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FAT IN MILK FROM STARCH IN FOOD.

F. H. HALL, W. H. JORDAN, C. G. JENTER AND F. D. FULLER.

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* Connected with Fertilizer Control.
† At Second Judicial Department Branch Station, Jamaica, N. Y.
¶ Absent on leave.

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OF

BULLETIN NO. 197.

FAT IN MILK FROM STARCH IN FOOD.

F. H. HALL.

One test insufficient. The scientific investigator is rarely content with proof furnished by a single test or by one individual. This is especially true in the study of biological problems; for the mysterious life forces are subject to so many modifications in different individuals that the behavior of the selected animal or plant under investigation in any instance can, at best, furnish only a presumption of the truth of some general law. Occasionally conditions can be so controlled and sources of error so carefully avoided that the presumption assumes almost the weight of final proof. Such was the case in the experiment reported in Bulletin No. 132 of this Station, by which the feeding, milk production and general behavior of one cow during a test lasting more than three months, made the conclusion inevitable that she formed some of her milk fat from the carbohydrates furnished in her food. Yet for proof that all cows can do this further experiments with other animals were thought necessary.

First test. In the investigation mentioned a grade Jersey was fed for 95 days on rations varying in total amount and in protein content from very full to very scant, with an ample supply of carbohydrates except during the 20 days

*This is a brief review of Bulletin 197 of this Station on the Food Source of Milk Fat, by W. H. Jordan, C. G. Jenter and F. D. Fuller. Any one specially interested in the detailed account of the investigations will be furnished, on application, with a copy of the complete Bulletin. The names of those who so request will be placed on the Station mailing list to receive future bulletins, popular or complete as desired.

Bulletins are issued at irregular intervals as investigations are completed, not monthly.

of light feeding, but with a marked deficiency of fat throughout the entire time. The effort was made to use foods as nearly fat-free as possible, the fatty matters being removed from the hay, corn meal and oats by chemical treatment.

From food containing only 5.7 lbs. of fat the cow made 62.9 lbs. of milk fat, and gained flesh. She thus could not have secured all the milk fat from food fat nor from stored body fat. Neither could she have formed the remainder of the secreted fat from the protein in the food, as only enough protein was decomposed in her body, while the record was kept, to make less than half of the fat formed during the same time, allowing the highest possible rate for fat formation from protein. When food fat, body fat and protein broken down fail to account for the fat produced, the carbohydrates alone remain as a possible source. We must conclude that in case of this cow, at least, part of the milk fat came from the starch, sugar and similar bodies in the food.

Recent trials.

Additional experiments have now been made which confirm this as a general law. Three cows were fed for periods varying from 4 days to 74 days, the food eaten, milk produced and excreta voided being weighed and analyzed as often as necessary to secure an accurate record of the nutrients fed and their disposal by the cows. Samples were also taken and burned in a calorimeter, so that the energy, or heat producing power, of the food, secretions and excretions was accurately determined.

Protein changes in fat-poor ration.

Cow 12 started with a ration containing 3⅓ lbs. of rice meal, and 1½ lbs. of wheat gluten, corn meal and ground oats from which the fat had been extracted, alfalfa hay, oat straw and sugar beets. This gave a protein supply of 2.6 lbs. daily and a nutritive ratio of about 1:6.5. The rice meal contained but little protein, the wheat gluten a very large proportion, so that by substituting one of these for the other the protein could be increased or diminished to a marked extent without materially altering the amount of dry matter fed. After three weeks of feeding on this ration an ounce of wheat gluten was withdrawn daily and an ounce of rice meal substituted until no gluten was fed and the entire amount of protein was lowered to

1.6 lbs., thus widening the nutritive ratio to 1:10.9. This wide ration was fed for a week; then gluten was added and rice meal withdrawn until the normal was again reached. These variations were so gradually made that no disturbance of the cow's functions was caused; yet they allowed a study of the effect of marked changes in protein content in a ration always poor in fat.

Fat changes in ration. Cow 10 was fed at first mixed hay, sugar beets, corn meal, 2 lbs. linseed meal and 1 lb. ground flaxseed, giving a nutritive ratio of about 1:7.5. As protein was changed for Cow 12, so fat was changed for Cow 10 by slowly substituting flaxseed, with nearly 40 per ct. fat, for linseed meal, with only 7 per ct. The ration at the start was rich in fat, containing 0.8 lb. daily; but was made richer until it reached a maximum of 1.4 lbs., far above any amount fed in practice. Surely if feeding can change the composition of milk, here should be shown increasingly rich milk. These fat changes were also made gradually, so that the cow was not disturbed, and the dry matter and nutritive ratio were little altered.

Herd ration. Cow 2 was used for comparison, she being a fat producer of marked ability, giving 2 lbs. of butter a day during the test and more than 500 lbs. in the year. She received the normal herd ration of 6 lbs. alfalfa hay, 40 lbs. corn silage, 10 lbs. sugar beets, 4½ lbs. wheat bran, 2¼ lbs. malt sprouts and 2¼ lbs. linseed meal, which affords a ratio of 1:5.6.

Digestibility of ration. Though study of the source of milk fat was the main purpose of the investigation, the completeness of the data secured made it possible to decide other questions.

The rations, though so different in character and passing through such marked changes, showed great uniformity in digestibility, the cows using about the same proportion of the dry matter fed in each case. This test, with other digestion trials of mixed rations, proves that the feeder will not be far wrong who assumes that 70 per ct. of the dry matter is digestible in rations made up partly of silage and containing a good proportion of high class grains.

Diminishing the quantity of protein in the ration appeared to make the whole ration, and especially the remaining protein, less digestible. When 2.6 lbs. of protein was fed to Cow 12, she digested 71.3 per ct. of the organic matter of the ration and 66 per ct. of the protein; but when the protein supply was reduced to 1.6 lbs. she utilized only 68.5 per ct. of the ration and 54.7 per ct. of the protein.

Rich milk from rich food?

These tests add strength to the scientist's claim that fat cannot be fed into the milk. In case of Cow 12 the milk yield decreased quite steadily from the beginning of the test when she was fresh, to about the middle of the time, after which it was quite constant. This shrinkage was quite uniform through the first feeding with maximum protein supply and the period of protein diminution; but there was no increase when the protein was being brought back to the normal nor during the last feeding on the protein-rich ration. The shrinkage in yield was accompanied by an increase in the percentage of fat and solids from 3.72 per ct. and 12.92 per ct., respectively, at the beginning, to 4.08 per ct. and 13.78 per ct. at the end of the test. This increase was quite uniform from week to week and seemingly connected in no way with the changes in protein. That is, the percentages of fat and solids increased as the protein diminished, but they continued to increase as the protein was again restored.

With Cow 10, where the large amount of fat fed would seem certain to influence the composition of the milk if any food element can do so, there was less change than with Cow 12. The daily milk yield, averaged weekly, varied less than a pound for the six weeks from minimum fat to maximum fat; and the percentage of fat was remarkably uniform, differing only .02 per ct. at the end of this time from what it was at the beginning.

Whence comes the fat?

By the exact analyses made it was easy to determine how much fat and protein each cow received during the time she was under test, how much she used in making milk and how much passed through her digestive system as unavailable. For the purposes of this investigation, in order to be on the safe side, is assumed that the cows could make an equal quantity of milk fat from the ether extract digested and that they made the largest possible amount of fat from the protein decomposed in their bodies. Both assumptions are manifestly contrary to probability, even to possibility. The chemists' "ether extract" from hay and grains and the fat from milk differ greatly in the proportions, and to some extent in the character, of the separate fats composing them. "Ether extract" from foods contains also many bodies not fats at all. Protein contains nitrogen, which is not found in fat and also contains the carbon hydrogen and oxygen of which fat is built up; but does not contain these elements in the proportions existing in fats. In the body the protein may split up into simpler compounds, the nitrogen it contains passing off in the urine. This urine nitrogen we take as the measure of the protein decomposed and then assume that from the remaining elements of this protein all the fat possible was formed, which is a very improbable assumption.

Thus counting the fat production at its highest from both food fat and protein we obtain from the data the following table:

RELATION OF MILK FAT TO FOOD FAT AND PROTEIN.

	Days of expt.	Fat digested from food.	Theoretical fat from protein.	Fat in milk.	Fat not accounted for from food fat and protein.	Gain in weight of cow.*
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Grade Jersey, fat-poor ration †.	59	3.3	17.1	38.8	18.4	33.
Cow 12, fat-poor ration	74	4.8	39.2	83.	39.	15.
Cow 2, normal herd ration	4	3.37	2.61	7.23	1.25	—
Cow 10, fat-rich ration	42	33.1	18.5	45.5	—6.1	18.

* Based upon average of ten days weighings.
† From Bul. 132, N. Y. Agl. Exp. Sta.

The table shows gain in weight for the cows, thus seeming to forbid any taking of stored body fat for making milk fat; so it seems certain that in three of the four cases some fat must have been formed from the carbohydrates of the food. In the fourth case, Cow 10 on a fat-rich ration, but little more fat than needed for milk fat was obtainable from all sources except the carbohydrates, even with the improbable maximum production allowed these sources. Some, if not most, of her increase in weight was undoubtedly fat, calling upon the surplus of 6.1 lbs., so her testimony tends in the same direction as that of the other cows, though it does not furnish unimpeachable proof.

Excess protein and energy.

In studies of milk production it has been found in general that a ration with a moderately narrow ratio and furnishing from 2¼ to 2½ lbs. of protein daily has given the best results. From the test given in Bulletin No. 132 and from these later ones it is evident that part of this protein is not used directly in maintaining the animal or in milk formation. When a pound of protein less than the maximum was fed to the grade Jersey described in Bulletin No. 132 or to Cow 12, the milk yield was not greatly decreased, but the amount of protein decomposed was lessened one-half. The cows seemed to make up for the decrease in protein, not by ceasing to produce their normal flow of milk, but by checking the break down of protein in other portions of their bodies.

Any animal, even one at rest, requires a certain amount of protein for maintenance, for repairing the tissues broken down by the movements of respiration, circulation, digestion, etc., and the cow in addition requires a considerable quantity with which to form the milk solids; but her needs for both these purposes are below what the feeding standards hold necessary. The excess may tend to stimulate secretion; it does not support it.

Somewhat similarly in both Cow 12 and Cow 10, the calorimeter determinations proved that the rations furnished an excess of energy, as measured by heat units, beyond what was needed for maintenance and to form milk solids. Of the energy furnished by the food, about one-third passes through the digestive system unutilized, and 10 per ct. more disappears in fluid and gaseous excretions, leaving from 55 to 60 per ct. to serve the real uses of the cow. Of this available energy, from 40 to 45 per ct. is used for maintenance, from 30 to 35 per ct. enters the milk solids, leaving about one-fourth of the total available energy unaccounted for.

What becomes of the energy and the surplus protein we cannot say, but since we know that diminishing the ration enough to get rid of these surpluses would result in a marked fall in production, we must conclude that they are in some way necessary in stimulating or in carrying forward the work of milk secretion.