# THE NUTRITIVE VALUE AND PALATABILITY OF MILO AS COMPARED TO BARLEY WHEN FED TO LACTATING DAIRY COWS

by

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# CHAPTER I

## INTRODUCTION

The production of milo, both in acreage and in yield, has greatly increased in recent years. The importance of sorghum grains, particularly in Africa and Asia, increases the significance of research on its adaptability as a livestock field. Most of the literature concerning the nutritive value of milo is based on old investigations. New cultural and feeding practices may result in different feeding recommendations.

Laboratory tests indicate that milo compares favorably with corn and barley; however, its palatability may vary considerably, and other factors may affects its acceptance as a livestock feed. It thus was desirable to examine the nutritive value of milo using newer feeding methods and to obtain information on factors affecting its palatability. The knowledge gained may be useful in obtaining maximum efficiency in the production of milk, meat and wool. This is particularly true in those areas where milo is a major crop, such as the Southwestern United States, where it could constitute a major part of the ration for dairy cattle. In other parts of the world, particularly in Africa and Asia,

many of the countries rely heavily on sorghum grains. They are economical and more uniformly available as they give high yields and are more resistant to drought than other grains such as barley, rice and corn.

This study was undertaken to determine the nutritive value of milo as compared to barley for milk production and to compare the effects of these two grains on some of the constituents of milk.

## CHAPTER II

## REVIEW OF LITERATURE

Several feeding trials have related the feeding values of yellow corn and milo and found them nearly equal when fed to fattening animals and to lactating dairy cows. Experiments done in Kansas in 1925 (5) failed to demonstrate any marked difference in the efficiency of ground corn and ground sorgo seed in maintaining the body weights or milk production of cows while on a liberal ration of alfalfa hay, grain and silage. There was no apparent difference in the palatability of a grain mixture in which ground sorgo seed was substituted for the ground corn portion of the mixture. Ground sorgo seed did, however, increase the per cent milk fat from 3.84 to 4.05 when it was included in the mixture.

In another experiment (6) where ground kafir was compared with ground corn it was shown that the corn was a superior feed for the production of milk and the maintenance of fat percentage. It was noted that there was no difference between the two feeds in their ability to maintain body weight and that the cows relished a mixture containing ground kafir equally as well as one containing corn.

An older experiment conducted in Kansas in 1906 (10) concluded that corn and alfalfa of good quality was a good ration for beef production, and that a mixture of ground kafir and corn made a good substitute for the corn, but was not quite its equal pound for pound, as steers fed ground corn and cob meal had slightly higher dressing percentages than those fed ground kafir and corn.

In South Dakota (19) results of two years' trials indicated that for milk production and maintenance of body weight Sooner milo grain was equal to yellow corn. Experiment stations further south in the United States reported yellow corn superior to Sooner milo for milk production (19). This would indicate that the Sooner milo grown in the northern states is superior to that grown in the southern states, or that the corn grown in the north is inferior to that of the south. The former supposition seems the more plausible. A more recent study (24) conducted in Kansas studied the comparative values of Midland milo, Westland milo, Pink Kafir, and corn as cattle-fattening feeds. It was found that there were no significant differences in the gain made by any of the four lots of steers. The dressing percentages were very nearly the same, with the corn fed steers being slightly lower. There were no appreciable differences in the carcass grades. It was concluded that the combine-type grain sorghums (Midland milo, Westland milo,

and Pink Kafir) were fully equal to corn when used to fatten yearling steers.

One author (17) reported that ground Sagrain seed had about 9/10 the feeding value of ground corn when fed to dairy cows. Milk production and fat percentage were slightly higher in favor of the ground corn (5.74% and 5.81% respectively).

Similar comparisons have been made between corn and barley, again with the second grain equal to or nearly equal to corn. In New Mexico (9), comparisons were made to determine the values of barley and kafir corn with corn, for stock feeding on pasture. The results indicated:

1. Barley was 3.3% below corn in feeding value.
2. Kafir - corn was about 6.6% below corn in feeding value.
3. Kafir - corn was about 3.4% below barley in feeding value.

The results showed corn to be superior to either of the grains as a concentrate, but this was largely overcome for barley and partially so for Kafir - corn, by the larger quantity of alfalfa hay used by the corn-fed lot as compared with either of the other two.

A report conducted in Arizona in 1929 (7) directly compared barley and milo for dairy cattle and found them equal.

A trial was conducted to study the feeding value of Hegari grain compared to that of rolled barley. The results indicate that the Hegari ration is as effective as the barley ration in maintaining the milk flow. The Hegari ration produced 0.83% more milk while the barley ration produced 0.006% more butterfat. This difference was attributed to uncontrolled factors or error. One old (9) and several recent (4, 11, 12) reports concerned with comparison of milo and barley in fattening rations. These indicated a variety of differences in the value of the two grains. The older report (9) indicated that there was no difference in their ability to promote fattening. One recent report (11) indicated that where milo is the only grain the animals tend to decrease in rate and efficiency of gain.

Specifically, the recent work shows milo to have a feeding value in fattening rations of about 5/6 that of barley, with one exception (12) occuring in a summer feeding trial where, under conditions of general low ratios of grain to roughage, the two grains appeared equal. The tests compared milo with barley, on summer and winter feeding programs. It was found that barley was superior to milo in a winter feeding program, and milo was equal to or slightly better than barley in a summer feeding program. This was attributed

to the lower fiber content of the milo. This equality in summer feeding has not been noted in more recent trials (11) which showed that in the summer heifers gained 15% faster on barley and produced a unit of gain on 8% less feed.

These recent findings are in apparent contradiction to numerous laboratory analysis, including proximate analysis, TDN, and net energy determinations, which indicate that the feeding values should be more nearly equal (16, 18). These values give no hint as to why barley should be superior to milo in a fattening ration, since in all but one category noted, milo has nearly equal or higher values than barley. The one exception is in crude fiber, where barley shows a higher percentage than milo and as fiber is not generally considered an attribute this too would be in favor of the milo.

Work in progress by the Animal Science Department at the University of Arizona suggests that barley is "digested" more rapidly in the rumen than milo, but as this has been determined by the use of silk bags suspended in the rumen the physiological significences of the differences so determined is unknown.

## CHAPTER III

## EXPERIMENTAL PROCEDURE

Twenty four cows (16 Holsteins, 8 Guernseys) from the University of Arizona dairy herd were selected. Using Lucas' (14) experimental design for four treatments (type of concentrate in this case) two cows were randomly assigned to each treatment sequence. Good quality alfalfa hay was fed. Each cow was fed individually, with both the hay and the grains, so that total feed consumption equalled 110% of Morrison's standard for maintenance and production. The rations, calculated on initial milk production and body weight, were fed through the entire trial without adjustment for changes in milk production and weight. In no case did milk production increase. The ratio between alfalfa hay and the experimental grain rations was 60:40 on a weight basis. The ingredients of the experimental concentrates are shown in Table 1.

As the grain was pelleted 5% molasses was added to each of the rations to facilitate the pelleting process. As the prime objective of this trial was to determine the available energy of milo as compared to barley, the barley was fed according to Morrison's tables and the milo was substituted on a pound for pound basis. The analyses

TABLE 1

INGREDIENTS OF THE EXPERIMENTAL DIETS

| | POUNDS | | | |
|---|---|---|---|---|
| Ration | 1 | 2 | 3 | 4 |
| Barley | 1900 | 1267 | 633 | -- |
| Milo | -- | 633 | 1267 | 1900 |
| Molasses | 100 | 100 | 100 | 100 |

TABLE 2

ANALYSIS OF THE ALFALFA HAY AND THE EXPERIMENTAL RATIONS

| | % Lignin | % Crude Protein | Cal./gm. |
|---|---|---|---|
| Alfalfa Hay | 7.40 | 19.16 | 4151.21 |
| Ration 1 | 1.01 | 11.52 | 4120.58 |
| Ration 2 | 1.00 | 10.98 | 4128.88 |
| Ration 3 | .84 | 10.20 | 4166.74 |
| Ration 4 | .64 | 9.61 | 4182.12 |

of these rations are shown in Table 2.

Each experimental period consisted of four weeks plus one week for changeover. Milk weights were recorded and milk samples were collected weekly during the four consecutive milkings at the end of each weekly period. Using composite milk samples the percent protein was determined by the Orange G Method of Udy (22), percent fat was determined by the standard Babcock method, and solids not fat (S.N.F.) were determined by the method of Watson (23).

All of the protein, fat and S.N.F. determinations were done weekly. Figures for each week were averaged to determine the average daily production for the entire period.

The cows were weighed on the last three consecutive mornings preceeding the end of each experimental period and the results averaged.

The fatty acids of the milk fats from the last week's sample for each period were extracted and analyzed as described by Brown et al (3). The methylesters were formed by the method of Luddy et al (15).

Rumen fluid samples were taken by rumen tube at the end of each period on the morning after the last milk sample had been taken. The rumen fluid samples were strained through two layers of cheese cloth, preserved by the addition of one part saturated mercuric chloride

solution to ten parts rumen fluid and stored under refrigeration at 40° F. until analyzed by the method of Keeney (13) for their volatile fatty acid (VFA) content.

A grab sample of feces was collected on the last two days of each experimental period. The dried composite sample was analyzed for per cent lignin (8). Combustible energy was determined using an adiabatic oxygen bomb calorimeter.[1] Percent protein was determined by the standard Kieldahl method.

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[1]Parr Instrument Co., Moline, Illinois

## CHAPTER IV

## RESULTS

The cattle consumed the experimental rations, including milo, at all levels offered, and appeared to suffer no adverse physiological or nutritional effects.

The production of milk and the composition of milk fat for the experimental rations are given in Table 3. There were no significant differences ($P>0.05$) in the total pounds of milk produced, in the fat percentages of the milk or in the S.N.F. content of the milk. The ration containing 2/3 barley and 1/3 milo caused a significant depression ($P<0.05$) in the protein content of the milk as compared to the other three rations.

Average body weights are given in Table 3. There were no significant differences ($P>0.05$) among the four rations.

The results of the gas liquid chromatography of the methyl esters of the milk lipids have shown that, in general, the increasing amount of milo in the ration increased the percent short chain acids (Table 4). In general, from $C_{10}1=$ through $C_{17}$ there was no consistent influence of ration on amounts of these acids appearing in the milk. Milo appeared to cause a depression in the $C_{18}$iso, $C_{18}2=$

TABLE 3

PRODUCTION AND COMPOSITION OF MILK PRODUCED ON THE EXPERIMENTAL DIETS

| | TREATMENT | | | |
|---|---|---|---|---|
| | 100% Barley | 2/3 Barley 1/3 Milo | 1/3 Barley 2/3 Milo | 100% Milo |
| Average Daily Milk Production (lb) | 30.22 | 29.73 | 30.50 | 30.23 |
| Fat (%) | 2.96 | 3.06 | 3.07 | 3.25 |
| Protein (%) | 3.68[a] | 3.59[a,b,c] | 3.69[b] | 3.70[c] |
| S.N.F. (%) | 8.59 | 8.61 | 8.59 | 8.61 |
| Body weight (lb) | 1316.2 | 1320.3 | 1314.8 | 1313.7 |

[a,b,c] Values with identical letters indicate a significant difference ($P<0.05$).

TABLE 4

INFLUENCE OF DIET UPON THE COMPOSITION OF THE MILK FAT

| | TREATMENT | | | |
|---|---|---|---|---|
| (%) | 100% Barley | 2/3 Barley 1/3 Milo | 1/3 Barley 2/3 Milo | 100% Milo |
| $C_6$ | 0.45[a,b] | 0.57[a] | 0.54[b] | 0.74[a,b] |
| $C_8$ | 0.70[a,b] | 0.79[a] | 0.77[b] | 0.90[a,b] |
| $C_{10}$ | 2.59[a] | 2.81[a,b] | 2.59[b] | 3.11[a,b] |
| $C_{10}1=$ | 0.30 | 0.37 | 0.32 | 0.41 |
| $C_{12}$ | 4.01 | 4.18 | 3.89 | 3.97 |
| $C_{13}$ | 0.34 | 0.44 | 0.41 | 0.40 |
| $C_{14}$ | 11.56 | 11.98 | 11.57 | 11.31 |
| $C_{14}1=$ | 2.72 | 2.77 | 2.91 | 2.59 |
| $C_{15}$ | 2.77 | 2.76 | 2.58 | 2.60 |
| $C_{16}$iso | 0.67 | 0.72 | 0.55 | 0.43 |
| $C_{16}$ | 31.82 | 32.22 | 30.58 | 31.30 |
| $C_{16}1=$ | 5.14 | 4.72 | 5.44 | 5.61 |
| $C_{17}$ | 3.01 | 3.17 | 3.52 | 2.97 |
| $C_{18}$iso | 0.68 | 0.63 | 0.50 | 0.37 |
| $C_{18}$ | 6.16 | 6.94 | 6.80 | 7.47 |
| $C_{18}1=$ | 20.53 | 20.23 | 21.71 | 20.97 |
| $C_{18}2=$ | 5.01[a,b] | 3.50[a,b] | 4.01[a] | 3.91[b] |
| $C_{18}3=$ | 1.54 | 1.19 | 1.30 | 0.97 |

[a,b] Values with identical letters indicate a significant difference ($P<0.05$).

and $C_{18}3=$ fractions. However, this trend was significant ($P<0.05$) only in the $C_{18}2=$ fraction.

The analyses of the VFA content of the rumen fluid (Table 5) have shown that milo significantly depressed ($P<0.05$) the molar percent propionate appearing in the rumen fluid. There were no significant differences ($P>0.05$) in any of the other molar percentages or in the total concentrations of any of the acids. There was, however, a consistent, but non-significant ($P>0.05$), increase in the molar percent acetate as the level of milo increased in the ration.

There was a significantly higher ($P<0.05$) digestability of the total ration where the concentrate contained either 2/3 milo or 100 percent milo (Table 6.) There were no significant differences ($P>0.05$) in the digestabilities of either combustible energy or protein.

TABLE 5

ANALYSES OF RUMEN FLUID

| V.F.A. OF RUMEN CONTENT | TREATMENTS 100% BARLEY | 2/3 BARLEY 1/3 MILO | 1/3 BARLEY 2/3 MILO | 100% MILO |
|---|---|---|---|---|
| Total VFA | 99.88 | 106.36 | 93.55 | 89.11 |
| Total Acetate | 56.33 | 62.12 | 55.83 | 55.79 |
| Molar % Acetate | 58.00 | 58.28 | 60.76 | 62.57 |
| Total propionate | 27.63 | 30.43 | 26.03 | 18.82 |
| Molar % propionate | 25.99[a] | 28.14[a,b] | 26.41[b] | 21.40[a,b] |
| Total Butyrate | 12.18 | 10.17 | 8.55 | 10.96 |
| Molar % Butyrate | 12.38 | 10.21 | 9.43 | 12.16 |
| Total valerate | 1.90 | 1.67 | 1.38 | 1.53 |
| Molar % valerate | 1.82 | 1.64 | 1.46 | 1.76 |
| Total higher acids | 1.89 | 1.93 | 1.74 | 1.89 |
| Molar % higher acids | 1.81 | 1.74 | 1.93 | 2.11 |

[a,b] Values with identical letters indicate a significant difference ($P<0.05$)

TABLE 6

AVERAGE DIGESTIBILITIES

| | TREATMENTS 100% BARLEY | 2/3 BARLEY 1/3 MILO | 1/3 BARLEY 2/3 MILO | 100% MILO |
|---|---|---|---|---|
| Digestibility of total ration | 75.37[a,b] | 75.66[c,d] | 77.23[a,c] | 77.06[b,d] |
| Digestibility of protein | 77.35 | 77.27 | 76.19 | 77.61 |
| Digestibility of combustible energy | 73.78 | 73.40 | 74.81 | 75.40 |

[a,b] Values with identical letters indicate a significant difference ($P<0.05$)

## CHAPTER V

## DISCUSSION

The results of this experiment comparing milo to barley have shown that in general one supports the production of milk as well as the other. They also show that the cows consumed both the milo and the barley with equal relish at all levels offered. As this was of major concern at the outset of the experiment, it is one of the most significant findings. Without high palatability, any other observations would be ineffective.

Body weights were maintained equally well on all the experimental rations which is in agreement with earlier work which compared milo and yellow corn (19), and Kafir and ground corn (6).

This experiment agrees well with previous work (7) since no significant differences were found in total pounds of milk produced or in the percent S.N.F. found in the milk produced on the two feeds.

Even though there was a significant depression of percent protein produced on the ration containing 1/3 milo this depression was slight (.1%) and not supported by any other trends. Therefore, it is felt that no conclusions can be drawn concerning the effects of these rations on protein content of milk.

Even though there were no significant differences in the percent fat of the milk, it is of note that there was a trend, with increasing amounts of milo causing slight increases in the percentage of fat.

Shaw and others (2, 20, 21) have developed the concept that acetate-propionate production by the rumen contents plays a major role in controlling whether the energy of the diet finds its way into milk fat or body fat deposition. Increases in acetate relative to propionate tend to be reflected in increases in fat content of the milk and increases in propionate relative to acetate tend to be reflected in increased tendencies to lay down body fat.

In general, in this experiment, increasing the barley in the rations has caused increases in the molar percent propionate (significant changes) and decreases in the molar percent acetate (not significant ones) so that the ratio of propionate to acetate increases with increasing barley. Shaw's concept receives support from this experiment from the observed slight though not significant decreases in butterfat percent with increasing barley. This experiment does not support Shaw's concept with regard to deposition of body fat, since no differences in support of body weight were noted, but the findings of Hubbert (11, 12) and Cardon (4) are in complete agreement with it, since they show that barley, presumably through increased rumen molar

percent propionate to acetate ratio, does support fat deposition better than milo.

The diet's influence on the composition of the milk fat is also in agreement with the concepts of Shaw et al. (20, 21) in that increasing amounts of propionate in the rumen not only lower percent fat in the milk but also cause a depression in the shorter chain acids appearing in the fat. These phenomena are also associated with an increase in the $C_{18}2^{=}$ fraction of the milk fat.

Even though both Cardon (4) and Hubbert (11, 12) found barley to have a higher digestibility than milo it is felt that this is not in disagreement with this experiment, where the two were nearly equal, because in this case they were being compared on their ability to support the production of milk and in the previous cases in their ability to support weight gain.

## CONCLUSIONS

The results of this experiment show that substituting milo for barley on a pound for pound basis in the ration of lactating cows leads to the following conclusions:

1. There were no significant differences in total pounds of milk produced or in the percentages of fat or SNF in the milk.

2. The feeding of 2/3 barley and 1/3 milo caused a small but significant depression in percent protein as compared to the other three rations.

3. Body weights were not affected by the feeding of the different rations.

4. There was a general increase in the short chain acids of the milk fat as the percentage of milo in the ration was increased with a significant decrease in the percentage of $C_{18}2^{=}$.

5. The percentage of propionate appearing in the rumen fluid was depressed by the feeding of milo.

6. Milo increased the digestibility of the entire ration but did not effect the digestibility of the combustible energy or the protein.

7. As it was fed in this study, milo was consumed by the cattle at all levels offered.

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# APPENDIX

TABLE 7

TREATMENT SEQUENCE AND AVERAGE DAILY INDIVIDUAL COW PRODUCTION OF MILK FOR EACH EXPERIMENTAL PERIOD

| COW NO. | TREATMENT SEQUENCE | PERIOD 1 (lbs.) | PERIOD 2 (lbs.) | PERIOD 3 (lbs.) |
|---|---|---|---|---|
| 414 | 1-2-1 [a] | 30.4 | 28.1 | 21.7 |
| 667 | 1-2-1 | 35.5 | 37.5 | 36.7 |
| 212 | 1-3-1 | 28.1 | 24.7 | 23.6 |
| 829 | 1-3-1 | 58.7 | 46.8 | 38.9 |
| 461 | 1-4-1 | 16.6 | 14.4 | 15.1 |
| 210 | 1-4-1 | 28.1 | 25.7 | 19.8 |
| 837 | 2-1-2 | 30.1 | 23.0 | 20.4 |
| 841 | 2-1-2 | 47.4 | 51.9 | 43.0 |
| 138 | 2-3-2 | 18.1 | 12.8 | 10.3 |
| 616 | 2-3-2 | 44.2 | 40.1 | 34.1 |
| 844 | 2-4-2 | 35.6 | 35.9 | 34.7 |
| 653 | 2-4-2 | 49.8 | 43.3 | 41.4 |
| 199 | 3-1-3 | 11.7 | 8.7 | 7.9 |
| 422 | 3-1-3 | 46.7 | 38.3 | 28.4 |
| 187 | 3-2-3 | 20.8 | 14.1 | 17.2 |
| 418 | 3-2-3 | 28.2 | 15.0 | 5.3 |
| 650 | 3-4-3 | 23.7 | 17.8 | 12.5 |
| 668 | 3-4-3 | 39.9 | 38.7 | 37.7 |
| 211 | 4-1-4 | 37.0 | 32.7 | 27.2 |
| 421 | 4-1-4 | 51.5 | 38.4 | 31.8 |
| 412 | 4-2-4 | 43.8 | 38.1 | 33.5 |
| 178 | 4-2-4 | 27.1 | 24.0 | 22.6 |
| 413 | 4-3-4 | 50.5 | 51.5 | 49.0 |
| 181 | 4-3-4 | 21.3 | 17.9 | 15.1 |

(a) Treatments are as follows:

1. 100% Barley
2. 2/3 barley - 1/3 milo
3. 1/3 barley - 2/3 milo
4. 100% milo

TABLE 8

AVERAGE COW MILK FAT PERCENTAGES FOR EACH EXPERIMENTAL PERIOD

| COW NO. | PERIOD 1 | PERIOD 2 | PERIOD 3 |
|---|---|---|---|
| 414 | 1.59 | 2.28 | 2.15 |
| 667 | 1.91 | 3.28 | 3.28 |
| 212 | 3.25 | 4.18 | 3.98 |
| 829 | 1.41 | 1.43 | 1.30 |
| 461 | 3.78 | 4.15 | 4.03 |
| 210 | 3.80 | 4.45 | 4.70 |
| 837 | 2.15 | 2.65 | 3.08 |
| 841 | 2.03 | 3.53 | 3.78 |
| 138 | 3.28 | 3.35 | 3.35 |
| 616 | 1.76 | 2.80 | 2.55 |
| 844 | 2.51 | 2.80 | 3.38 |
| 653 | 2.15 | 3.23 | 3.13 |
| 199 | 4.93 | 5.10 | 4.85 |
| 422 | 1.63 | 1.38 | 1.38 |
| 187 | 4.79 | 5.23 | 4.95 |
| 418 | 2.09 | 2.18 | 2.15 |
| 650 | 2.39 | 3.00 | 2.93 |
| 668 | 2.55 | 3.28 | 3.45 |
| 211 | 3.71 | 3.95 | 4.63 |
| 421 | 1.35 | 1.13 | 1.58 |
| 412 | 1.44 | 1.35 | 2.33 |
| 178 | 4.23 | 4.75 | 4.33 |
| 413 | 3.52 | 2.45 | 3.15 |
| 181 | 4.38 | 4.73 | 4.25 |

TABLE 9

AVERAGE COW MILK PROTEIN PERCENTAGES FOR EACH EXPERIMENTAL PERIOD

| COW NO. | PERIOD 1 | PERIOD 2 | PERIOD 3 |
|---|---|---|---|
| 414 | 2.75 | 3.03 | 3.47 |
| 667 | 2.81 | 3.02 | 3.45 |
| 212 | 4.10 | 4.39 | 4.43 |
| 829 | 2.95 | 3.46 | 3.89 |
| 461 | 3.91 | 4.20 | 4.25 |
| 210 | 3.94 | 4.35 | 4.27 |
| 837 | 3.36 | 3.72 | 3.69 |
| 841 | 3.84 | 4.02 | 3.98 |
| 138 | 3.93 | 4.25 | 4.20 |
| 616 | 3.15 | 3.78 | 3.92 |
| 844 | 3.33 | 3.63 | 3.78 |
| 653 | 3.23 | 3.88 | 3.93 |
| 199 | 4.14 | 4.22 | 4.15 |
| 422 | 3.07 | 3.47 | 3.93 |
| 187 | 4.14 | 4.26 | 4.36 |
| 418 | 2.51 | 2.77 | 3.13 |
| 650 | 3.31 | 3.71 | 3.93 |
| 668 | 3.04 | 3.55 | 3.75 |
| 211 | 3.48 | 4.00 | 4.11 |
| 421 | 2.88 | 3.39 | 3.78 |
| 412 | 2.76 | 3.14 | 3.46 |
| 178 | 3.73 | 4.04 | 4.09 |
| 413 | 2.92 | 3.11 | 3.55 |
| 181 | 3.80 | 4.06 | 3.93 |

TABLE 10

AVERAGE COW MILK SNF PERCENTAGE FOR EACH EXPERIMENTAL PERIOD

| COW NO. | PERIOD 1 | PERIOD 2 | PERIOD 3 |
|---|---|---|---|
| 414 | 7.24 | 7.24 | 7.10 |
| 667 | 8.19 | 8.25 | 8.12 |
| 212 | 9.33 | 9.61 | 9.63 |
| 829 | 8.56 | 8.45 | 8.47 |
| 461 | 9.22 | 9.47 | 9.38 |
| 210 | 9.16 | 9.47 | 9.43 |
| 837 | 8.39 | 8.32 | 8.31 |
| 841 | 8.80 | 9.42 | 9.15 |
| 138 | 8.54 | 8.37 | 8.56 |
| 616 | 8.48 | 8.70 | 8.59 |
| 844 | 8.74 | 8.73 | 8.99 |
| 653 | 8.65 | 8.97 | 9.07 |
| 199 | 8.67 | 9.04 | 8.71 |
| 422 | 8.66 | 8.43 | 8.88 |
| 187 | 8.78 | 9.12 | 9.11 |
| 418 | 7.76 | 7.34 | 7.03 |
| 650 | 8.38 | 8.38 | 8.36 |
| 668 | 8.64 | 8.92 | 8.85 |
| 211 | 8.97 | 9.15 | 9.14 |
| 421 | 7.84 | 7.83 | 7.88 |
| 412 | 7.83 | 7.87 | 7.77 |
| 178 | 8.91 | 9.19 | 9.08 |
| 413 | 8.71 | 8.65 | 8.88 |
| 181 | 8.42 | 8.56 | 8.28 |

TABLE 11

AVERAGE COW BODY WEIGHTS FOR EACH EXPERIMENTAL PERIOD

| COW NO. | PERIOD 1 (lbs.) | PERIOD 2 (lbs.) | PERIOD 3 (lbs.) |
|---|---|---|---|
| 414 | 1398 | 1483 | 1525 |
| 667 | 1195 | 1230 | 1220 |
| 212 | 963 | 930 | 938 |
| 829 | 1520 | 1553 | 1607 |
| 461 | 1323 | 1352 | 1415 |
| 210 | 1002 | 1015 | 1047 |
| 837 | 1415 | 1463 | 1483 |
| 841 | 1332 | 1320 | 1285 |
| 138 | 1077 | 1075 | 1100 |
| 616 | 1266 | 1307 | 1342 |
| 844 | 1216 | 1232 | 1245 |
| 653 | 1438 | 1495 | 1512 |
| 199 | 1223 | 1238 | 1292 |
| 422 | 1235 | 1307 | 1333 |
| 187 | 1222 | 1245 | 1260 |
| 418 | 1463 | 1498 | 1550 |
| 650 | 1762 | 1832 | 1875 |
| 668 | 1073 | 1135 | 1147 |
| 211 | 1107 | 1103 | 1138 |
| 421 | 1412 | 1413 | 1462 |
| 412 | 1493 | 1538 | 1495 |
| 178 | 1068 | 1123 | 1142 |
| 413 | 1393 | 1443 | 1430 |
| 181 | 1301 | 1350 | 1350 |

TABLE 12

COMPOSITION OF THE MILK FAT FOR EACH INDIVIDUAL COW

FOR PERIOD 1

| COW NO. | $C_6$ | $C_8$ | $C_{10}$ | $C_{10}{}^{1=}$ | $C_{12}$ | $C_{13}$ | $C_{14}$ | $C_{14}{}^{1=}$ | $C_{15}$ |
|---|---|---|---|---|---|---|---|---|---|
| 414 | .28 | .43 | 1.44 | .21 | 2.87 | .15 | 9.47 | 2.26 | 3.33 |
| 667 | .44 | .74 | 3.27 | .30 | 4.88 | .37 | 14.19 | 3.05 | 3.03 |
| 212 | .74 | 1.05 | 3.00 | .58 | 4.75 | .58 | 10.83 | 3.97 | 4.92 |
| 829 | .66 | .70 | 1.84 | .35 | 3.12 | .22 | 9.73 | 3.91 | 2.48 |
| 461 | .79 | .96 | 3.40 | .27 | 4.53 | .39 | 12.39 | 2.30 | 2.97 |
| 210 | .56 | .85 | 2.66 | .29 | 4.19 | .27 | 10.69 | 2.12 | 3.12 |
| 837 | .82 | 1.05 | 3.22 | 1.47 | 4.58 | 1.14 | 11.89 | 4.18 | 5.39 |
| 841 | .76 | .75 | 2.04 | .42 | 3.66 | .61 | 10.87 | 3.39 | 3.00 |
| 138 | 1.14 | 1.18 | 3.78 | .65 | 4.62 | .67 | 10.79 | 3.17 | 3.21 |
| 616 | .75 | .80 | 3.07 | .33 | 4.49 | .37 | 12.37 | 3.56 | 2.91 |
| 844 | .71 | .85 | 2.45 | .49 | 4.42 | .65 | 12.65 | 2.42 | 2.77 |
| 653 | .54 | .87 | 3.30 | .32 | 3.76 | .26 | 12.27 | 2.57 | .70 |
| 199 | .60 | .80 | 2.18 | .37 | 3.32 | .41 | 9.89 | 1.85 | 3.56 |
| 422 | .41 | .59 | 1.76 | .35 | 3.38 | .55 | 10.83 | 3.63 | 2.63 |
| 187 | .77 | .83 | 2.59 | .47 | 3.70 | .36 | 11.81 | 2.82 | 2.10 |
| 418 | .37 | .53 | 2.27 | .25 | 3.27 | .35 | 9.79 | 3.58 | 2.76 |
| 650 | .37 | .54 | 1.49 | .28 | 2.72 | .41 | 8.30 | 2.44 | 2.07 |
| 668 | .59 | .90 | 3.40 | .34 | 4.43 | .36 | 13.20 | 3.51 | 3.45 |
| 211 | .80 | .98 | 3.69 | .58 | 4.89 | .86 | 12.83 | 2.06 | 2.81 |
| 421 | .22 | .41 | 2.02 | .21 | 3.53 | .26 | 12.78 | 3.33 | 2.28 |
| 412 | .21 | .52 | 1.45 | .34 | 3.59 | .54 | 12.06 | 3.79 | 3.00 |
| 178 | .86 | .94 | 3.65 | .48 | 4.58 | .21 | 14.22 | 2.38 | 1.82 |
| 413 | 1.36 | 1.35 | 2.75 | .43 | 4.13 | .26 | 12.35 | 2.41 | 1.84 |
| 181 | .64 | .75 | 3.07 | .56 | 3.48 | .72 | 11.00 | 2.29 | 2.54 |

TABLE 12 (CONTINUED)

COMPOSITION OF THE MILK FAT FOR EACH INDIVIDUAL COW

FOR PERIOD 1

| COW NO. | $C_{16}$iso | $C_{16}$ | $C_{16}$1= | $C_{17}$ | $C_{18}$iso | $C_{18}$ | $C_{18}$1= | $C_{18}$2= | $C_{18}$3= |
|---|---|---|---|---|---|---|---|---|---|
| 414 | .38 | 26.99 | 8.62 | 3.72 | .49 | 4.83 | 25.69 | 5.87 | 2.97 |
| 667 | .52 | 30.23 | 4.08 | 2.03 | .55 | 6.91 | 19.78 | 4.21 | 1.41 |
| 212 | .78 | 28.36 | 4.77 | 3.85 | .54 | 2.42 | 20.24 | 5.49 | 1.13 |
| 829 | .44 | 27.50 | 7.01 | 3.71 | .65 | 2.86 | 27.05 | 5.70 | 2.10 |
| 461 | .39 | 32.53 | 3.49 | 1.24 | .22 | 8.63 | 21.35 | 3.20 | .95 |
| 210 | .47 | 32.57 | 5.40 | 3.45 | .39 | 4.56 | 20.51 | 5.40 | 2.49 |
| 837 | .61 | 27.26 | 7.02 | 4.34 | .37 | 3.29 | 18.28 | 3.81 | .56 |
| 841 | .71 | 30.14 | 5.07 | 3.39 | .75 | 6.05 | 22.63 | 3.90 | 1.35 |
| 138 | 1.15 | 30.54 | 4.55 | 3.27 | .79 | 4.99 | 19.00 | 5.32 | 1.17 |
| 616 | 1.26 | 28.40 | 3.20 | 1.17 | .48 | 2.95 | 25.84 | 6.22 | 1.81 |
| 844 | .60 | 27.92 | 3.90 | 3.00 | 1.08 | 7.09 | 20.99 | 5.67 | 2.37 |
| 653 | .70 | 28.19 | 4.75 | 2.29 | .38 | 4.43 | 25.06 | 6.46 | 1.61 |
| 199 | .35 | 28.60 | 3.99 | 2.22 | .35 | 11.12 | 25.28 | 3.93 | 1.18 |
| 422 | 1.24 | 26.70 | 6.10 | 2.82 | 1.67 | 4.10 | 24.61 | 6.43 | 2.19 |
| 187 | .41 | 35.02 | 4.96 | 4.21 | .47 | 8.36 | 18.99 | 1.57 | .62 |
| 418 | 1.00 | 27.72 | 5.25 | 2.92 | .65 | 6.18 | 25.22 | 5.65 | .23 |
| 650 | .50 | 21.85 | 4.55 | 2.41 | .69 | 8.79 | 36.05 | 5.27 | 1.25 |
| 668 | .52 | 33.35 | 6.12 | 2.79 | .69 | 4.99 | 18.36 | 2.25 | .74 |
| 211 | .64 | 35.01 | 2.96 | 1.22 | .46 | 7.31 | 19.31 | 2.78 | .84 |
| 421 | .50 | 29.02 | 7.13 | 1.20 | .52 | 2.71 | 24.55 | 6.50 | 2.81 |
| 412 | .72 | 30.55 | 6.06 | 2.67 | .80 | 3.50 | 23.27 | 5.45 | .95 |
| 178 | .30 | 35.28 | 3.52 | 1.86 | .25 | 6.97 | 18.45 | 3.64 | .61 |
| 413 | .29 | 29.33 | 2.38 | .83 | .28 | 7.75 | 27.75 | 3.59 | .90 |
| 181 | .98 | 31.71 | 3.67 | 2.46 | 1.11 | 8.35 | 17.86 | 6.37 | 2.43 |

TABLE 13

COMPOSITION OF THE MILK FAT FOR EACH INDIVIDUAL COW

FOR PERIOD 2.

| COW NO. | $C_6$ | $C_8$ | $C_{10}$ | $C_{10}$ 1= | $C_{12}$ | $C_{13}$ | $C_{14}$ | $C_{14}$ 1= | $C_{15}$ |
|---|---|---|---|---|---|---|---|---|---|
| 414 | .82 | .91 | 2.53 | .33 | 4.57 | .31 | 11.92 | 3.22 | 2.65 |
| 667 | .87 | 1.03 | 4.54 | .30 | 5.53 | .27 | 13.65 | 2.77 | 2.43 |
| 212 | .71 | .77 | 2.35 | .33 | 3.10 | .33 | 9.81 | 2.41 | 3.18 |
| 829 | .65 | .70 | 2.38 | .28 | 3.20 | .35 | 10.96 | 3.40 | 3.14 |
| 461 | .88 | 1.03 | 2.90 | .35 | 4.01 | .26 | 10.68 | 2.70 | 1.90 |
| 210 | .81 | .95 | 3.46 | .35 | 4.79 | .33 | 12.92 | 2.29 | 1.75 |
| 837 | .78 | .87 | 3.12 | .34 | 4.86 | .33 | 13.24 | 2.94 | 2.36 |
| 841 | .80 | .85 | 3.47 | .38 | 4.45 | .25 | 13.07 | 2.30 | 1.86 |
| 138 | .67 | .95 | 3.25 | .65 | 4.63 | .50 | 10.77 | 3.11 | 2.48 |
| 616 | .56 | .98 | 3.41 | .33 | 4.51 | .37 | 13.51 | 3.36 | 2.58 |
| 844 | .89 | .95 | 3.24 | .35 | 3.89 | .44 | 11.71 | 2.84 | 2.46 |
| 653 | .64 | .90 | 2.92 | .28 | 3.47 | .33 | 11.82 | 3.04 | 3.49 |
| 199 | .50 | .81 | 3.44 | .31 | 5.07 | .36 | 12.78 | 2.34 | 2.55 |
| 422 | .11 | .22 | 1.00 | .18 | 2.54 | .38 | 10.66 | 3.35 | 3.71 |
| 187 | .54 | .78 | 3.27 | .36 | 3.57 | .30 | 10.88 | 2.96 | 2.57 |
| 418 | .42 | .68 | 3.15 | .27 | 3.40 | .21 | 10.06 | 2.89 | 3.00 |
| 650 | .36 | .57 | 2.63 | .26 | 3.27 | .34 | 10.45 | 3.56 | 3.09 |
| 668 | .52 | .80 | 3.55 | .41 | 4.73 | .29 | 11.29 | 2.89 | 2.94 |
| 211 | .46 | .96 | 3.46 | .31 | 4.76 | .39 | 12.10 | 1.94 | 2.98 |
| 421 | .11 | .22 | 1.12 | .19 | 3.13 | .33 | 11.11 | 3.12 | 2.79 |
| 412 | .11 | .25 | 2.05 | .19 | 3.38 | .16 | 13.57 | 2.35 | 2.12 |
| 178 | .53 | .85 | 2.70 | .30 | 4.64 | .28 | 14.76 | 2.30 | 1.79 |
| 413 | .42 | .78 | 3.06 | .41 | 5.31 | .61 | 14.83 | 5.79 | 2.01 |
| 181 | .46 | .66 | 2.35 | .23 | 3.53 | .46 | 11.45 | 4.13 | 3.30 |

TABLE 13 (CONTINUED)

COMPOSITION OF THE MILK FAT FOR EACH INDIVIDUAL COW

FOR PERIOD 2

| COW NO. | $C_{16}^{iso}$ | $C_{16}$ | $C_{16}^{1=}$ | $C_{17}$ | $C_{18}^{iso}$ | $C_{18}$ | $C_{18}^{1=}$ | $C_{18}^{2=}$ | $C_{18}^{3=}$ |
|---|---|---|---|---|---|---|---|---|---|
| 414 | .51 | 3.22 | 5.17 | 2.38 | .08 | 6.11 | 21.00 | 4.21 | 1.12 |
| 667 | .33 | 33.95 | 5.20 | 2.46 | - | 7.22 | 16.12 | 2.81 | .52 |
| 212 | .20 | 37.24 | 7.93 | 3.38 | .46 | 6.75 | 17.84 | 2.71 | .51 |
| 829 | .41 | 27.54 | 7.22 | 3.04 | - | 5.04 | 25.18 | 5.70 | .81 |
| 461 | .37 | 33.94 | 4.72 | 2.81 | .35 | 8.58 | 19.31 | 3.54 | 1.49 |
| 210 | .43 | 34.58 | 6.77 | 2.90 | .62 | 6.04 | 17.17 | 3.10 | .74 |
| 837 | .42 | 33.40 | 5.02 | 2.24 | .24 | 5.72 | 19.39 | 3.74 | .93 |
| 841 | .19 | 35.23 | 5.79 | 1.47 | - | 5.66 | 19.64 | 3.75 | .83 |
| 138 | .53 | 30.17 | 6.15 | 2.78 | .34 | 5.17 | 21.95 | 5.24 | .66 |
| 616 | .31 | 33.17 | 5.51 | 2.40 | .29 | 5.99 | 18.49 | 3.62 | .60 |
| 844 | .54 | 33.57 | 6.12 | 3.60 | .29 | 7.65 | 18.00 | 2.79 | .70 |
| 653 | .30 | 36.99 | 5.50 | 2.87 | - | 6.26 | 17.13 | 3.51 | .56 |
| 199 | .42 | 38.09 | 6.48 | 2.69 | .42 | 4.90 | 15.53 | 3.74 | .57 |
| 422 | .86 | 32.35 | 8.26 | 3.45 | 1.51 | 3.53 | 21.33 | 2.86 | 1.70 |
| 187 | .36 | 36.93 | 5.94 | 2.56 | .35 | 7.27 | 17.56 | 3.18 | .60 |
| 418 | .53 | 26.94 | 7.42 | 4.30 | .50 | 7.54 | 22.38 | 5.31 | .99 |
| 650 | -- | 27.06 | 4.71 | 1.88 | -- | 9.12 | 28.51 | 3.27 | .92 |
| 668 | .23 | 33.10 | 7.08 | 3.12 | .20 | 5.31 | 19.69 | 3.28 | .58 |
| 211 | .42 | 36.41 | 5.04 | 2.82 | .65 | 6.20 | 16.90 | 3.46 | .74 |
| 421 | 1.59 | 28.99 | 6.42 | 2.63 | 2.09 | 3.72 | 21.96 | 8.58 | 1.82 |
| 412 | .54 | 37.09 | 3.38 | 1.44 | .62 | 5.70 | 22.90 | 2.73 | 1.47 |
| 178 | .42 | 39.14 | 2.85 | 2.32 | -- | 7.16 | 16.55 | 1.93 | 1.46 |
| 413 | .24 | 32.00 | 4.88 | 1.37 | .09 | 1.90 | 22.01 | 2.51 | 1.76 |
| 181 | 1.11 | 34.62 | 6.48 | 4.62 | .64 | 6.83 | 15.54 | 2.85 | .74 |

TABLE 14

COMPOSITION OF THE MILK FAT FOR EACH INDIVIDUAL COW

FOR PERIOD 3

| COW NO. | $C_6$ | $C_8$ | $C_{10}$ | $C_{10}$ 1= | $C_{12}$ | $C_{13}$ | $C_{14}$ | $C_{14}$ 1= | $C_{15}$ |
|---|---|---|---|---|---|---|---|---|---|
| 414 | .31 | .51 | 2.21 | .32 | 2.91 | .34 | 8.29 | 2.24 | 2.86 |
| 667 | .75 | 1.14 | 3.43 | .15 | 5.55 | .19 | 14.77 | 2.53 | 2.76 |
| 212 | .76 | 1.09 | 3.47 | .70 | 4.38 | .82 | 10.95 | 2.40 | 2.86 |
| 829 | .14 | .28 | 1.28 | .21 | 2.34 | .36 | 8.12 | 3.89 | 3.08 |
| 461 | .59 | .87 | 2.57 | m.21 | 4.24 | .18 | 11.89 | 2.39 | 2.38 |
| 210 | .60 | .88 | 3.22 | .29 | 4.10 | .43 | 11.31 | 1.86 | 2.37 |
| 837 | .41 | .77 | 2.87 | .43 | 5.02 | .94 | 12.74 | 2.65 | 3.40 |
| 841 | .73 | 1.04 | 3.61 | .39 | 4.86 | .36 | 14.32 | 2.02 | 1.64 |
| 138 | .38 | .60 | 2.06 | .22 | 3.41 | .14 | 9.35 | 2.37 | 2.46 |
| 616 | .53 | .61 | 2.98 | .38 | 5.37 | .53 | 13.29 | 2.43 | 2.71 |
| 844 | .78 | 1.17 | 3.31 | .16 | 5.27 | .45 | 14.13 | 2.04 | 2.09 |
| 653 | .75 | 1.02 | 2.67 | .26 | 4.10 | .21 | 12.27 | 1.92 | 1.84 |
| 199 | .70 | 1.01 | 3.81 | .31 | 3.53 | .47 | 10.42 | 2.10 | 2.93 |
| 422 | .05 | .30 | 1.21 | .31 | 2.46 | .53 | 7.95 | 3.73 | 4.75 |
| 187 | .36 | .60 | 3.11 | .14 | 3.64 | .24 | 9.38 | 1.33 | 1.62 |
| 418 | .21 | .39 | 1.53 | .12 | 2.69 | .31 | 8.18 | 1.78 | 2.37 |
| 650 | .31 | .53 | 1.73 | .29 | 3.25 | .48 | 8.87 | 3.14 | 2.91 |
| 668 | .73 | .66 | 2.37 | .25 | 4.00 | .30 | 11.45 | 2.05 | 2.17 |
| 211 | .75 | 1.06 | 3.04 | .22 | 4.73 | .24 | 13.19 | 1.32 | 1.56 |
| 421 | .42 | .67 | 2.62 | .16 | 3.32 | .17 | 12.18 | 1.83 | 1.84 |
| 412 | .73 | .90 | 3.36 | .23 | 3.28 | .13 | 10.83 | 1.61 | 2.09 |
| 187 | .79 | 1.27 | 3.51 | .53 | 5.52 | .48 | 13.35 | 2.49 | 1.86 |
| 413 | .69 | 1.03 | 3.60 | .48 | 4.14 | .67 | 13.02 | 2.11 | 2.51 |
| 181 | .56 | .80 | 2.13 | .31 | 3.57 | .41 | 9.83 | 2.61 | 2.53 |

TABLE 14 (CONTINUED)

COMPOSITION OF THE MILK FAT FOR EACH INDIVIDUAL COW

FOR PERIOD 3

| COW NO. | $C_{16}$iso | $C_{16}$ | $C_{16}$1= | $C_{17}$ | $C_{18}$iso | $C_{18}$ | $C_{18}$1= | $C_{18}$2= | $C_{18}$3= |
|---|---|---|---|---|---|---|---|---|---|
| 414 | .50 | 25.31 | 9.02 | 6.08 | .42 | 9.35 | 20.27 | 7.88 | 1.10 |
| 667 | .59 | 25.63 | 1.50 | .75 | - | 10.20 | 19.52 | 5.81 | 4.73 |
| 212 | .91 | 38.30 | 3.54 | 2.21 | .72 | 7.37 | 16.30 | 2.55 | .66 |
| 829 | .76 | 24.32 | 8.38 | 6.67 | .59 | 5.58 | 23.54 | 9.27 | 1.17 |
| 461 | .41 | 33.93 | 3.17 | 3.34 | .23 | 9.48 | 18.70 | 3.78 | 1.66 |
| 210 | .78 | 37.29 | 3.65 | 2.95 | .90 | 9.45 | 17.02 | 2.01 | .91 |
| 837 | 1.53 | 32.05 | 5.44 | 6.16 | .96 | 8.80 | 13.14 | 2.00 | .67 |
| 841 | .56 | 36.15 | 3.02 | 2.10 | .76 | 6.89 | 18.70 | 2.10 | .77 |
| 138 | .40 | 29.24 | 5.30 | 4.65 | .37 | 12.51 | 22.45 | 3.17 | .92 |
| 616 | .94 | 30.44 | 6.23 | 5.91 | .75 | 8.02 | 16.34 | 2.34 | .39 |
| 844 | .81 | 34.91 | 2.96 | 1.60 | .62 | 8.50 | 17.91 | 2.27 | 1.00 |
| 653 | .45 | 37.98 | 4.43 | 3.55 | .39 | 8.34 | 17.43 | 1.72 | .66 |
| 199 | .60 | 27.99 | 4.25 | 2.79 | .66 | 12.71 | 22.76 | 2.56 | .41 |
| 422 | .81 | 24.34 | 9.96 | 11.39 | .91 | 5.46 | 21.92 | 3.29 | .62 |
| 187 | .24 | 29.26 | 6.23 | 4.70 | .30 | 5.83 | 25.88 | 5.61 | 1.44 |
| 418 | .47 | 24.24 | 6.15 | 6.12 | .79 | 9.56 | 26.16 | 8.15 | .77 |
| 650 | 1.06 | 25.59 | 4.47 | 5.68 | .92 | 9.77 | 27.43 | 2.60 | .96 |
| 668 | .55 | 30.93 | 4.16 | 5.48 | .77 | 6.83 | 17.07 | 6.27 | 4.32 |
| 211 | .25 | 37.09 | 5.18 | 2.20 | .49 | 8.79 | 17.18 | 1.99 | .74 |
| 421 | .21 | 27.08 | 5.32 | 1.72 | .27 | 8.20 | 26.45 | 5.05 | 2.49 |
| 412 | .35 | 37.30 | 5.23 | 3.96 | .21 | 6.48 | 18.83 | 3.39 | 1.08 |
| 187 | .71 | 30.18 | 3.11 | 2.59 | .71 | 9.56 | 19.67 | 2.53 | 1.15 |
| 413 | 1.10 | 32.93 | 3.45 | 3.58 | .74 | 8.75 | 18.29 | 2.05 | .89 |
| 181 | .75 | 33.89 | 3.62 | 3.17 | 1.01 | 9.62 | 21.76 | 2.46 | .95 |

TABLE 15

VFA CONTENT OF THE RUMEN FLUID FROM THE EXPERIMENTAL COWS FROM PERIOD 1

| COW NO. | TOTAL VFA (uM/ ml.) | ACETATE (uM/ ml.) | ACETATE (Molar %) | PROPIONATE (uM/ ml.) | PROPIONATE (Molar %) | BUTYRATE (uM/ ml.) | BUTYRATE (Molar %) | VALERATE (uM/ ml.) | VALERATE (Molar %) | HIGHER ACIDS (uM/ ml.) | HIGHER ACIDS (Molar %) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 414 | 121.04 | 67.13 | 55.46 | 30.94 | 25.56 | 16.13 | 13.33 | 1.50 | 1.24 | 5.34 | 1.24 |
| 667 | 66.67 | 40.51 | 60.76 | 14.72 | 22.08 | 8.16 | 12.24 | 1.03 | 1.54 | 2.25 | 1.54 |
| 212 | 101.91 | 50.44 | 49.50 | 38.63 | 37.91 | 9.47 | 9.29 | 0.84 | .82 | 2.53 | .82 |
| 829 | 130.33 | 59.35 | 45.54 | 55.04 | 42.23 | 13.22 | 10.14 | 1.13 | .87 | 1.59 | .87 |
| 461 | 97.53 | 57.10 | 58.54 | 22.13 | 22.69 | 13.69 | 14.04 | 0.67 | .69 | 3.94 | .69 |
| 210 | 129.29 | 82.23 | 63.60 | 32.25 | 24.95 | 10.78 | 8.34 | 2.25 | 1.74 | 1.78 | 1.74 |
| 837 | 102.38 | 58.88 | 57.56 | 29.44 | 28.78 | 10.97 | 10.72 | 2.06 | 2.01 | 1.03 | 2.01 |
| 841 | 104.17 | 60.29 | 57.88 | 28.50 | 27.36 | 11.53 | 11.07 | 1.97 | 1.89 | 1.88 | 1.89 |
| 138 | 106.52 | 62.73 | 58.89 | 33.29 | 31.25 | 6.94 | 6.52 | 1.22 | 1.15 | 2.34 | 1.15 |
| 616 | 105.02 | 49.04 | 47.60 | 40.97 | 39.01 | 9.38 | 8.93 | 0.94 | .90 | 4.69 | .90 |
| 844 | 86.54 | 47.91 | 55.36 | 27.94 | 32.28 | 7.03 | 8.12 | 0.75 | .87 | 2.91 | .87 |
| 653 | 88.61 | 49.51 | 55.87 | 28.22 | 31.85 | 7.13 | 8.05 | 1.22 | 1.38 | 2.53 | 1.38 |
| 199 | 100.24 | 57.20 | 57.07 | 28.22 | 28.14 | 11.63 | 11.61 | 0.75 | .75 | 2.44 | .75 |
| 422 | 116.83 | 61.51 | 52.65 | 44.91 | 38.44 | 5.91 | 5.06 | 1.22 | 1.04 | 3.28 | 1.04 |
| 187 | 45.48 | 31.79 | 69.90 | 9.38 | 20.62 | 2.44 | 5.37 | 0.56 | 1.23 | 1.31 | 1.23 |
| 418 | 104.44 | 62.16 | 59.52 | 34.22 | 32.77 | 5.34 | 5.11 | 1.41 | 1.35 | 1.31 | 1.35 |
| 650 | 101.82 | 62.16 | 61.05 | 30.66 | 30.11 | 8.06 | 7.92 | 0.47 | .46 | .47 | .46 |
| 668 | 100.70 | 60.85 | 60.45 | 29.63 | 29.45 | 8.34 | 8.26 | 1.41 | 1.38 | .47 | 1.38 |
| 211 | 126.96 | 73.79 | 28.12 | 37.32 | 29.39 | 11.91 | 9.38 | 2.16 | 1.70 | 1.78 | 1.70 |
| 421 | 106.23 | 52.41 | 49.34 | 43.13 | 40.60 | 7.88 | 7.42 | 2.34 | 2.20 | .47 | 2.20 |
| 412 | 99.57 | 49.13 | 49.34 | 37.04 | 37.17 | 8.53 | 8.59 | 1.78 | 1.79 | 3.09 | 1.79 |
| 178 | 117.49 | 73.23 | 62.33 | 29.82 | 25.38 | 10.03 | 8.54 | 1.97 | 1.68 | 2.44 | 1.68 |
| 413 | 123.66 | 73.23 | 59.29 | 32.63 | 26.39 | 10.78 | 8.72 | .84 | .68 | 6.09 | .68 |
| 181 | 109.23 | 69.65 | 64.04 | 21.75 | 19.91 | 11.44 | 10.47 | 1.78 | 1.63 | 4.31 | 1.63 |

TABLE 16

VFA CONTENT OF THE RUMEN FLUID FROM THE EXPERIMENTAL COWS FROM PERIOD 2

| COW NO. | TOTAL VFA (uM/ ml.) | ACETATE (uM/ ml.) | ACETATE (Molar %) | PROPIONATE (uM/ ml.) | PROPIONATE (Molar %) | BUTYRATE (uM/ ml.) | BUTYRATE (Molar %) | VALERATE (uM/ ml.) | VALERATE (Molar %) | HIGHER ACIDS (uM/ ml.) | HIGHER ACIDS (Molar %) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 414 | 114.29 | 72.57 | 63.50 | 35.94 | 31.01 | 23.16 | 3.12 | .47 | .41 | 2.25 | 1.97 |
| 667 | 103.99 | 68.26 | 65.64 | 19.69 | 18.93 | 18.28 | 11.54 | 2.16 | 2.08 | 1.88 | 1.81 |
| 212 | 72.19 | 44.16 | 61.17 | 17.81 | 24.67 | 19.22 | 11.04 | .75 | 1.04 | 1.50 | 2.08 |
| 829 | 145.15 | 76.23 | 52.52 | 52.79 | 36.37 | 11.72 | 8.53 | 1.03 | .71 | 2.72 | 1.87 |
| 461 | 59.36 | 33.57 | 56.55 | 15.28 | 25.74 | 12.19 | 12.01 | 1.97 | 3.32 | 1.41 | 2.38 |
| 210 | 112.71 | 73.42 | 65.14 | 20.82 | 18.47 | 8.34 | 11.73 | 2.25 | 2.00 | 3.00 | 2.66 |
| 837 | 119.27 | 63.85 | 53.53 | 30.94 | 25.94 | 17.35 | 16.83 | 2.91 | 2.44 | 1.50 | 1.26 |
| 841 | 67.88 | 43.51 | 64.10 | 14.06 | 20.71 | 12.28 | 12.85 | .84 | 1.24 | .75 | 1.10 |
| 138 | 117.02 | 65.17 | 55.69 | 38.35 | 32.77 | 13.41 | 8.57 | 2.34 | 2.00 | 1.13 | .97 |
| 616 | 75.95 | 45.48 | 59.88 | 22.78 | 29.99 | 8.06 | 6.18 | 1.22 | 1.61 | 1.78 | 2.34 |
| 844 | 65.27 | 43.51 | 66.66 | 12.19 | 18.68 | 11.63 | 10.77 | .66 | 1.01 | 1.88 | 2.88 |
| 653 | 61.88 | 47.63 | 76.97 | 8.34 | 13.48 | 9.94 | 7.27 | .94 | 1.52 | .47 | .76 |
| 199 | 84.66 | 48.10 | 56.82 | 19.78 | 23.36 | 9.28 | 14.51 | 2.81 | 3.32 | 1.69 | 2.00 |
| 422 | 121.89 | 61.70 | 50.62 | 47.91 | 39.31 | 10.31 | 6.61 | 2.63 | 2.16 | 1.59 | 1.30 |
| 187 | 52.60 | 33.29 | 63.29 | 12.94 | 24.60 | 4.97 | 10.15 | .56 | 1.06 | .47 | .89 |
| 418 | 115.14 | 64.42 | 55.95 | 37.88 | 32.90 | 10.69 | 9.36 | 1.50 | 1.30 | .56 | .49 |
| 650 | 100.61 | 67.60 | 67.19 | 19.32 | 19.20 | 10.97 | 11.37 | 1.78 | 1.77 | .47 | .47 |
| 668 | 84.57 | 46.69 | 55.21 | 22.78 | 26.94 | 10.13 | 15.20 | 1.59 | 1.88 | .66 | .78 |
| 211 | 64.51 | 39.19 | 60.75 | 13.97 | 21.65 | 16.13 | 15.11 | 1.13 | 1.75 | .47 | .73 |
| 421 | 149.93 | 66.76 | 44.53 | 65.26 | 43.53 | 11.44 | 7.32 | 3.00 | 2.00 | 3.94 | 2.63 |
| 412 | 157.72 | 84.86 | 53.80 | 56.54 | 35.85 | 12.00 | 6.90 | 2.53 | 1.60 | 2.91 | 1.84 |
| 178 | 88.71 | 57.48 | 64.80 | 15.94 | 17.97 | 11.25 | 11.74 | 2.63 | 2.96 | 2.25 | 2.54 |
| 413 | 113.46 | 60.20 | 53.06 | 40.88 | 36.03 | 9.94 | 6.78 | 2.44 | 2.15 | 2.25 | 1.98 |
| 181 | 86.45 | 53.16 | 61.49 | 22.60 | 26.14 | 14.91 | 8.68 | 1.88 | 2.17 | 1.31 | 1.52 |

TABLE 17

VFA CONTENT OF THE RUMEN FLUID FROM THE EXPERIMENTAL COWS FROM PERIOD 3

| COW NO. | TOTAL VFA (uM/ ml.) | ACETATE (uM/ ml.) | ACETATE (Molar %) | PROPIONATE (uM/ ml.) | PROPIONATE (Molar %) | BUTYRATE (uM/ ml.) | BUTYRATE (Molar %) | VALERATE (uM/ ml.) | VALERATE (Molar %) | HIGHER ACIDS (uM/ ml.) | HIGHER ACIDS (Molar %) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 414 | 99.95 | 54.01 | 54.04 | 19.03 | 19.04 | 23.16 | 23.17 | 2.53 | 2.53 | 1.22 | 1.22 |
| 667 | 121.33 | 79.14 | 65.23 | 20.35 | 16.77 | 18.28 | 15.07 | 2.06 | 1.70 | 1.50 | 1.24 |
| 212 | 134.93 | 85.51 | 63.37 | 24.66 | 18.28 | 19.22 | 14.24 | 3.38 | 2.50 | 2.16 | 1.60 |
| 829 | 114.29 | 61.32 | 53.67 | 36.47 | 31.91 | 11.72 | 10.26 | 2.44 | 2.14 | 2.34 | 2.05 |
| 461 | 91.62 | 57.95 | 63.25 | 17.35 | 18.94 | 12.19 | 13.31 | 2.63 | 2.87 | 1.50 | 1.64 |
| 210 | 81.11 | 56.45 | 69.60 | 14.35 | 17.69 | 8.34 | 10.28 | 1.50 | 1.85 | .47 | .58 |
| 837 | 112.24 | 72.20 | 64.32 | 18.00 | 16.04 | 17.35 | 15.46 | 2.06 | 1.84 | 2.63 | 2.34 |
| 841 | 100.51 | 71.17 | 70.81 | 13.78 | 13.71 | 12.28 | 12.22 | 2.06 | 2.05 | 1.22 | 1.21 |
| 138 | 94.79 | 58.41 | 61.62 | 20.53 | 21.66 | 13.41 | 14.15 | 1.97 | 2.08 | .47 | .50 |
| 616 | 52.88 | 34.41 | 65.07 | 8.53 | 16.33 | 8.06 | 15.24 | 1.41 | 2.67 | .47 | .89 |
| 844 | 82.88 | 51.66 | 62.33 | 15.94 | 19.23 | 11.63 | 14.03 | 1.31 | 1.58 | 2.34 | 2.82 |
| 653 | 83.16 | 48.85 | 58.74 | 22.78 | 27.39 | 9.94 | 11.95 | .84 | 1.01 | .75 | .90 |
| 199 | 49.60 | 28.32 | 57.10 | 10.22 | 20.60 | 9.28 | 18.71 | .56 | 1.13 | 1.22 | 2.46 |
| 422 | 99.29 | 47.44 | 47.78 | 37.88 | 38.15 | 10.31 | 10.38 | 1.88 | 1.89 | 1.78 | 1.79 |
| 187 | 36.94 | 25.69 | 69.55 | 5.34 | 14.46 | 4.97 | 13.45 | .47 | 1.27 | .47 | 1.27 |
| 418 | 86.74 | 61.51 | 70.91 | 12.47 | 14.38 | 10.69 | 12.32 | 1.13 | 1.30 | .94 | 1.08 |
| 650 | 79.89 | 55.32 | 69.24 | 11.63 | 14.50 | 10.97 | 13.73 | 1.31 | 1.64 | .60 | .83 |
| 668 | 108.48 | 68.54 | 63.18 | 27.38 | 25.24 | 10.13 | 9.34 | 1.59 | 1.47 | .84 | .77 |
| 211 | 109.33 | 70.88 | 64.83 | 18.66 | 17.07 | 16.13 | 14.75 | 2.63 | 2.41 | 1.03 | .94 |
| 421 | 77.64 | 44.82 | 57.73 | 17.25 | 22.22 | 11.44 | 14.73 | 2.72 | 3.50 | 1.41 | 1.82 |
| 412 | 104.54 | 70.60 | 67.54 | 16.13 | 15.43 | 12.00 | 11.48 | 2.53 | 2.42 | 3.28 | 3.14 |
| 178 | 73.61 | 46.23 | 62.80 | 11.44 | 15.54 | 11.25 | 15.28 | 1.13 | 1.54 | 3.56 | 4.84 |
| 413 | 103.29 | 70.42 | 68.21 | 20.16 | 19.53 | 9.94 | 9.63 | 1.03 | 1.00 | 1.69 | 1.64 |
| 181 | 72.67 | 46.88 | 64.51 | 8.91 | 12.26 | 14.91 | 20.52 | 1.13 | 1.55 | .84 | 1.16 |

TABLE 18

PERCENT DIGESTIBILITY OF THE TOTAL RATION FOR EACH INDIVIDUAL COW

| COW NO. | PERIOD 1 | PERIOD 2 | PERIOD 3 |
|---|---|---|---|
| 414 | 76.04 | 76.63 | 73.62 |
| 667 | 77.72 | 76.76 | 77.81 |
| 212 | 76.53 | 81.02 | 74.90 |
| 829 | 74.17 | 76.24 | 76.13 |
| 461 | 77.44 | 78.04 | 77.16 |
| 210 | 75.04 | 74.88 | 76.97 |
| 837 | 72.18 | 75.57 | 73.99 |
| 841 | 76.76 | 76.74 | 77.23 |
| 138 | 75.15 | 76.29 | 76.15 |
| 616 | 74.80 | 74.68 | 74.42 |
| 844 | 73.32 | 73.32 | 69.31 |
| 653 | 77.56 | 79.25 | 77.06 |
| 199 | 77.74 | 75.44 | 78.35 |
| 422 | 76.51 | 72.18 | 76.03 |
| 187 | 77.34 | 75.23 | 77.45 |
| 418 | 76.75 | 73.81 | 76.84 |
| 650 | 78.00 | 77.55 | 78.39 |
| 668 | 78.70 | 79.57 | 77.26 |
| 211 | 78.93 | 76.76 | 77.77 |
| 421 | 77.45 | 74.02 | 75.51 |
| 412 | 77.40 | 76.56 | 75.22 |
| 178 | 78.39 | 78.13 | 77.34 |
| 413 | 78.31 | 73.85 | 73.77 |
| 181 | 77.85 | 76.56 | 78.00 |

TABLE 19

PERCENT DIGESTIBILITY OF THE TOTAL COMBUSTIBLE ENERGY OF THE RATION FOR EACH INDIVIDUAL COW

| COW NO. | PERIOD 1 | PERIOD 2 | PERIOD 3 |
|---|---|---|---|
| 414 | 74.99 | 73.89 | 71.07 |
| 667 | 76.54 | 73.57 | 75.80 |
| 212 | 75.05 | 76.10 | 72.99 |
| 829 | 73.46 | 72.91 | 73.45 |
| 461 | 75.96 | 75.83 | 74.67 |
| 210 | 73.38 | 72.36 | 75.11 |
| 837 | 72.88 | 74.74 | 72.85 |
| 841 | 75.05 | 74.95 | 76.34 |
| 138 | 73.94 | 73.40 | 75.02 |
| 616 | 73.37 | 72.41 | 72.15 |
| 844 | 70.53 | 75.89 | 65.29 |
| 653 | 75.95 | 77.07 | 75.94 |
| 199 | 75.98 | 71.69 | 76.00 |
| 422 | 74.62 | 69.93 | 73.60 |
| 187 | 76.15 | 72.47 | 74.96 |
| 418 | 74.78 | 71.60 | 75.06 |
| 650 | 76.47 | 75.67 | 76.11 |
| 668 | 76.10 | 77.24 | 75.40 |
| 211 | 76.89 | 75.39 | 74.20 |
| 421 | 76.33 | 71.91 | 73.80 |
| 412 | 75.35 | 74.44 | 69.46 |
| 178 | 77.35 | 75.79 | 74.73 |
| 413 | 77.09 | 71.99 | 74.88 |
| 181 | 76.08 | 73.08 | 75.45 |

TABLE 20

PERCENT DIGESTIBILITY OF THE CRUDE PROTEIN OF THE RATION FOR EACH INDIVIDUAL COW

| COW NO. | PERIOD 1 | PERIOD 2 | PERIOD 3 |
|---|---|---|---|
| 414 | 81.10 | 79.17 | 73.14 |
| 667 | 84.93 | 79.09 | 73.29 |
| 212 | 81.49 | 77.30 | 74.90 |
| 829 | 81.37 | 78.64 | 78.16 |
| 461 | 79.30 | 76.19 | 76.28 |
| 210 | 77.97 | 70.98 | 78.26 |
| 837 | 78.19 | 79.96 | 75.88 |
| 841 | 81.22 | 78.04 | 78.69 |
| 138 | 81.62 | 77.66 | 79.54 |
| 616 | 81.43 | 73.28 | 78.59 |
| 844 | 74.88 | 75.79 | 59.38 |
| 653 | 81.93 | 78.74 | 78.19 |
| 199 | 77.88 | 79.13 | 75.51 |
| 422 | 80.79 | 81.14 | 74.87 |
| 187 | 75.97 | 71.65 | 75.60 |
| 418 | 82.11 | 77.14 | 75.35 |
| 650 | 79.93 | 75.38 | 75.95 |
| 668 | 78.51 | 78.24 | 71.11 |
| 211 | 78.09 | 71.01 | 72.12 |
| 421 | 78.35 | 70.15 | 76.95 |
| 412 | 78.45 | 78.27 | 73.60 |
| 178 | 78.26 | 79.67 | 75.51 |
| 413 | 78.65 | 77.91 | 75.22 |
| 181 | 75.60 | 74.12 | 75.62 |

TABLE 21

RESULTS OF THE STATISTICAL ANALYSIS OF THE DATA

| | STANDARD ERROR | COEF. OF VARIATION | F VALUE |
|---|---|---|---|
| Average daily milk production | 0.87 | 6.11 | 0.27 |
| % fat in the milk | 0.14 | 10.46 | 1.44 |
| % protein in the milk | 0.04 | 2.58 | 3.71* |
| % SNF in the milk | 0.07 | 1.64 | 0.05 |
| Body weight | 7.55 | 1.20 | 0.29 |
| Composition of the milk fat | | | |
| $C_6$ | 0.07 | 34.48 | 6.27* |
| $C_8$ | 0.06 | 22.49 | 3.48* |
| $C_{10}$ | 0.20 | 19.22 | 3.22* |
| $C_{10}1=$ | 0.05 | 37.61 | 1.76 |
| $C_{12}$ | 0.26 | 14.71 | .46 |
| $C_{13}$ | 0.06 | 36.98 | .84 |
| $C_{14}$ | 0.52 | 9.79 | .55 |
| $C_{14}1=$ | 0.31 | 26.04 | .36 |
| $C_{15}$ | .28 | 22.62 | .25 |
| $C_{16}iso$ | .14 | 54.61 | 1.75 |
| $C_{16}$ | .79 | 6.61 | 1.62 |
| $C_{16}1=$ | .62 | 26.44 | .79 |
| $C_{17}$ | .57 | 38.12 | .38 |
| $C_{18}iso$ | .17 | 72.51 | 1.30 |
| $C_{18}$ | .72 | 23.66 | 1.10 |
| $C_{18}1=$ | 1.00 | 10.51 | .83 |
| $C_{18}2=$ | .31 | 24.63 | 8.72* |
| $C_{18}3=$ | .24 | 50.02 | 2.09 |
| VFA Content of Rumen Fluid | | | |
| Total VFA | 10.02 | 23.03 | 1.13 |
| Total Acetate | 5.31 | 20.71 | .67 |
| Molar % Acetate | 1.85 | 9.31 | 2.76 |
| Total propionate | 4.18 | 40.81 | 2.81 |
| Molar % propionate | 1.62 | 21.72 | 6.29* |
| Total Butyrate | 1.56 | 35.49 | 1.91 |
| Molar % Butyrate | 1.38 | 30.63 | 2.21 |
| Total valerate | .34 | 46.47 | .84 |
| Molar % valerate | .33 | 42.88 | .47 |
| Total Higher Acids | .39 | 44.88 | .09 |
| Molar % Higher Acids | .27 | 32.31 | .69 |

TABLE 21 (CONTINUED)

RESULTS OF THE STATISTICAL ANALYSIS OF THE DATA

| | STANDARD ERROR | COEF. OF VARIATION | F VALUE |
|---|---|---|---|
| % Total digestibility of ration | .61 | 2.28 | 4.85* |
| % Digestibility of combustible energy | .89 | 3.01 | 2.14 |
| % Digestibility of protein | 1.24 | 4.03 | .50 |

* Indicates a significant difference ($P<0.05$)