DIGESTIBILITY OF FATS TAKEN FROM THE ANIMAL BODY

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Note: Since fats from cattle are included in nearly all diets, the following resume of digestion experiments, conducted by the author while employed as physiological chemist at the U. S. Dept. of Agriculture, is given to supply information concerning the digestibility of such fats when included in a simple mixed diet.

For a long time it has been recognized that fats from different parts of the animal body exhibit a lack of uniformity as regards chemical and physical characteristics. Henriques and Hansen[1] reported that fats from the interior and exterior of the same animal were characterized by a difference in melting points and iodin numbers. Richardson[2] found that the melting point of leaf lard was several degrees higher than that of the back fat of the same animal. Some years later Richardson and Farey[3] reported a variation of 12° to 22° C. in melting points of leaf lard, ham fat, and back fat.

A number of investigators have studied the extent to which the composition of the diet influences the characteristics of the fats found in the fat depots of the body. Shutt[4] conduced a series of feeding experiments to determine the effect of the nature of the diet of pigs upon the quality of pork obtained from them and found a marked variation in appearance and characteristics of pork produced from different rations. The melting point of "soft pork" was often 10° C. lower than that of firm bacon. These results were substantiated by Richardson[2], who determined the characteristics of lard from oily hogs. Rosenfield[5] says a horse fattened on oats will produce a liquid fat, but if fattened up on hay the body fat will be much firmer and that the similarity of the body fat of the ox, sheep, roe and hart is directly referable to their diet of grasses. Rohmann[6] reports that fats foreign to the diet of birds may, just as in milk, pass into the secretion of the coccygeal gland.

Furth[1] quite evidently believes that the characteristics of the fats found in the human body are to some extent influenced by the nature of the diet, for he states that the skin fat of children fed upon human milk is always richer in insaturated fatty acids than of the artificially fed infants.

As a result of these observations the question very naturally arose as to the relative digestibility of fats taken from different parts of the body. Flurin[3] studied the relative digestibility of beef tallow and butter

[1]Skand. Arch. Physiol., Vol. 11 (1901), No. 3-4, pp 151-165.
[2]Jour. Amer. Chem. Soc., Vol. 26 (1904), No. 4, pp 372-374.
[3]Idem., Vol. 30 (1908), No. 7, pp 1191-92.
[4]Canada Expt. Farms Repts. (1889), pp 151-155: Idem. Bull. 38 (1901).
[5]Ergebn. d. Physiol., Vol. 1 (1902), p 676.
[6]Hofmeister's Beitr., Vol. 5:10 (1904) (Breslau).

and found on the average butter was 96% digested and beef tallow 93% digested. Levites[3] found butter and beef fat were both 96% digested. Grindley,[4] in an extended study of the effect of different methods of cooking upon the thoroughness and ease of digestion of meat beef, reports as follows:

Number of experiments	Cut and method of cooking		Digestibility of fat
5	Lean round of beef cooked in water at 80°-85°C.	1 hr.	92.6%
5	"	2 hrs.	90.4%
2	"	3 hrs.	96.6%
3	Lean round pan broiled		98.2%
3	" " fried in hot lard		97.7%
3	" " roasted		99.7%
3	Fat shoulder cooked in water 80°-85°C.	2 hrs.	97.3%
7	Beef ribs roasted		99.4%

Experimental

In view of the extensive use in the average dietary of fats derived from cattle, it has seemed of interest to compare the digestibility of fats taken from different parts of the body of beef animals, especially when the determination of these coefficients has been obtained under uniform experimental conditions. Accordingly, the essential data for interpreting the results of series of experiments with brisket fat, butter, cream, hard palate fat, kidney fat, oleo oil, oleo stearin, ox-marrow fat, and ox-tail fat have been brought together in a table which appears on page 13.

The experimental procedure for these experiments has been outlined in detail in previous papers. Briefly stated the experimental diet consisted of wheat biscuits, fruit, sugar, tea or coffee and a cornstarch blancmange which served as a vehicle for the fat under consideration and which was so flavored as to mask its presence. This diet was eaten by normal human subjects for a nine meal, or three-day period, and the difference between the amount of fat ingested and that excreted was considered as the amount digested.

Of the fats discussed below butter and cream were purchased as such in the open market. Kidney fat, brisket fat and hard palate fat were rendered from beef tallow, beef briskets and hard palates under laboratory conditions. The remaining fats, oleo oil, oleo stearin, ox-marrow fat and ox-tail fat were secured from one of the large packing houses and all of the fats were believed to be typical of those purchased by the average consumer.

In order to make an accurate comparison of the digestibility of fats taken from different parts of the animal body the fats should be obtained

[1]Problems of Physiol. & Pathological Chem. of Metabolism (1916), p 383, Lippincott Co., Phila. and London.

[2]Diss. Army Med. Acad., St. Petersburg (1890), p 52.

[3]Ztschr. Physiol. Chem. 49 (1906), No. 2-3, pp. 273-285.

[4]U. S. Dept. Agri. Office Expts. Sta. Bul. 193 (1907), p 41.

from the same animal. In this instance, however, such a procedure was impossible as the amount of brisket fat, hard palate fat, ox-marrow fat and ox-tail fat required for a series of experiments could not be obtained from a single animal. It is felt, however, that the results reported below are truly representative of the fats under consideration and that these results are applicable to these fats as obtained from commercial sources.

The data essential for comparison of the digestibility of the different fats under consideration are given in the table below. The discussion which follows contains additional information concerning the individual fats.

SUMMARY OF DIGESTION EXPERIMENTS WITH FATS TAKEN FROM DIFFERENT PARTS OF THE ANIMAL BODY

Number of experiments	Kind of fat studied	Amount of fat eaten daily	Digestibility of the entire ration			Digestibility of fat studied
			Protein	Fat	Carbohydrate	
		grams	%	%	%	%
7	Brisket Fat	82	58.4	92.8	96.4	97
8	Butter	100	70.5	93.9	96.4	97
7	Cream	78	65.2	92.7	96.1	97
3	Hard Palate Fat	90	50.9	90.5	97.6	94
10	Kidney Fat	100	75.6	88.9	96.7	94
8	Oleo Oil	59	52.8	90.4	96.0	97
3	Oleo Stearin	68	40.5	71.8	94.7	80
4	Ox-Marrow Fat	89	59.2	91.2	97.4	94
3	Ox-tail Fat	77	74.6	93.0	96.3	97

Brisket Fat

Brisket fat[1] is little used for dietary purposes as a separated fat, but relatively large amounts are consumed as a constituent of brisket which is quite generally sold in the form of "corned-beef." For the purpose of the experiments discussed above, a quantity of fresh briskets were purchased and the fat was separated from the connective tissue by the usual household procedure. In appearance the brisket fat was yellow, somewhat granular, slightly harder than butter and without noticeable characteristic flavor or odor. The brisket fat was incorporated in a special cornstarch blancmange and served as a part of the usual experimental diet. The data of the seven digestion experiments indicate that brisket fat is very completely utilized by the human body, being 97% digested. In these experiments where an average of 82 grams daily were ingested, brisket fat was well tolerated by all the subjects assisting in the investigation.

Milk Fat (Butter and Cream)

Two series of digestion experiments were conducted to determine the digestibility of milk fat. In the first series, of eight experiments,

[1]U. S. Dept. Agri. Bul. 507 (1917), p 8.

the milk fat was studied as a separate fat, namely butter[1], which was incorporated in the customary manner into the usual experimental ration. Often it is contended that the fat ingested in the form of an emulsion is more completely utilized by the human body than when it is taken as a separate fat, and to secure data in this connection a second series of digestion experiments were made in which milk fat was served in the form of cream[2]. This was incorporated into the diet in the same manner as butter and accordingly the two series of experiments should be directly comparable. In both instances the results of the individual experiments were close and the average values for the two series of experiments were the same, indicating a 97% utilization of milk fat when ingested either as cream or butter.

Hard-Palate Fat

The hard-palate fat[3] studied in the experiments reported here was obtained by water extraction of hard-palates from the roof of the mouth of beef animals, secured from an abattoir shortly after they were removed from the animal. The hard-palates, which contain about 11% of fat, were minced and boiled for two or three hours and on cooling the extracted fat, which forms a solid cake on the surface of the liquor, was removed and scraped free of adhering particles, tissue, or other solids. Prepared in this manner it was yellow, slightly granular, without noticeable flavor, melted at 34° C, had an iodin number of 52.53 and a refracture index of 1.4586. The subjects who assisted in the digestion experiments with hard-palate fat maintained their normal physical condition during the experimental period, which gave evidence that hard-palate fat did not cause unpleasant physiological action. Judged by these digestion experiments, the digestibility of hard-palate fat, 94%, is less than that of brisket or milk fat.

Kidney Fat

Ten digestion experiments were made to determine the digestibility of beef kidney fat[1]. On an average the subjects ate 100 grams of kidney fat daily, but in three experiments the subjects ingested an average of 130 grams, 137 grams and 151 grams daily for three consecutive days, without producing any laxative effect, which indicates that beef kidney fat is well tolerated by the human digestive tract. These results are in agreement with the quite general practice in some localities in Europe of the families of small means to eat rendered beef fat, "drippings," on their bread in place of butter. The digestibility of beef fat, 93%, as determined in the experiments reported here is identical with the result 92.8% reported by Flurin for the digestibility of beef tallow.

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[1]U. S. Dept. Agri. Bul. 310 (1915), p 14.
[2]U. S. Dept. Agri. Bul. 507 (1917), p 11.
[3]U. S. Dept. Agri. Bul. 613 (1919), p 8.

Oleo Oil and Oleo Stearin

While there is relatively little commercial demand for beef tallow, there is an enormous demand for the softer fats and oils. Recognizing this demand the packing houses make a commercial separation of the harder and softer constituents of beef tallow into what is known in the trade as oleo oil and oleo stearin. Some oleo oil is consumed as a separated fat by persons who because of religious or dietary customs prefer it to other animal fat, but the larger part is used in the manufacture of oleomargarine. The oleo stearin, which is utilized for food purposes, is practically all used in the preparation of compounded culinary or table fats. For the purpose of the experiments reported here a supply of oleo oil and oleo stearin was secured direct from the manufacturer. The former was yellow, and barely solid at room temperature, while the latter was white, and very hard and both were without noticeable odor or taste. To determine the digestibility of these fats eight experiments were made with oleo oil[2] and three with oleo stearin[3]. Since the experimental conditions were identical for both series and two subjects assisted in both series, it may be interesting to note that with subject J.F.C. the digestibility of oleo oil was 12% higher than for oleo stearin and with subject T.G.H. the digestibility was 9% higher for oleo oil. The digestibility reported for olea oil is 97%, which is the same as that reported for butter. Contrasted with this figure is 80% reported for the digestibility of oleo stearin, which is the lowest figure that has been reported for any fat of animal origin.

Ox-Marrow Fat

The product known in the trade as "Ox-Marrow" is prepared in the packing houses by sawing off both ends of the shank bones from the beef animals, heating them in water at about 160° to 170° F and blowing out the contents with compressed air. This crude product is processed and packed in cans.

Many investigators have studied the nature and composition of ox-marrow. Friedwald and Ruhrah[1] report the use of bone marrow, rich in fat, for treatment of tuberculosis and pernicious anemia, preference being given to marrow from young animals. Zink[2] found that yellow marrow fat consisted chiefly of olein, palmitin and stearin but it has a higher acetyl value than fats from other parts of the body. Forrest[3] concluded that red marrow contained two proteins, one a globulin, coagulating at 47-50° C, containing no phosphorus, and one a nucleo-albumin

[1]U. S. Dept. Agri. Bul. 310 (1915), p 8.
[2]U. S. Dept. Agri. Bul. 613 (1919), p 12.
[3]Idem., p 15.

containing phosphorus. Glikin[4] states that iron occurs in the bone marrow but decreases in amount as the animal increases in age.

For a long time particular dietetic and therapeutic potency has been ascribed to ox-marrow, but regardless of any special value that it may possess from a therapeutic standpoint, its large fat content is a source of energy. To secure data concerning the possible use of this energy by the body, four digestion experiments were conducted under the usual experimental conditions. The results of these experiments[5] indicate that marrow fat is not quite as well utilized as fats from other parts of the body and consequently does not yield as high an energy value. Furthermore, each of the four subjects, who on an average ate 59 grams of ox-marrow fat per day, reported physiological disturbances as a result of the ingestion of this fat. It is of course possible that the limit of tolerance for this particular fat had been exceeded and that had a smaller amount been consumed normal physiological processes would have followed.

Ox-Tail Fat

Ox-tail fat, which is a common constituent of ox-tail soup, is to some extent separated and sold as a by-product of the packing industry. Correspondence with the packing houses supplied information to the effect that ox-tail fat was practically all utilized as an edible fat, either as a constituent of ox-tail soup, as a component of culinary fats, or as an ingredient of oleomargarine. The chemical and physical characteristics of the ox-tail fat procured for the purpose of the digestion experiments discussed were found to be iodin number 56.58, melting point 36.8°-37.0° C and index or refraction at 40°C 49.00. At room temperature it separated into solid and liquid portions, both of which were of a light yellow color and in the ratio of about four to one.

Three digestion experiments[1] were made to determine the digestibility of ox-tail fat and it was found to be 97% digested. On an average the subjects ate 77 grams daily with no indication of any physiological disturbances, indicating that this fat is a very efficient source of energy.

Summary

The digestion experiments reported above were all conducted under like experimental conditions, thereby making possible a close comparison of the results obtained for the individual fats studied. The fats under

[1]Diet in Health & Disease. W. B. Saunders & Co., Phila. and London 1913, 4 ed., p 144.
[2]Chem. Zentbl., Vol. 68 (1897), No. 5, p 196.
[3]Jour. Physiol., Vol. 17 (1894-5), p 175.
[4]Ber. Deut. Chem. Gesell., Vol. 41 (1908), No. 5, p 910.
[5]U. S. Dept. Agri. Bul. 613 (1919), p 17.

[1]U. S. Dept. Agri. Bul. 613 (1919), p 19.

consideration were obtained from different parts of the body of cattle but due to the amount of fat required for even three or four digestion experiments it was impossible to use fats from only one animal.

In comparing the digestibility of fats from the different parts of the body it is interesting to note that brisket fat, butter, cream, and ox-tail fat were equally well absorbed, being 97% digested and hard-palate fat, kidney fat and ox-marrow fat were 94% digested. While the difference in digestibility, 97% to 94%, is not large, one can hardly avoid speculating as to why the animal body should produce fats as far as digestibility is concerned fall into two distinct groups.

None of the fats studied produced other than normal physiological reactions, except ox-marrow fat, but with this fat each of the four subjects experienced digestive disturbances as the result of the ingestion of 59 grams of ox-marrow fat daily, which would indicate that the limit of tolerance for this fat was much lower than for other beef fats. With the possible exception of ox-marrow fat, all the beef fats are very completely digested and are well tolerated by the human body.