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MILK FAT FROM FAT-FREE FOOD.

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*Connected with Second Judicial Department Branch Station.
†Connected with Fertilizer Control.

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MILK FAT FROM FAT-FREE FOOD.

F. H. HALL.

A mistaken popular idea. It is quite commonly believed that the fat in an animal's body or in the milk secreted comes directly from the fat in the food eaten. With those who hold this idea the anima seems to correspond quite closely to the dairyman's churn; the mastication, digestion and assimilation of the food simply serve to separate from the other food compounds the fat particles already existing and to store them up in fatty tissue or in milk; as the beating, shaking and gathering in the churn unite the minute fat globules of the milk into the firm masses of butter.

Chemical tests, however, and microscopic examinations prove that the animal fats are quite different from each other and from the fats in corn, linseed meal and clover hay; yet, from a ration containing only these foods, the hog will form lard; the steer, tallow; and the cow, butter. It would be difficult, if not impossible, to combine the ordinary foods so that any animal could select, from the mixture, fats like in kind and quantity to those in its own adipose tissue.

Theories of fat formation. This theory of direct transfer of fats was held for a long time, even by scientists, but is now abandoned by them. Various other theories have been advanced: Some have held that the body and milk fats are formed by simple chemical transformations of the various food fats; others, that the carbohydrates, which contain no chemical elements not found in the fats, are chiefly concerned in their formation; and others, that the nitrogenous compounds of the food, the

*This is a brief review of Bulletin No. 132 of this Station on The Source of Milk Fat, by W. H. Jordan and C. G. Jenter. Anyone specially interested in the detailed account of the investigations will be furnished, on application, with a copy of the complete Bulletin.

proteids, are broken up to form fats, the nitrogen, which protein contains and fat does not, being excreted in the urine.

A difficult problem.

All scientific observers know that the problem is much too complex to be explained by the mere transfer of fat particles; and find the solution far from easy. The food can be followed without much trouble until it has been digested; samples can be obtained from mouth, stomach, intestines, even from the vessels into which the absorbed, liquified food has been poured, and the chemical changes studied; but the transformations made in the living tissues are beyond the direct reach of microscope and chemical reagent. The investigations must needs be made by giving foods of particular character—fat-free, protein-free, carbohydrate-free—and noting the effects produced in weight and composition of flesh, fat, milk and refuse matters, or by feeding ordinary materials whose composition is known and determining by analysis of products and excreta the disposition made of the different nutrients.

Facts about body-fat formation.

In this way foreign investigators have demonstrated that the fat formed in the bodies of the sheep, pigs, geese and dogs upon which they experimented could not have come wholly from the fats in the food fed, nor even from the fats and the transformed protein, but must have come, in part at least, from starch and sugar and other carbohydrates. These experiments have not proven that the fat in the food and the protein in the food do not *help* to make the body fat, but they have proven that they do not make *all* of it.

What we have known about the source of milk fat.

Even less has been known about the source of milk fat; for the experiments along this line have been so short or the balances in favor of one source or another have been so small that it has been impossible to say whether the milk fat has come entirely from the fat in the food or in the body of the cow herself, from the carbohydrates in the food, from the protein in the food, or from breaking down of the protein tissue of the udder.

So inconclusive are all these results that it was determined to carry on an experiment at this Station on a more extended scale than had ever before been attempted along this line.

Conditions sought in experiment. Certain requirements seem to be necessary for obtaining conclusive data, and the experiment was planned to secure the following conditions: (1) Foods nearly free of fat were to be used, so that if milk fat was produced in usual quantity a large amount must come from the cow's body or from the carbohydrates and protein of the food; (2) the experiment to be continued so long that any large draft upon the fat in the cow's body would show in her condition; (3) the protein in the ration to be varied from a quantity below to one above the actual needs of the animal in order to discover if possible just how little protein metabolism (change by physiological processes) is necessary to maintain a given production of milk fat; (4) such data to be recorded—weights of animal and of water drank, and weights and composition of food, milk, urine and feces—as would enable the experimenter to determine at any time just how much had been gained or lost in weight and how much fat or protein had been consumed by the cow and how much used by her in formation of body weight and milk or voided in excreta.

Details of experiment. For the purposes of the experiment it was necessary to have a large quantity of food as nearly fat-free as possible, so a thousand pounds of finely chopped timothy hay and fifteen hundred pounds each of corn meal and ground oats were sent to the works of the Cleveland Linseed Oil Company at South Chicago and were there treated repeatedly with a solvent. It was found impossible to extract all of the fat, but so small a quantity was left that a good ration could be fed which would contain only two ounces of fat daily. This process rendered the food somewhat less palatable to the animal, so a cow was selected with a vigorous appetite, a young grade Jersey which had been giving milk about four months and was somewhat thin in flesh. The experiment continued from April 12 to July 30 and, with few exceptions, the animal ate the rations readily and completely.

Beginning with the second week of the experiment the milk was weighed and daily samples taken for analysis throughout the entire time of the feeding, one hundred and two days.

Beginning at this time, also, the urine and feces were collected separately, the cow being watched night and day for this purpose, were weighed and samples taken for analysis daily for sixty-six days until the last period of the experiment.

For the first two weeks the cow was given foods containing the normal amounts of fats to determine her behavior under natural conditions. For the next eight days she was fed a ration of the extracted foods similar in amount to that first fed—10 pounds hay, 6 pounds corn meal, 5 pounds ground oats and 1 pound wheat gluten. For the next week one-half pound more daily wheat gluten was given to increase the proportion of protein up to or beyond the animal's probable full requirement for maintenance and milk production. Then the gluten was decreased and the corn meal increased at the rate of one-fourth pound daily until at the end of five days no gluten was fed and the corn meal had been raised to seven and one-half pounds. This was continued for eight days, at the end of which time the amount of each ingredient of the ration was diminished one-third. This was thought to be less than the animal's needs and was continued for twenty days. Then for three days one-fourth pound gluten was added daily and finally the original ration of extracted foods was fed for thirty-six days.

General results.

The cow seemed to keep in perfect health throughout the experiment, showing no signs of fever or other unnatural symptoms, although she drank larger quantities of water than usual. There was a gradual and quite uniform increase in weight and an apparent laying on of fat throughout the experiment, except during the twenty days of scant feeding, when there was no especial change. To judge by all outward signs she was a fatter animal at the end of the experiment than when the feeding began.

Milk fat not all in food fat or body fat.

The milk secreted while feeding the extracted foods was similar in composition to that produced from the normal foods. There was a drop in the percentage of milk solids for a few days following the change to the fat-poor foods, but in a very short time the milk became as rich as before. During the ninety-five days, 62.9 lbs. of milk fat was produced, while the food contained only 5.7 lbs. of digestible fat, so that 57.2 lbs. of milk fat could not have come from food fats. It is not possible, either, that this surplus came from fat already stored in the cow's body. By analyses, made in England, of the entire body of a well-fed ox, it was found that such an animal contained only 7.1 per cent of fat. Even if this cow had been as fat as the ox, which is improbable, her body would have contained at the start only 61 lbs. of fat, practically all of which would have been needed to produce the 57.2 pounds of fat in the milk; and the removal of this from her body would have left her exceedingly thin in flesh. On the contrary she was lean when the experiment began and apparently gained fat steadily. She certainly was 47 pounds heavier at the end and could not have made all this gain in muscular tissue; for flesh formation requires nitrogen, and during fifty-nine days of the time, all, or very nearly all, of the nitrogen consumed by the cow reappeared in her milk and excreta.

If the fat had been taken from her body and its weight replaced by water or food in the intestines, as some may suggest, she would necessarily have appeared full or bloated; for such a substitution would require the presence in stomachs and intestines of 104 pounds of matter to replace 47 pounds of increased weight and 57 pounds of removed body fat. It is safe to say, then, that the fat in the milk could not have come from fat in the food or from that stored in the animal's body.

Protein insufficient.

In the fifty-nine days during which records of the income and outgo of both fat and nitrogen were kept, 38.8 pounds of fat was found in the milk. According to any accepted theory of fat formation by protein decomposition, the nitrogen of the protein and part of the other elements are not used, the nitrogen appearing in the urine. The highest figures given by any investigator allow 51.4 pounds of fat from 100 pounds of protein; so to form this 38.8 pounds of fat the metabolism of at least 75 pounds of protein would be required. In the urine, however, there was found only nitrogen enough to account for the decomposition of 33.3 lbs. of protein or the formation of 17.1 lbs. of fat, leaving 21.7 lbs. of fat unaccounted for. In this fifty-nine days the digested food fat was only 3.3 pounds and the cow's weight increased 33 pounds without flesh formation as revealed by disappearance of nitrogen. The fat in the milk then, could not have been formed from fat in food, fat in body or protein in food, singly or all united; so part, at least, must have been formed from the carbohydrates of the food.

Why is protein necessary?

It is generally held that, to maintain the best results in milk flow, and to make each pound of digestible matter in the ration most efficient, more than two pounds of digestible protein, two and one-half pounds being the amount agreed upon, should be fed the cow in connection with a sufficient supply (12½ pounds) of carbohydrates. But the results of this experiment indicate that protein takes no necessary part in providing raw material for the secretion of milk fat, so a large part of this generous protein supply is not needed for constructive purposes. Why, then, is it necessary? For necessary we know it to be. Is it not probable that its effect is stimulative—that protein excites and assists metabolic changes in other materials rather than enters into them itself? If future experiments support the conclusions of the one here discussed it will seem most rational that the great value of narrow rations rests upon the stimulative effect of the protein in them.

Rich food and rich milk.

In all the varying changes of the rations fed during this long period, the composition of the milk remained very uniform. As already noted, when the extracted foods were first fed the milk was poorer for a few days but soon resumed its normal composition. Thereafter it continued about the same whether the ration was well supplied with protein or contained none at all; whether poor in carbohydrates or rich; and even when the supply of all ingredients was below the animal's real needs the milk did not suffer in quality, though it diminished in quantity. Such changes as did take place, however, were due to variations in the fat; the casein, sugar, salts, etc., remained remarkably uniform.