose of this project was to find out how much hay, silage, or both, a Jersey dry cow will eat in terms of dry matter per day and to compare the consumption of the three rations.

In addition, the following aspects have also received attention in this thesis:

1. To find out whether the dry cows on the three roughage rations could consume enough T.D.N. to maintain their body weight over the "dry period".
2. To observe the behaviour and reaction of the cows towards the three rations.

This investigation was also undertaken with a view of testing the applicability and merits of the two Latin Squares Design (7) for dairy cattle feeding experiment.

Section III.

LITERATURE REVIEW.

Although it is very important to know the amount of dry matter that a dairy cow will eat on roughage alone, there is a paucity of data in the literature in this regard. Apparently this subject has not been subjected to systematical investigation. This is probably due to the fact that in all other overseas dairying countries dairy stock are usually rationed and ad lib feeding of high quantity of roughage is not practised; hence the quantity of roughage that can be eaten by a cow is not a matter of importance.

At present, all the evidence is collected from records of experiments which were designed for other purposes, but connected with the feeding of roughage to dairy cattle.

One of the first experimental investigations in which dairy cattle were fed on hay and silage alone was by Graves and co-workers in 1928 and 1929 (6).

They fed Holstein cows on grass hay and grass silage alone.

In the 1928 trial, cows on hay (average body weight 1,332 lb.) ate on the average 32.8 lb. hay a day or 27.3 lb. dry matter; cows on silage (average body weight 1,320 lb.) ate 83.9 lb. silage or 21.2 lb. dry matter.

In the 1929 experiment, the hay-fed cows (average body weight 1,369 lb) consumed an average of 44 lb. of hay a day, while the silage-fed cows (average body weight 1,381 lb) consumed 103.6 lb. of silage. The average daily dry matter consumption was 36.7 and 26 lb. respectively.

In both trials, the cows were found to consume more dry matter in the form of hay than in silage.

The result obtained by comparing the dry matter consumed by two cows when the ration was hay or silage alone, with the amount consumed when the ration contained both hay and silage, indicated that while adding hay to the ration of a cow receiving silage increased the consumption of dry matter, adding silage to the ration of a cow receiving hay, on the other hand resulted in a decrease of dry matter consumption.

In the summary, they also concluded the following points:

1. There was a marked preference of the cows for hay and silage made from immature grass as compared to that made from mature grass. The consumption was 10% greater on the hay and 20% greater on the silage

made from the less mature grass.

2. If hay is of good quality and is made from grass at an immature stage of growth, the cows on hay alone can consume enough hay to supply the nutrient needed for body maintenance, but the cows on silage alone did not consume enough silage to provide the nutrients required for maintenance.

In another trial by the same workers (9) the fact that cows on silage consumed less dry matter per day than cows on hay and that the cows on silage were not able to consume sufficient to meet their nutrient requirements as those on hay was confirmed.

Results from an experiment in which three groups of ten Holstein cows were fed hay - silage alone and hay plus silage, by Hodgson and Knott (10) also indicates that cows on hay alone consumed more dry matter than did the cows on silage alone. The group on hay plus silage was also found to consume more dry matter than did the group on silage. There was little difference in consumption between cows on hay and those on hay plus silage.

The comparisons of dry matter consumption quoted above were confined to grass hay and grass silage. There has been reported a number of feeding experiments dealing with alfalfa hay alone or with corn silage or comparing alfalfa hay with grass hay and/or grass silage.

In the following tables 2 and 3, different reports from various experimental Stations in U.S.A. on the daily consumption of Alfalfa hay alone and of alfalfa hay and corn silage combined respectively are summarised. All the investigations were carried out with Holstein milking cows.

Table 2. Average daily consumption by Holstein cows on Alfalfa hay alone.

Experiment Station.	Experimental Period. (days.)	Daily Feed Consumption. (lb.)
Utah (6)	188	34.9
B.D.I. Field Stations (2)	356	39.7
Oregon (11)	342	30.5
Kansas (12)	304	30.4
California (13)	341	29.7
Nevada (14)	304	36.9
Average for 6 Stations.	306	33.7

Table 3. Average daily consumption by Holstein cows on Alfalfa hay and Corn Silage.

Experiment Station.	Experimental Period. (days).	Daily Feed Consumption (lb)	
		Alfalfa hay	Corn silage.
Utah (6)	181	22.8	42.2
Montana (15)	201	20.0	49.6
Kansas (12)	304	14.5	35.5
Average for 3 stations.	229	19.6	42.5

It can be seen from the above tables 2 and 3, the Holstein cows on Alfalfa hay alone consumed on the average 33.7 lb. daily and when they were on Alfalfa hay plus corn silage, they consumed an average of 19.6 lb. of the former and 42.5 lb. of the latter. An extensive study on feeding value of Alfalfa hay compared with mixed hay and grass silage as a ration for dairy cattle has been carried out by Hodgson and Knott.

In an experiment with 41 Holstein cows on all roughage ration, they reported in 1938 (16) the daily dry matter consumption per 1000 lb. live-weight for the various roughage rations as follows:

Alfalfa hay alone	...	...	...	26 lb.
Mixed grass hay and grass silage	...	...	...	22 lb.
Mixed grass hay alone	...	...	...	19 lb.
Grass silage alone	...	...	...	18 lb.

The cows consumed more dry matter in the form of grass hay than in grass silage, and more in grass hay plus grass silage than in either grass hay or grass silage alone. But the highest daily consumption was for the Alfalfa hay as a sole ration.

In 1940, the same authors (17) feeding two groups of nine Holstein cows on Alfalfa hay alone and on mixed grass clover hay and grass silage reported a similar result. The consumption of dry matter for the cows fed Alfalfa hay (average body weight 1,379 lb) was much more than the cows fed the mixed hay and silage ration (average body weight 1,329 lb), being 33.2 and 26.1 lb. per day respectively.

The cows in the latter group consumed about 56 per cent. of their dry matter in the form of hay. The consumption of dry matter per 1000 lb. of live-weight

for the Alfalfa-fed cows was 24.2 lb. and for the hay and silage fed cows 20.6 lb. They consider that lower palatability was responsible for lower dry matter consumption for the mixed hay and grass silage ration.

In New Zealand, the only report on dry matter consumption by dairy cows in the literature appears to be that by Sears and Hill (18). They, in determining the digestibility of grass silage by Friesian and Jersey cows, found that two Friesian cows weighing an average of 1,062 lb. consumed on the average 20.7 lb. of dry matter daily, while two Jersey cows weighing an average of 870 lb. ate 17.3 lb. They consider that the cows were not eating to capacity and suggest that the factor of palatability of the ration was involved.

Apart from these studies quoted above, which mostly concern this thesis, a number of workers, chiefly in the United States, as a result of investigations in connection with feeding of roughage to dairy cows has reported that quality and palatability of roughage affected its consumption. Some of these are cited below: that dairy cows consumed more of the better grades of alfalfa, timothy and soybean hay than they did of the poorer grades, by Woodward and Graves (19); that unfavourable curing condition produced a decrease in consumption of grass, hay - by Williard, (20).

Dawson (21) also reported that Holstein cows consumed first-grade grass hay at 40 lb. per cow per day; second grade 38 lb; third grade 33 lb.

Bechtel and Associates (22) in feeding Alfalfa hay as the sole source of dry matter in the ration to Holstein and Jersey cows found the daily intake of dry matter per 1000 lb. body-weight was:

20 lb. for normal hay	(good leafy hay from outer portion of a stack)
15 lb. for brown hay	(from inner portion of a stack)
10 lb. for charred hay	(from a partially burned stack).

In Sweden (23) an extensive experiment to determine the daily dry matter intake of dairy cows had been carried out. Various feeding stuffs were fed ad lib. It was found that the amount of food which a cow will readily consume and her intake of dry matter depends primarily on the palatability of the feeding stuffs.

Cows preference for variety in their diet and increased dry matter consumption with increased variety of food have also been reported by many workers.

Meigs and Converse (24) found that cows do not eat at their best on rations in which either Alfalfa or Timothy hay is the sole roughage; that combining the

two increases their appetite and particularly their willingness to eat a large quantity of hay. Also when offered both kinds of hay at the same time, the cows which had been on either as the sole roughage for any length of time almost always showed a preference for the other.

Cows receiving no hay except Alfalfa develop a craving for other kinds of hay or roughage - has also been reported by Erf (25), and by Graves and co-workers (9).

Dawson (21) even observed that cows after being fed on a rather fine leafy hay for extended periods may have craved the more stem<sup>y</sup> and coarser kinds. The cows increased their daily hay intake as they were shifted from the first to the later cut hay, but also increased consumption when they were again shifted to final cut hay.

The addition of concentrates or grain to a roughage ration resulting in an increased total consumption of dry matter has been reported by Wall, 1918 (13), Jensen 1942 (26), and Autrey, Cannon and Erpe 1942 (4).

Watson (27) working with sheep also reported increased food consumption with increased variety of food.

Besides palatability and variety, a number of other factors affecting roughage consumption have appeared in the literature.

Graves etc., (2) (6) found that unless cattle have access to a larger amount of roughage (10% more) than they would consume, total amount consumed will be reduced.

Cows increasing their hay consumption with increased allowance has also been reported by Williard (20).

Arny and Hodgson (28) observed that cows ate more Alfalfa hay as they became accustomed to the change. Graves et al (9) found that when cows were changed from immature grass to mature hay or silage a prompt decline resulted in consumption though this might have been due to the quality of the ration. Changing from a lot of chopped lucerne hay to one of the same hay fed in the long condition resulting in decreased consumption has also been reported by Watson (27) working with sheep.

Jones (11) found that chopped hay was consumed more readily than the long hay and according to Graves et al (8) cows did not consume as much dry matter while grazing as when fed grass clippings.

Hodgson and Knott (16) in an experiment with 41 mature Holstein cows on all

roughage ration found that there was little correlation between the dry matter consumption and weight and age, but that there was a correlation between milk production and dry matter consumption.

Helms (29) on the other hand reported that milk production did not influence the amount of grass consumed since the dry cows ate as much as the heavy milkers.

Woodward (30) has found that Jersey cows consumed somewhat more dry matter per unit of body weight than Holsteins. However, he considers that the cause might have been the difference in size of the two breeds. In the same article, he also reported that a warm temperature did not materially lessen the consumption of grass.

Finally factors depressing roughage consumption, have been reported: Phosphorous deficiency by Huffman (31) ; With cows; unbalanced ration and rations containing an excessive proportion of roots and protein deficient rations by Watson (32), Woodman (33) all working with sheep.

Summarising these results quoted above from other workers, it appears that a dairy cow would consume on the average from 19 to 26 lbs. of dry matter per day per 1000 lb. live-weight for hay, while from 16 to 20 lb. for silage would be the average consumption. The dry matter consumption for hay or for hay plus silage was always higher than for silage. But between hay and hay plus silage, there was no consistent difference. Palatability and variety of the ration appeared to affect mostly the amount of roughage consumed. Other factors inherent in the ration, such as amount of food offered, balance of ration, etc., were also important. Factors inherent in the animal itself such as size, age, breed and milk production seemed to play a less prominent part in influencing a cow's appetite for roughage. However, further work is required in this regard.

This brief survey of literature does indicate that there is a big lack of data and much scope for research work in this field.



Section IV.

PLAN OF EXPERIMENT.

A. DESCRIPTION OF THE EXPERIMENTAL DESIGN.

In the simplest feeding experiments for dairy cattle, the group feeding method, where each group of cows receives only a single ration throughout the trial, is usually employed. This method has an advantage of simplicity. But it has some serious disadvantages.

Firstly, where the experiment consists of more than one ration, the consumption of rations can scarcely be compared using this method, because the consumption of a given ration is almost entirely dependent upon the individuality of cows receiving the ration.

Since cows are variable in this respect, the variation between consumptions of rations is large, though it may be reduced by skilful grouping of the cows.

Secondly, where more than one ration is attempted within limited experimental resources available, with this method the number of cows receiving each ration is necessarily decreased as the number of rations fed is increased. Consequently error in the consumption of each ration due to small size of the cow sample is increased with the increase of number of rations fed.

Switch-back design, as shown below represents an attempt to overcome the above difficulties by letting all the rations attempted be received in turn by every cow.

Switch-back Design.

(with 2 rations, A and B.)

Cow	Period I	period II
1	A	B
2	B	A

But this method also contains some undesirable features.

1. With this design, the animals consume a given ration at different periods or at a given period consume different rations. Therefore the variation in consumptions of different rations due to the influence of period, such as stage of pregnancy and weather conditions etc., cannot be eliminated.
2. In this method, it is difficult to feed the cows with more than two rations. If a third ration is fed, it usually serves as a control ration and is continuous rather than reversed afterwards.

3. If the amount eaten in one period is influenced by the ration given in the previous period, it is difficult, with this method to eliminate through statistical treatment, the changeover effect of the rations, because the sizes of the change-over effects are not known. Hence, in an attempt to overcome these difficulties, a design (7) involving the use of two 3 x 3 Latin squares (first and complementary) as shown in fig. 1 and 2 respectively was employed.

**Figure 1.** 3 x 3 Latin Square.  
(With 3 rations, A, B & C, and 3 Periods, I, II & III)

Cow	Period I	Period II	Period III
1	A	B	C
2	B	C	A
3	C	A	B

**Figure 2.** 3 x 3 Complementary Latin Square  
(With 3 rations A, B & C and 3 Periods I, II & III)

Cow	Period I	Period II	Period III
4	A	C	B
5	B	A	C
6	C	B	A

It can be seen from fig. 1 and 2 that this design has many desirable features as compared with the Switch-back design.

1. Three rations can be fed to the cows without the necessity of using one as a control.
2. With this design, in any experimental period, one-third of the cows are receiving each ration.

Thus if the appetite from period to period is the same (or as similar as possible) for the three cows (or three lots of cows) within each Latin square, the three experimental periods will be equally represented in the consumption for any ration.

This enables the effects of period such as stage of pregnancy, weather conditions etc., on the consumption of any given ration to be eliminated.

3. The design, with two Latin squares, one complementary to the other, is such that each ration is preceded by each of the other rations on equal number of times throughout the trial. This allows an unbiased estimate of the

effect of one ration on the ration in the following period to be obtained.

i.e. the design permits the proper evaluation of ration effect alone as distinct from the ration effect plus carry-over effects from the preceding ration.

4. Individuality of animals is largely eliminated by double changing of them from one ration to another two rations.

In the present experiment, three rations A, B & C were fed and three experimental periods I, II, III were used. Thus with two 3 x 3 Latin squares, as shown in fig. 1 and 2, six sequences of rations were made possible, three sequences within each Latin square. The twelve cows employed in the experiment were then first divided into four groups, each of three cows on the basis of expected capacity for food, the three cows within each group being chosen as similar as possible in live-weight, age, condition and stage of pregnancy. Then the four outcome groups of cows were allotted in the following way to the 6 sequences of rations at the three periods.

Firstly, two groups were allotted at random to each Latin Square,

Secondly, within each group, cows were allotted at random to sequences of rations, one to each.

Thus within each Latin Square there were two groups of cows and within each group, each of three cows received one sequence of rations.

In other words, each group constituted an independent experiment in its respective Latin square.

Consequently, when 4 groups of cows (I, II, III & IV) were considered together, the cows would receive the 3 rations (A, B & C) at the 3 periods (I, II & III) in the following way:

1. Within each Latin square of 2 groups of cows, 2 cows, one cow from each group, received each of the 3 sequences of rations throughout the experimental period.
2. 4 cows, one cow from each group, received each ration in each period.
3. Each cow had every ration at some time, sooner or later, during the experiment so that finally each ration would be received by every cow used in the trial.

This can best be shown in the following Figure 3.

**Figure 3.** Two 3 x 3 Latin Squares  
(with 3 rations A, B & C, received by 4 groups of cows, I, II, III & IV, at 3 periods I, II, & III). (Figure is illustrated on page 13)

Figure 3.

Group No.	Cow No.	Period I	Period II	Period III
I	1	A	B	C
	2			
	3	B	C	A
	4			
II	5	C	A	B
	6			
III	7	A	C	B
	8			
	9	B	A	C
	10			
IV	11	C	B	A
	12			

B. MATERIALS USED.

Animals Used.

The twelve mixed aged dry pedigree Jersey cows used in this experiment were selected from the Massey College Dairy Herd. Two animals were three years old, seven four years old and three ten to twelve years old. Their live weights ranged from 714 to 680 lbs. with an average of 602 lb. They on the whole were in average to good condition at the start of the experiment. All cows except one (Frivolous) were in calf and with the exception of two cows, Toy and Barbara, which were in the first half of pregnancy, all were pregnant for six to seven months. Prior to the experiment they were all in milk. Before they were subjected to this trial, all of them were running in the College's Dairy Herd with other dairy cows and therefore were treated the same as any other cows in the herd. During periods of low pasture production such as dry summer or late winter and early spring these cows received some hay, or silage, or both, as supplement in addition to what they could obtain from grazing. None of these cows had been housed indoors previously.

(Data concerning the cows used in the experiment are found in Table 5)

Feeds Used:

The hay and silage used in this experiment were made from grass cut from pastures on the Massey College and D.R.I. farms respectively, during the summer of 1947.

In general, the hay was rather poor and steamy. It was cut from poor pasture and contained a certain amount of rushes and weeds. The silage, however, was of better than average quality having been made from good pastures

out at an early stage of growth.

Table 4 shows their average dry <sup>matter</sup> weather percentages and percentage compositions.

Table 4. Chemical Analysis of Feeds (Moisture-free basis)

Feed	Average Percentage Dry Matter.	Percentage Composition of Feed.				
		Crude Protein	Ether Extract	Total Ash	Crude Fibre	Nitrogen Free Extract.
Hay	85.4	6.36	0.81	5.46	38.23	59.22
Silage	20.5	16.20	1.05	7.62	39.20	35.93

METHODS OF EXPERIMENT.

1. Grouping of Cows.

The twelve Jersey Cows used in this experiment were divided into four groups of three cows each, the animals in each trio being selected for as much uniformity as possible in body weight, age, condition and date due to calving.

The four outcome groups of cows and the data used in grouping them are shown in Table 5.

Table 5. Data on the four groups of Dry Pregnant Jersey Cows used  
In the Experiment.

Outcome Group No.	Cow Name	Age at start of Experiment Yrs. Mths.		Live weight at start of Experiment. (lb)	Condition at start of Experiment.	Date due to calve	Stage of Pregnancy (Mbs)
I	addy	2	10	732	average	15/9/48	6.3
	Katie	3	10	749	average	10/9/48	6.5
	Yu Rena	3	9	771	+ average	18/8/48	7.3
II	Yuten	3	10	849	+ average	11/9/48	6.5
	Art	3	1	817	average	4/9/48	6.7
	Yuscha	3	10	817	average	24/9/48	7.1
III	Vicky	3	9	880	+ average	17/8/48	7.3
	Ynetta	3	10	862	+ average	3/6/48	6.9
	Gally	3	9	860	+ average	5/9/48	6.7
IV	Barbara	9	10	714	average	12/11/46	4.4
	Fry	10	10	793	+ average	29/10/48	4.9
	Frivolous	11	8	785	- average		

Figure 4 shows the picture of the 4 outcome groups of cows.

Figure 4. The Four Groups of Cows Used in the Experiment.

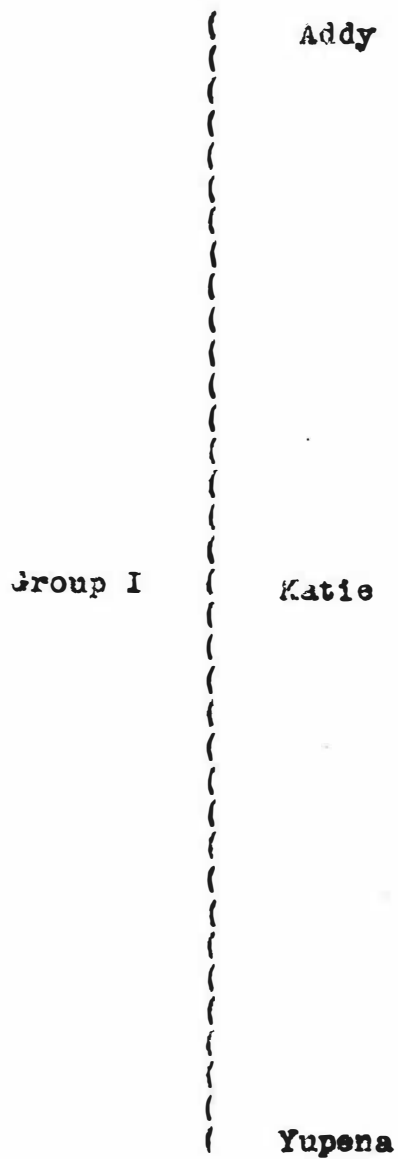


Figure 4 (Continued)

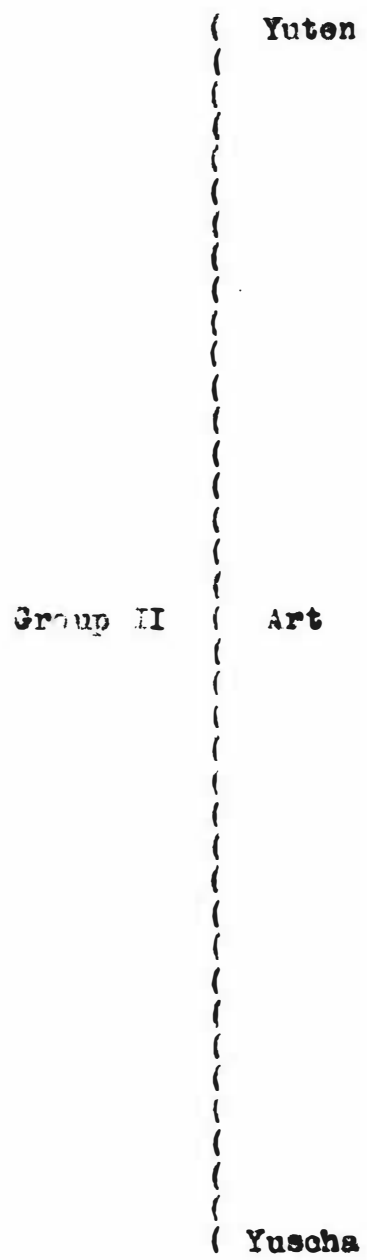
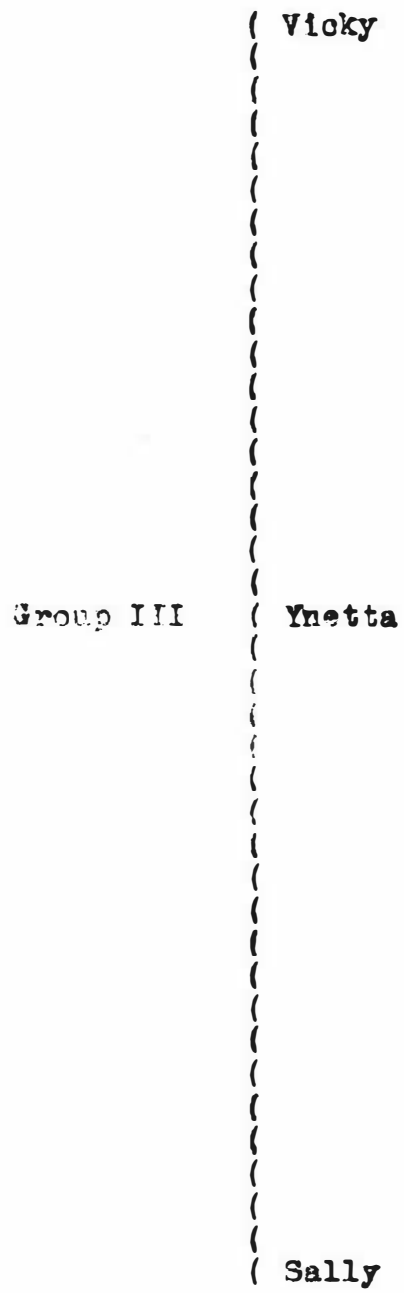


Figure 4 (Continued)







get the cows accustomed to the feeds they would receive in the experiment, and to indoor condition and masks. Thus the total length of period employed for the whole experiment was as follows:

14 days for preliminary period

42 days for experimental period

It was undertaken over the winter months, starting on 1st of June and ending on 27th July.

### 3. Rations Used:

The rations fed in this experiment were:

- (A) Hay .. fed alone ad lib.
- (B) Silage fed alone ad lib.
- (C) 30 lb. of silage plus hay fed ad lib.

### 4. Feeding Schedule:

The feeding schedule by periods for the four groups of cows are shown in Tables 6 and 7

Table 6. The Feeding Schedule by Periods for Group I & II Cows.

(2 weeks each)

Group No.	Cow Name.	Period I 15/6 - 28/6	Period II 29/6 - 12/7	Period III 13/7 - 26/7
I	Addy	A	B	C
	Art			
	Katie	B	C	A
	Yuten			
II	Yupena	C	A	B
	Yuscha			

Table 7. The Feeding Schedule by periods for Group III & IV Cows

(2 weeks each)

Group No.	Cow Name.	Period I 15/6 - 28/6	Period II 29/6 - 12/7	Period III 13/7 - 26/7
III	Sally	A	C	B
	Barbara			
	Vicky	B	A	C
	Toy			
IV	Ynetta	C	B	A
	Frivolous			

## 5. Management.

During the whole experimental period, the cows were kept from grazing pasture and housed in the sheds.

Two sheds of Massey College and Dairy Research Institute respectively were used (Figures 5 and 6). The shed at Massey College is just an ordinary shed with six large partitions, the floor of each is covered with a wooden board. Group I and II cows were kept there. The Dairy Research Institute shed is an airy feeding barn, equipped with feeding-stalls (Figures 7 and 8) and water troughs (Figure 9). The remaining two groups of cows (Groups III and IV) were kept there. The cows were housed at the sheds during the night. Saw-dust was used to cover the floor as bedding, and to prevent the cows from getting sore feet.

For a part of each day, the cows were allowed to run in a paddock of 1 acre to exercise and rest (Figures 10 and 11).

Muzzles were put onto the cows before they were turned out. (Figure 12) The muzzles were of Ruakura Animal Research's origin, with slight modification. They are so designed that the cows had no access to grass but could drink water when they were in the paddock. (Figure 13).

They were usually turned out at noon and stayed in the paddock until about 4 p.m., when they would be brought in for feeds and over the night. (Figure 14).

The hind flanks and legs of the animals kept at Dairy Research Institute shed were clipped at the start of the experiment to prevent them from getting too dirty. All the animals were groomed and brushed daily. The sheds were also cleaned daily.

## 6. Feeding:

The cows were fed twice daily; once in the morning at 8 a.m. and again in the afternoon, at 5 p.m. The amount eaten during the evening feeding, plus the amount eaten in the following morning was taken as one day's intake. They were fed individually, so that any food left by them could be conveniently removed and weighed.

In the Dairy Research Institute barn, the feeding stalls were used. (Figure 15) In the Massey College's shed, hay-racks lined with cut sacks were employed, one hay-rack of two divisions for each cow. Each division was further sub-divided into two parts by a piece of wood to refrain the cows from throwing feeds onto the floor.

The 'A' (Hay) ration was fed ad lib.

The 'B' (Silage) ration was also allowed ad lib.

The 'C' (Hay and Silage) ration consisted of 30 lb. of silage plus hay fed ad lib.

In Massey College's shed, the hay and silage were put to the cows separately,

one ration at each division of the hay-rack. In Dairy Research Institute shed, the hay and silage were put together in the feeding pen, the silage being put on the top of the hay with a piece of cut sack in between them, so that the cows could eat the 30 lb. silage first before they ate the hay. The rations, though fed ad lib, were not offered much in excess of the amount they could consume. This was to prevent the cows from excessive selecting of the better leafy portion of the feeds and refusing the coarser part.

All the daily rations of hay and silage offered to them were weighed. The portion left by each cow from the two feedings was removed and weighed after the cows were turned out to exercise.

The animals kept in the Dairy Research Institute feeding barn had access to water all the time. The animals kept in the College's shed were watered three times daily, once at evening's feeding, twice in the morning, and they had access to water during the time when they were in the paddock. No mineral supplements were given during the trial.

Figure 5. Massey College Shed. The Cows in their Respective Partitions are shown.

Figure 6. Dairy Research Institute shed. The Cows standing in their Feeding Stalls are shown.

Figure.7. Dairy Research Institute shed feeding stalls, with one cow standing in each stall.

Figure 8. A close view of a feeding stall.

Figure 9. Water provision device at Dairy Research Institute shed.

Figure 10. A view of the cows on the paddock.

Figure 11.      A close view of a cow on the paddock.

Figure 12.      A close view of muzzles.

Figure 13.      Drinking water with muzzle on.

Figure 14. Cows coming in for Feeds.

Figure.15. Feeding Stall at D.T.I. shed with feed in the bin.

## 7. Sampling of feeds and refused feeds.

### A. Sampling of Feeds.

Two samples, 'A' and 'B', ('A' sample from feeds offered to College shed cows and 'B' sample D.R.I. shed cows) of hay and silage, offered to the cows were each taken daily during the evening feeding after mixing the feed. This would give daily two samples of hay and two samples of silage, each silage sample weighed wet 250 grams and each hay sample 100 grams. The reason for taking only 100 grams for hay sample was that it was too bulky to handle when it was taken at 250 grams.

These feed samples (two hay and two silage) were dried at a temperature of 165°F, in an electric oven at P.R.B. for about six hours.

After the moisture was determined, the moisture-free hay and silage were ground and a representative portion of each of them was then put into their respective air-tight bottles.

At the end of the experiment, duplicate composite hay and silage samples were each taken from the ground samples for chemical analysis.

The average dry matter percentage of the two samples ('A' and 'B') of each feed was used for calculating the daily dry matter intake for all cows.

### B. Sampling of Refused Feeds.

At noon of each day each cow's refused feed from the evening and morning feed was removed and weighed.

After mixing, a sample for each cow was taken daily, the silage sample weighed wet 250 grams, and the hay sample 100 grams.

This would give daily the following number of samples of refused feed.

4 hay samples from four cows on hay

4 silage samples from four cows on silage

4 hay samples from four cows on hay and silage.

Samples were not taken from refused feeds weighed less than 2 lb. and the average D.M.% determined from the other samples was used. These samples of refused feeds (8 hay and 4 silage) were also dried at a temperature of 165°F for six hours. No chemical analysis of refused feed was attempted owing to the number of analyses involved.

## 8. Weighing of animals.

Each animal was weighed weekly, on Tuesday before the morning feeding.

## 9. Collection of data.

The following records were collected and kept:

- a. Weights of all feeds daily offered to and refused by each cow.



- b. Weekly weight of each animal.
- c. D.M. percentages of all daily feed offered and refused by each cow.
- d. Chemical composition of rations offered to the cows.

The health and condition and peculiarity of the cows were observed from day to day during the whole experimental period and all facts of any apparent significance or value were recorded as noticed.

Section V.

RESULTS.

Before the records of food consumption are considered, the following general observations may be noted.

At the start of the experiment, all the animals showed signs of restlessness when they were first being put indoors and their appetites fluctuated from day to day considerably. Apparently this was due to the fact that they had not been used to the indoor condition previously, and did not like the sudden change of environment. However, after the two week's preliminary feeding period, they had become thoroughly accustomed to the new conditions, and settled down well. All the animals, except two (Sally and Frivolous) which were nervous, were rather docile throughout the experiment and there was no difficulty in getting them indoors for feeds and in handling them.

The animals ate hay or silage readily, though they did not seem to eat either feed to their full capacities. Every cow displayed the keenest interest in each new feed (hay or silage) offered at the beginning of each period, but after they had been on that new feed for a week or so they manifested a desire for other feed, i.e. if they were on hay they developed a craving for silage, and vice versa. This interesting fact that cows desired a change of feed, or variety in their diet was further indicated by the observation that, when both hay and silage were offered at the same time, the cows which had been on either as the sole roughage during the previous period, almost always showed a very definite preference for the other for a few days.

The animals not only desired a change of feed, but even a change of quality within the same feed. An offer of brown sweet silage from the top of the stack instead of green sour silage from the bottom of the stack or vice versa provided a stimulation of appetite for the animals.

When a quantity of feed much greater than they could normally consume was offered, they ate more, possibly due to the fact that they could select more freely the more leafy and palatable parts and leave the coarser parts.

When feed of better quality was offered, they also ate more. This was especially so in the case of hay. A large amount of feed was usually refused when the hay offered contained a certain amount of rushes. Speaking generally, the cows seemed to relish silage more than hay. This was indicated by their preference for the former after they had been on both feeds for three or four days irrespective of which feed, as the sole ration, they were on previously. On

the other hand, they did not appear to show a consistent appetite for silage as for hay. On hay, they had shown on the whole, a fairly constant appetite throughout the experiment, but on silage, the first four or five days of every period, they showed a fairly keen appetite; after four or five days, there was in every period a distinct fall in consumption. This was especially so at Period II when the silage offered contained a large percentage of moisture.

There was a considerable amount of selection in the consumption of both rations, especially hay. The refused feeds were usually the coarser and more stemmy parts of the feeds.

The cows on the same ration varied considerably in their appetites; while some cows ate their food consistently from day to day, some appeared to gorge themselves one day and lost their appetites the following day. The animals, (cows of Group II) which were very docile throughout the experiment consumed noticeably more than those which were less quiet. (Cows, Sally and Barbara).

The two groups of cows (Group I and II) which were kept in the College shed had more freedom of movement during the feeding hours than those two groups (Group III and IV) kept at the Dairy Research Institute feeding barn and appeared to eat considerably more, but whether the freedom of movement during the feeding hours was the factor responsible or not is not known. During the period when the cows were indoors (from 4 p.m. to 12 a.m.) those on hay alone were estimated to drink from four to six gallons of water; the cows on hay plus silage drank about half this amount, while the cows on silage drank very little.

Throughout the experiment, temperatures were cool. The mean maximum temperature for the entire experimental period was 55.4°F and mean minimum 40.6°F. The daily meteorological details for the whole trial are shown in appendix. (Tables IXX to XXXI).

Data on average daily feed, dry matter, T.D.N. Consumption and live weight change of cows for Periods I, II and III are shown in tables 8, 9 and 10 respectively.

In appendix I, are given the day-by-day records of consumption (Tables I to XXV). The hay offered to the cows at Period I, II and III was very much the same in dry matter percentage, the average for Period I, II and III being 85.6, 85.1 and 85.5 per cent respectively.

The silage offered to the cows during the three periods, however, owing to the fact that it came from different position in the stack, varied in dry matter percentage. The silage offered at Period II had a distinctly lower D.M. Con-

tent, the average for the period being 17.6% as compared with 22.6% for Period I and 21.4% for Period III.

Table 8.

DATA ON AVERAGE DAILY CONSUMPTION AND LIVE WEIGHT CHANGES FOR PERIOD I.

(14 days, 15/6/48 - 28/6/48)

Out- come Group	Cow name.	Av. Live Weight for the Period. (lb)	Ration	Feed Consumed		D.M. Consumed.		1 <sup>st</sup> , D. N.				Live Wt. at start of Period (lb)	Live Wt. at end of Period (lb)	Gain(+) or Loss(-) in weight (lb) (%)	
				Per Cow. (lb)	per 1000 lb. Live Wt. (lb)	Per Cow. (lb)	Per 1000 lb. Live Wt. (lb)	Per Cow con- sumed (lb)	Per 1000 Live Wt. con- sumed. (lb)	<sup>2</sup> Per cow req- uired (lb)	Excess(+) or Def- iciency(-) (lb) (%)				
I	Addy	738	Hay	19.4	26.3	16.7	22.6	9.98	13.3	6.09	+3.89 +64	732	757	+25	+3.4
II	Art	840	Hay	22.4	26.7	19.3	23.0	11.54	13.7	6.80	+4.74 +70	817	852	+35	+4.3
III	Sally	864	Hay	16.9	19.6	14.7	17.0	8.79	10.2	7.00	+1.79 +26	860	868	+8	+0.9
IV	Barbara	716	Hay	16.7	23.3	14.5	20.3	8.67	12.1	5.91	+2.76 +47	714	725	+11	+1.5
Average of 4 cows 790				18.9	23.9	16.3	20.6	9.74	12.3	6.44	+3.30 +51	781	801	+20	+2.5
I	Yupena	775	Hay Silage	12.6 30.0	16.3 38.7	11.6 6.8	17.8 22.9	10.93	14.1	6.36	+4.57 +72	771	773	+2	+0.3
II	Yuscha	840	Hay Silage	17.1 30.0	20.4 35.7	14.9 6.8	21.7 25.8	13.26	15.8	6.80	+6.46 +95	817	851	+34	+4.2
III	Ynetta	853	Hay Silage	10.8 29.8	12.7 34.9	9.6 6.8	16.4 19.2	10.09	11.8	6.91	+3.18 +46	862	864	+2	+0.2
IV	Frivolous	777	Hay Silage	11.6 30.0	14.9 38.6	10.3 6.8	17.1 22.0	10.51	13.5	6.33	+4.18 +66	785	789	+4	+0.5
Average of 4 cows 811				13.0 30.0	16.0 37.0	11.5 6.8	18.3 22.6	11.22	13.8	6.61	+4.61 +70	809	819	+10	+1.2
I	Katie	748	Silage	71.0	94.9	16.1	21.5	10.30	13.8	6.17	+4.13 +67	749	767	+18	+2.4
II	Yuten	858	Silage	76.7	89.4	17.6	20.5	11.26	13.1	6.95	+4.31 +62	849	874	+25	+2.9
III	Vicky	884	Silage	79.8	90.3	18.1	20.5	11.58	13.1	7.07	+4.51 +64	880	892	+12	+1.4
IV	Toy	784	Silage	63.2	80.6	14.2	18.1	9.09	11.6	6.39	+2.70 +42	793	776	-17	-2.1
Average for 4 cows 819				72.7	88.7	16.5	20.1	10.56	12.9	6.68	+3.88 +58	818	827	+9	+1.1

1. Calculated on dry matter consumed and assumed digestibility; digestion coefficients taken from Watson & Horton (<sup>37</sup>) for hay and Sears & Sill (<sup>17</sup>) for silage.

2. Calculated from Morrison's Feeding standard (<sup>36</sup>).

Table 9.

DATA ON AVERAGE DAILY CONSUMPTION AND LIVE WEIGHT CHANGE FOR PERIOD II. (14 days: 29/6/48 - 12/7/48)

Out- come Group.	Cow name.	Av. Live Weight for the Period. (lb)	Ration	Feed Consumed		D.M. Consumed.		1 T. D. N.				Live Wt. at start of Period (lb)	Live Wt. at end of Period (lb)	Gain(+) or Loss(-) in weight (lb) (%)	
				Per Cow (lb)	per 1000 lb. Live Wt. (lb)	Per Cow. (lb)	per 1000 lb. Live Wt. (lb)	Per Cow con- sumed (lb)	Per 1000 lb. Live Wt. con- sumed. (lb)	Per cow re- quired (lb)	Excess(+) or Def- iciency(-) (lb) (%)				
I	Yupena	796	Hay	21.1	26.5	18.0	22.6	10.76	13.5	6.49	+4.27 +66	773	811	+38	+4.7
II	Yuscha	872	Hay	23.7	27.2	20.2	23.2	12.07	13.8	7.06	+5.01 +71	851	884	+33	+3.7
III	Vicky	905	Hay	17.3	19.1	14.9	16.5	8.91	9.9	7.24	+1.67 +23	892	906	+14	+1.5
IV	Toy	800	Hay	15.5	19.4	13.4	16.8	8.01	10.0	6.52	+1.49 +23	776	803	+27	+3.3
Average of 4 cows				19.5	23.1	16.6	19.7	9.92	11.8	6.84	+3.08 +45	823	851	+28	+3.4
I	Katie	783	Hay Silage	10.5 30.0	13.4 38.3	9.1 5.3	14.4 13.4	8.23	11.3	6.38	+2.45 +38	767	785	+18	+2.3
II	Yuten	903	Hay Silage	14.3 29.6	15.8 32.8	12.3 5.2	17.5 19.4	10.74	11.9	7.22	+3.52 +49	874	917	+43	+4.9
III	Sally	385	Hay Silage	11.4 30.0	12.9 33.9	10.0 5.3	15.3 17.3	9.37	10.6	7.08	+2.29 +32	868	899	+31	+3.6
IV	Barbara	730	Hay Silage	9.7 30.0	13.3 41.0	8.2 5.3	14.1 19.3	8.65	11.9	6.02	+2.63 +44	725	727	+2	+0.3
Average of 4 cows				11.5 29.8	13.9 36.1	10.0 5.3	15.3 18.6	9.37	11.4	6.72	+2.65 +39	808	832	+24	+3.0
I	Addy	743	Silage	49.7	66.9	3.8	11.4	5.44	7.3	6.13	-0.69 -11	757	724	-33	-4.4
II	Art	855	Silage	83.8	98.0	14.6	17.0	9.34	10.9	6.93	+2.41 +35	852	857	+5	+0.6
III	Ynetta	847	Silage	45.4	53.6	8.0	9.5	5.12	6.0	6.86	-1.74 -25	864	825	-39	-4.5
IV	Frivolous	776	Silage	61.3	78.8	10.8	13.9	6.91	8.9	6.38	+0.55 +8	789	770	-19	-2.4
Average of 4 cows				60.0	74.4	10.5	13.0	6.72	8.3	6.57	+0.15 +2	816	794	-22	-2.7

1 Calculated on dry matter consumed and assumed digestibility; digestion coefficients taken from Nelson & Horton (37) for hay and Sears & Sill (18) for silage.

2 Calculated from Morrison's Feeding Standard (36)



TABLE. 10. DATA ON AVERAGE DAILY CONSUMPTION AND LIVE WEIGHT CHANGE FOR PERIOD III. (14 days: 13/7/48 - 26/7/48).

Out- come Group.	Cow name.	Av. Live Weight for the Period. (lb)	Ration	Feed Consumed		D.M. Consumed.		<sup>1</sup> T. D. N.				Live Wt. at start of Period (lb)	Live Wt. at End of Period (lb)	Gain (+) or Loss (-) in weight (lb) (%)	
				Per cow (lb)	per 1000 lb. Live Wt. (lb)	Per Cow (lb)	per 1000 lb. Live Wt. (lb)	Per cow con- sumed (lb)	Per 1000 lb. Live Wt. con- sumed. (lb)	<sup>2</sup> Per Cow re- quired (lb)	Excess (+) or Def- iciency (-) (lb) (%)				
I	Katie	785	Hay	16.5	21.0	14.4	18.3	8.61	11.0	6.40	+2.21 +35	785	779	- 6	-0.8
II	Yuten	928	Hay	21.1	22.7	18.2	19.6	10.38	11.7	7.42	+3.46 +47	917	936	+19	+2.0
III	Ynetta	837	Hay	18.5	22.1	16.0	19.1	9.56	11.4	6.78	+2.78 +41	825	844	+19	+2.3
IV	Frivolous	783	Hay	16.5	21.1	14.6	18.6	8.73	11.1	6.38	+2.35 +37	770	793	+23	+2.9
Average	of 4 cows	833		18.2	21.8	15.8	19.0	9.44	11.3	6.75	+2.69 +40	824	838	+13	+1.6
I	Addy	749	Hay Silage	12.2 27.3	16.3 36.4	10.5 5.8 16.3	21.8	9.99	18.0	6.18	+3.81 +62	724	771	+47	+6.5
II	Art	861	Hay Silage	12.9 29.0	15.0 33.6	11.1 6.2 17.3	20.1	10.61	12.3	6.97	+3.64 +52	857	873	+16	+1.9
III	Vicky	918	Hay Silage	13.0 30.0	14.2 32.7	11.4 6.4 17.8	19.4	10.91	11.9	7.34	+3.57 +49	906	929	+23	+2.5
IV	Toy	811	Hay Silage	9.3 30.0	11.5 37.0	8.4 6.4 14.8	18.3	9.12	11.3	6.61	+2.51 +38	803	827	+24	+3.0
Average	of 4 cows	835	Hay Silage	11.9 29.0	14.3 34.7	10.3 6.2 16.5	19.8	10.13	12.1	6.76	+3.37 +50	822	850	+28	+3.4
I	Yupena	798	Silage	69.9	87.5	14.9	18.7	9.54	12.0	6.50	+3.04 +47	811	792	-19	-2.3
II	Yuscha	865	Silage	81.0	93.6	17.2	19.9	11.01	12.7	7.01	+4.00 +57	884	867	-17	-1.9
III	Sally	913	Silage	73.3	80.3	15.6	17.1	9.98	10.9	7.30	+2.68 +37	899	944	+45	+5.0
IV	Barbara	715	Silage	57.2	80.0	12.3	17.2	7.87	11.0	5.90	+1.97 +33	727	705	-22	-3.0
Average	of 4 cows	823		70.4	85.5	15.0	18.2	9.60	11.7	6.71	+2.89 +43	830	827	- 3	-0.4

<sup>1</sup> Calculated on dry matter consumed and assumed digestibility; digestion co-efficients taken from Watson & Horton (37) for hay, and Sears & Sill (18) for silage.

<sup>2</sup> Calculated from Morrison's Feeding Standard.

### Feed Consumption.

The individual cow's average daily feed consumption for each period is shown in Tables 8, 9 and 10. The average daily consumption for 'A' ration (hay) was much the same for the three experimental periods, being --

18.9 lb. for Period I  
19.4 lb. for Period II  
18.2 lb. for Period III

For 'B' ration, (silage) however, it was not so similar, being --

72.7 lb. for Period I.  
60.0 lb. for Period II  
70.4 lb. for Period III.

In Period II, the cows consumed on the average much less silage than the other two periods. The possible cause of this will be discussed in Section VI.

For 'C' ration (Hay and Silage) it was

30.0 lb. silage and 13 lb. hay for Period I.  
29.8 lb. silage and 11.5 lb. hay for Period II.  
29.6 lb. silage and 11.9 lb. hay for Period III.

For the entire experiment, the average daily feed consumption was:

18.8 lb. of hay for the cows on 'A' ration.  
67.7 lb. of silage on 'B' ration.

and 29.6 lb. of silage plus 12 lb. hay on 'C' ration.

The highest average daily consumption by any individual cow for hay was 23.7 lb. (Yuscha), the lowest 15.5 lb. (Toy); for silage, the highest 83.8 lb. (Art), the lowest 45.4 lb. (Ynetta) and for the hay portion in ration 'C', the highest 17.1 lb. (Yuscha), the lowest 9.3 lb. (Toy).

Per 1,000 lb. live weight, the amount of feed consumed daily were:

22.9 lb. hay for 'A' ration  
82.9 lb. silage for 'B' ration  
and 35.9 lb. silage plus 14.7 lb. hay for 'C' ration.

(Note:- the silage portion of 'C' ration was not fed ad lib. The cows were allowed to eat 30 lb. per day plus hay fed ad lib.)

### Dry Matter Consumption:

The average daily dry matter consumption of each cow for each period is shown in tables 8, 9 and 10. For the experiment as a whole, the average daily dry matter consumption standard deviation and coefficient of variation for the animals



on the three rations are shown in the following table, 11.

**Table 11. Average Daily Dry Matter Consumption on the Three Rations.**

Ration	Mean Consumption (lb.)	Standard deviation (lb.)	Co-efficient of Variation. (%).
A (hay)	16.2	1.94	12
B (Silage)	14.0	3.21	23
C (30 lb. Silage plus hay) ad lib.)	16.7	2.05	12

The range of the amount consumed daily was much greater for B ration than for the other two:

for A ration, from 13.4 to 20.2 lb.

for B ration, from 8.0 to 18.2 lb. and

for C ration, from 14.1 to 21.7 lb.

Per 1000 lb. live weight, the pounds of dry matter consumed per day were:

19.7 lb. for ration A

17.2 lb. for ration B and

20.3 lb. for ration C.

The average daily consumption for ration A and ration C was very much the same for the three periods; for ration A, being 16.3 lb. for Period I

16.6 lb. for Period II

15.8 lb. for Period III

for ration C, being 18.3 lb. for Period I

15.3 lb. for Period II

16.5 lb. for Period III

But for ration B, the average consumption was very much lower for Period II, when silage offered contained a large percentage of moisture, being 10.5 lb. per day as compared with 16.5 lb. for Period I and 15.0 lb. for Period III.

Except that in Period I when cows consumed slightly more of ration B than of ration A, and that in Period II, slightly more of ration A than ration C, for the entire experiment, the consumed dry matter for the three rations was of the following order:

1. C ration
2. A ration
3. B ration.

But a picture of differences in dry matter consumption between rations is not com-

pleted until statistical analysis is applied to estimate the variability of the data as influenced by differences between cows, between groups, and between periods etc., also to adjust the carry-over effect of the rations.

Adjustment for carry-over effect was carried out by the method of least squares (7) and the whole procedure is presented in appendix 2.

There were little differences in mean dry matter consumption per cow per period of two weeks before and after the adjustments indicating little carry-over effects of the rations were present. (See Table XXXVI in the Appendix).

Simple analysis of variance, as given in table 12, is used to break down the ration differences. The details of analysis are given in Appendix 2.

The separate group analyses are shown in table XXXIII.

**Table 12.** Analysis of Variance of dry matter Consumption Units: Total Consumption Per Cow Per Period (two weeks), in lb.

Source of Variation.	Degrees of freedom.	Sum of squares.	Mean squares.	P
Between Groups	3	17035	5678	SS
Between cows within Groups.	8	8492	1062	N.S.
Between Periods	2	9752	4876	S.S.
Period X Group Interaction.	6	2114	352	N.S.
Between rations	2	9914	4957	S.S.
Ration X Group Interaction	6 )	967 (	161 )	N.S.
Error	8 ) 14	6395 ) 7362	799 ) 526	
Total	35	54669		

The analysis reveals that the difference between rations are approximately the same in all groups; i.e. the "ration x group interaction" mean square is less than the error mean square. Hence this term was included in the experimental error.

The mean square of the ration effects, 4957, is significantly greater than the error mean square, 526, signifying that there was an appreciable difference between the rations in dry matter consumption. However, subdivision of sum of squares of ration-effects (34) as shown in table 13, shows that the difference between ration 'A' and 'C' is not significant. Consequently the highly significant difference was only between ration 'A' (or 'C') and ration 'B.'

**Table. 13.** Subdivision of Sum of Squares of Ration effects.

Source of Variation.	Degrees of Freedom.	Sum of squares.	Mean squares	P.
Between rations	2	9914	4957	S.S.
Between ration B & Ration A plus C.	1	9661	9661	S.S.
Between ration A and C.	1	253	253	N.S.

Table 14 shows the dry matter consumption totals and mean units for each ration and the standard error per cow.

**Table 14.** Dry Matter Consumption Totals and Mean Units:  
lb. for 2-week periods.

Ration	Ration totals (12 cows)	Ration Means	Standard error per cow.
A (Hay)	2729	227.4	± 6.63
B (Silage)	2351	195.9	
C (Hay plus silage.)	2807	233.9	
General total	7887	General mean 219.1	

The standard deviation of the error term is 22.93 lb. (  $\sqrt{526}$  ) or 10.47 per cent of the general mean 219.1 lb. The standard error per cow for a 2-week period is 6.63 lb. (  $\frac{22.93}{\sqrt{12}}$  ) or 3.03 per cent of the mean.

These differences in dry matter consumption between rations can be shown more clearly in the following figure 16, which shows graphically the total dry matter consumption for each ration, for the entire trial.

The daily dry matter consumption for each period is shown by curves in Figures 17, 18 (each curve is an individual cow's record) and Figure 19 (each curve is the average record of two cows).

An inspection of the above curves reveals a number of features connected with the influence of rations on dry matter consumption:

1. The change from hay or hay plus silage<sup>2 silage</sup> always resulted in decreased dry matter consumption, but the reverse was not always true.
2. Adding silage to cows receiving hay ration (i.e. change from hay to hay plus silage) always led to an increase of dry matter consumption, but adding hay to cows receiving silage ration (i.e. change from silage to hay plus silage) gave inconsistent effects.
3. The consumption for ration 'A' (hay) and ration 'C' (hay plus silage) tended to be increased slightly towards the end of each period. On the other hand, there was a tendency for a drop in consumption for 'B' ration (silage) towards the middle and end of each period. This drop in consumption was especially marked in Period II when the dry matter content of silage offered was low.

The summation of dry matter intake of all cows in each period (Figure 20) indicates that the cows consumed the largest amount of dry matter in Period I, the lowest in Period II. The amount consumed in Period III was intermediate of the two. This was not to be expected. Normally one would expect the consumption in Period III to be the highest since the cows were more accustomed to the rations and indoor conditions.

Statistical analysis (Table 12) has shown that these differences in dry matter consumption between periods are highly significant. However, subdivision of sum of squares of Period effects (Table 15) (34) shows that there was no significant difference between Period I and Period III. Hence the highly significant difference would be only found between Period I ( or Period III) and Period II.

Table 15. Subdivision of Sum of Squares of Period Effects.

Source of Variation	Degrees of Freedom.	Sum of Squares.	Mean Squares.	P.
Between Periods	2	9752	4876	S.S.
Between Period II and Period I plus Period III	1	8002	8002	S.S.
Between Period I and III.	1	1750	1750	N.S.

The dry matter consumption of each group of cows is shown in Figure 21 (for each period) and Figure 22 (for the entire experiment).

It can be seen from Figure 21 that in each period the total dry matter consumption differed appreciably between groups. For the experiment as a whole (Figure 22) Group I and III were similar in the total amounts consumed, but Group II consumed much more, while Group IV consumed considerably less than Group I or Group III.

The F test (35) has revealed that these differences in consumption between groups are highly significant (See Table 12), the mean square for that term being 5678 as compared with only 526 for the error. This, with the fact that difference between cows within groups are not significant (Table 12) shows that the arrangement of cows into the four outcome groups was well justified.

The fact that the amount of dry matter consumed was not related to body weight, age or stage of pregnancy is interesting, but this will be discussed in Section VI.

#### T.D.N. Consumption:

Table 8, 9 and 10 show the calculated daily T.D.N. consumption of each cow for each period. In calculating the nutrient requirements of the cows, the higher optimum requirements for nutrients to sustain body maintenance as outlined in Morrison's Feeding Standard (35) were employed, and the average body weights of the cows for each period were the basis.

The nutrients consumed were calculated from the average daily consumption of dry matter (Table, 8, 9, 10) and from the Chemical analysis for the hay and silage used in the trial (Table 4).

The digestion coefficient of nutrients were taken from Watson and Horton (37) for hay and Sears and Sill (18) for silage. These are shown in the following Table 16.

Table 16.      Coefficient of Digestibility for Hay and Silage as reported  
by other Investigators.  
(on moisture-free basis.)

Feed	Reported by	Crude Protein %	Ether Extract %	N.F.E. %	Crude Fibre %
Hay	Watson & Horton	45.0	32.0	66.0	64.0
Silage	Sears & Sill	50.1	73.8	64.8	78.7

There are no digestion coefficients entirely satisfactory for application to the hay used, but since the hay fed in this trial was cut from poor pasture and had low protein content (6.36%), its digestibility would be similar to that obtained by Watson and Horton with poor hay. The material they used had a

crude protein content of 6.54 per cent, and crude fibre of 40.16 per cent, which was comparable to that used in this trial. The coefficients were obtained with sheep.

For silage the reason for taking the digestion coefficient from Sears and Sill was that apart from the material they used to obtain the coefficients being similar to the silage fed in this experiment (crude protein 11.5% and crude fibre 32%), the condition and the animals (dry Jersey and Friesian cows) with which the coefficients were obtained were comparable to this trial.

The calculated percentages of digestible nutrients for the hay and silage used are shown in the following table 17.

Table 17. Digestible Nutrients of Hay and Silage.

(on moisture-free basis)

Feed	Crude Protein %	Ether Extract %	N.F.E. %	Crude Fibre %	T.D.N. %
Hay	2.86	0.58	31.10	25.23	59.77
Silage	8.12	1.74	23.28	30.85	63.99

For the entire experiment, the mean daily consumption of T.D.N., the standard deviation and coefficient of variation for the three rations are shown in the following table 18.

Table 18. Average daily T.D.N. Consumption on the Three Rations.

Ration	Mean Consumption (lb)	Standard Deviation (lb)	Coefficient of Variation. (%)
A (Hay)	9.70	1.39	14.3
B (Silage)	8.96	2.18	24.3
C (30 lb of Silage plus hay ad lib.)	10.24	1.20	11.6

The pounds of T.D.N. consumed per day per 1000 lb. live weight were:

11.8 lb. for A ration

11.0 lb. for B.ration

12.4 lb. for C ration.

As in dry matter consumption, the range of consumption was much greater for B ration than for A and C, as shown in table 18. Likewise, the differences in T.D.N. consumption between rations paralleled closely those in dry matter consumption, the C ration being consumed the highest amount, followed by A ration

and then B ration in that order. But the differences were not so marked as in dry matter consumption owing to the fact that the T.D.N. per cent of silage is higher than that of hay.

In each period, the cows on each ration consumed on the average considerably more nutrients than they required for maintenance. The average excess in nutrients consumption for the whole experiment when measured against Morrison's "higher" optimum requirement was:

45% for the cows on hay ration

34% on silage ration, and

53% on hay plus silage.

The excess for the cows on hay ration and those on hay plus silage was consistently high for the three periods; for hay being 51, 45 and 40 per cent for Period I, II and III respectively; for hay plus silage, 70, 39, and 50 per cent.

The excess for silage was rather inconsistent, being 58, and 43 per cent for Period I and III, but only 2 per cent for Period II..

Among the individual cows, cows on hay plus silage or hay alone all consumed nutrients in excess of their requirements. One cow (Yuscha) on hay plus silage consumed an amount of 95 per cent above her maintenance requirement, and one cow (Art) on hay as much as 70 per cent above requirements. The lowest excess on hay plus silage ration was 32 per cent by Sally; on hay 23 per cent, by Vicky and Toy.

On silage ration, two cows (Addy and Ynetta) in Period II failed to consume sufficient nutrients to meet their calculated requirement, being 11 and 25 per cent deficient respectively. One cow (Frivolous) was barely able to maintain herself, consuming 8 per cent excess. The largest excess on silage was 67 per cent, by Yuten.

#### Changes in Body Weight:

The gain or loss in weight of each individual cow in each period is shown in table 8, 9 and 10. The detailed data on body weight of cows are given in Appendix I (Tables XXVI to XXVIII). A number of factors made it difficult to determine the effect of rations on live weight. These included variation in food intake, and water consumption, different in gut content, stage of growth of the animals, and stage of pregnancy etc.

It will be noted from table 8, 9 and 10 that there was a few cases in which animals lost weight despite the fact that their calculated nutrients consumption was considerably above requirements. (The possible causes for these discrep-



ancies will be discussed in Section VI) However, in general, the gain or loss in weight of cows parallels rather closely the dry matter and T.D.N. consumption.

For cows on hay ration, the average gain in weight for Period I, II and III was 20, 28 and 13 lb. respectively (or 2.5, 3.4 and 1.6 per cent of their initial average body weight);

On hay plus silage, the gains were 10, 24, and 28 lb. (or 1.2, 3.0 and 3.4 per cent of body weight).

The cows on silage gained on the average 9 lb. (1.1, per cent of body weight) in period I, but lost 22 lb. (2.7 per cent of body weight) in Period II, and 3 lb. (0.4 per cent of body weight) in Period III.

For the entire experiment, the average gain in weight was 20 lb. (or 2.5 per cent of their body weight) for the cows on hay ration, and 21 lb. (2.6 per cent of body weight) on hay plus silage; the cows on silage ration lost 16 lb. (2 per cent of body weight) on the average. The curves in Figures 23 and 24 show graphically the body weight change in each cow for each period.

From a study of these curves and those in Figure 17 and 18, it can be seen that the curves for body weight follow fairly closely those for dry matter consumption.

In general, the cows on hay or hay plus silage tended to increase in weight while the cows on silage tended to lose weight, with the exception of Yuten and Katie in Period I, Art in Period II, and Sally in Period III, which increased or maintained their weights. The gain or loss in weight of cows quoted above has not allowed for increased weight due to foetal development. The gain would have been less or the loss more were a weight allowance due to pregnancy made. However, since stage of pregnancy was one of the factors to be considered in grouping the cows, and since one cow from each group was on each ration in each period, the increased weight due to pregnancy would not make the estimate of ration effects on body weight biased.

The following table 19 shows the stage of pregnancy of and a weight increase due to pregnancy for each cow. (Based on data obtained by Dr. L. Wallace, of Ruakura Animal Research Station, from the slaughter of pregnant Jersey cows). It will be noted that within each group the cows were comparable, except possibly with Group IV which included one empty cow (Frivolous). However, since Dr. Wallace's data is based on the average cow, the weight increase due to pregnancy of each individual cow might vary widely.

Table 19. Body Weight Increase due to Pregnancy during the Experiment.  
(Based on Dr. L. Wallace's Data).

Group No.	Cow name.	Stage of pregnancy		Weight increase due to foetal development. (lb)
		Start of Expt. (Mos.)	End of Expt (Mos.).	
I	Addy	6.3	7.6	20
	Katie	6.5	7.9	25
	Yupena	7.3	8.6	30
II	Yuten	6.5	7.9	25
	Art	6.7	8.0	26
	Yuscha	7.1	8.4	33
III	Vicky	7.3	8.6	30
	Ynetta	6.9	8.3	28
	Sally	6.7	8.0	26
IV	Barbara	4.4	5.7	10
	Toy	4.9	6.3	12
	Frivolous	Empty ?	?	?

Health and Condition of the Cows:

The cows were in noticeably good condition when they were on hay or hay plus silage. When on silage ration, they scoured as a rule after they had been on the feed for two or three days. This was especially so in Period II when the silage offered was from the bottom of the stack and contained a large percentage of moisture. When the cows were scouring they lost their condition slightly and did not show such good flesh as the cows on the other two rations. However, they appeared to be in normal health, and recovered their condition as soon as they were changed on to hay or hay plus silage.

In the last few days of each period, the cows on hay alone occasionally showed sign of constipation.

Two old cows (Barbara and Frivolous) developed sore feet during the trial due to long hours of standing on the concrete when receiving feeds.

Section VI.

DISCUSSION.

The results of this trial show that with feeds of the type and quality used in the experiment, a dry Jersey cow will eat

16.7 lb. of dry matter on hay plus silage

16.2 lb. on hay, and

14.0 lb. on silage.

Although these results were obtained with a small number of animals and from an experiment carried out in a short period, they indicate the respective limits of a dry Jersey cow's appetite for the three rations concerned. This information is important in dairy cattle feeding in New Zealand, where 75 per cent of the dairy cattle population is Jersey (38), and over the dry period, the dairy cows live chiefly on hay and/or silage such as those used in the experiment, with little pasture available.

The chief problem in using hay and silage as a feed for dairy cows is that hay is low in nutrients whereas silage is low in dry matter as well as nutrients. To obtain an adequate supply of nutrients for maintenance and production, a dairy cow on roughage ration must eat a large quantity of dry matter. Since the capacity of a cow to deal with bulk is limited, it is essential that the roughage ration should be of such quality that sufficient nutrients within the limit of her ingestive capacity are provided. The information obtained from this trial thus provides a basis for such considerations, whenever feeds of the type and quality used in the experiment are fed to cows.

Expressing these results per 1000 lb. live weight of the cows, the daily dry matter intake was:

20.3 lb. for hay plus silage

19.7 lb. for hay

17.2 lb. for silage

This appears to contradict the common belief that a dairy cow's appetite in terms of dry matter is  $2\frac{1}{2}$  to  $2\frac{3}{4}$  per cent of her body weight. As far as the dry Jersey cows used in the experiment are concerned, they ate an amount of dry matter varying from about 1.7 per cent on silage to about 2.0 percent on hay plus silage of their body weight. A comparison of dry matter intakes obtained from this trial (on 1000 lb. live weight basis) with those obtained by other workers is given in the following table.20.

**Table 20.** Comparison of Dry Matter Consumption of Dairy Cows  
on Grass hay and/or Silage.  
(on 1000 lb. live weight basis)

Reported from -	Animal Used	Dry matter intake per 1000 lb. Live weight on -		
		Hay (lb)	Silage (lb)	Hay plus Silage (lb)
This Trial	12 Dry Jersey Cows	19.7	17.2	20.3
Sears & Sill (18)	2 Dry Jersey Cows	---	19.8	---
	2 Dry Friesian Cows.	---	18.9	---
Hodgson & Knott (16)	41 Holstein milking cows.	19.0	18.0	22.0
Graves et al (8)	4 to 5 Holstein milking Cows	1928 20.4	16.1	---
		1929 26.8	18.8	---

In general, the results of this trial are slightly lower than those of other workers. The possible causes for this discrepancy are suggested as follows:

1. feeds of different quality were used. The hay used in this trial was rather poor. The silage offered in Period II had a high moisture content, (the effect of this will be discussed later on).
2. The experimental conditions under which the results were obtained might be widely different.
3. Dry cows might have a different food intake from cows in milk.
4. The question of breed might be involved.
5. Also, the frequent change of rations involved in the design used in this experiment and the short experimental periods employed in this trial might be factors.
6. The way in which the hay plus silage ration was fed in this experiment might also be a factor since the silage portion was restricted to 30 lb. daily.

It will be noted that except for one case in which Graves et al in 1929 (8) found the amount of hay (dry matter) consumed was 2.68 per cent of cow's body weight, results from all other workers as well as this trial, indicate that a dairy cow's appetite for roughage (hay and silage) is below  $2\frac{1}{2}$  per cent of her body weight.

In the consumption of dry matter, there was considerable variation from cow to cow on each ration. When on the silage alone the cows exhibited the greatest individuality. The coefficient of variation derived from standard deviation and

the mean daily consumption for the twelve cows was 12 per cent for cows on hay, and hay plus silage, but 23 per cent for cows on silage. The mean daily consumption and its standard error for the twelve cows was:

16.7 - 0.592 lb. on hay plus silage.

16.2 - 0.560 lb. on hay

14.0 - 0.925 lb. on silage

The variation in consumption between cows on silage was nearly twice as big as between those on the other two rations. This indicates that for body maintenance purposes, hay plus silage or hay alone are more suitable than silage alone.

For the experiment as a whole, the consumption was greatest for the C ration (hay plus silage) followed by A ration (hay) and lowest for the B ration (silage). Statistical analysis shows that the difference between A ration and C ration was not significant, but the difference between A ration (or C ration) and B ration was highly significant. These results are in agreement with those of Hodgson and Knott (16) who reported that Holstein Cows consumed more dry matter in the form of hay plus silage, than hay or silage fed alone. They are also in agreement with those obtained by Graves et al (8) who found cows consumed more dry matter in the form of hay than in the form of silage.

However, the results of this trial require some further explanations. The highly significant difference between hay plus silage (or hay) and silage ration was apparently largely due to low dry matter consumption for silage in Period II. The average daily consumption in Period I for silage was 16.5 lb. which was even higher than that for hay (16.3 lb.) In Period III, it was 15 lb. which was only slightly lower than that for hay (15.8 lb.) But in Period II, it was only 10.5 lb. as compared with hay 16.6 lb. and hay plus silage 15.3 lb.

Two factors were involved in this low dry matter consumption for the silage ration in Period II.

- (1) The silage offered during the period was drawn chiefly from the lower portion of a stack and as a result of this, it had a low dry matter percentage -- average for the period 16.7 per cent as compared with 21.6 per cent for Period I and 21.4 per cent for Period III.
- (2) lower feed consumption (average 60 lb daily as compared with 72.7 lb. for Period I and 70.4 lb. for Period III).

The following possible causes for lower silage consumption in Period II are suggested.

1. on silage supplied during the period, cows scoured rather badly. This

might affect feed consumption.

Silage with a high dry matter may be more acceptable to dairy cows over a sustained period of feeding than a silage with a high moisture content. In the period, consumption dropped off very sharply after the cows had been on the feed for three or four days (See Appendix table XVI)

3. Cold weather might affect consumption of a watery food. During Period II, especially in the middle and towards the end of the period, there were several frosty nights. (See Appendix table XXX). In these cold nights, while the cows seemed to eat more hay, they ate less silage.
4. Acidity or sour taste of the silage offered might be a factor. In Period II, the silage fed came chiefly from the lower portion of a stack and had a slightly lower pH (Table 21) and a distinctly sour taste.

Table 21. pH Value and Taste of Silage Used.

Position of a stack from which the silage was drawn.	pH Value (average of 3 samples)	Taste.
Top	4.8	sweet
Middle	4.0	sweet to sour
Bottom	4.6	sour

The fact that cows consumed more dry matter in the order of hay plus silage, hay and silage has two important implications in practice;

- (1) that cows prefer "variety" in their diet, and can be induced to take a higher dry matter intake by introducing "variety" consideration into the feeding of dairy cows (such as feeding hay and silage together, instead of hay or silage alone.)
- (2) That cows can have a higher dry matter intake on foods that have a higher dry matter content (such as hay compared with silage) i.e. less bulky foods.

The low dry matter consumption for silage ration in Period II as a result of feeding silage with a high moisture content incidentally is further evidence of the importance of bulkiness as a factor in preventing cows from consuming a high dry matter intake.

An interesting fact arising out of the trial was that despite the more advanced stage of pregnancy and heavier body weight, the cows consumed less total dry matter for Period III (2653 lb) than for Period I (2856 lb) This appears to indicate that there was no apparent relationship between dry matter consumption and

stage of pregnancy, nor between dry matter consumption and increasing body weight in mature cows.

Another interesting situation found in this experiment was that dry matter consumption did not appear to be related to body weight or age. In the case of body weight this was indicated by the facts that

1. Group II cows consumed the greatest amount of total dry matter (2292 lb) though it was not the heaviest group (average body weight 869 lb).
2. Group III was the heaviest group (average body weight 878 lb) and yet its total dry matter intake (1914 lb) was just as much as Group I which had an average weight of only 768 lb.

In the case of age this was indicated from the total dry matter consumption of Group I and Group IV. These two groups had the same average body weight. Group I (3-4 years old) consumed more dry matter than Group IV which included three old cows (10-12 years old)

However, these are just interesting points mentioned in passing; the number of animals used in the trial was too small and the feeding period was too short to allow any definite conclusion to be made on these points.

The methods employed in this experiment on the whole have proved to be satisfactory, particularly the technique used to keep the experimental animals from access to grazing (muzzles). But in the measurement of dry matter intake, there were several sources of experimental error that require to be discussed.

#### 1. Grouping of Animals.

As mentioned earlier, the success of this design depends largely on the uniformity in appetite and in change of appetite from period to period of the cows within each group. This would allow the three experimental periods to be represented equally in the consumption for any ration. But, owing to a situation in that only a short preliminary feeding period was possible, the animals had been grouped on factors that might be related to appetite (such as body weight, condition, age and stage of pregnancy) instead of their approximate appetites. This would consequently produce a ration difference within any period. (e.g. an animal within a group would consume more of one ration than her mates on the other two rations if she had a bigger appetite.)

However, statistical analysis has shown that the grouping has been carried out justifiably, as indicated by the fact that there was no significant difference in consumption between cows within groups but a highly significant difference between groups.

2. An important source of error was possibly introduced through not being able



to offer to the cows feeds of a uniform quality throughout the trial. This would introduce period difference and ration difference. For instance, in Period II, the silage offered had a high moisture content which caused a low dry matter consumption for silage ration in that Period. This was largely responsible for the significant difference in consumption between Period I (or III) and Period II, and the significant difference between hay ration (or hay plus silage ration) and silage ration; (Since there was neither significant difference between Period I and Period III, nor between hay ration and hay plus silage ration.)

The hay used in the experiment, however, was rather uniform throughout the experiment, its average dry matter percentage being 85.6, 85.1 and 85.5 for Period I, II and III respectively.

3. Another source of error was possibly introduced through the necessity of using a small number of groups of cows and short experimental periods on account of limited experimental resources and time (the dry period) available. The fact that the difference between groups was highly significant on statistical analysis shows that the use of more groups of cows in each Latin Square would give more accurate results.

4. Still a further possible source of error was from inaccurate measurements. (a) the error introduced through the necessity of using the hay racks for feeding the animals in the college shed was an important one. This method has not proved to be entirely satisfactory. The cows were inclined to throw the feeds, especially hay, on to the floor in searching for more palatable parts of the feed. The feeds on the floor were often mixed up with dung and urine, consequently in collecting the refused feeds, this amount on the floor had to be estimated. However, this amount was not large, usually under one pound.

(b) Error due to sampling of feeds for dry matter determination. Owing to the bulky nature of the feeds used, the amount of feeds and refused feeds sampled daily was not in proportion to the amount of feeds offered or refused, but was 250 grams for silage and 100 grams for hay. This method of sampling has been checked by repeating the method twelve times with each feed. It was found, as shown in table 22, that the widest difference in dry matter percentage between samples was 2.5 per cent for hay and 1.6 per cent for silage. This means that for every pound of feed consumed, the difference in dry matter consumption due to difference in dry matter percentages was within 0.025 lb. for hay and 0.016 lb. for silage.

**Table 22.** Variation in Dry Matter Percentage of Feed Samples.

Sample.	1	2	3	4	5	6	7	8	9	10	11	12
Hay	85.0	86.0	84.5	86.5	85.0	85.5	84.8	85.0	85.5	84.0	84.5	84.5
Silage	17.2	16.8	16.6	17.6	16.4	17.8	17.2	17.2	17.8	16.7	18.0	17.8

(c) Error introduced through using the average dry matter percentage of two daily feed samples (Sample A and B) for calculating the daily dry matter intake for all cows. But the difference in dry matter percentage between the two daily feed samples was not large, usually within 1.5 for both hay and silage. This again means that for every one pound of feed (hay or silage) consumed, the difference in dry matter intake due to the use of the average dry matter percentage was within .015 lb.

Another minor error introduced was through the fact that refused feed which weighed less than 2 lb. was not sampled for dry matter determination -- the dry matter percentage for this was the average of the dry matter percentages determined from other cows' refused feeds.

5. Finally, it should be mentioned that the dry matter consumption for hay plus silage ration did not represent the cows' appetite for both hay and silage. The silage portion was restricted to 30 lb. daily and only the hay portion was fed ad lib. The cows' appetite for hay plus silage ration would have been different had both hay and silage been fed ad lib.

The two 3 x 3 Latin Squares has proved to be applicable and suitable for dairy cattle feeding experiments. One of the main reasons for employing this design in this experiment was to adjust for carry-over effects of rations, which can be anticipated in a short time experiment owing to the shortness of the change-over period.

The results indicate that the design has been successful in making this adjustment, and in overcoming criticisms of other experimental designs which did not permit the proper evaluation of ration effect alone as distinct from the ration effect plus carry-over effect from the preceding ration.

In addition the design was also successful in:

1. Enabling the consumption of three rations to be compared with limited time and experimental animals available,
2. eliminating largely the effect of individuality of the cows and the effects of period (such as stage of pregnancy, weather conditions etc.) on the consumption of any ration.

But this design was disadvantageous in

1. involving a frequent change of rations, which might upset a cow's appetite
2. lacking simplicity of group feeding, trial and Switch-back design etc.
3. requiring a very careful grouping of the cows.

The results of T.D.N. calculation based on dry matter consumed, chemical analysis of the feeds and assumed digestion coefficients show that for the whole trial the cows on the average obtained

10.24 ± 0.346 lb. of T.D.N. on hay plus silage,

9.70 ± 0.402 lb. on hay, and

8.96 ± 0.630 lb. on silage.

The difference in T.D.N. consumption between hay plus silage ration (or hay ration) and silage ration was not as marked as for dry matter consumption owing to the digestibility per cent (calculated on assumed digestion coefficients and Chemical analysis of the feed) for silage being higher than that for hay. But T.D.N. consumption parallels closely the dry matter consumption. Cows receiving hay plus silage consumed largest amount of T.D.N. per day, followed by cows on hay, and the cows on silage in that order.

On the average, the animals on every ration consumed more nutrients than they required for maintenance (calculated on Morrison's Feeding Standard) The average excess in T.D.N. consumption for hay plus silage ration was 53 per cent

for hay	...	45 per cent
and for silage	..	34 per cent.

These results indicate --

1. that the dry dairy cows on the rations used in the experiment had the capacity to consume sufficient dry matter to exceed their nutrient requirements for body maintenance.

This is important in this country in view of the fact that hay and silage are used extensively and that dairy cows exist largely on the two roughages with little pasture available during poor winter and dry summer periods.

2. that dairy cows could not consume as much nutrients on silage alone as on hay, or hay plus silage despite the fact that silage has a higher nutrient content on dry matter basis than hay. This shows the problem of providing an adequate supply of nutrients to dairy cows when feed of low dry matter, as well as low nutrient content (i.e. bulky) such as silage is used.

An animal on such a bulky ration in the first place will not be able to take a high amount of dry matter because of the limit of her appetite. In the second place she will not be able to obtain a high nutrient intake because of low nutrient content of the feed on a dry matter basis. In other words, when a bulky food

such as silage is used as a source of nutrients, for dairy cows, appetite, by restricting the amount of food eaten, is more likely to be a factor in limiting nutrient intake. In this connection, it is interesting to quote the following evidence from Cronshaw (39). During a survey of dairying conditions made by the N.I.R.D. in England and Wales in 1942, the cattle fed chiefly on bulky foods were found to be getting 5 - 10 per cent less starch equivalent per animal than before the war when concentrates were used for cattle, in spite of the fact that the actual dry matter intake was 5 per cent more.

There were two possible sources of error in the estimation of T.D.M. consumption:

1. Error arising from the use of assumed digestion coefficients, for hay (37), for silage (18) (see table 16).

This was likely to be an important source of error. The difference between the assumed digestibility (calculated on digestion coefficients taken from other workers) and the actual digestibility might be due to:

- a. Difference in animals used. But according to Morrison (40) cows and sheep digest most kinds equally well.
- b. Difference in quality of feeds used. According to Maynard (41) as the nutritive ratio becomes wider, the digestibility of all nutrients tends to be lower.
- c. Difference in the amount of food fed.

Eckles (42) Forbes et al (43) (44), and Mitchell et al (45) showed that digestibility in the dairy cow was lower at full feed than at maintenance level of feeding.

- d. Difference in amount of exercise etc.

Schneider and Ellenberger (46) reported that moderate exercise tends to increase digestibility.

In this connection, it is interesting to compare the digestibilities of hay and silage as obtained with those calculated through the use of McMeekan's regression equation of crude fibre on digestibility of organic matter ( $Y = 9261 - 0.96X$  where  $Y$  is the digestibility of organic matter,  $X$  the crude fibre content of the feed) (47) as shown in the following table 23.

**Table.23.** Digestibilities of Hay and Silage.  
(on organic matter basis)

Basis on which digestibility Calculated.	Hay	Silage.
Assumed digestion coefficient. (see Table 16)	63.66%	70.16%
Regression Equation of Crude fibre on digestibility of organic matter (47).	53.57%	51.25%

Both digestibilities were calculated from Chemical Composition of feeds on the organic matter basis as shown in table 24.

**Table 24.** Chemical Composition of Feeds Used.  
(on organic matter basis)

Feed	Percentage Composition of Feed.			
	Crude Protein	Ether Extract	Crude Fibre.	N.F.E.
Hay	6.77	0.86	40.67	51.70
Silage	16.59	1.15	43.08	40.18

It can be seen from Table 23, that the two digestibilities were not only very different from each other but rather conflicting. Based on assumed digestion coefficients, the silage was more digestible than hay, but based on Regression Equation of Crude fibre, the result was the reverse. (This was apparently due to the fact that the silage used had an abnormally high fibre content).

It seems that the digestibility per cents for both hay and silage so calculated were far too high for the feeds actually used, when compared with those obtained through regression coefficient of crude fibre. However, McMeekan's equation was not very adequately applied to the feeds used in the experiment. First, it was developed from crude fibre contents of 50 different feedstuffs. Second, the data for the feedstuffs were from Woodman which were old and of miscellaneous origin. Many fodders were determined "by difference" which is very inaccurate.

2. Another possible source of error in the results of T.D.N. Consumption might have been introduced since only one chemical analysis of the feeds fed in the trial was made, and then used as a basis for calculating the nutrient consumption for the whole experiment. The feeds used were not uniform in quality; the silage offered in Period II, as mentioned earlier, had a low dry matter percentage. Hence the results from the single chemical analysis would only represent the approximate percentage composition of the feeds used.

In this connection, it will be noted (from table 4) that the fibre content of

the silage used was rather high. It was thought that this might arise from an error in chemical analysis, but repeated chemical test with duplicate samples has given similar results. Possibly, it was a sampling error.

The results on body weight changes of the cows on the three rations appear on the whole to parallel the level of dry matter and T.D.N. consumption, especially the former. The cows on hay plus silage, and hay ration both gained for the whole trial an average weight of about 20 lb. (or 2.5 per cent of their initial body weight) as a result of higher dry matter and excessive T.D.N. Consumption. The lower dry matter and T.D.N. consumption for the animals on silage, on the other hand, was reflected in a loss of body weight. They on the average, lost 16 lb. for the three periods or 2 per cent of their initial body weight. This loss of body weight for the silage-fed cows was largely due to the weight loss in Period II. The silage-fed cows on the average gained 9 lb. (or 1.1 per cent of their body weight), in Period I, and only lost 3 lb. in Period III (or 0.4 per cent of body weight). But in Period II, they lost 22 lb. (or 2.7 per cent of body weight). This bigger loss of body weight of silage-fed cows in Period II was possibly the result of low dry matter and T.D.N. consumption in the Period. The silage-fed cows in Period II only consumed on the average 2 per cent of T.D.N. in excess of requirements as compared with 45 per cent for hay-fed cows and 39 per cent for cows on hay plus silage. The average gain or loss in body weight for the cows on the three rations was not strictly in agreement with the average excess in T.D.N. consumption for the three rations as shown in the following:

Average excess in T.D.N. Consumption.			Average gain (+) or loss (-) in body weight.	
Cows on hay plus silage	53%		+	21 lb.
Cows on hay ... ..	45%		+	20 lb.
Cows on silage ... ..	34%		-	16 lb.

The following possible factors responsible for these conflicting results may be suggested:

1. The calculated digestibilities for hay and silage might have been too high for the feeds actually used in the experiment. This error, as discussed before, might have been introduced through the use of assumed digestion coefficients or single chemical analysis of the feeds for the whole trial -- or both.
2. Error arising from Variation in Weight of Cow.

As mentioned earlier, factors such as variation in food intake and water consumption, difference in gut content, stage of growth of the animals and stage of pregnancy etc. made the determination of ration effects on body weight difficult.

A single weight measurement of a cow, according to Bartlett (48), is liable to considerable error owing to the great variation in the gut content, also according to Baker and Guilbert (49) cyclic variations may occur in the day-to-day deviation of cattle weights.

In view of the big variation involved in weighing the cattle, the data on body weights of the cows obtained in this trial through weighing the animals only once weekly would be expected to be subject to large error.

3. Another possible cause arose, in the case of the silage-fed cows, where there was a possible loss of nutrients consumed through scouring. During the whole trial and especially in Period II, the silage-fed cows scoured rather badly. This might be responsible for the loss of body weight. In Period II, for instance, three out of four cows on silage lost weight, one being just able to maintain herself.

4. The fact that cows on hay plus silage and on hay gained little in weight despite of excessive T.D.N. consumption could possibly be explained partly in terms of fat deposition. During the trial, the cows on the two rations put on considerable condition. This fattening would have entailed 2.25 times more energy expenditure than that for growth of muscle since according to Maynard (50) fat has 2.25 times more energy than protein (muscle).

5. Also, according to Forbes et al (44) there is even more difference in the utilisation of the digested nutrients in liberal and scanty rations than there is in the percentage digested. They found the net energy value of a feed was 20 per cent less when steers were fed 2.5 times as much as they required for maintenance than when they received only 1.5 times their maintenance needs. Since the consumption of T.D.N. exceeded requirement considerably in this trial, utilisation of the digested nutrients would be therefore less.

6. Finally, the calculated maintenance requirement based on Morrison's Feeding Standard which only allows for maintenance might have been too low for the cows used all of which except one (Frivolous) were in calf and all except two (Barbara and Toy) were in advanced stage of pregnancy. However, pregnancy does not involve a large increase in energy intake over the maintenance requirement(51).

Although the gain or loss of body weight for the cows on the three rations was not entirely in agreement with T.D.N. Consumption for the three rations and possibly subjected to large error, nevertheless it indicates clearly that silage-fed cows could not maintain themselves as well as the cows on the other two rations.

Hence the results of this trial in general, apart from indicating the respect-



ive limits of a cow's appetite for the three rations in question, and providing a basis for supplying adequate nutrients to dairy cows, show clearly that "bulk" owing to the limit of a cow's appetite is a big problem in providing adequate nutrients to dairy cattle with bulky roughages.

Under the grassland system of farming a situation similar to the problem found in this experiment arises in practice, when quality of pasture is low relative to its quantity production such as in dry summer or poor winter. The cows have to eat large amounts of roughage in order to obtain the necessary nutrients for maintenance and production.

Another analogous problem exists when a dairy cow's nutritive requirement is large relative to the quantity of grass she can eat even high quality grass such as in early lactation, or with high producers. It is believed that the loss of body weight of a cow during her early stage of lactation is due to her inability to consume enough grass to meet the nutritive requirement for her high milk production and consequently draws on her body reserves. It is also believed that the inability of the cows to consume large amounts of roughage in the early months of lactation may be a limiting factor in production.

For increasing utilisation of bulky roughage in practice, the following methods may be suggested:

1. Whenever hay or silage is made, more attention should be paid to the qualitative rather than the quantitative aspect in yield; that is, the aim should be to produce maximum nutrients per pound of roughage, and decrease the bulk of roughage to a minimum. This means that grass for hay or silage should be cut as immature or early as possible.
2. Make the bulky roughages as palatable as possible, i.e. preserve them in such a way that they do not lose all the leaves or become charred and mouldy etc., and therefore unpalatable. Palatability is the most important factor in governing food intake according to Fissmer (23) and Bartlett (52).
3. Whenever possible, feed cows with hay and silage combined, rather than with either one as a sole ration. If a single roughage is fed for maintenance purposes, use hay rather than silage. For supplementing pasture for production purpose, however, silage is a more suitable ration owing to its higher nutritive content on a dry matter basis as compared with hay.
4. Consider the matter of breeding cows which can tolerate a larger quantity of dry matter. This is a matter not entirely out of the question. It is believed that the dairy cows in Denmark consume far more dry matter than the cows do in England. (39).



5. Train cows to increase their dry matter intake.

In England, as a result of "steaming up" practice, the cows, it is said, are gradually acclimatised to high dry matter intake before parturition. Hence, in New Zealand, high plane feeding over the "dry period" for dairy cows may serve the same purpose.

Finally, more information about a cow's appetite and factors affecting it are required before roughage as a feed for dairy cows can be more successfully and efficiently utilised. In the future, investigations on this field may be planned along two lines:

1. the determination of a cow's dry matter intake on various kinds of roughages, single and combined, including dry matter intake on pasture,
2. the study of factors that will affect a cow's appetite for food such as (a) factors inherent in the cow itself (body weight, age, breed, milk production, condition, health, growth, pregnancy, exercise and psychological factors etc.)  
(b) factors inherent in the ration (palatability, digestibility, variety, bulk of ration, amount of food offered and balance and deficiency of rations, etc.)

With a better knowledge of a cow's dry matter intake and factors affecting it, not only nutrient intake of dairy cows can be adequately ensured and utilisation of bulky roughage can be increased, but also nutritional studies for grazing animals (such as determination of digestibility of feeding stuffs, milk production efficiency studies, and comparison of efficiency of rations for dairy cows, etc.) which cannot be adequately investigated so far, can be undertaken.

Section VII.

SUMMARY AND CONCLUSIONS.

1. A dairy cattle feeding experiment was conducted during the winter months of June and July in 1948 to study the dry matter intake of dry Jersey Cows on three roughage rations --
  - 'A' Hay fed ad lib.
  - 'B' Silage fed ad lib.
  - 'C' 30 lb. Silage plus Hay fed ad lib.
2. Twelve Jersey dry cows were used. A design involving the use of two 3 x 3 Latin Squares was employed. The twelve Jersey cows were divided into four groups of three individuals. Each group of cows constituted an independent experiment. The experiment consisted of three two-week experimental periods. The layout was such that each cow in each group received a different ration during each period, and each ration was preceded by each of the other rations an equal number of times throughout the trial.
3. The average daily consumption of dry matter for the entire experiment was:
  - 16.7 ± 0.592 lb. for the cows on hay plus silage ration
  - 16.2 ± 0.561 lb. on hay ration, and
  - 14.0 ± 0.925 lb. on silage ration.The amounts of dry matter consumed daily per 1000 lb. live weight were:
  - 20.3 lb. for hay plus silage ration
  - 19.7 lb. for hay ration, and
  - 17.2 lb. for silage ration.
4. Cows receiving the hay ration or the hay plus silage ration consumed significantly greater amounts of dry matter than did those on silage alone. Cows also consumed more dry matter in the form of hay plus silage than in the form of hay alone, but the difference was not significant on statistical analysis.
5. The total digestible nutrients (T.D.N.) consumption was calculated on the basis of dry matter consumed and chemical analysis of the feeds used. The digestion coefficients were taken from Watson and Horton (37) for hay and for silage from Bears and Sill (18).
6. For the experiment as a whole, the average daily consumption of T.D.N. was
  - 10.2 ± 0.346 lb. for cows on hay plus silage ration.
  - 9.7 ± 0.402 lb. on hay ration, and
  - 9.0 ± 0.630 lb. on silage ration.Per 1000 lb. live weight, the pounds of T.D.N. Consumed per day were:

12.4 lb. for hay plus silage ration

11.8 lb. for hay ration, and

11.0, lb. for silage ration.

7. The cows on hay plus silage ration and those on hay alone consumed considerably more than sufficient nutrients to meet their estimated maintenance requirements and as a result gained weight. This was not the case with the silage-fed cows which on the average could not maintain their body weight, although their average T.D.N. consumption did exceed their maintenance requirement. Reasons are suggested for these conflicting results.

8. The results are discussed in relation to problems of feeding dairy cattle in practice.

9. The two 3 x 3 Latin Squares design employed in this experiment was proved to be suitable for dairy cattle feeding experiment. It was successful in allowing a thorough analysis and interpretation of the results, including the adjustment for carry-over effect of rations.

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Section VIII.

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APPENDIX I.

In the following Appendix are given for each period the detailed data on:

1. daily feed offered
2. daily dry matter percentages of feeds determined
3. daily dry matter offered
4. daily feed refused
5. daily dry matter percentages of refused feeds determined
6. daily dry matter refused
7. daily feed consumed
6. daily dry matter consumed
9. body weight of individual cows
10. daily Meteorological details.

Data on feed and dry matter consumption for Period I are given in tables I to VIII; for Period II in tables IX to XVI; for Period III in tables XVII to XXV.

Data on live weight of cows are given in tables XXVI to XXVIII while daily meteorological details are shown in tables ~~XXIX~~ to XXXI.

TABLE I.

AMOUNT OF FEED (lb) OFFERED DAILY TO INDIVIDUAL COWS AT PERIOD I. (14 days: 15/6/48 - 28/6/48)

Group No.	Cow Name	Ration	15/6	16/6	17/6	18/6	19/6	20/6	21/6	22/6	23/6	24/6	25/6	26/6	27/6	28/6
			DATE													
I	Addy	Hay	25.0	25.0	21.0	22.5	24.5	22.5	23.0	19.0	22.5	26.5	24.0	26.0	22.0	20.5
II	Art	Hay	25.0	25.0	24.5	24.0	25.0	23.5	25.5	23.5	27.0	32.0	27.5	27.0	24.5	25.5
III	Sally	Hay	25.0	25.0	20.0	20.0	22.5	22.5	18.5	23.0	24.0	20.0	22.5	20.0	23.0	20.0
IV	Barbara	Hay	25.0	25.0	20.0	23.0	22.0	21.5	19.0	20.0	22.0	20.0	20.5	21.0	20.0	20.0
I	Yupena	Hay	20.0	20.0	18.0	19.0	21.5	20.0	21.0	18.5	20.0	20.0	21.5	22.0	20.0	16.0
		Silage	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
II	Yuscha	Hay	20.0	20.0	22.5	21.5	23.5	33.0	23.0	20.0	20.0	23.0	26.0	22.0	20.0	20.6
		Silage	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
III	Ynetta	Hay	20.0	20.0	18.0	18.0	18.0	19.0	17.0	16.0	17.5	16.5	17.5	16.0	16.0	15.0
		Silage	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
IV	Frivolous	Hay	20.0	20.0	18.0	18.0	19.5	20.0	17.0	19.0	17.0	16.5	16.5	15.5	15.0	15.0
		Silage	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
I	Katie	Silage	100.0	100.0	90.0	90.0	95.0	100.0	90.0	90.0	80.0	79.0	80.0	80.0	86.0	90.0
II	Tuten	Silage	100.0	100.0	90.0	90.0	90.0	100.0	90.0	90.0	80.0	71.0	80.0	80.0	84.0	90.0
III	Vicky	Silage	100.0	100.0	96.0	90.0	100.0	100.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0
IV	Toy	Silage	100.0	100.0	93.0	90.0	90.0	90.0	90.0	90.0	80.0	70.0	73.0	70.0	64.0	76.0



TABLE II.

DAILY DRY MATTER PERCENTAGES OF FEEDS FOR PERIOD I. (14 days: 15/6/48 - 28/6/48)

Feeds	Sample	Date														Average for Period I.
		15/6	16/6	17/6	18/6	19/6	20/6	21/6	22/6	23/6	24/6	25/6	26/6	27/6	28/6	
HAY	A	83.5	85.2	86.0	86.8	86.5	86.0	84.0	85.0	87.0	87.0	88.0	86.0	84.5	84.5	85.6
	B	84.7	84.6	84.4	86.5	87.0	87.0	83.0	85.5	84.0	88.0	86.5	86.4	86.0	84.6	85.6
	AVERAGE	84.0	84.9	85.2	86.7	86.8	86.5	83.5	85.3	85.5	87.5	87.3	85.7	85.3	84.6	85.6
SILAGE	A	20.8	21.5	22.0	22.0	23.2	23.2	23.0	24.4	25.2	22.8	24.0	22.4	23.2	18.8	22.6
	B	21.6	21.9	22.0	22.6	23.4	23.2	22.8	24.4	25.2	24.8	24.0	22.4	20.4	18.8	22.6
	AVERAGE	21.2	21.7	22.0	22.3	23.3	23.2	22.9	24.4	25.2	23.8	24.0	22.4	21.8	18.8	22.6

TABLE III.

AMOUNT OF DRY MATTER (lb) OFFERED DAILY TO INDIVIDUAL COWS AT PERIOD I. (14 days: 15/6/48 - 28/6/48)

Group No.	Cow Name	Ration	DATE.													
			15/6	16/6	17/6	18/6	19/6	20/6	21/6	22/6	23/6	24/6	25/6	26/6	27/6	28/6
I	Addy	Hay	21.0	21.2	17.9	19.5	21.3	19.5	19.2	16.2	19.2	23.2	21.0	22.3	18.8	17.3
II	Art	Hay	21.0	21.2	20.9	20.8	21.7	20.3	21.3	20.1	23.1	28.0	24.0	23.1	20.9	21.6
III	Sally	Hay	21.0	21.2	17.0	17.3	19.5	19.5	15.5	19.6	20.5	17.5	19.6	17.1	19.6	16.9
IV	Barbara	Hay	21.0	21.2	17.0	19.9	19.1	18.6	15.9	17.1	18.8	17.6	17.9	18.0	17.1	16.9
I	Yupena	Hay	16.8	16.9	15.3	16.5	18.7	17.3	17.5	15.8	17.1	17.5	18.8	18.9	17.1	13.5
		Silage	6.4	6.5	6.6	6.7	7.0	7.0	6.9	7.3	7.6	7.1	7.2	6.7	6.5	5.6
II	Yuscha	Hay	16.3	16.9	19.2	18.6	20.4	23.6	19.2	17.1	17.1	20.1	22.7	18.9	17.1	17.3
		Silage	6.4	6.5	6.6	6.7	7.0	7.0	6.9	7.3	7.6	7.1	7.2	6.7	6.5	5.6
III	Ynetta	Hay	16.8	16.9	15.3	15.6	15.6	16.4	14.2	13.7	15.0	14.4	15.3	13.7	13.7	12.7
		Silage	6.4	6.5	6.6	6.7	7.0	7.0	6.9	7.3	7.6	7.1	7.2	6.7	6.5	5.6
IV	Frivokun	Hay	16.3	16.9	15.3	15.6	16.9	17.3	14.2	16.2	14.5	14.4	14.4	13.3	12.8	12.7
		Silage	6.4	6.5	6.6	6.7	7.0	7.0	6.9	7.3	7.6	7.1	7.2	6.7	6.5	5.6
I	Katie	Silage	21.2	21.7	20.0	20.1	22.1	23.2	20.6	22.0	20.2	18.8	19.2	17.9	18.8	16.9
II	Yuten	Silage	21.2	21.7	20.0	20.1	21.0	23.2	20.6	22.0	20.2	16.9	19.2	22.4	18.3	16.9
III	Vicky	Silage	21.2	21.7	21.1	20.1	23.3	23.2	20.6	22.0	22.7	21.4	21.6	20.2	19.6	16.9
IV	Toy	Silage	21.2	21.7	20.6	20.1	21.0	20.9	20.6	22.0	20.2	16.7	17.5	15.7	14.0	14.3

TABLE. IV.

AMOUNT OF FEED (lb) REFUSED DAILY BY INDIVIDUAL JERSEY COWS AT PERIOD I. (14 days: 15/6/48-28/6/48)

Group No.	Cow Name	Ration	D A T E													
			15/6	16/6	17/6	18/6	19/6	20/6	21/6	22/6	23/6	24/6	25/6	26/6	27/6	28/6
I	Addy	Hay	7.0	10.0	1.0	1.0	2.5	5.0	5.5	2.0	--	3.0	4.0	4.5	5.0	2.5
II	Art	Hay	4.5	3.0	1.0	0.5	1.0	4.0	2.0	2.0	0.5	4.5	10.0	2.5	8.5	1.5
III	Sally	Hay	9.0	10.5	7.0	1.5	4.0	6.0	0.5	4.0	6.5	3.0	3.5	2.0	8.5	3.0
IV	Barbara	Hay	7.0	11.0	0.5	7.0	7.0	12.5	2.0	2.5	2.5	3.0	4.5	3.0	1.5	1.5
I	Yupere	Hay	6.5	9.0	5.5	3.5	8.5	11.5	8.5	0.5	11.0	2.0	11.5	9.0	8.0	6.0
		Silage	--	--	--	--	--	--	--	--	--	--	--	--	--	--
II	Yuscha	Hay	3.0	2.5	5.0	1.0	1.5	13.0	4.0	3.5	6.0	2.5	10.5	5.5	8.0	6.5
		Silage	--	--	--	--	--	--	--	--	--	1.0	--	--	--	--
III	Ynetta	Hay	8.5	10.0	7.5	6.5	8.5	9.5	1.5	3.5	13.0	3.0	8.0	4.0	7.5	0.5
		Silage	--	1.0	1.0	1.0	--	--	--	--	--	--	--	--	--	--
IV	Privolous	Hay	6.5	5.0	6.5	10.0	2.0	1.5	5.5	5.0	7.5	11.0	7.5	5.5	9.5	1.0
		Silage	--	--	--	--	--	--	--	1.0	--	--	--	--	--	--
I	Katie	Silage	16.0	28.0	18.0	18.0	19.5	11.0	17.5	32.0	20.0	16.5	11.5	9.0	14.5	14.5
II	Yuten	Silage	14.0	22.0	12.5	16.5	17.0	22.5	14.0	19.0	11.0	2.0	3.5	1.0	4.0	2.5
III	Vicky	Silage	14.0	13.5	14.5	15.0	22.5	25.5	8.0	14.0	17.5	11.0	13.5	9.5	5.0	5.0
IV	Toy	Silage	18.0	24.5	24.0	25.5	11.5	40.0	31.0	31.0	36.0	21.0	9.5	11.5	6.0	1.5

TABLE V.

DAILY DRY MATTER PERCENTAGES OF REFUSED FEEDS FOR PERIOD I. (14 days: 15/6/48-28/6/48)

Ration Cow Re- ceived.	Refused by Cow-	Refuse Sample	D a t e.													
			15/6	16/6	17/6	18/6	19/6	20/6	21/6	22/6	23/6	24/6	25/6	26/6	27/6	28/6
HAY	Addy	Hay	82.0	79.0	83.0	82.0	82.0	83.5	84.0	83.0	83.7	84.0	86.0	81.0	82.0	82.7
	Art	Hay	80.5	80.0	83.0	82.0	82.5	82.0	83.0	83.0	83.7	83.0	84.0	82.5	80.5	82.7
	Sally	Hay	82.0	83.0	82.5	80.0	83.0	82.0	80.0	80.0	83.0	83.0	83.0	82.0	79.0	78.6
	Barbara	Hay	82.5	81.0	83.0	83.0	80.0	82.5	82.0	79.5	81.0	79.0	79.0	80.5	80.0	78.6
HAY	Yupena	Hay	81.5	82.0	83.0	82.0	83.0	84.0	84.0	83.0	84.5	84.0	83.5	82.5	82.0	83.5
		Silage	---	---	---	---	---	---	---	---	---	---	---	---	---	---
AND	Yuscha	Hay	80.0	84.0	84.0	82.0	82.5	84.0	82.0	83.0	83.0	83.5	84.5	84.0	81.5	82.0
		Silage	---	---	---	---	---	---	---	---	---	23.6	---	---	---	---
SILAGE	Ynetta	Hay	80.0	83.0	83.5	78.0	81.0	83.0	80.0	79.5	79.0	80.0	77.0	79.0	82.0	78.6
		Silage	---	21.0	20.6	23.0	---	---	---	---	---	---	---	---	---	---
	Frivolous	Hay	79.6	83.5	80.0	80.0	81.0	82.5	78.0	79.0	83.0	81.0	80.0	78.0	80.0	78.6
		Silage	---	---	---	---	---	---	---	23.8	---	---	---	---	---	---
SILAGE	Katie	Silage	21.2	22.8	22.0	22.3	23.2	23.2	24.6	25.2	26.8	24.0	23.6	21.6	22.0	18.0
	Yuten	Silage	20.2	21.6	22.2	22.5	22.8	22.8	24.8	25.0	25.6	23.2	22.8	21.6	22.4	18.0
	Vicky	Silage	20.4	20.8	20.0	22.4	22.8	23.2	24.8	23.2	25.2	24.0	20.8	22.6	22.2	18.0
	Toy	Silage	20.8	21.2	21.2	22.3	23.1	23.6	25.2	24.4	26.0	24.4	21.6	22.0	21.6	18.0

N.B. Figures in red were the average of the dry matter percentages determined from other cows' refused feeds.



TABLE VI.

AMOUNT OF DRY MATTER (lb) REFUSED DAILY BY INDIVIDUAL COWS  
AT PERIOD I. (14 days: 15/6/48 - 28/6/48)

Group No.	Cow Name.	Ration.	DATE.													
			15/6	16/6	17/6	18/6	19/6	20/6	21/6	22/6	23/6	24/6	25/6	26/6	27/6	28/6
I	Addy	Hay	5.7	7.9	0.8	0.8	2.1	4.2	4.6	1.7	---	8.5	3.4	3.7	4.1	2.1
II	Art	Hay	3.6	2.4	0.8	0.4	0.8	3.3	1.7	1.7	0.4	3.7	8.4	2.1	6.8	1.2
III	Sally	Hay	7.4	8.7	5.8	1.2	3.3	4.9	0.4	3.2	5.4	2.5	2.9	1.6	6.7	2.4
IV	Barbara	Hay	5.8	8.9	0.4	5.8	5.6	10.3	1.6	2.0	2.0	2.5	3.6	2.4	1.2	1.2
I	Yupena	Hay	5.3	7.4	4.6	2.9	7.1	9.7	7.1	0.4	9.3	1.7	9.6	7.4	6.6	5.0
		Silage	---	---	---	---	---	---	---	---	---	---	---	---	---	---
II	Yuscha	Hay	2.4	2.1	4.2	0.8	1.2	12.6	3.3	2.9	5.0	2.1	8.9	4.6	6.5	5.3
		Silage	---	---	---	---	---	---	---	---	---	0.2	---	---	---	---
III	Ynetta	Hay	6.8	8.3	6.3	5.1	6.9	7.9	1.2	4.4	10.3	2.4	6.2	3.2	6.2	0.4
		Silage	---	0.2	0.2	0.2	---	---	---	---	---	---	---	---	---	---
IV	Frivolous	Hay	5.2	4.2	5.2	8.0	1.6	1.3	4.3	4.0	6.2	8.9	6.0	4.3	7.6	0.3
		Silage	---	---	---	---	---	---	---	0.2	---	---	---	---	---	---
I	Katie	Silage	3.4	6.4	4.0	4.0	4.5	2.6	4.3	8.1	5.4	4.0	2.7	1.9	3.2	2.6
II	Yuten	Silage	2.9	4.8	2.8	3.7	3.9	5.1	3.5	4.8	2.8	0.5	0.8	0.2	0.9	0.3
III	Vicky	Silage	2.9	2.8	2.9	3.4	5.1	5.9	2.0	3.3	4.4	2.5	2.8	2.2	1.1	0.9
IV	Toy	Silage	3.7	5.2	5.1	5.7	2.7	9.4	7.3	7.5	9.4	5.1	2.1	2.5	1.3	0.3

TABLE VII.

AMOUNT OF FEED CONSUMED (lb) DAILY BY INDIVIDUAL COWS AT PERIOD I. (14 days: 15/6/48 - 28/6/48)

Group No.	Cow Name.	av. Live Wt. for Period.	Ration	D A T E														Av. daily consumption of 14 day of 4 cows.
				15/6	16/6	17/6	18/6	19/6	20/6	21/6	22/6	23/6	24/6	25/6	26/6	27/6	28/6	
I	Addy	738	Hay	18.0	15.0	20.0	21.5	22.0	17.5	17.5	17.0	22.5	23.5	20.0	21.5	17.0	18.0	19.4
II	Art	840	Hay	20.5	22.0	23.5	23.5	24.0	19.5	23.5	21.5	26.5	27.5	17.5	24.5	16.0	24.0	22.4
III	Sally	864	Hay	16.0	14.5	13.0	18.5	18.5	16.5	18.0	19.0	17.5	17.0	19.0	18.0	14.5	17.0	16.9
IV	Barbara	716	Hay	18.0	14.0	19.5	16.0	15.0	9.0	17.0	17.5	19.5	17.0	16.0	18.0	18.5	18.5	16.7
I	Yupena	775	Hay	13.5	11.0	12.5	15.5	13.0	8.5	12.5	18.0	9.0	18.0	10.0	13.0	12.0	10.0	12.6
			Silage	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
II	Yuscha	840	Hay	17.0	17.5	17.5	20.5	22.0	18.0	19.0	16.5	14.0	20.5	15.5	16.5	12.0	13.5	17.1
			Silage	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	29.0	30.0	30.0	30.0	30.0	30.0
III	Ynetta	853	Hay	11.5	10.0	10.5	11.5	9.5	8.5	15.5	10.5	4.5	13.5	9.5	12.0	9.0	14.5	10.8
			Silage	30.0	29.0	29.0	29.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	29.8
IV	Frivolous	777	Hay	13.5	15.0	11.5	8.0	17.5	18.5	11.5	14.0	9.5	5.5	9.0	10.0	5.5	14.0	11.6
			Silage	30.0	30.0	30.0	30.0	30.0	30.0	30.0	29.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
I	Katie	743	Silage	84.0	72.0	72.0	72.0	75.5	89.0	72.5	58.0	60.0	63.5	63.5	71.0	61.5	75.5	71.0
II	Yuten	858	Silage	86.0	78.0	77.5	73.5	73.0	77.5	76.0	71.0	69.0	69.0	76.5	79.0	80.0	87.5	76.7
III	Vicky	884	Silage	86.0	86.5	81.5	75.0	77.5	74.5	82.0	76.0	72.5	79.0	76.5	80.5	85.0	85.0	79.8
IV	Toy	784	Silage	82.0	75.5	69.0	64.5	78.5	50.0	59.0	59.0	44.0	49.0	63.5	58.5	58.0	74.5	63.2

TABLE VIII.

AMOUNT OF DRY MATTER (lb) CONSUMED DAILY BY INDIVIDUAL COWS AT PERIOD I. (14 days: 15/6/48-28/6/48)

Group No.	Cow Name	Av. Live Wt. for Period	Ration	DATE														Av. daily consumption of each cow.	Av. daily consumption of 14 days of 4 cows.
				15/6	16/6	17/6	18/6	19/6	20/6	21/6	22/6	23/6	24/6	25/6	26/6	27/6	28/6		
I	Addy	738	Hay	15.3	13.3	17.1	13.7	19.2	15.3	14.6	14.5	19.2	20.7	17.6	13.6	14.7	15.2	15.7	16.5
II	Art	840	Hay	17.4	18.8	20.1	20.4	20.9	17.0	19.6	18.4	22.7	24.3	15.6	21.0	14.1	20.4	19.3	
III	Sally	864	Hay	13.6	12.5	11.2	16.1	16.2	14.6	15.1	16.4	15.1	15.0	16.7	15.5	12.9	14.5	14.7	
IV	Barbara	716	Hay	13.2	12.3	13.3	14.1	13.5	3.3	14.3	15.1	16.3	15.0	14.3	13.6	15.9	15.7	14.5	
I	Yupena	775	Hay	11.5	9.5	10.7	13.6	11.6	7.6	10.4	15.4	7.8	15.3	9.2	11.5	10.5	9.5	11.0	18.5
			Silage	6.4	6.5	6.6	6.7	7.0	7.0	6.9	7.3	7.6	7.1	7.2	6.7	6.5	5.6	6.8	
II	Yuscha	840	Hay	14.4	14.3	15.0	17.8	19.2	16.0	15.9	14.2	12.1	13.0	13.8	14.3	10.6	12.0	14.9	
			Silage	6.4	6.5	6.6	6.7	7.0	7.0	6.9	7.3	7.6	6.9	7.2	6.7	6.5	5.6	6.8	
III	Ynetta	853	Hay	10.6	8.8	9.0	10.5	3.7	8.5	13.0	9.3	4.7	12.0	9.1	10.5	7.5	12.3	9.6	
			Silage	6.4	6.3	6.4	6.5	7.0	7.0	6.9	7.3	7.6	7.1	7.2	6.7	6.5	5.6	6.8	
IV	Privolous	777	Hay	11.5	12.7	10.1	7.6	15.3	13.0	9.9	12.2	8.3	5.5	8.4	9.0	5.2	11.9	10.3	
			Silage	6.4	6.5	6.6	6.7	7.0	7.0	6.9	7.1	7.6	7.1	7.2	6.7	6.5	5.6	6.8	
I	Katie	748	Silage	17.3	15.3	16.0	16.1	17.6	20.6	13.3	13.9	14.8	14.8	16.5	16.0	15.6	14.3	16.1	16.5
II	Yuten	858	Silage	18.3	16.9	17.2	13.4	17.1	18.1	17.1	17.2	17.4	16.4	13.4	22.2	17.4	16.4	17.6	
III	Vicky	884	Silage	18.3	18.9	18.2	16.7	18.2	17.3	18.6	18.7	18.3	18.8	18.8	18.0	18.5	16.0	18.1	
IV	Toy	784	Silage	17.5	16.5	15.4	14.4	18.3	11.5	12.8	14.4	10.3	11.6	15.4	13.2	12.7	14.0	14.2	



TABLE IX.

AMOUNT OF FEEDS (lb) OFFERED DAILY TO INDIVIDUAL COWS AT PERIOD II. (14 days: 29/6/43-12/7/43)

Group No.	Cow Name.	Ration.	DATE													
			29/6	30/6	1/7	2/7	3/7	4/7	5/7	6/7	7/7	8/7	9/7	10/7	11/7	12/7
I	Yupena	Hay	26.5	26.0	21.0	21.0	21.0	24.5	21.5	22.0	25.0	23.5	29.0	23.5	26.5	25.0
II	Yuscha	Hay	30.0	26.5	29.0	29.5	29.5	25.0	27.5	26.5	27.0	25.5	28.0	25.5	30.5	27.0
III	Vicky	Hay	23.5	20.5	20.0	19.0	20.0	20.0	17.0	20.0	22.5	19.0	20.0	22.0	23.0	21.0
IV	Toy	Hay	22.5	19.0	15.0	15.0	16.0	13.0	17.0	19.5	20.0	19.0	18.0	20.0	22.0	18.5
I	Katie	Hay	18.0	20.0	16.0	17.0	16.5	15.0	14.5	17.0	16.0	15.0	15.0	15.0	16.0	16.0
		Silage	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
II	Yuten	Hay	19.0	20.0	16.5	17.0	18.0	15.0	15.0	18.0	16.5	17.5	17.0	15.0	19.5	19.0
		Silage	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
III	Sally	Hay	16.5	15.0	15.5	15.0	15.0	19.0	15.0	15.0	15.5	15.0	14.0	15.5	15.0	15.0
		Silage	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
IV	Barbara	Hay	18.0	15.0	15.0	15.0	15.0	16.0	15.0	16.0	14.0	14.0	13.5	13.0	14.0	14.0
		Silage	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
I	Addy	Silage	97.0	100.0	100.0	92.0	90.0	70.0	45.0	50.0	50.0	50.0	50.0	40.0	52.0	50.0
II	Art	Silage	111.5	107.0	113.5	110.0	100.0	80.0	85.0	93.0	90.0	93.0	90.0	100.0	97.5	91.0
III	Ynetta	Silage	84.0	100.0	76.5	80.0	74.0	70.0	60.0	60.0	60.0	60.0	65.0	60.0	70.0	70.0
IV	Mrivolous	Silage	84.0	100.0	100.0	100.0	82.0	70.0	64.5	68.0	70.0	63.0	75.0	75.0	80.0	72.0



TABLE. X.

DAILY DRY MATTER PERCENTAGES OF FEEDS FOR PERIOD II. (14 days: 29/6/48 - 12/7/48)

Feeds	Sample	D A T E														Average for the Period
		29/6	30/6	1/7	2/7	3/7	4/7	5/7	6/7	7/7	8/7	9/7	10/7	11/7	12/7	
HAY	A	86.0	85.5	85.0	83.0	85.0	85.4	86.5	84.5	85.0	85.0	84.0	86.5	84.5	85.0	85.0
	B	86.0	86.0	85.0	83.0	87.0	86.5	87.0	86.0	84.4	84.0	85.0	84.0	84.5	84.0	85.2
	Average	86.0	85.8	84.0	83.0	86.0	85.0	86.8	85.3	84.7	84.5	84.5	85.3	84.5	84.5	85.1
SILAGE	A	13.8	14.8	20.0	17.6	18.0	18.6	16.4	18.4	17.6	17.6	18.0	17.6	18.2	20.0	17.6
	B	14.0	16.2	17.0	17.2	17.9	18.8	18.8	16.8	18.0	16.8	17.6	18.4	19.8	20.0	17.6
	Average	13.9	15.5	18.5	17.4	17.9	18.7	17.6	17.6	17.8	17.2	17.8	18.0	19.0	20.0	17.6

Table XI.

AMOUNT OF DRY MATTER (lb) OFFERED DAILY TO INDIVIDUAL COWS AT PERIOD II. (14 days: 29/6/48 - 12/7/48)

Group No.	Cow Name	Ration.	DATE													
			29/6	30/6	1/7	2/7	3/7	4/7	5/7	6/7	7/7	8/7	9/7	10/7	11/7	12/7
I	Yupena	Hay	22.3	22.3	17.5	17.4	19.1	21.1	18.7	18.8	19.5	19.9	24.5	20.1	22.4	21.1
II	Yuscha	Hay	25.8	22.7	24.4	24.5	25.4	22.4	23.9	22.6	22.9	21.6	23.7	21.3	25.3	22.8
III	Vicky	Hay	20.2	17.6	16.8	15.8	17.2	17.2	14.8	17.1	19.1	18.1	16.9	18.8	19.4	17.8
IV	Toy	Hay	19.4	18.3	18.1	12.5	13.8	15.5	14.8	16.6	16.9	16.1	15.2	17.1	18.6	18.6
I	Katie	Hay	16.5	17.2	13.4	14.1	14.2	12.9	12.6	14.5	13.6	12.7	12.7	12.8	13.5	13.5
		Silage	4.2	4.7	5.6	5.2	5.4	5.6	5.3	5.3	5.3	5.2	5.3	5.4	5.7	6.0
II	Yuten	Hay	16.3	17.2	13.9	14.1	15.5	12.9	13.0	13.7	14.0	14.3	14.4	12.8	16.5	16.1
		Silage	4.2	4.7	5.6	5.2	5.4	5.6	5.3	5.3	5.3	5.2	5.3	5.4	5.7	6.0
III	Sally	Hay	14.2	12.9	13.0	12.8	12.9	16.3	13.0	12.8	13.1	12.7	11.8	13.2	12.7	12.7
		Silage	4.2	4.7	5.6	5.2	5.4	5.6	5.3	5.3	5.3	5.2	5.3	5.4	5.7	6.0
IV	Barbara	Hay	15.5	12.9	12.6	12.5	12.9	13.8	11.3	12.8	11.9	11.8	14.1	11.1	11.8	11.8
		Silage	4.2	4.7	5.6	5.2	5.4	5.6	5.3	5.3	5.3	5.2	5.3	5.4	5.7	6.0
I	Addy	Silage	13.5	15.5	18.5	16.0	15.1	13.1	7.9	8.8	8.9	8.6	8.9	7.2	9.9	10.0
II	Art	Silage	15.5	16.6	21.0	19.1	17.9	15.0	15.0	16.4	16.0	16.0	16.0	13.0	18.5	18.2
III	Ynetta	Silage	11.7	15.5	14.2	13.9	13.3	13.1	8.8	8.8	8.9	8.6	9.8	9.0	13.3	14.0
IV	Prudence	Silage	11.7	15.5	18.5	17.4	14.7	13.1	13.5	12.0	12.5	11.7	13.4	13.5	15.2	14.0

TABLE XII.

AMOUNT OF FEEDS (lb) REFUSED DAILY BY TWELVE INDIVIDUAL COWS AT PERIOD II.  
(14 days: 29/6/43 - 12/7/48)

Group No.	Cow Name	Ration	DATE													
			29/6	30/6	1/7	2/7	3/7	4/7	5/7	6/7	7/7	8/7	9/7	10/7	11/7	12/7
I	Yupena	Hay	3.0	5.5	3.5	1.0	0.5	4.5	1.5	1.0	0.5	5.0	4.5	3.5	1.5	3.0
II	Yuscha	Hay	2.0	8.0	4.0	2.5	4.0	5.0	3.0	5.0	1.0	5.5	1.5	3.5	2.5	9.5
III	Vicky	Hay	7.5	3.0	3.5	1.5	2.0	4.0	1.5	0.5	5.0	1.5	6.5	1.5	4.0	3.0
IV	Toy	Hay	7.5	4.5	4.5	1.5	0.5	4.0	2.5	1.5	4.0	2.5	2.5	3.0	4.0	2.5
I	Katie	Hay	3.0	11.0	5.0	2.5	5.0	7.0	4.0	4.5	5.0	9.5	3.5	7.0	5.0	7.5
		Silage	2.0	---	---	---	---	---	---	---	---	---	---	---	---	---
II	Yuten	Hay	1.5	8.0	1.5	2.5	5.5	4.0	0.5	1.0	0.5	7.5	2.5	0.5	1.5	4.0
		Silage	2.0	3.0	1.0	---	---	---	---	---	---	---	---	---	---	---
III	Sally	Hay	3.0	3.0	1.0	3.0	5.5	12.0	3.5	4.0	4.5	4.0	3.0	2.5	3.5	3.5
		Silage	---	---	---	---	---	---	---	---	---	---	---	---	---	---
IV	Barbara	Hay	6.0	3.0	3.5	3.5	4.5	8.0	6.5	4.0	4.5	5.0	3.5	4.5	5.0	7.5
		Silage	---	---	---	---	---	---	---	---	---	1.0	---	---	---	---
I	Addy	Silage	4.0	19.0	18.0	25.5	53.5	42.0	1.0	11.0	10.0	9.5	14.0	10.0	15.0	7.5
II	Art	Silage	4.0	7.0	14.5	10.0	35.5	17.0	17.0	13.5	12.0	13.0	5.0	15.0	15.0	9.0
III	Yetta	Silage	2.0	36.0	11.0	24.0	28.5	46.0	18.0	14.0	15.0	19.0	15.5	5.5	16.0	43.0
IV	Privolous	Silage	4.0	11.0	8.5	32.0	36.5	25.0	26.0	17.0	22.0	12.0	5.0	12.5	22.5	16.5

TABLE XIII.

DAILY DRY MATTER PERCENTAGES OF REFUSED FEEDS FOR PERIOD II. (14 days: 29/6/48 - 12/7/48)

Ration Cow Re- ceived.	Refused By Cow -	Refuse Sample	DATE.													
			29/6	30/6	1/7	2/7	3/7	4/7	5/7	6/7	7/7	8/7	9/7	10/7	11/7	12/7
HAY	Yupena	Hay	83.0	83.5	82.0	81.0	81.4	83.0	85.0	82.3	83.0	79.0	83.0	79.0	79.0	81.5
	Yuscha	Hay	83.7	84.0	82.0	81.0	82.0	82.0	85.0	82.6	83.0	84.0	83.0	78.7	79.0	83.0
	Vicky	Hay	78.0	79.5	80.0	77.0	81.0	82.0	81.7	80.7	80.0	77.0	81.0	77.7	82.0	82.0
	Toy	Hay	80.0	81.0	78.0	78.0	81.0	83.0	81.7	80.7	82.0	77.0	80.0	78.5	81.0	77.6
HAY AND SILAGE.	Katie	Hay	84.5	82.0	80.0	81.0	82.0	82.5	85.0	82.0	83.0	82.5	83.0	78.5	79.0	80.0
		Silage	14.0	---	---	---	---	---	---	---	---	---	---	---	---	---
	Yuten	Hay	83.7	84.0	81.0	81.0	80.4	83.0	85.0	82.3	83.0	84.0	83.0	78.7	79.0	80.0
		Silage	14.0	16.3	18.4	---	---	---	---	---	---	---	---	---	---	---
	Sally	Hay	80.0	80.0	79.0	80.0	79.0	77.0	82.0	81.4	77.0	76.0	80.0	77.7	77.6	75.0
		Silage	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Barbara	Hay	82.0	80.0	78.0	78.0	83.0	79.0	81.5	80.0	78.0	78.0	79.0	77.0	70.0	76.0
		Silage	---	---	---	---	---	---	---	---	---	17.3	---	---	---	---
SILAGE.	Addy	Silage	14.0	16.6	17.2	18.6	17.8	17.2	17.2	19.2	20.8	21.6	17.6	20.4	20.0	19.0
	Art	Silage	14.0	16.0	19.6	18.4	18.0	16.8	17.2	18.8	19.6	20.0	17.8	21.0	19.2	19.6
	Ynetta	Silage	13.6	16.0	17.4	17.8	17.9	16.0	17.8	19.2	18.4	17.0	17.6	18.2	19.6	18.6
	Privolous	Silage	13.6	16.8	16.8	18.4	17.6	17.2	17.6	20.0	19.6	17.6	17.2	18.2	19.0	19.2

N.B. Figures in red were the average of dry matter percentages determined from other cows' refused feeds.



TABLE XIV.

AMOUNT OF DRY MATTER (lb) REFUSED DAILY BY INDIVIDUAL COWS AT PERIOD II. (14 days: 29/6/48-12/7/48)

Group No.	Cow Name.	Ration	DATE													
			29/6	30/6	1/7	2/7	3/7	4/7	5/7	6/7	7/7	8/7	9/7	10/7	11/7	12/7.
I	Yupena	Hay	2.5	4.6	2.9	0.8	0.4	3.7	1.3	0.8	3.4	4.0	3.7	2.3	1.2	2.4
II	Yuscha	Hay	1.7	6.7	3.5	2.0	3.3	4.1	2.6	4.1	0.8	4.6	1.3	2.8	2.0	7.9
III	Vicky	Hay	5.9	2.4	2.8	1.2	1.6	3.3	1.2	0.4	4.0	1.2	5.3	1.2	3.5	2.5
IV	Toy	Hay	6.0	3.7	3.5	1.2	0.4	3.3	2.0	1.2	3.3	1.9	2.0	2.4	3.2	1.9
I	Katie	Hay	2.6	9.0	4.0	2.0	4.1	8.8	3.4	3.7	4.2	7.8	2.9	5.5	4.0	6.0
		Silage	0.3	---	---	---	---	---	---	---	---	---	---	---	---	---
II	Yuten	Hay	1.3	6.7	1.2	2.0	4.4	3.3	0.4	0.8	0.4	6.3	2.1	0.4	1.2	3.2
		Silage	0.3	0.5	0.2	---	---	---	---	---	---	---	---	---	---	---
III	Sally	Hay	2.4	2.4	0.8	2.4	4.4	9.2	2.9	3.3	3.5	3.0	2.4	1.9	2.7	2.6
		Silage	---	---	---	---	---	---	---	---	---	---	---	---	---	---
IV	Barbara	Hay	4.5	2.4	2.7	2.7	3.7	6.3	5.3	3.2	3.5	3.9	2.8	3.5	3.5	5.7
		Silage	---	---	---	---	---	---	---	---	---	0.2	---	---	---	---
I	Addy	Silage	0.6	3.2	3.1	4.7	9.5	7.2	0.2	2.1	2.1	2.1	2.5	2.0	3.0	1.4
II	Art	Silage	0.6	1.1	2.8	1.8	6.4	2.9	2.9	2.5	2.4	2.6	0.9	3.2	2.9	1.8
III	Ynetta	Silage	0.3	5.6	1.9	4.3	5.1	7.4	3.2	2.7	2.8	3.2	2.7	1.0	3.1	7.9
IV	Prividous	Silage	0.5	1.9	1.4	5.9	6.4	4.3	4.6	3.4	4.3	2.1	0.9	2.3	4.3	3.2

TABLE XV.

AMOUNT OF FEED (lb) CONSUMED DAILY BY INDIVIDUAL COWS AT PERIOD II. (14 days: 29/6/48-12/7/48)

Group No.	Cow Name.	Av. Live Wt. for Period (lb)	Ration	DATE														Av. daily consumption of 14 days of each cow.	Av. Daily consumption of 14 days of 4 cows
				29/6	20/6	1/7	2/7	3/7	4/7	5/7	6/7	7/7	8/7	9/7	10/7	11/7	12/7		
I	Yupena	796	Hay	23.5	20.5	17.5	20.0	20.5	20.0	20.0	21.0	22.5	18.5	24.5	20.0	25.0	22.0	21.1	19.4
II	Yuscha	872	Hay	28.0	18.5	25.0	27.0	25.5	21.0	24.5	21.5	26.5	20.0	26.5	22.0	23.0	17.5	23.7	
III	Vicky	905	Hay	16.0	17.5	16.5	17.5	18.0	16.0	15.5	19.5	17.5	17.5	13.5	20.5	19.0	18.0	17.3	
IV	Toy	800	Hay	18.0	14.5	13.5	13.5	15.5	14.0	14.5	18.0	16.0	16.5	15.5	17.0	13.0	16.0	15.5	
I	Katie	783	Hay	15.0	9.0	11.0	14.5	11.5	8.0	10.5	12.5	11.0	5.5	11.5	8.0	11.0	8.5	10.5	HAY 11.6
			Silage	28.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	
II	Yuten	903	Hay	17.5	12.0	15.0	14.5	12.5	11.0	14.5	15.0	16.0	10.0	14.5	14.5	18.0	15.0	14.3	
			Silage	28.0	27.0	29.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	29.6	
III	Sally	885	Hay	13.5	12.0	14.5	12.0	9.5	7.0	11.5	11.0	11.0	11.0	11.0	13.0	11.5	11.5	11.4	SILAGE 29.6
			Silage	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	
IV	Barbara	730	Hay	12.0	12.0	11.5	11.5	10.5	8.0	6.5	11.0	9.5	9.0	10.0	8.5	9.0	6.5	9.7	
			Silage	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	29.0	30.0	30.0	30.0	30.0	30.0	
I	Addy	743	Silage	93.0	81.0	82.0	66.5	36.5	28.0	44.0	39.0	40.0	40.5	36.0	30.0	37.0	42.5	49.7	60.0
II	Art	855	Silage	106.5	100.0	99.0	100.0	64.5	63.0	68.0	79.5	78.0	80.0	85.0	85.0	82.5	82.0	83.8	
III	Ynetta	847	Silage	82.0	64.0	65.5	56.0	45.5	24.0	32.0	36.0	35.0	31.0	39.5	44.5	54.0	27.0	45.4	
IV	Privdas	778	Silage	80.0	89.0	91.5	68.0	46.5	45.0	38.5	51.0	43.0	56.0	70.0	52.5	57.5	55.5	61.3	

TABLE XVI.

AMOUNT OF DRY MATTER (lb) CONSUMED DAILY BY INDIVIDUAL COWS AT PERIOD II. (14 days: 29/6/48-12/7/48)

Group No.	Cow Name.	Av. Live Wt. for Period	Ration	D A T E														Av. daily consumption of 14 days of each cow.	Av. daily consumption of 14 days of 4 cows.
				29/6	30/6	1/7	2/7	3/7	4/7	5/7	6/7	7/7	8/7	9/7	10/7	11/7	12/7		
I	Yupena	796	Hay	20.3	17.7	13.7	16.6	17.7	17.4	17.4	18.0	19.1	15.9	20.8	17.3	21.2	18.7	18.0	16.6
II	Yuscha	872	Hay	24.1	16.0	21.1	22.5	22.1	18.5	21.5	18.5	22.1	17.0	23.4	19.0	23.9	14.9	20.2	
III	Vicky	905	Hay	14.3	15.2	14.0	14.6	15.6	13.9	18.6	16.7	15.1	14.9	11.6	17.6	16.1	15.3	14.9	
IV	Toy	800	Hay	13.4	12.6	11.6	11.3	13.4	12.2	12.8	15.4	13.6	14.2	8.2	14.7	15.4	13.7	13.4	
I	Katie	783	Hay	12.9	8.2	9.4	12.1	10.1	7.1	9.2	10.8	9.4	4.9	9.8	7.3	9.5	7.5	9.1	15.3
			Silage	3.9	4.7	5.8	5.2	5.4	5.6	5.3	5.3	5.3	5.2	5.3	5.4	5.7	6.0	5.3	
II	Yuten	903	Hay	15.0	10.5	12.7	18.1	11.1	9.6	12.6	12.9	13.6	8.5	2.3	12.4	15.3	12.9	12.3	
			Silage	3.9	4.2	5.4	5.2	5.4	5.6	5.3	5.3	5.8	5.2	5.3	5.4	5.7	6.0	5.2	
III	Sally	885	Hay	11.8	10.5	12.2	10.1	8.5	7.1	10.1	9.5	9.6	9.7	9.4	11.3	10.0	10.1	10.0	
			Silage	4.2	4.7	5.6	5.2	5.4	5.6	5.3	5.3	5.3	5.2	5.3	5.4	5.7	6.0	5.3	
IV	Barbara	730	Hay	10.6	10.5	9.9	9.8	9.2	7.5	6.0	9.6	8.4	7.9	1.3	7.6	8.3	6.1	8.8	
			Silage	4.2	4.7	5.6	5.2	5.4	5.6	5.3	5.3	5.3	5.0	5.3	5.4	5.7	3.0	5.3	
I	Addy	743	Silage	12.9	12.3	15.4	11.3	6.6	5.9	7.7	6.7	6.8	6.5	6.4	5.2	6.9	8.6	8.5	10.5
II	Art	855	Silage	14.9	15.5	18.2	17.3	11.5	12.1	12.1	13.9	13.6	13.4	15.1	14.8	15.6	16.4	14.6	
III	Ynetta	847	Silage	11.4	9.7	12.3	9.6	8.2	5.7	5.6	6.1	6.1	5.4	7.1	8.0	10.2	6.1	8.0	
IV	Fridous	778	Silage	11.2	13.6	17.1	11.5	8.3	8.8	8.9	8.6	8.2	9.6	12.5	11.2	10.9	10.8	10.8	



TABLE XVII.

AMOUNT OF FEEDS (lb) OFFERED DAILY TO INDIVIDUAL COWS AT PERIOD III. (14 days: 13/7/48-26/7/48)

Group No.	Cow Name.	Ration	DATE													
			13/7	14/7	15/7	16/7	17/7	18/7	19/7	20/7	21/7	22/7	23/7	24/7	25/7	26/7.
I	Katie	Hay	23.5	20.0	20.0	20.0	20.5	23.0	22.0	20.5	22.5	21.5	23.0	24.0	22.0	26.5
II	Yuten	Hay	24.5	22.0	24.5	25.0	24.0	23.0	24.0	24.5	24.5	25.0	25.0	25.0	25.5	27.0
III	Ynetta	Hay	23.5	20.0	21.5	19.0	20.5	21.0	24.0	21.0	21.0	21.0	20.0	20.0	22.0	22.5
IV	Frivolous	Hay	23.0	19.0	20.5	19.0	20.5	19.0	20.0	19.5	20.5	19.5	19.5	20.0	20.5	22.0
I	Addy	Hay	17.5	15.0	15.5	15.5	15.0	15.0	14.5	17.0	16.0	14.5	15.5	16.0	16.5	18.0
		Silage	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
II	Art	Hay	19.5	17.0	16.0	16.0	18.0	15.0	15.0	13.5	16.0	16.5	16.5	17.0	16.5	16.5
		Silage	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
III	Vicky	Hay	16.0	13.0	16.0	19.0	18.0	17.0	18.0	15.5	15.5	16.0	18.5	16.0	17.5	17.5
		Silage	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
IV	Toy	Hay	13.0	14.0	13.0	15.0	14.0	15.0	14.0	13.5	14.0	13.0	15.0	14.0	14.5	14.5
		Silage	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
I	Yupena	Silage	83.5	78.0	80.0	84.0	92.0	88.5	84.0	72.0	80.0	72.5	66.5	37.0	87.0	89.5
II	Yuscha	Silage	104.0	97.0	107.0	106.0	100.0	95.0	104.0	110.0	93.5	80.0	92.5	112.5	107.0	99.0
III	Sally	Silage	86.5	84.5	73.0	86.0	88.0	89.0	80.0	81.5	81.0	78.0	79.0	82.0	100.0	97.0
IV	Barbara	Silage	80.0	75.0	87.0	81.0	82.0	81.0	75.0	73.5	70.0	63.0	69.0	65.0	73.0	83.0



TABLE XVIII.

DAILY DRY MATTER PERCENTAGES OF FEEDS FOR PERIOD III. (14 days: 13/7/48-26/7/48)

FEEDS	Sample	D A T E														Average for Period III.
		13/7	14/7	15/7	16/7	17/7	18/7	19/7	20/7	21/7	22/7	23/7	24/7	25/7	26/7	
HAY	A	86.4	84.5	85.5	87.0	87.0	86.4	86.5	86.0	84.0	84.0	87.0	85.5	85.0	85.4	85.7
	B	85.8	85.0	83.0	86.0	87.0	86.5	86.0	86.0	84.8	84.5	86.5	84.0	84.5	84.6	85.5
	Average	86.0	84.8	84.3	86.5	87.0	86.5	86.3	86.0	84.4	84.3	86.8	84.3	84.8	85.0	85.5
SILAGE	A	21.2	18.4	20.0	22.4	22.0	23.4	24.8	24.0	23.6	22.8	24.0	20.2	16.0	17.0	21.4
	B	21.8	18.4	20.6	21.6	22.8	23.2	24.0	23.2	23.4	23.6	23.5	19.6	17.0	17.5	21.4
	Average	21.5	18.4	20.3	22.0	22.4	23.3	24.4	23.6	23.5	23.2	23.8	19.9	16.5	17.3	21.4

TABLE XX.

AMOUNT OF FEEDS (lb) REFUSED DAILY BY INDIVIDUAL COWS AT PERIOD III. (14 days: 13/7/48-26/7/48)

Group No.	Cow Name	Ration.	DATE													
			13/7	14/7	15/7	16/7	17/7	18/7	19/7	20/7	21/7	22/7	23/7	24/7	25/7	26/7
I	Katie	Hay	21.0	5.0	4.5	4.5	6.0	3.0	5.5	4.0	3.0	2.0	8.0	8.5	7.0	5.5
II	Yuten	Hay	3.5	3.0	0.5	3.5	2.5	2.5	9.0	1.0	3.0	4.0	2.5	5.5	5.5	1.5
III	Ynetta	Hay	6.5	4.5	0.5	1.0	4.0	3.0	5.0	2.5	2.5	2.0	2.0	2.5	1.0	1.5
IV	Frivolous	Hay	6.5	4.5	4.5	3.5	5.0	3.5	3.0	2.5	2.5	1.0	6.5	1.0	0.5	3.0
I	Addy	Hay	2.5	3.5	4.5	3.5	8.5	3.0	5.0	2.0	5.0	1.5	3.0	3.5	4.0	1.0
		Silage	22.0	13.5	—	—	—	—	—	1.0	2.0	—	—	—	—	—
II	Art	Hay	5.5	5.0	3.5	2.5	5.0	2.0	4.5	1.5	3.5	4.0	5.5	4.0	2.0	3.5
		Silage	10.0	4.0	—	—	—	—	—	—	—	—	—	—	—	—
III	Vicky	Hay	3.5	4.5	4.5	2.5	6.0	3.0	5.0	3.5	3.5	3.5	8.5	4.0	1.5	3.5
		Silage	—	—	1.5	—	—	—	—	—	—	—	—	—	—	—
IV	Toy	Hay	2.5	5.0	5.5	4.5	4.5	3.5	5.5	6.5	5.0	4.5	2.0	2.5	2.0	3.0
		Silage	—	—	—	—	—	—	2.0	—	—	—	—	—	—	—
I	Yupena	Silage	16.5	16.0	6.0	3.0	14.0	29.0	6.0	13.0	19.5	5.0	5.0	5.0	8.0	18.0
II	Yascha	Silage	16.5	26.0	21.0	15.0	25.0	24.0	16.0	25.0	36.0	13.0	24.0	10.5	4.0	14.0
III	Sally	Silage	8.5	10.5	5.5	13.5	8.5	26.0	16.5	7.0	15.5	8.0	14.0	8.0	3.5	14.0
IV	Barbara	Silage	9.5	16.5	10.0	13.0	16.0	34.5	14.0	20.0	28.0	18.0	21.0	13.0	10.0	33.0

TABLE.XXI.

DAILY DRY MATTER PERCENTAGES OF REFUSED FEEDS FOR PERIOD III. (14 days: 13/7/48 - 26/7/48)

Ration Cow Received	Refused by Cow -	Refuse Sample.	D A T E													
			13/7	14/7	15/7	16/7	17/7	18/7	19/7	20/7	21/7	22/7	23/7	24/7	25/7	26/7
HAY	Katie	Hay	83.0	81.5	85.0	81.5	83.5	81.5	80.0	83.0	80.0	83.0	80.0	78.0	79.5	83.5
	Yuten	Hay	84.0	81.5	85.0	80.0	83.8	81.8	84.0	83.0	84.0	82.0	81.2	82.0	84.0	81.7
	Ynetta	Hay	80.0	79.0	80.0	77.0	77.0	9.5	83.0	77.5	76.0	76.0	76.8	72.5	80.0	77.5
	Frivolous	Hay	79.5	77.5	80.0	79.0	78.5	80.0	81.3	77.5	79.0	79.0	78.0	72.5	80.0	76.0
HAY AND SILAGE	Addy	Hay	83.5	83.0	85.0	81.0	83.0	82.0	84.0	83.0	82.0	83.0	80.0	78.5	81.0	81.7
		Silage	22.4	19.6	---	---	---	---	---	25.6	24.2	---	---	---	---	---
	Art	Hay	83.5	80.0	85.0	80.8	85.0	81.8	83.5	83.0	82.0	84.0	82.5	80.0	81.5	80.0
		Silage	21.2	19.6	---	---	---	---	---	---	---	---	---	---	---	---
	Vicky	Hay	79.7	76.0	79.0	77.0	80.0	79.0	80.0	79.0	80.0	76.0	78.0	74.0	80.0	78.5
		Silage	---	---	19.8	---	---	---	---	---	---	---	---	---	---	---
	Toy	Hay	79.7	76.0	82.0	75.0	78.0	79.5	81.0	76.0	76.0	73.0	75.5	71.0	80.0	78.0
		Silage	---	---	---	---	---	---	23.2	---	---	---	---	---	---	---
SILAGE	Yupena	Silage	22.4	19.6	23.2	23.2	21.2	24.0	23.0	26.0	24.4	24.4	23.6	16.4	16.4	18.4
	Yuscha	Silage	22.0	19.6	21.6	23.2	21.6	20.0	22.8	25.2	24.0	24.0	22.8	18.0	17.2	17.6
	Gally	Silage	20.8	20.0	19.6	21.4	20.4	22.0	23.6	24.8	24.0	23.2	21.6	17.4	16.4	17.8
	Barbara	Silage	20.2	20.8	20.0	21.6	21.2	22.8	22.8	24.0	22.8	22.4	20.8	16.0	16.8	18.0

N.B. Figures in red were the average of dry matter percentages determined from other cows' refused feeds.

TABLE XXII.

AMOUNT OF DRY MATTER (lb) REFUSED DAILY BY INDIVIDUAL COWS AT PERIOD III. (14 days: 13/7/48-26/7/48)

Group No.	Cow Name.	Ration	DATE													
			13/7	14/7	15/7	16/7	17/7	18/7	19/7	20/7	21/7	22/7	23/7	24/7	25/7	26/7
I	Katie	Hay	9.1	4.1	3.8	3.7	5.0	2.5	4.4	3.3	2.4	1.7	6.4	6.6	5.6	4.6
II	Yuten	Hay	2.9	2.5	0.4	2.8	2.1	2.1	7.6	0.8	2.5	3.3	2.0	4.5	4.6	1.2
III	Ynetta	Hay	5.2	3.6	0.4	0.8	2.9	2.4	4.2	1.9	1.9	1.5	1.5	1.8	0.8	1.2
IV	Frivolous	Hay	5.2	3.5	3.6	2.8	3.9	2.8	2.4	1.9	2.0	0.8	5.1	0.7	0.4	2.2
I	Addy	Hay	2.1	2.9	3.8	2.8	7.1	2.5	4.2	1.7	4.1	1.3	2.4	2.8	3.2	0.8
		Silage	4.9	2.7	---	---	---	---	---	0.3	0.5	---	---	---	---	---
II	Art	Hay	4.6	4.0	3.0	2.0	4.3	1.6	3.8	1.2	2.9	3.4	4.5	3.2	1.6	2.8
		Silage	2.1	0.8	---	---	---	---	---	---	---	---	---	---	---	---
III	Vicky	Hay	2.8	3.4	3.6	1.9	4.8	2.4	4.0	2.8	2.8	2.7	6.6	3.0	1.2	2.8
		Silage	---	---	0.3	---	---	---	---	---	---	---	---	---	---	---
IV	Toy	Hay	2.0	3.8	4.5	3.4	3.5	6.8	4.5	4.9	3.8	3.3	6.8	1.8	1.6	2.3
		Silage	---	---	---	---	---	---	0.5	---	---	---	---	---	---	---
I	Tupena	Silage	3.7	3.1	1.4	0.7	3.0	7.0	1.4	3.4	4.8	1.2	1.2	0.8	1.3	3.3
II	Yuscha	Silage	3.6	5.1	4.5	3.9	5.4	4.3	3.7	6.3	8.6	3.1	5.5	1.9	0.7	2.5
III	Sally	Silage	1.8	2.1	1.1	2.9	1.7	5.7	3.9	1.7	3.7	1.9	3.0	1.4	0.6	2.5
IV	Barbara	Silage	1.9	3.4	2.0	2.8	3.4	7.9	3.2	4.8	6.4	4.0	4.4	2.1	1.7	5.9



TABLE XXIV.

AMOUNT OF FEED (lb) CONSUMED DAILY BY INDIVIDUAL COWS AT PERIOD III. (14 days: 13/7/48-26/7/48)

Group No.	Cow Name	Av. Live Wt. for Period	Ration	D A T E														Av. daily consumption of 14 days of each cow.	Av. daily consumption of 14 days of 4 cows.
				13/7	14/7	15/7	16/7	17/7	18/7	19/7	20/7	21/7	22/7	23/7	24/7	25/7	26/7		
I	Katie	785	Hay	12.5	15.0	15.5	15.5	14.5	20.0	16.5	16.5	19.5	19.5	15.0	15.5	15.0	21.0	16.5	18.2
II	Yutan	928	Hay	20.0	19.0	24.0	21.5	21.5	20.5	15.0	23.5	21.5	21.0	22.5	19.5	20.0	25.5	21.1	
III	Ynetta	837	Hay	17.0	15.5	21.0	18.0	16.5	18.0	19.0	18.5	18.5	19.0	18.0	17.5	21.0	21.0	18.5	
IV	Frivolous	783	Hay	16.5	14.5	16.0	15.5	15.5	15.5	17.0	17.0	18.0	18.5	18.0	19.0	20.0	19.0	16.5	
I	Addy	749	Hay	15.0	11.5	11.0	12.0	6.5	12.0	9.5	15.0	11.0	13.0	12.5	12.5	12.5	17.0	12.2	HAY 11.9 SILAGE 29.0
			Silage	8.0	16.5	30.0	30.0	30.0	30.0	30.0	29.0	28.0	30.0	30.0	30.0	30.0	30.0	27.3	
II	Art	861	Hay	14.0	12.0	12.5	13.5	13.0	13.0	10.5	15.0	12.5	12.5	11.0	13.0	14.5	15.0	15.9	
			Silage	20.0	26.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	29.0	
III	Vicky	918	Hay	12.5	13.5	11.5	16.5	12.0	14.0	13.0	12.0	12.0	12.5	10.0	12.0	16.0	14.0	13.0	
			Silage	30.0	30.0	28.5	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	
IV	Toy	811	Hay	10.5	9.0	9.5	10.5	9.5	6.5	8.5	7.0	9.0	8.5	6.0	11.5	12.5	11.5	9.5	
			Silage	30.0	30.0	30.0	30.0	30.0	30.0	28.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	
I	Yupena	798	Silage	66.5	62.0	74.0	81.0	78.0	58.5	78.0	59.0	60.5	67.5	61.5	82.0	79.0	71.5	69.9	70.4
II	Yuscha	865	Silage	87.5	71.0	86.0	88.0	75.0	71.0	88.0	85.0	57.5	67.0	68.5	102.0	103.0	85.0	81.0	
III	Sally	913	Silage	78.0	74.0	87.5	72.5	79.5	63.0	65.5	74.5	65.5	70.0	65.0	74.0	96.5	83.0	73.3	
IV	Barbara	716	Silage	70.5	68.5	77.0	68.0	66.0	46.5	61.0	53.5	42.0	45.0	48.0	52.0	63.0	50.0	57.2	

TABLE XXV. AMOUNT OF DRY MATTER (lb) CONSUMED DAILY BY INDIVIDUAL COWS AT PERIOD III. (14 days: 13/7 /48-26/7/48)

Group No.	Cow Name	Av. Live wt. for Period.	Ration	D A T E														Av. daily consumption of 14 days of each cow.	Av. daily consumption of 14 days of 4 cows.
				13/7	14/7	15/7	16/7	17/7	18/7	19/7	20/7	21/7	22/7	23/7	24/7	25/7	26/7		
I	Katie	785	Hay	11.1	12.9	13.1	13.6	12.8	17.5	14.6	14.3	16.6	16.4	13.6	13.7	13.1	17.9	14.4	15.8
II	Yuten	928	Hay	18.1	16.2	20.3	18.8	18.8	17.9	13.1	20.2	18.2	17.7	19.7	16.7	17.0	21.8	18.2	
III	Ynetta	887	Hay	15.0	13.4	17.7	15.6	14.9	15.8	16.6	20.2	15.8	16.2	16.9	15.2	17.9	17.9	16.0	
IV	Frivolous	783	Hay	14.6	12.6	13.7	13.6	13.9	13.6	14.9	14.9	15.3	15.6	11.9	16.3	17.0	16.5	14.6	
I	Addy	749	Hay	12.9	9.8	9.3	10.6	5.9	10.5	8.3	12.9	9.4	10.9	11.1	10.8	10.8	14.5	10.5	16.6
			Silage	1.6	2.8	6.1	6.6	6.7	7.0	7.3	6.8	6.6	7.0	7.1	6.0	5.0	5.2	5.8	
II	Art	861	Hay	12.2	10.4	10.5	11.8	11.4	11.4	9.1	13.0	10.6	10.5	9.8	11.2	12.4	11.2	11.1	
			Silage	4.4	4.7	6.1	6.6	6.7	7.0	7.3	7.1	7.1	7.0	7.1	6.0	5.0	8.2	6.2	
III	Vicky	918	Hay	11.0	11.9	9.9	14.5	10.5	12.3	11.5	10.5	10.3	10.8	9.5	10.6	13.6	12.0	11.4	
			Silage	6.5	5.5	5.8	6.6	6.7	7.0	7.3	7.1	7.1	7.0	7.1	6.0	5.0	5.2	6.4	
IV	Toy	811	Hay	9.2	8.1	8.2	9.6	8.7	6.2	7.6	6.7	8.0	7.7	5.2	10.1	10.7	10.0	8.4	
			Silage	6.5	5.5	6.1	6.6	6.7	7.0	6.8	7.1	7.1	7.0	7.1	6.0	5.0	5.2	6.4	
I	Yupena	798	Silage	14.3	11.3	14.8	17.8	17.6	13.6	19.1	13.6	14.0	15.6	14.6	16.5	13.1	12.2	14.9	15.0
II	Yuscha	865	Silage	18.8	12.8	17.2	19.2	17.0	17.3	21.7	19.7	13.4	15.5	16.5	20.6	17.0	14.6	17.2	
III	Sally	913	Silage	16.8	13.6	13.8	16.0	18.0	15.0	15.6	17.5	15.3	16.2	15.8	14.9	15.9	14.3	13.6	
IV	Barbara	715	Silage	15.3	10.4	15.7	15.0	15.0	11.0	15.1	12.6	10.1	10.6	12.0	10.8	10.3	3.5	12.3	

TABLE XXVI.

DATA ON BODY WEIGHT (lb) OF INDIVIDUAL COWS FOR PERIOD I. (14 days: 15/6/48-28/6/48)

Group No.	Cow Name	Ration cow Received.	Date of Weighing.			Av. Live Wt. for Period.
			15/6/48	22/6/48	29/6/48	
I	Addy	Hay	732	726	757	738
II	Art	Hay	817	851	852	840
III	Sally	Hay	860	864	868	864
IV	Barbara	Hay	714	708	725	716
<hr/>						
I	Yupena	Hay } Silage }	771	782	775	775
II	Yuscha	Hay } Silage }	817	853	851	840
III	Ynetta	Hay } Silage }	862	853	864	853
IV	Frivolous	Hay } Silage }	785	757	789	777
<hr/>						
I	Katie	Silage	749	727	767	743
II	Yuten	Silage	849	851	874	858
III	Vicky	Silage	880	881	892	884
IV	Toy	Silage	795	785	776	784

**TABLE XXVII. DATA ON BODY WEIGHT (lb) OF INDIVIDUAL COWS FOR PERIOD II. (14 days: 29/6/48-12/7/48)**

Group No.	Cow Name	Ration cow Received.	Date of Weighing.			Av. Live Wt. for Period.
			29/6/48	6/7/48	13/7/48	
I	Yupena	Hay	773	804	811	796
II	Yuscha	Hay	851	882	884	872
III	Wicky	Hay	892	917	906	905
IV	Toy	Hay	776	821	803	800
I	Katie	Hay Silage }	767	796	785	783
II	Yuten	Hay Silage }	874	919	917	903
III	Sally	Hay Silage }	868	889	899	885
IV	Barbara	Hay Silage }	725	739	727	730
I	Addy	Silage	757	747	724	743
II	Art	Silage	852	856	857	855
III	Ynetta	Silage	864	852	825	847
IV	Frivolous	Silage	789	775	770	778



TABLE XVIII.

DATE ON BODY WEIGHT (lb) OF THE INDIVIDUAL COWS FOR PERIOD III. (14 days: 13/7/48-26/7/48)

Group No.	Cow Name	Ration cow Received.	Date of Weighing.			Av. Live Wt. for Period.
			13/7/48	20/7/48	27/7/48	
I	Katie	Hay	785	790	779	785
II	Yutan	Hay	917	930	936	928
III	Ynetta	Hay	825	843	844	837
IV	Privolous	Hay	770	786	793	783
I	Addy	Hay Silage)	724	742	771	749
II	Art	Hay Silage)	857	853	873	861
III	Vicky	Hay Silage)	906	918	929	915
IV	Toy	Hay Silage)	803	804	827	811
I	Yupena	Silage	811	792	792	798
II	Yuscha	Silage	884	843	867	865
III	Sally	Silage	899	897	944	915
IV	Barbara	Silage	727	712	705	715

TABLE XXIX.

## DAILY METEOROLOGICAL DETAILS FOR PERIOD I.

(14 days: 15/6/48-28/6/48)

Items	D A T E														
	15/6	16/6	17/6	18/6	19/6	20/6	21/6	22/6	23/6	24/6	25/6	26/6	27/6	28/6	Average
Maximum Temperature	48.8	54.6	54.0	49.4	53.0	57.0	59.0	58.2	53.3	59.8	63.2	55.8	53.2	51.2	55.0
(degree F) Minimum	36.0	31.8	31.5	36.3	45.5	49.2	47.0	43.0	35.8	43.2	48.3	42.7	44.0	45.6	41.4
Relative Humidity (%)	94.0	93.0	97.0	66.0	84.0	97.0	87.0	76.0	79.0	97.0	82.0	76.0	80.0	79.0	84.8
Rainfall (inches)	0.11	Trace	Nil	Nil	0.01	0.15	0.03	0.05	Nil	0.1	0.03	0.01	0.03	1.25	
Hours of Sunshine	3.3	6.4	6.9	0.3	1.5	1.9	1.0	3.9	8.0	4.6	4.0	4.0	0.5	Nil	
Frost	2.7	5.8	6.0	2.2	---	---	---	---	2.0	---	---	---	---	---	
Wind	light air	slight breeze	calm	slight breeze	mod- erate breeze	light air	slight breeze	light air	slight breeze	calm	light air	slight breeze	mod- erate breeze	mod- erate breeze	

TABLE XXX.

DAILY METEOROLOGICAL DETAILS FOR PERIOD II.

(14 days: 29/6/48 - 12/7/48.)

Items	DATE														Average
	29/6	30/6	1/7	2/7	3/7	4/7	5/7	6/7	7/7	8/7	9/7	10/7	11/7	12/7	
Temperature <del>Maximum</del>	55.7	57.5	55.0	58.5	52.8	53.8	59.4	55.6	55.0	57.3	55.0	57.0	55.5	56.1	56.0
(degree F) <del>Minimum</del>	45.8	40.8	43.2	47.0	34.3	35.9	33.8	31.7	40.5	43.2	34.2	40.0	37.3	35.8	38.3
Relative humidity (%)	82.0	82.0	81.0	83.0	89.0	96.0	87.0	82.0	98.0	80.0	97.0	80.0	91.0	81.0	86.4
Rainfall (inches)	Nil	Nil	trace	0.13	0.13	Nil	Nil	Nil	0.13	0.1	Nil	0.02	0.16	Nil	
Hours of Sunshine	3.8	4.4	1.9	3.0	0.1	8.5	7.9	8.9	3.3	0.9	2.1	7.6	3.3	8.9	
Wind	gentle breeze	gentle breeze	fresh breeze	strong breeze	light air	calm	light air	slight breeze	light air	light air	calm	moderate breeze	light air	gentle breeze	
Frost (Deg.)	—	—	—	—	3.0	2.5	4.5	6.5	—	—	4.2	—	2.2	3.0	

TABLE XXXI.

DAILY METEOROLOGICAL DETAILS FOR PERIOD III.

(14 days: 13/7/48-26/7/48)

Items	D A T E														Average for the Period.
	13/7	14/7	15/7	16/7	17/7	18/7	19/7	20/7	21/7	22/7	23/7	24/7	25/7	26/7	
Temperature Maximum	51.0	55.7	53.5	52.2	52.8	49.3	54.7	58.3	60.3	56.6	—	61.0	56.0	55.0	55.1
Minimum (degree F)	35.6	43.2	40.5	33.2	41.6	42.8	47.0	52.0	49.2	42.3	—	46.0	51.6	46.4	41.8
Relative Humidity (%)	72.0	72.0	86.0	91.0	76.0	74.0	84.0	85.0	88.0	92.0	—	83.0	82.0	88.0	82.0
Rainfall (inches)	Nil	0.39	Nil	Nil	Nil	Nil	Nil	0.15	0.14	0.12	—	0.22	0.04	0.09	
Hours of Sunshine	0.2	0.7	5.4	3.8	5.1	2.7	6.3	Nil	Nil	0.4	—	4.7	0.5	Nil	
Wind	gentle breeze	slight breeze	light air	calm	light air	light air	fresh breeze	fresh breeze	gentle breeze	light air	—	gentle breeze	gentle breeze	light air	
Frost	1.5	—	—	4.5	—	—	—	—	—	—	—	—	—	—	

APPENDIX 2.

STATISTICAL TREATMENT OF RESULTS.

1. Procedure.

As mentioned before, in this design of experiment, each group of three cows constitute an independent experiment (Figures 1 and 2). The experimental error then, can be estimated by analysing each group separately by an analysis of variance. This is shown as follows:-

	Degree of freedom.
Between cows ... ..	2
Between periods ... ..	2
Between rations ... ..	2
Error ... ..	<u>2</u>
Total ... ..	<u>8</u>

In the estimate of error, the differences between cows and between periods are not included because by the nature of the design, these are excluded from the true errors of the ration means. This type of analysis is carried out for each of the four groups of cows. Then, on combining the four analyses, the following subdivision of degrees of freedom is obtained for the whole experiment..

	Degree of free dom.
Between cows within groups ...	6
Between periods within groups ...	6
Between rations ... ..	2
Interaction of rations and groups	6
Between groups ... ..	3
Error ... ..	<u>8</u>
Total ... ..	<u>35</u>

The eight degrees of freedom for between cows, between periods and error are the sums of the corresponding terms in the four groups. Similarly, eight degrees of freedom are obtained for between rations, but these are divided into two lots; 2 degrees of freedom for the average differences between rations and 6 degrees of freedom representing interaction of rations and groups. This is done on account of the fact that the differences between the rations were not the same in all groups. The remaining 3 degrees of freedom are for the differences between the group totals.

2. Analysis of variance of the daily dry matter intake.

The averaged consumption of dry matter per cow per each period is given in

table XXXII.

**TABLE XXXII.** Individual total Dry Matter Consumption:  
(lb. per cow per period) (Total of 14 days)

Group No.	Cow Name.	Period I.		Period II.		Period III.		Total.
I	Addy	A	234	B	119	C	230	583
	Katie	B	226	C	202	A	201	629
	Yupena	C	249	A	252	B	208	709
	Period Total		709		573		639	1921
II	Yuten	B	247	C	245	A	255	747
	Art	A	271	B	204	C	243	718
	Yuscha	C	303	A	263	B	241	827
	Period Total		821		732		739	2292
III	Vicky	B	253	A	209	C	249	711
	Ynetta	C	229	B	112	A	224	565
	Sally	A	205	C	214	B	219	638
	Period Total		687		535		692	1914
IV	Barbara	A	203	C	197	B	172	572
	Toy	B	199	A	188	C	207	594
	Frivolous	C	239	B	151	A	204	594
	Period Total		641		536		583	1760

A = Hay fed ad lib.      B = Silage fed ad lib.  
C = 30 lb. silage plus hay fed ad lib.

Each group of the four groups in the above table was analysed separately, and the degrees of freedom as well as the sums of squares of the four analyses (Table XXXIII) were combined (Table 12) according to the procedure previously described.

**TABLE XXXIII.** Analysis of Variance (34) of D.M. Consumption by each Group of Cows: total consumption per cow per period, in lb.

Group I.

Items	Degrees of Freedom.	Sums of Squares	Mean Squares.
1. Between cows within groups	2	2709	1355
2. Between Periods	2	3083	1542
3. Between Rations	2	3819	1910
4. Error	2	3229	1615
5. Total	8	12840	



Group II.

Items	Degrees of Freedom.	Sums of Squares.	Mean Squares.
1. Between cows within Groups.	2	2124	1062.
2. Between Periods	2	1632	816
3. Between Rations	2	2645	1323
4. Error	2	47	24
5. Total	8	6448	

Group III.

Items	Degrees of Freedom.	Sums of Squares.	Mean Squares.
1. Between cows within Group.	2	3552	1776
2. Between Periods	2	5308	2654
3. Between Rations	2	1943	972
4. Error	2	2787	1394
5. Total	8	13590	

Group IV.

Items	Degrees of Freedom.	Sums of Squares.	Mean Squares.
1. Between cows within Group.	2	107	54
2. Between Periods	2	1843	922
3. Between Rations	2	2474	1237
4. Error	2	332	166
5. Total	8	4756	

3. Adjustment for carry-over effect.

Owing to the shortness of the change-over period from one ration to another, a carry-over effect of the ration given in the previous period may be anticipated.

With one Latin Square design, simple averages do not give unbiased estimates of the effects of the rations. e.g. with the layout shown in figure 1, ration A is preceded by ration C in both the second and third periods, and similarly B by A and C by B. If A has carry-over effect and C a large carry-over effect, the consumption for ration A may be increased by the beneficial carry-over effect of C, while those for B be unaffected by A.

But with the two Latin squares design used in this experiment, (figures 1 and 2) a direct evaluation of the carry-over effects is possible. This may be seen by examining the total dry matter consumption of each of the six sets of cows (each

set received one sequence of rations), shown in table XXXIV.

**TABLE XXXIV.** Total Dry Matter Consumption for each of the six sets of Cows. (Totals for 2 cows (4 weeks) in lb.)

Set No.	Cow Name.	Period I	Period II	Period III	Set Total	Grand Total
1	Addy Art.	A 505	B 323	C 473	1303	7889
2	Katie Yuten	B 473	C 447	A 456	1376	
3	Yupena Yuscha	C 552	A 535	B 449	1536	
4	Sally Barbara	A 408	C 411	B 391	1210	
5	Vicky Toy	B 452	A 397	C 456	1305	
6	Ynetta Frivolous	C 468	B 263	A 428	1159	

A = Hay

B = Silage

C = Hay plus Silage.

The results during the first Period do not require adjustment, since all cows received the same preceding ration.

In period II, two sets of cows, 3 and 5, receiving Hay. Of these, set 3, having had hay and silage (C) in the previous period, consumed a total of D.M. of 535 lb., while set 5, having had silage (B) in the previous period, consumed a total of 397 lb. The difference, 138 lb., is an estimate of the difference between the carry-over effect of C and that of B ration.

Similarly, a comparison of the carry-over effects of C and A ration is obtained from sets 1 and 6, at Period II, and a comparison between B and A rations from sets 2 and 4.

The same comparisons are repeated with the results in Period III.

These are shown as follows:

In Period II:

Set 3 consumed 535 lb. ration A having had ration C in Period I.  
Set 5 consumed 397 lb. ration A having had ration B in Period I.

difference = 138 lb. (between the carry-over effect of C and B ration).

Set 1 consumed 323 lb. ration B having had ration A in Period I.  
Set 6 consumed 263 lb. ration B having had ration C in Period I.

difference = 60 lb. (between A and C ration).

Set 2 consumed 447 lb. ration C having had ration B in Period I.  
Set 4 consumed 411 lb. ration C having had ration A in Period I.

difference = 36 lb. (between B and A).



In Period III:

Set 2 consumed 456 lb. ration A having had ration C in Period II.  
Set 6 consumed 428 lb. ration A having had ration B in Period II.

difference = 28 lb. (between C and B).

Set 3 consumed 449 lb. ration B having had ration A in Period II.  
Set 4 consumed 391 lb. ration B having had ration C in Period II.

difference = 58 lb. (between A and C).

Set 1 consumed 473 lb. ration C having had ration B in Period II.  
Set 5 consumed 456 lb. ration C having had ration A in Period II.

difference = 17 lb. (between B and A)

It can be seen from the above six comparisons, the carry-over effects of each ration on the other two rations were not in the same direction. Thus cows having received ration C in the previous period ate more ration A but less B; cows having had ration A, more ration B but less C; and cows having had ration B, more ration C but less A.

These inconsistent effects of each ration on the other two rations, indicate that little, if any, real carry-over effects were present. However, for the sake of completeness in using this experimental design, estimations of the direct effects of the rations, free from the disturbance due to carry-over effects (i.e. adjustment for carry-over effect) were carried out by a technique known as the method of least squares. (7).

In this procedure, the observed dry matter consumption for any cow in any period is expressed as a linear function of the effects of the cow's ingestive capability, the period, the current and previous rations, and the experimental error. For example, consider a cow receiving in succession A, B and C rations. Its dry matter consumption,  $Y_1$ ,  $Y_2$ , and  $Y_3$  in the three periods are expressed as follows:

$$Y_1 = m + P_1 + d_a + e_1$$

$$Y_2 = m + P_2 + d_b + Y_a + e_2$$

$$Y_3 = m + P_3 + d_c + Y_b + e_3$$

where  $m$  = mean dry matter consumption for the cow

$P_1, P_2, P_3$  = effects of the three periods

$d_a, d_b, d_c$  = direct effects of the rations

$Y_a, Y_b$  = residual effects of the rations given in the previous period.

$e_1, e_2, e_3$  = experimental errors.

No parameter is required to represent residual effects in the first period. The constants  $P_1, P_2, P_3$  remain unchanged for all three cows in the same group, since only the group averages of the differences between periods are eliminated from the experimental error. After setting up equations of this type for every cow, the

constants are estimated by minimizing the sum of squares of the experimental errors.

The data required for calculating the adjusted consumption for each ration are shown in the following table XXXV (obtained from table XXXIV).

**TABLE XXXV.** Data for calculating the adjusted consumption for each ration.

Ration	Ration total	Total consumption of all cows after having been on:	Total of sets (cows) receiving same ration at Period III.	Grand Total.	$\frac{2}{3} (T)$
A	2729	A ration = 1639(a)	set 2 + set 6 = 2535 ( $S_2 + S_6$ )	7889 (T)	5258
B	2351	B ration = 1745(b)	set 3 + set 4 = 2746 ( $S_3 + S_4$ )		
C	2607	C ration = 1645(c)	set 1 + set 5 = 2608 ( $S_1 + S_5$ )		

A = Hay

B = Silage

C = Hay plus Silage.

The adjusted mean consumptions per cow per period ( $\bar{Y}$ ) (total of two weeks) are then given by the following equations:

A ration -

$$\begin{aligned}
 48 \bar{Y}_a &= 5A + (2a-b-c) + S_2 + S_6 - \left(\frac{2}{3}\right) T \\
 &= 5 \times 2729 + (2 \times 1639 - 1745 - 1645) + 2535 - 5258 \\
 &= 10,810
 \end{aligned}$$

$$\text{Hence } \bar{Y}_a = 225.2$$

B ration -

$$\begin{aligned}
 48 \bar{Y}_b &= 5B + (2b-a-c) + S_3 + S_4 - \left(\frac{2}{3}\right) T \\
 &= 5 \times 2351 + (2 \times 1745 - 1639 - 1645) + 2746 - 5258 \\
 &= 9,449
 \end{aligned}$$

$$\text{Hence } \bar{Y}_b = 196.9$$

C ration -

$$\begin{aligned}
 48 \bar{Y}_c &= 5C + (2c-a-b) + S_1 + S_5 - \left(\frac{2}{3}\right) T \\
 &= 5 \times 2607 + (2 \times 1645 - 1639 - 1745) + 2608 - 5258 \\
 &= 11,291
 \end{aligned}$$

$$\text{Hence } \bar{Y}_c = 235.2$$

The corresponding unadjusted mean consumption "per cow per period" are the totals A, B and C divided by 12 (the number of cows in each total).

The adjusted as well as the unadjusted mean consumption per cow per period are given in the following table XXXVI.

**TABLE XXIV.**      **Mean Dry Matter Consumption per Cow per Period of Two Weeks**  
**Before and After Adjustments for carry-over Effects.**

Ration	Mean Consumption before adjust- ment.	Mean Consumption after adjust- ment.	Difference in consumption due to adjust- ment.
A	227.4	225.2	- 2.2
B	195.9	196.9	+ 1.0
C	232.9	233.2	+ 1.3

As shown in the above table, there were little differences in mean consumptions before and after adjustments for carry-over effects, indicating little carry-over effects were present.