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Milk as the Sole Diet of Ruminants

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MILK AS THE SOLE DIET OF RUMINANTS

By A. C. McCandlish.

From time imemmorial milk has been regarded as the food best adapted to the complete nourishing of mammalia. It is the sole diet of all mammals during the earlir part of their post-natal development and is recognized as an excellent staple in the diet of the adult human, especially in the case of invalids. On the farm it is used extensively in the feeding of young animals, and in the case of the hog it is fed in large quantities to more mature individuals.

Within the last decade many investigations have been made concerning the nutritive value of milk and other food-stuffs and thruout these investigations milk has measured up to all expected standards. The object of this paper is to show that in spite of the high nutritive value of milk there are limitations to its use—limitations which are inherent, not in the milk itself, but in the class of animals to which it is fed.

PREVIOUS WORK

The food nutrients recognized as essential to the animal organism are carbohydrates, fats. proteins, ash and water, and table I demonstrates that all of these constituent groups are abundant in milk.

The proteins, fats and carbohydrates are present in the proportions that are recognized as being suited for the growth of young animals and the ash constituents are also abundant.

Within recent years it has been shown that all proteins are not of equal value for nutritional purposes as the nutritive value of a protein is determined by its amino-acid constitution. Some proteins are inefficient because they do not contain all the amino-acids necessary for the life, growth and normal physiological development of animals. It has been shown, however, that the milk proteins are efficient (6), that is, they will in the presence of a sufficiency of non-protein and inorganic nutrients, support life, promote growth, and foster all normal physological functions.

Table I—Average Composition of Milk (10).

Constituent	%
Water	87.17
Fat	3.69
Casein	3.02
Albumen	.53
Sugar	4.88
Ash	.71

Ash is another food constiuent which, altho present in sufficient quantities, may not be qualitatively suited to the requirements of the animal, but it has also been proved that the ash of milk satisfactorily meets the demands of the

young growing animal (8), providing in the proper proportions all of the inorganic constituents needed for the proper functioning of the animal body.

Still another factor has been recognized as limiting the nutritive value of feeds and that is the presence or absence of substances known as "food-accessories," "vitamines," or "fat-soluble A" and "water-soluble B." These are complex compounds of an unknown nature which are anti-neuritic in action and both of which are absolutely essential to life. They are found only in minute quantities and many food-stuffs are lacking in one or both of them. It has now been proved beyond doubt that whole milk contains sufficient of these unknowns to give complete physiological functioning (7).

Milk, consequently, fulfills both quantitatively and qualitatively all the chemical requirements of a good ration for mammalia, but in spite of this fact it cannot be successfully used as the sole feed of ruminants at all times. Ruminants are specially adapted to the handling of bulky feeds such as hay, silage, roots and other roughages and they begin to use these at a very early age. In the case of calves, this is usually when about three weeks old, and in practice they are generally provided with such roughages as soon as they can consume them.

In only a few instances have records been obtained of ruminants being fed for any considerable time on rations lacking roughage, but Sanborn (9) reports that in the case of both sheep and cattle fed on grain alone the stomachs weighed less than normal and this was most noticeable in the case of the rumen—the stomach compartment specially adapted for the handling of bulky material. Davenport (1) found that calves could not be raised on a diet consisting of milk alone or grain alone and also noticed that as a rule no digestive disturbances accompanied such a ration.

The fact that milk can successfully be the sole diet of mammalia other than ruminants has been demonstrated by McCollum (2), who was able to raise a sow pig to maturity on milk alone. The sow also reproduced normally.

EXPERIMENTAL WORK

In the experiments reported here, two calves were used and they were fed on milk alone from birth until the time of their death. The animals are described in table II.

Table II—Animals Used.

Calf No.	355	366
Breeding	Grade Jersey	Grade Holstein
Date of birth	9-25-16	12-17-16
Birth Weight	65 lbs.	90 lbs.

Both calves were allowed to remain with their dams for a few days after birth and were

Table III—Feed Consumption by Ten-day Periods.

Period No.	Calf No. 355		Calf No. 366	
	Milk lbs.	Salt lbs.	Milk lbs.	Salt lbs.
1	36		90	
2	90		90	
3	90		90	
4	90		90	.04
5	128		111	.05
6	120		129	.06
7	120		150	.04
8	126	.32	150	.03
9	146	.25	150	.11
10	150	.17	150	.21
11	150	.05	150	.10
12	150	.02	150	.03
13	150	.04	150	.04
14	150	.06	150	.03
15	141	.05	150	.03
16	120	.03	150	.02
17	120	.07	174	.03
18	120	.18	108	.03
19	123	.17		
20	142	.02		
21	99	.03		

then put on a whole milk ration. The amount of milk fed was limited to what the calves seemed able to handle satisfactorily and tho they might possibly have become accustomed to larger quantities, it was deemed advisable to keep their consumption of milk comparable to that of other animals of similar weight in the herd and thus prevent digestive troubles as far as possible.

No roughage, grain or water was offered to either of the calves, and at first no salt was given, but from the time calf no. 355 was 70 days old a salt roll was kept in front of him at all times and the same treatment was given calf no. 366 from the time he was 30 days old.

The calves were kept in a pen bedded at first with shavings and later with sand, as they showed a tendency to eat the shavings. Their food consumption by ten-day periods is given in table III.

In the first 10 day period calf no. 355 sucked for 6 days and no 366 for 3 days. The last period for no. 355 contains only 8 days and that for no. 366 only 6 days, as no. 355 died when 208 days old and no. 366 at the age of 176 days.

It will be noted that up until he was about 100 days old, no. 355 had an increasing capacity for milk, but from that time the appetite remained regular for a little over a month and then declined, tho there was an increase in milk consumption for a week or so before death. In the case of no. 366, maximum capacity was reached earlier and remained constant until about the same length of time before death, when it again increased.

The animal, no. 355, that received no salt until 70 days old, showed an enormous appetite for salt during the first 30 days in which it was available. From this time on his salt consumption decreased and with the exception of a short time between the ages of 170 and 190 days it did not again reach a marked elevation during the experiment. Calf no. 366 received salt earlier in his life and did not at any time have such an excessive consumpton, tho between the ages of 80 and 110 days his consumption of salt was large.

There were no marked digestive disturbances, except in the

Table IV—Live Weights and Body Measurements.

	Calf No. 355				Calf No. 366				Ave. for 66 Heifers			
Ave. Days	Weight lbs.	Height in.	Depth in.	Width in.	Weight lbs.	Height in.	Depth in.	Width in.	Weight lbs.	Height in.	Depth in.	Width in.
Birth	65				90				56			
30	76	29.9	12.6	7.1	103	28.0	14.3	7.5	76	28.0	11.0	6.3
60	107	31.1	13.0	7.5	139	30.3	14.3	7.9	96	29.5	12.3	6.7
90	132	32.3	13.8	7.9	165	32.7	14.7	8.7	131	32.7	13.5	7.9
120	145	33.9	15.0	8.3	174	35.0	15.7	8.7	180	33.9	14.7	8.7
150	144	33.5	15.4	8.3	172	35.4	15.7	9.1	235	36.2	16.1	9.8
180	137	34.6	15.0	8.3					289	37.8	17.3	11.0

case of calf no. 366, which was bloated for a few days before death, the bowels of the animals being usually laxative, tho not noticeably so. The faeces were rather foul smelling. The calves showed by their actions that their rations were not entirely complete. They ate to a slight extent the shavings that were at first used as bedding, gnawed the wood in the walls of the pen, and licked the hair from each other. These substances, however, were not consumed in amounts sufficient to cause very noticeable digestive derangements.

Records of the live weights and body measurements of the calves obtained every thirty days are given in table IV. The live weights given are the averages for three successive daily weighings. The body measurements taken were height at withers, depth of chest and width of hooks. For the sake of comparison, the measurements of the heifer calves in the herd which were fed normal rations are given. Difference in sex will not have much influence on these figures for comparative purposes owing to the sexual immaturity of the animals and also to the fact that calf no. 355 was castrated when 22 days old.

It can be seen that the experimental animals grew fairly well until they were about three months of age, but from this time on they did not thrive. They continued to gain slowly in weight for another thirty days, after which their live weights decreased gradually until the time of death. The body measurements appeared to increase about normally until the time the live weight increase ceased to be rapid and from this time on the measurements changed only slightly—in fact, they were almost constant. A greater increase in height than is shown by the figures probably did occur, but owing to the fact that the animals began to go down on their pasterns about the time that the live weight ceased to increase, the true height could not be accurately measured.

The increases in live weight and body measurements can be more easily appreciated when they are shown as percentages of

Table V—Percentage Increase in Live Weight and Body Measurements.

Calf	Weight	Height	Depth	Width
No. 355	111	14	19	17
No. 366	91	27	11	21
Ave. for 66 Heifers	345	35	57	75

the original figures, as in table V. The increases in live weight from birth to the time of death in the case of the experimental animals, and to the age of six months in the case of the herd average, are expressed as percentages of the birth weights, while the body measurements are compared in the same way from the time the animals were thirty days old.

During their lifetimes the experimental animals practically doubled their live weights, while during similar lengths of time calves normally fed attained weights about four times as great as their birth weights. Similarly the increases in body measurements in the case of the calves fed milk alone were much less than normal. Of the increases in body measurement, the height was the most nearly normal, while width was farthest from it.

In addition to the variations in weight and body measurements, there were other abnormal symptoms which tho very appreciable were not capable of being directly measured or determined. The animals became very much emaciated and unthrifty in appearance. Their coats were long and staring and the hair fell out freely. Patches of the body became practically devoid of hair and sores were also apparent. As has already been mentioned, the animals were down on their pasterns and could not stand up properly and they walked with a very stiff gait.

One very noticeable feature of the experiment was the occurrence of fits. These fits were first apparent when the animals were between three and four months of age and continued to occur at frequent but irregular intervals up until about three weeks before the deaths of the animals. These fits were all very similar and frequently started for no apparent reason and could almost always be induced by leading the animal around for a few minutes. The animal would fall down and bellow as if in pain; the jaws would stick open and the legs become rigid; the muscles became tense and hard; respiration slowed and in severe attacks entirely stopped. Where respiration did not stop the animal would recover in a few minutes, and where breathing ceased, artificial respiration had to be resorted to, to resuscitate the calf. The fits were practically identical with those of an epileptic nature.

Post-mortem examinations of both calves were made. The bones of no. 355 were very flexible as if insufficient ash were present; the leg bones could be bent comparatively easily, while the ribs had a very thin coating of hard material with a soft core. None of the bones were as rigid as would be expected in

an animal of similar age. There was one atrophied kidney (perhaps congenital) with hypertrophy of the other. The mesenteric lymph glands were much enlarged and there was an apparent leucemia. The rumen was of normal size, but the walls were evidently atonic, due apparently to a development of lymphoid tissue. The omasum was smaller than would be expected, tho the two remaining compartments of the stomach appeared to be normal. The contents of the rumen resembled thin cottage cheese mixed with hair.

The bones of calf no. 366 appeared to be in fairly good condition, tho one or two of the ribs might previously have been broken and healed. The mesenteric lymph glands were enlarged and both kidneys were in bad condition with cysts. All the stomach compartments were of about normal size, but there were streaks of dark brown or black pigment on the inner wall of the abomasum. The contents of the rumen were similar to those in the case of calf no. 355.

DISCUSSION OF RESULTS

A diet of whole milk alone tho apparently giving good results until the animals are about three months old very probably cannot be relied on as the sole ration for calves of greater age. Its inability to properly nourish older calves is probably not due to any defect in the quantity or quality of the nutrients it supplies. Cattle and other ruminants begin to consume roughages at an early age and the lack of roughage may consequently give an explanation of the results obtained in this work.

In table VI are given the food requirements of the experimental calves according to the modified Wolff-Lehmann feeding standard and the amounts of nutrients with which they were actually supplied.

In this table the animals have been taken together rather than individually and the milk consumption is taken for all 30-day periods which were completed. It was assumed that the daily milk consumption of the calves while sucking was the same as in the succeeding days of the first 10-day period. From these figures the total amount of nutrients actually consumed by the animals were obtained, while the nutrients required to keep the

Table VI—Nutrients Required by and Supplied to Calves.

Age Days	Weight lbs.	Milk lbs.	Nutrients Supplied			Nutrients Required		
			Dry Matter lbs.	Digestible Crude Protein lbs.	Total Digestible Nutrients lbs.	Dry Matter lbs.	Digestible Crude Protein lbs.	Total Digestible Nutrients lbs.
1- 30	168	579	79	19	104	71	16	84
31- 60	213	668	91	22	120	102	21	107
61- 90	272	842	115	28	151	158	27	139
91-120	309	900	122	30	161	196	30	160
121-150	318	873	119	29	166	205	31	165

Table VII—Excess of Nutrients Supplied to Calves.

Age Days	Excess of Nutrients Supplied		
	Dry Matter, lbs.	Digestible Crude Protein, lbs.	Total Digestible Nutrients, lbs.
1- 30	8	3	20
31- 60	—11	1	13
61- 90	—43	1	12
91-120	—74	0	1
121-150	—86	—2	1

animals in good growing condition were obtained from the modified Wolff-Lehmann feeding standard.

The actual surplus or deficit of nutrients supplied will be more valuable for comparative purposes.

It is evident that thruout the experiment the calves were receiving enough total digestible nutrients to keep them growing and increasing in live weight, tho, as is shown in table VII, the excess of nutrients decreased as the work advanced. The same holds true for the supply of digestible crude protein, tho in this case the excess was never so great and in the last 30-day period there was a small deficit. The supply of dry matter was sufficient for the needs of the calves during the first 30-day period only and from then on there was a deficit which rapidly became larger.

Apparently the calves were being supplied with sufficient digestible nutrients to keep them growing and in good thrift, but they were not able to utilize those nutrients. At first their demand for dry matter, other than digestible nutrients, was negligible, but as they became older this demand increased more rapidly than did the need for digestible nutrients. The absence of this dry matter, which should have been provided in the form of roughage, led to inefficient digestive activity and consequently the animals were unable to utilize the nutrients which they consumed and so they failed to grow normally.

The digestive tract of a ruminant is large and capacious and before digestion can be normal, bulky feeds must be present to distend the digestive organs, stimulate peristalsis, separate the particles of more concentrated feeds and so allow of their being properly mixed with and acted on by the digestive fluids. Milk, being highly digestible and free from fibrous material, is not a "bulky" feed, tho its nutrients are present in a rather large volume of water, and so it cannot, when fed alone, induce the digestive system of older ruminants to function properly. It is quite efficient with young calves, however, as in their case the rumen is relatively smaller in comparison with the rest of the digestive tract than it becomes ultimately.

Where digestion is retarded or hindered, as would occur if the digestive system became atonic, due to the absence of roughage, the materials not completely acted on by the digestive juices

would remain in the alimentary canal and undergo putrefactive changes. The products of such putrefaction are toxic and when absorbed from the alimentary canal can product auto-intoxication, with symptoms similar to those found with the experimental animals in this case.

Another fact worthy of note is that these calves were at times, when averaging about 150 lbs. in live weight, consuming over half as much salt per day as would a 1,000 lb. animal. It has been found at this station that normally fed calves of similar weight will consume about .01 lbs. of salt per day, while the experimental animals consumed as much as .03 lbs. per day.

This excessive salt consumption may have been an attempt to correct digestive disturbances, or it may have been caused by other physiological demands, or it may simply have been due to the calves forming a pernicious habit.

That sodium chloride can produce tetanic convulsions such as were evident in the case of the experimental calves has been shown on several occasions. Loeb (3) demonstrated the contractions and final tetanus of muscles in contact with certain salt solutions and he later (4) showed that solutions of common salt could cause rhythmical twitchings and an increase in the irritability of muscles and nerves. This is due to an increase in the concentration of sodium ions and can be counteracted by the addition of calcium salts. It has also been pointed out by MacCallum (5) that intravenous injections of solutions of sodium chloride increase peristalsis. There is a possibilty, therefore, that the fits to whch the experimental calves were subject may have been due in some way to excessive salt consumption.

SUMMARY

Milk, tho capable of forming the sole diet of young ruminants, cannot be used for such purposes with more mature individuals. This is due not to the fact that its nutrients are present in improper quantities or poor in quality, but probably to the inability of the animals to properly digest and utilize it unless provided with some roughage at the same time.

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