

DIGESTION OF STARCH BY THE YOUNG CALF

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PREVIOUS INVESTIGATIONS

There is considerable evidence that young animals thrive on a ration containing starch, but a rather extensive search in the literature failed to discover any data concerning the question as to how soon after birth the calf can begin to digest starch. The investigation here described was undertaken for the purpose of ascertaining how early in its life the calf can utilize starch or starch-containing feeds. The practical application, of course, is in supplementing or supplanting the milk ration of the young calf with other feed.

The literature contains many accounts of feeding experiments with young animals where starch alone or as the principal component of some feed has been used. The purposes of these experiments, however, have been largely to determine the effect of starch upon the health, the rate of gain in weight, the cost of raising, or the digestibility of some other component of the ration rather than the actual digestibility of the starch itself. The record of but one experiment was found in which the feces of young starch-fed calves were tested for the presence of starch.

Ewing and Wells¹ report the use of starch in combination with corn silage and cottonseed meal in the ration of 12-month-old steers on digestion trial. In their summary they state that when as much as 47.3 per cent of the net energy of the ration was supplied in the form of starch the iodine test did not indicate the presence of starch in the feces.

There are recorded in the medical literature on the diet and hygiene of children several investigations in which the actual digestibility of starch by children was studied. Kerley, Campbell, and Mason² report the examination for starch of 324 stools, collected under controlled conditions at the New York Infant Asylum from 60 children, all under 1 year of age, who had been fed either wholly or in part on barley water. The barley water was prepared by boiling raw barley flour for 1½ hours. The stools were examined for starch by the Von Jaksch iodine test, with

¹ EWING, Perry van, and WELLS, C. A. THE ASSOCIATIVE DIGESTIBILITY OF CORN SILAGE, COTTONSEED MEAL, AND STARCH IN STEER RATIONS. *Ga. Agr. Exp. Sta. Bul.* 115, p. 269-296, 7 diag., 1915.

² KERLEY, C. G., CAMPBELL, W. C., and MASON, H. N. A FURTHER CONTRIBUTION TO THE STUDY OF STOOLS OF STARCH-FED INFANTS. *In Jour. Amer. Med. Assoc.*, v. 47, no. 10, p. 763-765. 1906.

Lugol's solution. Of the 60 children, 33 always gave negative iodine tests, indicating complete utilization of the starch. Among the remainder, 8 usually gave a negative test, 12 usually gave a positive test, and 7 always a positive test for starch. Of the 41 children showing a good capacity for starch utilization one 19-day-old child received 9.2 gm. of barley flour daily for 2 days; one 21-day-old child received 14.6 gm. every 24 hours; one child 1 month and 22 days old received 25.9 gm. the first day and 25.3 gm. a day for the following four days; and another child 1 month and 19 days old received 12 gm. daily for three days.

Heubner,¹ in a paper presented before the Berlin Medical Society, describes an investigation conducted at Leipzig for the purpose of determining the digestibility of starch in the food of artificially fed children. The children received during 1-day and 2-day periods a carefully prepared starchy gruel which was fed in place of milk, at the same intervals and in the same quantity as the milk feeding. Carbon was used to identify the experimental stools, and the feces from each child were assembled, dried, and analyzed for starch. A 7-weeks-old child received 24.6 gm. of rice flour during a 25-hour period, and no starch was found in the feces. Another child 14 weeks old received 53 gm. of rice flour during a 39-hour period, and 0.1689 gm. of starch was found in the feces. A third child 1 year old received, in addition to 72 gm. of butter, 133 gm. of rice flour during a 48-hour period, and 0.2804 gm. of starch was found in the feces. A fourth child, 14 weeks old, received 57 gm. of a specially prepared oatmeal during a 34-hour period, and 0.2611 gm. of starch was found in the feces.

In an elaboration of the work done by Heubner at Leipzig, Carstens² gives the results of digestion experiments on eight children from 5 to 14 weeks old. Some of these children received starch from rice flour, some from a prepared oatmeal flour, and some from two different proprietary infant foods. The same methods were followed as in the Heubner investigation. The quantity of undigested starch varied from a trace in the feces of two children, one 9 weeks and one 15 weeks old, respectively, to 5.08 gm., or 6.23 per cent of the amount ingested by a child 6½ weeks old.

Krüger¹ who worked with fetal and newborn calves found that the ptyalin is secreted in the salivary glands as early as the seventh month of fetal life, but that while the quantity increases up to birth, even at that time it is too small to be of any importance in the digestion of food.

¹ HEUBNER, O. UEBER DIE AUSNÜTZUNG DES MEHLS IM DARM JUNGER SÄUGLINGE. *In* Berlin. *Klin. Wchnschr.*, Bd. 32, No. 10, p. 201-204, 1895. *Literatur*, p. 204.

² CARSTENS, J. H. WEITERE ERFAHRUNGEN ÜBER DIE AUSNÜTZUNG DES MEHLS IM DARME JUNGER SÄUGLINGE. *In* *Verhandl. Gesell. Kinderheilk.*, Bd. 12, p. 169-176. 1895.

¹ KRÜGER, Friedrich. DIE VERDAUUNGSFERMENTE BEIM EMBRYO UND NEUGEBORENEN. 80 p. Wiesbaden, 1891. *Literatur*, p. 79-80.

EXPERIMENTAL WORK

Two male calves, each 4 days old, were selected. Each was fed 5.44 kgm. of whole milk a day in two feedings. Beginning at 4 days of age, each calf received 40 gm. of ordinary cornstarch per feeding, in addition to the milk, for a period of three days. The starch ration was prepared as follows: The weighed quantity of cornstarch was placed in a pail and mixed with a little milk, then the bulk of the milk was added and the mixture well stirred. The calf consumed the mixture with eagerness and without any apparent digestive disturbance. To make sure that all the starch was consumed, the pail was rinsed once or twice with milk and the calf permitted to drink the rinsings. The starch-feeding period was followed by a rest period of about five days, during which only whole milk was fed; then the calves again received starch in addition to their whole-milk ration exactly as in their first 3-day period. The length of the periods and the duration of the

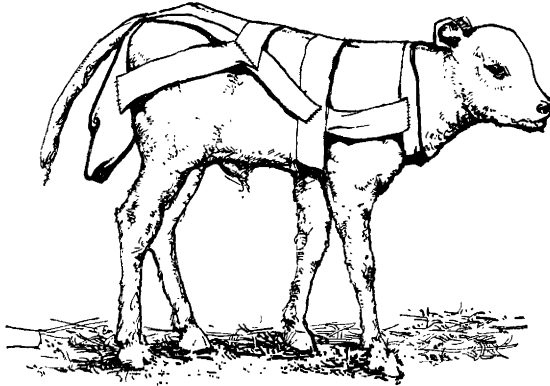


FIG. 1.—Bag for receiving feces and harness for supporting it.

experiment are shown in Table I. The cornstarch fed to calf 1 contained, according to analysis, 77.02 per cent of pure starch, and that fed calf 2, 76.32 per cent. The feces were received in a closely fitting rubber bag supported by a harness as shown in figure 1. Collections were made during the three starch-feeding days and the three days following. The feces were removed from the bag each day and immediately dried on the premises in an electric oven at about the temperature of boiling water. The dried feces, representing a starch-feeding period and the three subsequent days, were united and ground in a mill. The analyses were made according to the methods adopted by the Association of Official Agricultural Chemists, the malt-diastase method being selected for the starch determinations.

The feeding was conducted at the Bureau of Animal Industry's Experiment Farm, Beltsville, Md., and the analytical work was done at the Dairy Division laboratories in Washington. The results are given in Tables I and II.

TABLE I.—Composition of feces of calves

Animal and period.	Age of calf when feces were collected.	Weight of dry feces.	Nitrogen in feces.		Ether extract in feces.		Starch in feces.	
			Gm.	Per cent.	Gm.	Per cent.	Gm.	Per ct.
CALF 1:								
1.....	4	288.98	14.07	4.87	6.36	2.20	144.2	49.91
2.....	12	270.28	13.74	5.08	11.95	4.42	101.5	37.56
3.....	20	244.87	14.20	5.80	13.75	5.62	67.8	27.70
4.....	30	179.40	11.66	6.50	7.36	4.10	15.2	8.49
5.....	39	202.00	17.25	8.54	14.71	7.28	2.2	1.07
CALF 2:								
1.....	4	283.49	14.27	5.03	12.08	4.26	146.0	51.48
2 ^a	14	.....	.....	.....	.....	.....	.....	.....
3.....	23	190.21	13.54	7.12	24.25	12.75	6.7	3.53
4.....	31	152.95	10.28	6.72	17.58	11.49	1.6	1.03

^a Sample was lost at the farm.

TABLE II.—Proportion of starch digested by calves

Animal and period.	Starch fed.	Starch in feces.	Starch digested.	
			Gm.	Per cent.
CALF 1:				
1.....	184.9	144.2	40.7	22.02
2.....	184.9	101.5	83.4	45.11
3.....	184.9	67.8	117.1	63.34
4.....	184.9	15.2	169.7	91.79
5.....	184.9	2.2	182.7	98.81
CALF 2:				
1.....	183.2	146.0	37.2	20.30
2 ^a	183.2	.....	.....	.....
3.....	183.2	6.7	176.5	96.32
4.....	183.2	1.6	181.6	99.10

^a Sample was lost at the farm.

CONCLUSIONS

The figures in Table II for digested starch show that the calves when from 4 to 7 days old were able to digest about one-fifth of the quantity consumed; in one case 22.02 per cent and in the other 20.30 per cent. When calf 1 was 12 to 15 days old, the percentage of starch digested had more than doubled and when 3 weeks old it had nearly tripled, while at 4 weeks in the case of calf 1 and at 3 weeks in calf 2, the percentage of starch digested was well over 90.

While it is quite probable that a calf but a few hours old can not digest an appreciable amount of starch, it can readily be seen that the quantity of starch-splitting enzymes must increase very rapidly in the first few days of life, for the calves under experiment, when only 3 to 4 weeks old, were able to digest a ration nearly 10 per cent of the dry matter of which was starch.

These results indicate that the milk ration of a calf but a few days old may be supplemented with a starchy food and that the starchy material may be rapidly increased as the calf grows older.