FAT EXCRETION.

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The feces of animals normally contain some fatty material which consists mainly of fatty acids and their salts (soaps), a smaller amount of cholesterol and its derivatives, and a little fat. The fatty acids and fats are generally assumed to be unabsorbed residues of the fat of the food and a food fat is said to be well or poorly absorbed according as the amount of fatty substance recoverable from the feces is relatively small or large. In some cases, and especially when the amount is large, there is little doubt that the assumption is approximately correct and that the fat and fatty acids found represent largely unabsorbed food fat, but there is considerable evidence to indicate that in many or perhaps most instances the feces fat has no direct relationship to the fat of the food, but represents rather some form of excretion from the intestinal tract. Friedrich Müller (1) in studies of the feces fat of the two professional fasters Cetti and Breithaupt found in the case of Cetti that the fatty material of the fasting feces was about 36 per cent of the dry material and that 39 per cent of it was fat, 45 per cent fatty acids, and 16 per cent cholesterol. In the case or Breithaupt the fatty material composed 28 per cent of the dry matter and of this, neutral fat and cholesterol formed 47 per cent, fatty acids (and soaps) 53 per cent. In two periods with food on the same subject the lipoid material formed, in the first period, 24 per cent of the dry material, and of this 36.5 per cent consisted of neutral fat and cholesterol and 62.6 per cent of fatty acid. In the second food period the lipoid material constituted 28 per cent of the dry substance, and of this 29 per cent was neutral fat and 71 per cent fatty acid and

soap. The percentage of total lipoid material in the feces during the food period thus differed but little from that of the fasting period, although the proportion of fatty acid and soap was relatively considerably higher during the food period. Also, since the amount of feces was greater, the absolute amount of lipoid material excreted during the feeding period was greater than during the fasting period. In the same article Müller refers to some earlier experiments (2) with dogs in which he found a lipoid content in the feces of 20 to 47 per cent of the dry substance, consisting mainly of fatty acid. Thus in one dog (2) weighing 23 kilos. in a 7 day fast the excretion was about 2.68 gm. of dry material per day, of which the fatty material amounted to about 34 per cent, and consisted of 67 per cent of fatty acid (and soap) and the remainder of neutral fat and cholesterol. He believed that this material originated as an excretion of the intestine and pancreas. In another dog weighing 18 kilos, on a diet of lean meat the feces amounted to 6.1 gm. of dry matter per day and contained 25 per cent of fatty material, of which 62 per cent was fatty acid and 38 per cent cholesterol, fat, etc. The addition of small amounts of fat to the diet affected the lipoid content of the feces only slightly, but larger amounts increased the lipoid output. The latter finding is not, however, incompatible with his assumption of a fat excretion, since where large amounts of fat are ingested a larger excretion might be expected.

Hermann (3) isolated loops of intestine and found that they filled up in the course of 3 or 4 weeks with material very similar to feces, and an examination of this material by Ehrenthal (4) demonstrated the presence of fat, soaps, and cholesterol. F. Voit (5) repeated the work and confirmed their results, finding that the contents of the intestinal ring had the same composition as hunger feces and almost the same as meat feces. In addition to ash and nitrogen there was always fatty material to the extent of 30 to 36 per cent, of which up to one-third (generally less than one-tenth) was neutral fat, one-half to four-fifths free fatty acid, and one-tenth to one-third soaps.

By the use of fistulas further information regarding intestinal secretion was obtained. Gumilewski (6) obtained from a low Thiry-Vella fistula in dogs a continuous secretion which was small in amount in fasting, 1 cc. per hour from an 11 cm. length of

intestine, but increased to 7 to 10 cc. during digestion. Röhmann (7) found little or no secretion from a high loop while considerable secretion was obtained from a low loop. Some time ago one of us (B) examined the secretion from a permanent Thiry fistula (consisting of about 14 inches of jejunum) in a healthy dog.[1] The secretion was collected on fat-free pads of gauze which were then boiled out with alcohol to extract the lipoid material. The alcoholic extracts were evaporated to small volume, diluted with water, acidified, the fatty matter was extracted with ether, the solvent evaporated, and the residue dried and weighed. In a 5 day period a total of 0.72 gm. of lipoid material consisting almost entirely of fatty acids was recovered. The animal was well fed during the period. It was not possible to repeat this important experiment at the time and the dog was disposed of. Numerous attempts have been made since then to obtain suitably operated animals but none survived the operation and resulting complications long enough to be used for an experiment.

The results noted above indicate that much fatty material is to be found in the intestine and feces which are entirely independent of the food. The question as to whether it is to be regarded as a secretion is complicated by the fact that in the feces and in intestinal loop contents there is much cellular material (bacteria. etc.), which contains fatty compounds and contributes to the "fat" content. The importance of this source of fat cannot be estimated. As regards the contents of intestinal rings, Voit (5) does not regard it as important since the nitrogen content is too low and the ash too high to be of cellular origin. The fact that the free flowing secretion from the intestinal fistulas contains little cellular material but considerable soap points to a true secretion.

Aside from the undetermined influence of lipoid from cellular material it is reasonable to assume that if the fatty material of the feces represents a true excretion of the intestine its nature would be independent of the food and of the food fat. If it represents unabsorbed food residues its nature would depend on that of the food fat. Certain modifications of this general assumption should probably be made in view of the probability

[1] Obtained through the kindness of Dr. Barney Brooks of the Washington University School of Medicine, St. Louis.

that on the one hand some of the food fat after absorption may be excreted into the intestine and on the other that the absorption of food fat from the intestine may be selective, less desirable, and possibly similar portions of all types of fat being rejected and appearing in the feces.

With these ideas in mind feeding experiments were carried out with two fats of widely different composition, and the feces fat was examined. Cats were used for the experiments. They were kept in cages throughout the period but allowed the free run of the room during a portion of the day for exercise. Their basal diet was a practically fat-free mixture of starch and extracted casein with meat extract for flavoring and bone ash to provide bulk. Experiments were conducted with (*a*) a diet of lean meat, (*b*) the basal diet alone, (*c*) the basal diet plus olive oil, (*d*) the basal diet plus coconut oil; in every case making the amount of the daily food such as to supply 100 calories per kilo of body weight. Generally the food was entirely eaten up, but occasionally when olive oil was fed and more frequently with coconut oil it was necessary to feed forcibly a portion of the oil in order to make sure that the cats received the required amount. Although apparently remaining in good health the animals lost weight steadily throughout the experiment.

The meat used contained from 2 to 7 per cent of fat with an iodine number of about 46 and a melting point of about 43°C. The casein was mainly prepared fresh from skim milk, but some commercial casein was used. In preparing it for use all samples were extracted with alcohol and ether and as used the casein-starch basal diet contained only a few milligrams of fatty substance in 100 gm. The coconut oil was fed in the form of the commercial butter substitute "Nucoa." This substance consists almost entirely of coconut oil but the flavor is somewhat disguised and is less objectionable than that of the commercial oil. The fatty acids of the material used melted at about 25°C. and had an iodine number of 8.8. The olive oil had an iodine number of 88.2.

Each experiment lasted a week, the periods being marked off by charcoal. The feces were collected as passed, kept in a stoppered bottle under 95 per cent alcohol until the end of the period when the whole was transferred to a large Erlenmeyer

TABLE I.

Feces "Fat" on Various Diets.

Subject No.	Fat eaten.	"Fat" in feces.	Percentage of "fat" in feces to fat in diet.	Iodine No. of feces "fat."	M.P. of feces fat.
		Fat-free diet.			
	gm.	*gm.*	*per cent*		*°C.*
1		1.70		36.3	38
		3.29		32.6	42
2		0.86		37.1	26
3		1.47		27.4	39
4		1.47		30.0	30
		Meat diet.			
1	50	6.00	12.0	39.0	44
	28	0.87	3.1	43.8	34
2	34	2.37	6.9	34.8	33
3	28	1.10	3.9	42.3	36
4	28	3.84	13.7	30.5	35
		Coconut oil.			
1	44	2.17	5.1	25.0	32
2	45	2.46	5.5	24.4	34
3	24.3	1.82	7.6	31.0	30
4	52	3.55	6.9	21.6	27
		Olive oil.			
1	30	1.50	5.0	38.7	30
	50	2.00	4.0	53.2	26
2	45	2.51	5.6	41.0	32
	50	1.81	3.6	44.8	30
3	50	2.76	5.5	49.8	33
	50	1.33	2.7	52.2	25
4	50	3.0	6.0	44.3	37
	50	3.0	6.0	32.7	40
Averages.					
Fat-free diet.....		1.76		32.7	35
Meat diet		2.83	7.9	38.1	36
Coconut oil.....		2.50	6.3	24.8	31
Olive oil.....		2.24	4.8	44.6	31

flask. Alcohol was added to cover the material, then 10 gm. of stick potassium hydroxide, after which the flask was connected with a reflux condenser and boiled for 5 hours. At the end of the time the mixture was diluted with water, acidified with hydrochloric acid, and completely extracted with ether. The extracts were united, washed with water, the ether was distilled off, and the residue dried in a vacuum desiccator for 24 hours. The residue was then extracted with petroleum ether, the extract filtered, the ether distilled off, and the fatty residue dried as before and weighed. In this series of experiments no account was taken of the cholesterol-like substances (unsaponifiable matter). In determining their fat content the food materials were treated in the same way as the feces. Iodine number determinations were made by the Wijs method. Five experiments were carried out with the fat-free and meat diets, four with coconut oil, and eight with olive oil. The results of the experiments are given in Table I.

DISCUSSION.

Total Fat.—The total "fat" in the feces varies a great deal on all the diets so that the average has not much meaning; but inspection of the data on the experiments will show that, as would be expected, there is less fat in the feces on the fat-free diet than on the others. Of the other three the meat diet yields the largest amount, due probably to enclosure of fat by the tissue, and the olive oil the least. Probably for the same reason (enclosure) the percentage feces fat of food fat is highest on the meat diet.

Iodine Number.—The iodine number is highest on the olive oil diet and lowest on the coconut oil, but in neither case does it approach the values of the fat fed, having rather a value not so greatly different from that of the fat-free diet. It is plain that the fat of the food has some influence on the feces fat but the influence is not great, especially when the amounts of fat fed are moderate, as in these experiments.

Melting Point.—The melting point of the feces fat is relatively constant, but is consistently lower on the fat diets than on either the fat-free or the meat diet, showing again the influence of the fat of the diet on the feces fat. The melting point of the feces fat is almost always below body temperature.

These results show, in agreement with the work of earlier investigators, that "fat" is to be found in the feces whether it is present in the food or not, and that fat in the food increases the feces fat, but only to a comparatively small extent. They show further that the nature of the "fat" of the feces is to a great extent independent of the food fat, being much the same no matter which of two widely different fats were fed or whether none was fed at all. Taken altogether they indicate a continuous output of "fat" in the feces of a constant composition independent of the diet.

The constancy of the feces fat independent of the diet favors the idea of a fat excretion, but might, of course, be explained as due to a constant output of cellular waste from the intestine and from bodies of bacteria. The answer of Voit to this possibility (see above) is not convincing, since the presence of much cellular material in the feces cannot be denied. The fact that fatty material can be collected from isolated portions of the intestine under conditions which to a large extent exclude a cellular origin (Thiry fistula) is a better answer to the objection, but unfortunately there is not much evidence of this nature available. It is not unlikely that feces fat may have more than one origin just as the fatty material from the skin comes partly from desquamated epithelium, and partly from the sebaceous glands.

SUMMARY.

When moderate amounts of fat are fed the fat of the feces is largely independent of the diet, and in composition approaches that from a fat-free diet.

The comparative constancy of composition of the feces fat favors the idea of a fat excretion from the intestine but while an excretion is probable it cannot be regarded as proven in view of the undetermined influence of lipoid from free cellular material.

The feces fat cannot ordinarily be regarded as unabsorbed food fat and, therefore, feeding experiments as a test of the extent of utilization of food fat are of doubtful value unless account be taken of the amount and kind of fat which appears in the feces independently of the food.

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