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INFLUENCE OF CRUDE FIBER IN THE RATION ON EFFICIENCY OF FEED UTILIZATION BY DAIRY COWS[1]

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INTRODUCTION

Roughages commonly fed to dairy cows in Hawaii tend to be high in fiber. One of these roughages is "strip cane," and another is "cane tops," both of which are obtained as waste or by-products from sugar plantations. Near Honolulu other roughages are grown as soiling crops (Napier grass, *Pennisetum purpureum*) or obtained in wild state from gulches and other waste areas (koa haole, *Leucaena glauca*). These and other roughages are unusually high in crude fiber. For example, strip cane contains 44 per cent crude fiber, sugar cane tops, 37 per cent, Napier grass, 41 per cent and koa haole, 37 per cent crude fiber when calculated on the dry matter basis. Therefore, in this area, it is very important that an investigation be made as to the correct balance of crude fiber to total digestible nutrients in the rations fed to cattle.

REVIEW OF LITERATURE

Many investigators have worked on various phases of nutrition closely related to the problem mentioned above. Henke (6) reported that the 4 per cent F.C. milk production was 25.4 lb. per cow daily when the average concentrate consumption was 19.8 lb. as compared to 24.1 lb. when concentrate consumption averaged 15.4 lb. Napier grass was fed as the roughage. In another experiment the same author (5) studied pineapple tops as a substitute for Napier grass when the concentrate rations were kept equal. The 4 per cent F.C. milk yield averaged 5.5 per cent higher when pineapple tops were fed. The amount of crude fiber calculated on the percentage of dry matter in the feed was 12.4 per cent as compared to 21.1 per cent when Napier grass was fed. However, the content of digestible protein was slightly higher in the pineapple tops group. At the Massachusetts Station high concentrate feeding also was compared with rather low allowance of concentrates and a maximum amount of roughage (8). On a high concentrate ration the milk yield was 31.7 lb. daily, as compared with 27.7 lb. for the ration containing a smaller amount of concentrates. This experiment, as well as those carried out at the Hawaii Agricultural Experiment Station, was concerned primarily with the economic phase of this type of feeding.

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As to the physiological optimum of crude fiber in the rations, relatively little work has been done. Working with fattening lambs, Cox (4) found that when using the proportions 35 : 65, 45 : 55 and 55 : 45 of concentrates to roughage, the best gain in weights always was obtained for the 45 : 55 ratio. The concentrates in this, as in most of the other experiments, consisted of corn; in some of the experiments cottonseed meal also was used. The roughage consisted of alfalfa meal or alfalfa hay and Atlas silage.

Other workers have obtained similar results for growing pigs. In one series of experiments, increasing amounts of oats were used with corn and in another series, increasing amounts of ground wheat straw were used with corn (10). The intake of metabolizable energy and necessary nutrients in the different groups were kept equal; the only difference between groups was the increasing amount of crude fiber or roughage. In the oats-corn series the best gain in the pigs was obtained in the group receiving 75 per cent oats and 25 per cent corn. In the wheat straw meal-corn series, the best result was obtained in the group receiving 7 per cent wheat straw meal and 93 per cent corn.

A number of other experiments have been carried out from time to time dealing with different phases of nutrition closely related to this problem, and Cox has given a review of them (4). He finds, however, that work pointed specifically to determination of the significance of this factor (by Cox named the ''physical balance'') has been sketchy and has lacked continuity. Therefore, it appears important that investigations of this type be carried out with milking cows and possibly also with beef cattle.

PLAN OF EXPERIMENT

Four lots of three cows each from the station dairy herd were used for the experiment. The cows were of the Holstein-Friesian breed with an age averaging close to 7 yr. The number of lactation days averaged 127 and the daily milk yield per cow, 32.6 lb., with a fat percentage of 3.48. Four per cent F.C. milk averaged 30 lb. daily per cow. The weight of the cows averaged 1,182 lb. at the start of the experiment. From the averages given above, it is evident that variations occurred among individual cows. Therefore, it was necessary to design the experiment in such a way that errors in final results due to variation among cows could be excluded as far as possible.

The four lots of cows were used during a 16-wk. change-over design for four rations containing decreasing amounts of crude fiber. The lots were divided at random after the age, weight, milk production and days since calving were considered. The four rations were designated by the letters A, B, C and D according to the following Latin square scheme, as suggested by Cochran *et al.* (3) :

Period	Cows				Cows				Cows			
	1	2	3	4	5	6	7	8	9	10	11	12
I	A	B	C	D	A	B	C	D	A	B	C	D
II	B	A	D	C	D	C	B	A	C	D	A	B
III	C	D	A	B	B	A	D	C	D	C	B	A
IV	D	C	B	A	C	D	A	B	B	A	D	C

This design means that for each period each one of the four rations is tested on three cows. By the end of the experiment the four rations are tested on all 12 cows.

The composition of the concentrate rations used is given in table 1.

TABLE 1

Concentrate Mixtures

Mixture no.	Cane molasses	Pineapple bran	Soybean oil meal	Meat meal	Fish meal	Salt	Bone meal	Sum
	(lb.)	*(lb.)*	*(lb.)*	*(lb.)*	*(lb.)*	*(lb.)*	*(lb.)*	*(lb.)*
15a	250	430	200	50	50	10	10	1000
15b	250	500	130	50	50	10	10	1000
15c	250	540	90	50	50	10	10	1000
15d	250	575	55	50	50	10	10	1000

The chemical composition of these mixtures and also of other feeds used in the experiment is given in table 2.

TABLE 2

Percentage chemical composition of feed and concentrate mixtures

	Moisture	Protein	Ether extract	Crude fiber	Ash	N-free matter	Calculated	
							D.P.	T.D.N.
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Napier grass	75.57	1.28	0.47	9.02	2.98	10.68	0.77	14.61
Molasses	20.30	2.27	....	....	11.16	66.26	0.73	59.67
Conc. mixture 15a	12.70	16.08	2.60	8.83	8.69	51.10	11.95	64.93
" " 15b	12.52	12.72	2.53	9.75	8.38	54.10	9.02	65.97
" " 15c	12.71	11.16	2.57	10.34	9.03	54.19	7.29	65.46
" " 15d	13.37	10.46	2.67	10.46	8.61	54.43	6.84	64.34
Soybean oil meal	10.25	43.02	4.16	5.65	5.39	31.53	36.56	79.06

The roughage used consisted of mature Napier grass produced on the station's dairy farm. Before feeding, the grass was always chopped into pieces of 1 to 2 in. in length. The amounts of roughage used in rations A, B, C and D were 60, 40, 20 and 0 lb., respectively.

The calculated composition of the complete rations is presented in table 3. In this example, the average milk production of the cows was 28 lb. daily of 4 per cent F.C. milk.

In planning the rations, the main concern was to obtain, as far as possible, equal amounts of digestible protein and total digestible nutrients in each of the ration for the same level of milk production. Sufficient amounts of carotene and minerals were provided in different rations. The only variable factor was the crude fiber content. The four different concentrate mixtures were composed, one for each ration, to simplify the feeding work. At lower or higher levels of production, some of the mixtures needed supplements of a slight amount of soybean oil meal to raise the protein content to a suitable level. Table 3 shows that nutrients provided in different rations parallel each other as closely as possible. The crude fiber in the rations is slightly lower than the 24, 22, 18 and 14 per cent originally planned for rations A, B, C and D, respectively.

TABLE 3

Composition of rations

Feed	Amount	Dry matter	D.P.	T.D.N.	Nutritive ratio	Ether extract	Crude fiber	Crude fiber of D.M.
	(lb.)	*(lb.)*	*(lb.)*	*(lb.)*		*(lb.)*	*(lb.)*	*(%)*
Ration A								
Napier grass	60.0	14.658	0.462	8.765		0.279	5.412	
Conc. #15a	13.7	11.960	1.637	8.895		0.356	1.210	
Molasses	3.0	2.390	0.022	1.790		....	....	
Soybean oil meal	0.3	0.269	0.110	0.237		0.012	0.017	
Sum		29.28	2.231	19.69	1:9	0.647	6.64	22.7
Requirement[a]			2.134	18.36				
Ration B								
Napier grass	40.0	9.772	0.308	5.844		0.188	3.608	
Conc. #15b	18.8	16.446	1.696	12.402		0.475	1.832	
Molasses	2.0	1.594	0.015	1.193		....	....	
Sum		27.81	2.019	19.44	1:10	0.663	5.44	19.6
Requirement			2.134	18.36				
Ration C								
Napier grass	20.0	4.886	0.154	2.922		0.094	1.804	
Conc. #15c	23.6	20.600	1.720	15.448		0.606	2.441	
Molasses	1.0	0.797	0.007	0.597		....	....	
Soybean oil meal	0.3	0.269	0.110	0.237		0.012	0.017	
Sum		26.55	1.991	19.20	1:10	0.712	4.27	16.1
Requirement			2.134	18.36				
Ration D								
Conc. #15d	28.6	24.776	1.955	18.401		0.763	2.990	
Soybean oil meal	0.3	0.269	0.110	0.237		0.012	0.017	
Sum		25.05	2.065	18.64	1:9	0.775	3.01	12.0
Requirement			2.134	18.36				

[a] Requirement calculated for cows weighing 1,200 lb.

All concentrate was fed individually. For practical purposes, the roughage was weighed out daily to each lot of three cows. Normally all feed was eaten. In cases where leftovers occurred, these were weighed back and the net consumption of feed recorded.

All ingredients in the concentrate mixtures were sampled and analyzed for dry matter, ash, protein, fat, crude fiber and *N*-free extract. For control, samples also were taken of the concentrate mixtures and analyzed as above for each separate mixture. A sample of the Napier grass used was taken each day and analyzed for dry matter content. The daily samples were composited and chemical analysis as above carried out for each period. Results of the analysis are given in table 2.

All milk produced by the cows was weighed daily. The fat test of the milk was taken during Monday afternoon, Tuesday morning and afternoon and Wednesday morning each week. A Babcock tester was used.

After the milk and fat test for each week was finished, the amount of concentrate to be fed during the week to follow was calculated. The feed intake was equalized for different groups according to milk production. Morrison's feeding standards for good cows under usual conditions were followed.

Weight of animals was taken before and at the end of each period during three successive daily weighings. As it appeared worthwhile to follow the general well being and physical condition of the animals fed the different rations as closely as possible, pulse, temperature and respiration rate measurements were taken weekly. These readings always were started at 3:30 p.m. before milking of the cows. For comparison of night and day records, data also were assembled in the mornings, readings starting at 4:00 a.m. The morning readings were continued for 5 wk. Temperature was obtained with a so-called veterinary thermometer inserted into the rectum approximately 3 in. and left for 3 min. Respiration rate was determined by number of flank movements per minute. In determining pulse rate, the tips of the fingers were placed on the under side of the tail where the movements per minute of the coccygeal artery were counted.

RESULTS

Generally, the course of the experiment proceeded according to plan. During some of the experimental days, particularly during the last week of June, rather high climatic temperatures apparently influenced the well being and milk production of the cows. This incident did not interfere with the final results of the experiment.

For one cow (no. 175), abnormally low milk production was obtained during the last period of the experiment, particularly during the last week. From 17 lb. of milk daily in the beginning of this period, the yield decreased to 8 lb. and low production then continued until the dry state was reached. Therefore, normal data for this cow during the period mentioned are missing. By use of Snedecor's (13) formula, the missing value was calculated. The original incorrect value is given within parenthesis in table 4 and the calculated value is marked with an asterisk.

During the whole of the experiment, consumption of the different rations used was good. Only for the ration A (including 60 lb. Napier grass daily) a few weigh-backs occurred; of 15,020 lb. of this roughage fed, less than 0.5 per cent of the total was not eaten. In the groups fed 40 and 20 lb. roughage daily, all roughage was consumed. Slight leftovers occasionally occurred during the first week of each period, after the switchover from one ration to another had taken place. All concentrate was eaten, except for ration D, where 7 lb. were left by one cow and 4.5 lb. by another one during the first part of period I.

In order to minimize carry-over effects from one period to a following, the data for the first week in each period are omitted in the following calculations. By this omission the source of error introduced by the leftovers mentioned above also is excluded.

The results in milk yield for the different rations are collected in table 4.

After analysis of variance of the data for milk yield presented in table 4, the analytical results were assembled in table 5. By examination of the mean squares, it is found that results obtained for points 1 to 4 listed in the table are

TABLE 4

4% F. C. milk yield, in pounds, obtained for different rations
(One seventh of the milk production for each period is given in the table)[a]

Period	Group 1 Cows					Group 2 Cows					Group 3 Cows				
	226	289	292	172	Total	277	175	219	176	Total	192	287	259	224	Total
I	A 96	B 97	C 85	D 91	369	A 57	B 88	C 85	D 80	310	A 58	B 67	C 74	D 58	257
II	B 86	A 83	D 83	C 86	338	D 62	C 82	B 65	A 65	274	C 62	D 65	A 62	B 50	239
III	C 82	D 85	A 64	B 65	296	B 51	A 58	D 67	C 59	235	D 60	C 56	B 63	A 45	324
IV	D 75	C 80	B 62	A 55	272	C 43	D 65[b] (36)	A 57	B 39	204	B 50	A 44	D 64	C 50	208
Totals	339	345	294	297	1,275	213	293	274	243	1,023	230	232	263	203	928

Treatment totals:

Group 1 *Sum*	Group 1 *Daily av.*	Group 2 *Sum*	Group 2 *Daily av.*	Group 3 *Sum*	Group 3 *Daily av.*
A = 298	24.83	A = 237	19.75	A = 209	17.42
B = 310	25.83	B = 243	20.25	B = 230	19.17
C = 333	27.75	C = 269	22.42	C = 242	20.17
D = 334	27.83	D = 274	22.83	D = 247	20.58

[a] The reason that only one seventh of the milk production for each period is given, and not the total sum, is due to the fact that giving the same final result this method decreases the labor needed in successive calculations.

[b] This figure was calculated according to the formula for missing data in a Latin square, as reported by Snedecor (13).

highly significant. The mean square for between rations is 228.25 and the mean square for errors is 21.10. The F-value, therefore, is $228.25/21.10 = 10.82$. According to Snedecor's tables (13) for the distribution of F, an F-value of only 5.18 is needed in this case for significance at the 1 per cent point.

It should be mentioned that a test for significance also was carried out with use of the original milk yield value for cow 175 in period 4 without making use of the above-mentioned corrected value. In this case, an F-value of 4.52 was obtained, which still is sufficient for significance close to the 1 per cent point.

TABLE 5

Analysis of variance of 4% fat corrected milk units (lb.)

	Degrees of freedom	Sum of squares	Mean squares
1. Between groups	2	4019.54	2009.77
2. Between cows within groups	9	1925.38	213.93
3. Between periods within groups	9	3324.38	369.38
4. Between rations	3	684.75	228.25
5. Ration × group interactions	6	21.13	3.52
6. Error	17[a]	358.74	21.10
7. Total	46[a]	10333.92	

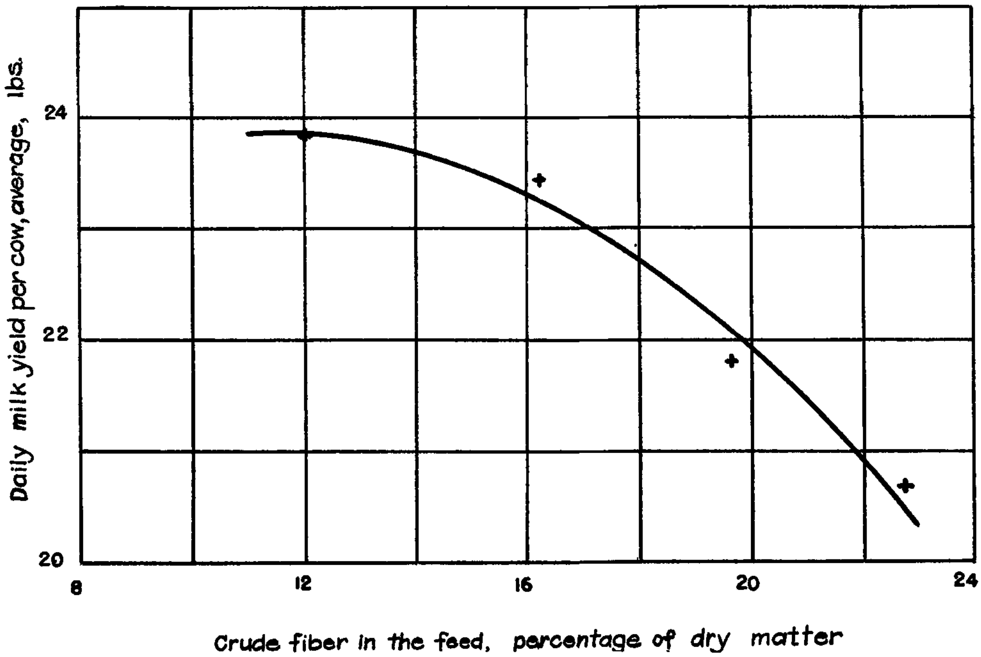
[a] One degree of freedom subtracted for cow 175.

It is clear, therefore, that the amount of crude fiber in the rations tested had a definite influence upon the milk yield. This is graphically illustrated in figure 1, where the average daily milk yields in pounds obtained for the different rations tested are plotted against the crude fiber content of the feed. The curve in the graph is fitted by free hand. It is seen that the yield of milk definitely decreased as soon as the crude fiber content in the feed increased over 16 per cent, calculated on the dry matter basis.

Effect of different rations on weights of cows during experiment. The average body weights for the cows on rations A, B, C and D were, at the start of the first period, 1,177, 1,154, 1,141 and 1,255 lb., respectively; at the start of the second period, 1,182, 1,157, 1,126 and 1,148 lb.; at the start of the third period, 1,196, 1,145, 1,266, 1,006 lb.; at the start of the fourth period, 1,121, 1,237, 1,211, 1,085 lb.; and at the end of the fourth period, 1,234, 1,169, 1,061 and 1,214 lb. The average weight of all cows at the beginning of the experiment was 1,182 lb.

At the end of the experiment the average weight was 1,170 lb. Each figure was based upon weighings taken during 3 successive days. Therefore, it appears that a loss in weight of 12 lb. per cow occurred during the 16 wk. of experiment. This loss is very truly a result of the more concentrated feed for part of the cows and could hardly be ascribed to a real loss in body weight. An example will illustrate this. Cow no. 172 had an initial weight of 1,401 lb. when she started on ration D. After 4 wk. on this concentrated ration her weight was 1,266 lb. From this ration she was turned over in period II to the slightly less concentrated ration C. At the end of this period her weight had increased to 1,291 lb. From this ration she was fed the still less concentrated ration B in period III, and an increase in weight to 1,347 lb. resulted. In the last period she was fed ration A and this increased her weight to 1,411 lb. at the end of the experiment.

Since these differences in body weight occurring over a short time could not be due to real gain in body tissues, they must be ascribed to different weights of the digestive channel content. According to Sisson and Grossman (12), the stomachs of large cattle have a capacity of 40 to 60 gal. and those of medium size, 30 to 40 gal. This would correspond to about 40 gal. or 150 l. for the cows used in this experiment and illustrates the large feed capacity of the cows.



An examination of the rations used in the experiment listed in table 1 reveals that for a cow milking 28 lb. daily, ration A for 1 day weighed 77 lb.; ration B, 61 lb.; ration C, 45 lb. and ration D, 29 lb. Although these rations contain the same amount of T.D.N. and D.P. and although the difference in dry matter content is not more than 4.23 lb. between rations *A* and *D*, it is obvious that the coarser nature of rations *A* and *B* must affect the weight of the animals, as borne out in the example for cow no. 172. This study illustrates the danger in emphasizing changes in weight occurring in experiments of this type.

Effect of different rations upon pulse rate. In order to study whether the type of feeding had any influence upon the pulse rate of the cows, the afternoon readings were collected in table 6. After analysis of variance of the pulse rates presented in table 6, the analytical results were assembled in table 7. The mean square for between rations is 136.81 and for the error, 30.07. The F-value for between rations, therefore, is 136.81/30.07 = 4.55. In Snedecor's tables for the distribution of F with $n^1 = 3$ and $n^2 = 18$, the value of F for the 5 per cent point is 3.16 and for the 1 per cent point, 5.09. As is seen, the significance comes closer

TABLE 6

Pulse rate of cows at afternoon readings
(Average for last 3 wk. of each period)

Period	Group 1 Cows					Group 2 Cows					Group 3 Cows				
	226	289	292	172	Total	277	175	219	176	Total	192	287	259	274	Total
	Pulse-rate/min.[a]														
I	A 64	B 76	C 69	D 61	270	A 68	B 72	C 64	D 67	271	A 69	B 76	C 68	D 55	268
II	B 65	A 69	D 57	C 74	265	D 78	C 68	B 62	A 64	272	C 70	D 63	A 59	B 75	267
III	C 72	D 60	A 76	B 73	281	B 72	A 80	D 59	C 68	279	D 65	C 67	B 69	A 72	273
IV	D 59	C 61	B 53	A 60	233	C 77	D 71	A 53	B 72	273	B 71	A 64	D 52	C 71	258
Totals	260	266	255	268	1,049	295	291	238	271	1,095	275	270	248	273	1,066

Treatment totals:

	Group 1 *Sum*	Group 1 *Daily av.*	Group 2 *Sum*	Group 2 *Daily av.*	Group 3 *Sum*	Group 3 *Daily av.*
	A = 269	67.3	A = 265	66.3	A = 264	66.0
	B = 267	66.8	B = 278	69.5	B = 291	72.8
	C = 276	69.0	C = 277	69.3	C = 276	69.0
	D = 237	59.3	D = 275	68.8	D = 235	58.8

[a] The figures mean average pulse rate for the last 3 wk. of each period.

TABLE 7

Analysis of variance of pulse rate per minute for experimental cows

	Degrees of freedom	Sum of squares	Mean squares
1. Between groups	2	67.63	33.82
2. Between cows within groups	9	652.12	72.46
3. Between periods within groups	9	357.62	39.74
4. Between rations	3	410.42	136.81
5. Ration × group interactions	6	262.20	43.70
6. Error	18	541.26	30.07
7. Total	47	2291.25	....

to the 1 than to the 5 per cent point. This means that the rations used in this experiment did influence the pulse rate of the cows.

We are not aware from earlier reports that increase in roughage fed to milk cows would affect the pulse rate, although Thomas (14) recently has reported that feeding 120 to 130 per cent of required T.D.N. to producing cows increases the heart rate. Exercise or carrying a burden increases the heart rate and it appears that the increase in roughage fed to cows is a parallel to that phenomenon.

Respiration rate. The data obtained for respiration rate were treated in the same way as were the data for pulse rate. No significant influences of rations upon respiration rate occurred. The *P*-value obtained for this influence fell between 0.2 and 0.05.

The afternoon respiration rate varied from 24 to 68 per minute, with an average of 37.8 ± 3.32.

Body temperature. Similarly, body temperature reflected no significant influence of types of rations. Variations in afternoon body temperature were from 100.0 to 102.8° F. Average body temperature was 101.3 ± 0.182° F.

Morning readings versus afternoon readings for pulse rate, respiration rate and body temperature. In table 8 the averages of pulse rate, respiration rate and body temperature measured at 4 to 5:15 in the mornings as compared to measurements at 3:30 to 4 in the afternoon are given. The readings in the mornings were taken to see whether or not the surrounding air temperature would influ-

TABLE 8

Averages of pulse rates, respiration rates and body temperatures

	No. of observations	Mean	Standard error	Lowest value observed	Highest value observed
Morning readings					
Pulse rate/min.	60	72.2	± 1.446	52	104
Respiration rate/min.	60	32.4	± 1.155	22	66
Body temperature (° F.)	60	101.5	± 0.065	100	102.5
Afternoon readings					
Pulse rate/min.	180	66.3	± 3.470	48	88
Respiration rate/min.	192	37.8	± 3.320	24	68
Body temperature (° F.)	192	101.3	± 0.182	100	102.8

ence the characters measured. The lowest air temperature at night was about 15° F. below the highest temperature during the day. Minimum temperature for the nights when pulse rates were taken averaged 70.8° F., whereas maximum temperatures in afternoons of the same days averaged 85° F.

In table 8 an indication is given that the pulse rate decreases with increase in temperature. This is in agreement with results of Kleiber and others, as reported by Brody (2). Due to the lack of sweat glands in species such as cows and pigs, the skin is not cooled by sweating and therefore less blood is sent to the surface when environmental temperature rises. However, the difference in rate for morning and afternoon readings as reported here ($72.2 - 66.3 = 5.9°$ F.) is not sufficient for statistical significance. Neither is there any significant difference between morning and afternoon readings of respiration rate and body temperature.

DISCUSSION

The influence of percentage of crude fiber in the feed upon milk production is clearly demonstrated. A number of experiments have been carried out where the amount of roughage and its influence upon the milk production has been studied. In most cases of this work, the emphasis is put upon the character of roughage as such and less on the fiber content of the feed.

Morrison (9) discusses milk production on roughage alone and also the effect of successive additions of concentrate, and refers to a number of feeding experiments. As the level of concentrate feeding was increased in these experiments, the amount of additional milk secured per pound of concentrate decreased steadily. The decrease in milk per pound of concentrate fed was from 1.3 lb. milk at a high level of roughage to 0.3 lb. at a low level. The highest level of roughage was taken as 11,338 lb. of hay or "hay equivalent" fed per cow per year. The low level was taken as 7,385 lb. of hay or "hay equivalent" per year. However, the milk yields in different groups were not strictly comparable because at the higher levels of concentrates the digestible nutrient intake was about 16 per cent above the standard used, while in the medium levels of concentrate feeding it was only "a trifle" more than advised in the standards used. Probably different results would have been obtained if all the groups had been fed at the same level of total digestible nutrients and protein.

Among workers who have suggested that the feeding of milk cows is regulated according to crude fiber content of the feed, is Axelsson (1). He believes that the amount of crude fiber in the feed given shows an optimum value. Logically such an optimum occurs. As mentioned before, Cox has observed such an optimum in experiments with fattening lambs. The best gains in weight of the lambs were obtained for the 45:65 ratio of concentrate to roughage. In our experiment the best milk production was obtained when the fiber content was decreased to 16 per cent or below (calculated on dry matter basis). All rations with more than 16 per cent fiber resulted in a significantly lower milk production.

An interesting experiment in this field recently has been reported by Huffman and Duncan (7). These workers used 12 cows in 15 trials to study the effect on milk production after a part of the total digestible nutrients in alfalfa had been replaced by corn. The replacement of a part of the alfalfa hay by corn on an equal total digestible nutrient basis always resulted in an increased production of 4 per cent fat corrected milk. After the change back to an all-alfalfa ration, a definite drop in milk production occurred. Possible explanations for the increased production are discussed in the report mentioned. It is suggested that the corn grain supplies an unidentified factor or factors needed to balance alfalfa hay for milk production.

It should be noted that in all the trials reported (7), a lower level of crude fiber was fed when part of the hay was replaced by corn. For example, in trial no. *1 b* a decrease from 29 per cent to 23 per cent fiber occurred.[2] In trial 2, the decrease was from 31 to 24 per cent fiber. In trial 3, the decrease in fiber was from 32 to 25 per cent and in trial 4, it was from 32 to 19 per cent. Similar results were obtained for the other trials. From the results obtained in our experiment, we believe that this reduction in the level of fiber definitely has influenced the milk production.

In a study of the optimum level of crude fiber in the feed it should be remembered that crude fiber has different chemical composition in different feeds and that its main components, cellulose, lignin and pentosans, may occur in quite different ratios (11). Therefore, it could not be expected that the optimum value for fiber in feeding experiments always will be the same in different feeds. Variations may occur according to the type of roughage used. For the type of fiber occurring in the two main feeds used in this experiment, namely, pineapple bran and Napier grass, the results mentioned in this paper may be expected, however. On the other hand, it appears possible that in a roughage such as clover hay and alfalfa, the optimum level of crude fiber may coincide with another, possibly a higher, level of the fiber.

SUMMARY

A feeding experiment has been carried out with different levels of crude fiber in the feed of dairy cows of Holstein-Friesian breed. Except for fiber, other nutritive factors (digestible protein and T.D.N.) were kept alike in different rations. A sufficient supply of vitamins and minerals also was provided. Four different rations were tried, namely, A with 60 lb. Napier grass, B with 40 lb. Napier grass, C with 20 lb. Napier grass daily per cow and D with no Napier grass. The balance needed of protein and T.D.N. was made up of pineapple bran, soybean oil meal, meat meal, fish meal and molasses. The crude fiber content for different rations were in percentage of dry matter as follows: A, 22.7 per cent; B, 19.6 per cent; C, 16.1 per cent; and D, 12.0 per cent. The effect of the level of crude fiber in the feed upon milk production was highly significant. With increase over 16 per cent in crude fiber content of the feed, a drop in milk production occurred, regardless of the fact that equal amounts of T.D.N. and digestible protein were fed.

The average daily yield of 4 per cent F.C.M. per cow for 12 wk. was 20.6 lb.

[2] Figured on the dry matter basis.

on ration A, 21.7 lb. on ration B, 23.4 lb. on ration C, and 23.8 lb. on ration D. Pulse rates per minute for cows with no roughage were 62, and increased to 69 with roughage. The statistical significance of this influence of rations fell close to the 1 per cent point.

For high milk production, the crude fiber level in the feed should not exceed 16 per cent when calculated on basis of dry matter content of the ration. This holds true for feeds such as mature Napier grass and pineapple bran as major constituents of the rations.

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