

## THE ABSORPTION OF FAT DURING THE CONSUMPTION OF DIETS RICH IN WHOLE-GRAIN AND WHITE BREADS

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It is a common observation that if a diet in which the staple cereal is 'refined' is replaced by one based on a lightly milled cereal product, a considerable increase occurs in the amount of faeces excreted: thus, several workers have reported that the substitution of 1 lb. of white bread by 1 lb. of bread made from high extraction flour, in the otherwise normal diet of adult humans, may cause the wet and dry weights of faeces excreted daily to be doubled. This increased faecal excretion is usually accompanied by a greater frequency of motions. These two factors led early observers, such as Rubner (1925), to regard a diet yielding bulky stools as being wasteful of nutrients—a view founded on the assumption that the increase in the excretion consisted mainly of food which had escaped digestion. The Royal Society investigation (1918) on the digestibility of breads made from flours of different extraction rates, however, revealed that the greater part of what leaves the intestine is not the undigested residuum of food eaten, but material produced in the bowel itself. Other studies have confirmed this conclusion. For example, McCance & Widdowson (1947) recently carried out experiments in which wheat flours of 80 and 90% extraction rates formed the almost exclusive diets of adult humans; they found that although the amount of faeces excreted daily during the consumption of the latter flour was appreciably larger, the protein of both flours was completely digested and absorbed. Notwithstanding such findings, opinions expressed in many of the current text-books on 'physiology and nutrition' indicate that Rubner's view still finds wide acceptance.

In this paper an attempt will be made to determine whether there is any significant difference in the absorption of fat during the consumption of (a) a bulky diet (including 1 lb. whole-grain bread daily, and yielding a bulky stool), and (b) a non-bulky diet (including 1 lb. white bread daily, and yielding a much smaller excretion of faeces). It should be explained that the term 'fat' is used in its broadest sense to include all ether-soluble substances. The difference between the amounts of fat consumed and excreted is reckoned as 'absorbed' fat. Since faecal fat includes both unabsorbed and endogenous fats, the above conception, as others have noted, is open

to objection; indeed, with a low fat intake, the endogenous loss may be large in comparison with the amount of unabsorbed fat excreted, in which case the percentage absorption figure may be quite misleading. With diets of similar fat intake, however, such data are useful for purposes of comparison.

The only similar study bearing on this issue, of which the author is aware, is that of Sealock, Basinski & Murlin (1941), who investigated the digestibility of fat and other nutrients in whole wheat as compared with white bread dietaries. Their subjects were ten healthy adult males; the balance periods lasted for 6 days, and the diet included the consumption of 10–11 oz. of the different breads, and about 5 oz. fat daily. From their results they concluded that the consumption of whole-wheat products does not interfere with the absorption of fat.

In South Africa, in the same year, the white bread then consumed by the majority of the European population was replaced by a standard loaf made from 95 to 100% extraction flour; the baking of other types of bread was forbidden. In view of the controversy on the bread issue occurring at that time, the Research Committee of the National Nutrition Council decided to initiate an investigation into the effect of the standard bread, with its high phytate phosphorus content, on the metabolism of certain mineral salts, with special reference to calcium. For this purpose long-term balance experiments were carried out on adult subjects when consuming diets which contained 1 lb. standard or white breads daily, but which, with minor limitations, were otherwise normal. The results of this work have been already reported (Walker, Fox & Irving, 1946, 1948). Since all samples had been preserved in case of further analytical data being required, it was considered desirable, at a later date, to estimate the fat contents of the food eaten, and of the faeces excreted during the various dietetic periods. With this information, it was thought that the above conclusion reached by Sealock *et al.* (1941) might be tested under somewhat different dietetic conditions, i.e. when the diet contains more bread, less fat, and when prolonged periods of observation are employed.

## EXPERIMENTS

*Subjects.* Three of the subjects were research biochemists, and the fourth a reliable laboratory technician. Their initials, age, height and weight were as follows: (1) F.F., 52 years, 180 cm., 65 kg.; (2) A.W., 31 years, 163 cm., 51 kg.; (3) L.O., 30 years, 168 cm., 64 kg.; (4) L.G., 33 years, 168 cm., 75 kg.

During the investigation they lived at home, pursuing their usual avocations.

*Plan of the experiments.* The dietetic periods were planned in the following manner: A, from 1 to 2 weeks on the usual everyday diet; B, from 4 to 9 weeks on a diet which contained 1 lb. standard bread

experimental periods B and C. Further, it is considered an advantage that the fats from the different sources and also the amounts consumed were such as the subjects were habituated to.

For the first subject, F.F., only periods A and B were observed, as this part of the investigation was of a preliminary nature, carried out to gain acquaintance with the procedure. The balance technique was substantially the same as that described by McCance & Widdowson (1942). The fat contents of the diets of the first three subjects were calculated from the tables of these workers (1940); it has been observed in other studies that the difference between the calculated and determined fat intakes is usually very small. The fat intakes of the fourth subject, L.G.,

Table 1. *Fat metabolism data observed during the different dietary periods*

Average figures are given in all cases

Subject	Dietary period	Period	Duration of period	Fat intake daily (g.)	Fat excretion daily (g.)	Fat absorption (%)	Dry faeces daily (g.)	Fat in faeces (%)
F.F.	Usual diet	A	3 days	110	5.6	94.9	46.7	12.0
	Standard bread diet	B	22 days	115	4.4	96.2	48.6	9.0
A.W.	Usual diet	A	2 weeks	70	4.3	93.9	41.9	10.2
	Standard bread diet	B	9 weeks	55	4.6	91.6	45.6	9.9
	White rolls and potatoes diet	C*	4 weeks	68	3.5	94.8	19.9	17.5
	White bread diet	C	4 weeks	64	3.1	95.1	19.3	15.9
	Usual diet	D	3 weeks	69	4.5	93.5	35.8	12.6
L.O.	Usual diet	A	2 weeks	73	4.8	93.4	35.4	13.7
	Standard bread diet	B	8 weeks	86	4.5	94.7	40.0	11.2
	White bread diet	C	3 weeks	82	4.8	94.1	24.2	19.8
	Usual diet	D	2 weeks	70	4.4	93.7	30.4	14.5
L.G.	Usual diet	A	1 week	84	5.2	93.8	35.5	14.7
	Standard bread diet	B	4 weeks	112	7.3	93.5	54.0	13.5
	White bread diet	C	1 week	109	5.0	95.5	43.7	11.4
	Usual diet	D	1 week	72	4.9	93.2	27.6	17.9

\* A.W.'s diet, during the first 4 weeks of period C, included fairly large amounts of white rolls and potatoes for reasons which are irrelevant to the present investigation; it was a 'low residue' diet, and may thus be included in his white bread period.

(95–100% extraction rate); C, from 1 to 4 weeks on a diet which contained 1 lb. white bread (70% extraction rate); and D, a return to the usual diet for a period of from 1 to 3 weeks. During the usual diet periods A and D, from 4 to 7 oz. standard bread were consumed daily.

As previously stated, the opportunity of investigating the absorption of fat under the different dietetic conditions was only considered after the completion of the balance experiments. Since subjects had been bidden to consume a diet which was reasonably regular from week to week, it was anticipated that the respective fat intakes would not vary to any marked extent throughout the investigation. The results show that for each subject the variations were not unusually large, particularly during the

were determined directly on the food aliquots. These determinations, and those of the faecal fats, were carried out by the Soxhlet method, using ether as solvent.

## RESULTS

The above results, and also corresponding figures obtained by other observers with adult humans, are summarized in Table 2.

In study no. 3, the figures include the results obtained during both the whole-wheat bread and white bread periods.

In all studies (with limitations in no. 3), the diets consumed were reported to be bland and composed of easily digestible foods; in no. 6, 9 g. 'Imbicoll' daily were ingested 'to encourage defaecation by

subjects who might otherwise be costive when taking the low residue diet'.

Studies nos. 4 and 5 were undertaken on hospital patients used as 'controls' in experiments investigating defective fat absorption; the remaining studies were carried out on healthy working adults.

entitled 'An experimental study of rationing', McCance & Widdowson (1946), have reported some fat balance figures which at first sight may be considered to be out of harmony with the above conclusion. Certain of the results obtained on four subjects are summarized in Table 3.

Table 2. *Fat absorption data of the present study compared with other reported data*

Study no.	Observer	Days of observation	No. of observations	Fat intake daily (g.)	Fat excretion daily (g.)	Fat absorption (%)	Dry faeces daily (g.)	Fat in faeces (%)
Present study:								
	Usual everyday diet	4-35	7	69-110	4.3-5.6	93.2-94.9	27.6-46.7	10.2-17.9
	Standard bread diet	22-63	4	55-115	4.4-7.3	91.6-96.2	40.0-54.0	9.0-13.5
	White bread diet	7-56	3	64-109	3.1-5.0	94.1-95.5	19.3-43.7	11.4-19.8
1	Atwater <i>et al.</i> (1900)*	2-4 2-6	7 13	20-40 60-80	3.2 3.6	89 95	— —	— —
2	Schmidt & Strasburger (1910)	3	3	111	6.1	94.5	15-21	Up to 23
3	Sealock <i>et al.</i> (1941)	6	10	140-171	2.9-6.3	95.7-97.4	—	—
4	Reckers <i>et al.</i> (1943)	4-7 70	2 1	35 60	3.3-4.2 3.0	88-90.5 95	— —	— —
5	Cooke <i>et al.</i> (1946)	2-4	50	50	0.5-4.5	91-99	—	—
6	Wollaeger <i>et al.</i> (1947)	3	11	102	1.8-6.7	93.4-98.2	13.6-39.1	9.3-19.6

\* Quoted from Wollaeger *et al.* (1947).

Table 3. *Summary of fat absorption data reported by McCance & Widdowson (1947)*

Diet	Fat intake daily (g.)	Fat excretion daily (g.)	Fat absorption (%)	Dry faeces daily (g.)	Fat in faeces (%)
Control period of 7 days; usual everyday diet consumed which included 3-4 oz. white bread daily	105-153	3.2-5.9	94.4-97.9 av. 96.5	14-30	14-22.5
Two (not consecutive) experimental periods of 7 days; the diet was of 'rationed' foods and included large amounts of 92% extraction bread	35-50	3.2-6.6	82.0-92.4 av. 88.4	22-70	9.5-14.5

## DISCUSSION

From these results it would seem that for adult humans consuming intakes of fat of 50 g. daily and upwards, an absorption figure exceeding 90% may be regarded as normal. In the present study, the substitution of whole-grain bread by white bread in diets of similar fat intake led to an average alteration in fat absorption of less than 2%—93.3-94.9%.

It is therefore concluded that the daily consumption of a fairly large amount of almost whole-grain bread does not affect the absorption of fat to any significant extent.

In a recent Medical Research Council publication,

McCance & Widdowson comment: 'A superficial examination of the present figures suggests that the fat in these particular foods (mainly margarine) was unusually poorly absorbed. The comparison is unfair, because the digestibility of fat has usually been investigated... by incorporating 60-100 g. of the pure fats into an almost fat-free diet. The digestion and absorption of small quantities of fat in natural vegetable foods is a problem which has been less considered. It might well be found that the present figures were by no means exceptional for such food-stuffs.' It should be noted, first, that during the 'rationing' periods, the amounts of fat excreted, and the proportions of fat in the faeces, are not abnormal, judging by data given in Table 2. Secondly, for

reasons mentioned earlier, fat absorption percentages observed during different diets may be compared with fairness only when the fat contents of such diets are equal or at least of the same order. Now Atwater *et al.* with daily fat intakes of 20–40 g., and Reckers *et al.* with fat intakes of 35 g. (Table 2), obtained absorptions of 89 and 88–90.5% respectively—both using *non-bulky* diets. Of the eight fat balances reported by McCance & Widdowson, the five lowest fat intakes ranged from 35 to 42 g., and averaged 39 g. daily; the observed fat absorptions averaged about 89%; the diet, it will be remembered, was *bulky* in character. Thus under the above experimental conditions the bulkiness or otherwise of the diets scarcely affects the proportion of fat absorbed. The figures of McCance & Widdowson cannot therefore be regarded as unusual.

The conclusion of Sealock *et al.* (1941) has been confirmed by the results obtained in the present study; additional support is provided by an examination of data reported by other workers. In view of the observations that bread made from high extraction flour does not appear to interfere with the absorption of fat to any appreciable extent, a further objection to the use of such bread as the staple is thereby removed.

#### SUMMARY

1. The fat metabolism of three healthy European adult males has been followed for periods lasting

from 7 to 22 consecutive weeks; a fourth subject was observed for a much shorter period. During this time the subjects consumed: A, their usual diet; B, a diet including 1 lb. of standard bread, made from 95 to 100% extraction flour; C, a diet including 1 lb. white bread, made from 70% extraction flour; and D, their usual diet. During the usual diet periods A and D, standard bread was also eaten. While each subject consumed the type and amount of fat he was accustomed to, his variations in intake, especially during the experimental diet periods B and C, were small. The intakes of the four subjects ranged from 55 to 115 g. daily.

2. The average absorption of fat during the usual diet periods was 94.0%; during the standard bread diet, it also averaged 94.0%; during the white bread diet, it averaged 94.9%.

3. It is concluded that with daily fat intakes of the order used in this investigation, a diet rich in whole-grain bread when compared with one rich in white bread does not lead to any appreciable diminution in the amount of fat absorbed.

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