The Digestibility of Some Tropical Oils[1]

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EARLIER studies[2] from this laboratory have reported the chemical composition of several not so well-known vegetable oils of the tropics. In view of the fact that none of these oils was investigated with regard to nutritive value, it seemed desirable to determine their digestive coefficients, when fed to laboratory animals (albino rats).

The present study was limited to avocado (*Persea Persea* Cockerell) oil (liquid fraction), to the seed oils of the papaya (*Carica papaya*, L.), grapefruit (*Citrus maxima* (Burm) Merrill), and *guanábana* (*Annona muricata*, L.), as these were the only oils of which we had appreciable amounts. For the purpose of comparison, butter-fat and lard were also tested by the same procedure.

MATERIAL AND METHODS UTILIZED

All samples of the above mentioned oils were over a year old; none, however, showed any organoleptic signs of rancidity. The butter-fat and lard were fresh, though. Eight mature white rats (5 males and 3 females), weighing from 190 to 250 g. and kept in round metal cages with raised bottoms, were used in the experiment.

The percentage composition of the basal fat-free diet, fed to these animals, was as follows: casein—18.0 percent; cornstarch—68.0 percent; sucrose—8.0 percent; salt mixture[3]—3.0 percent; agar—3.0 percent. Its fat content was very low, with only 0.12 percent (0.0886 percent unbound fat and 0.0314 percent bound fat). For all practical purposes, this diet was considered fat-free.

Except for part of the cornstarch that was substituted by the oil under investigation, the experimental diets fed were of the same composition as that of the basal low-fat diet. These diets contained

1. Received for publication March 7, 1946.

2. C. F. Asenjo and J. A. Goyco, Puerto Rican fatty oils. I. Expressed avocado pulp oil. Oil and Soap, **19**:129–140, 1942; II. The characteristics and composition of *guanábana* seed oil. J.Am.Chem.Soc. **65**:208–209, 1943; III. The composition of the solid fraction of expressed avocado pulp oil. J.Am.Pharm.Assoc., **32**:259–260, 1943; Expressed tropical almond (Talisay) oil. J.Am.Chem.Soc., **65**:1417–1418, 1943; The characteristics and composition of expressed papaya (*Carica papaya* L.) seed oil. Oil and Soap, **20**:218–219, 1943; The characteristics of Puerto Rican grapefruit seed oil. *Unpublished results.*

3. P. B. Hawk and V. L. Oser, Modified Osborne-Wendel salt mixture. Science, **74**:309. 1931.

between 10 and 11.12 percent fat, the exact fat content in each one being determined by the same procedure utilized in determining the free and bound fats in the feces. Such values are given in Table 1. To one kilo of each of the above diets, the following vitamins were added: 1,600 U.S.P. units of Vitamin A, 4 mg. of riboflavin, 1 mg. of pyrodoxin, and 1 mg. of thiamin. The diets were throughly mixed by hand.

EXPERIMENTAL PROCEDURE

During a period of ten days, the eight rats were fed 41 calories daily (11 g. of the fat-free diet and 9.7 g. of the oil diets). After a preliminary period of three days, the feces were collected for seven consecutive days, these periods being marked off by ferric oxide. The food consumed by each animal was also determined. Table 1 shows the exact fat content of each diet and the schedule followed.

TABLE 1

Fat Content of Experimental Diets and Schedule Followed in Digestion Experiments

Trial No.	*Fat Admixed with Basal Diet*	*Percentage of Fat in Diet*
1	None (fat-free diet)	0.12
2	Butter-fat	11.12
3	Avocado oil	10.56
4	Grapefruit seed oil	10.25
5	Papaya seed oil	10.34
6	Lard	10.65
7	None (fat-free diet)	0.12
8	*Guanábana* seed oil	10.50
9	None (fat-free diet)	0.12

The feces collected daily were kept under acetone. After each trial, the acetone was permitted to evaporate, after which the feces were dried in a vacuum dessicator over $CaCl_2$ to constant weight. They were then ground to a fine powder in a mortar and extracted with anhydrous ethyl for twelve consecutive hours in a Soxhlet apparatus. The residue of the ethyl ether extract was considered to be neutral fat, free fatty acids, and unsaponifiable matter. The ethyl ether extracted feces were then extracted with 0.1N ethereal HCl, thus removing all soap fats. After evaporating the acid ethereal extract, the residue left was treated with petroleum ether to purify the soap fats. The total fat was equal to the sum of the neutral fat, the free fatty acid, the unsaponifiable fraction, and the soap fat fraction.

Three trials were run off on the fat-free diet. The fat found in the feces of the rats, while on this fat-free diet, was considered to be of metabolic origin.

TABLE 2

Total Fat in the Feces of Rats on a Fat-free Diet (Average of Eight Rats)

Trial No.	*Diet Eaten (7 Days) g.*	*Gain or Loss in Weight (7 Days) g.*	*Weight of Dry Feces (7 Days) g.*	*Weight of Total Fats in Feces (7 Days)*	
				Range g.	*Average g.*
1	77.0	+8.9	4.428	0.208–0.112	0.148
7	71.2	−7.0	3.794	0.163–0.067	0.097
9	77.0	+5.0	4.088	0.113–0.045	0.072

An average of 0.106 g. of metabolic fat per rat was found for the seven-day period. This value was utilized in correcting for the metabolic fat in the feces of the same rats in the various digestion experiments. Table 2 gives the details of the runs made on the fat-free diet.

The true digestibility of each fat was calculated after correcting for the quantity of metabolic fat excreted during the seven-day test, and the amount of fat excreted in excess of metabolic fat considered as unabsorbed dietary fat. It was assumed that each rat excreted the same quantity of metabolic fat when receiving a fat-free diet or a fat-containing diet.

As the fats were fed at a level never above 11.12 percent of the diet, no correction was made for the unsaponifiable matter in the fat fed or in the fat excreted. Hoagland and Snider[4] have shown that this correction may be disregarded when the diets fed contain 15 percent, or less, of fats low in unsaponifiable matter, provided the correction is made for the crude metabolic fat excreted during the time the experimental animal is fed a fat-free diet. All our fats were low in unsaponifiable matter.

To further check the correction of the value obtained, a single male rat was kept for seven consecutive weeks on the fat-free diet. As can be seen in Table 3, this rat excreted an average of 0.100 g. of fat per week. Such a value, as well as the range of variation exhibited, is very close to that obtained after running the above eight rats through three trials on the fat-free diet.

4. R. Hoagland and G. G. Snider, Nutritive properties of lard and other shortenings. Bull. No. 821, U.S.Dept.Agric., 1942

TABLE 3

Fat Excretion of a Single Male Rat Maintained for Seven Consecutive Weeks on the Fat-free Diet

Week	*Diet Eaten (7 Days) g.*	*Gain or Loss in Weight (7 Days) g.*	*Weight of Dry Feces (7 Days) g.*	*Weight of Total Fat in Feces (7 Days) g.*
1	77.0	+4.0	4.118	0.089
2	77.0	+4.0	4.107	0.076
3	77.0	+4.0	4.442	0.149
4	77.0	+5.0	4.665	0.118
5	77.0	+7.0	3.825	0.089
6	77.0	+2.0	3.952	0.093
7	77.0	+3.0	3.920	0.087
Average	77.0	+3.6	4.150	0.100

The digestive coefficients of the fats were calculated for each of the eight rats on each oil; however, in Table 4, only the minimum, maximum, and average values of each group, together with other pertinent data, are reported.

TABLE 4

Digestive Coefficients of the Different Fats While the Fat Constituted Approximately 10 Percent of the Diet (Average of Eight Rats)

Name of Fat and Trial No.	*Diet Eaten (7 Days) g.*	*Fat Consumed (7 Days) g.*	*Gain in Weight (7 Days) g.*	*Digestive Coefficient*	
				Range Percent	*Average Percent*
Butter-fat (2)	67.9	7.6	6.6	98.9–99.9	99.4
Avocado oil (3)	53.9	5.6	4.2	98.7–99.8	99.2
Grapefruit seed oil (4)	62.27	6.4	3.6	98.6–99.9	99.3
Papaya seed oil (5)	65.9	6.8	1.8	98.5–99.9	99.4
Lard (6)	57.8	6.2	3.5	98.6–100	99.6

RESULTS AND CONCLUSIONS

With the only exception of the diet containing *guanábana* seed oil, the rats readily consumed all other oil-containing diets. The aversion to the *guanábana* seed oil might have been due to a disagreeable flavor inherent in the oil, or to one acquired through ageing. This oil, however, did not exhibit the characteristic odor and taste of rancid fats.

All the oils tested, as well as the butter-fat and lard, exhibited digestive coefficients above 99 percent. It therefore seems that the rat, when fed avocado oil (liquid fraction), papaya seed oil, and

grapefruit seed oil at a level of about 10 percent of the diet, utilizes these oils as efficiently as it does the butter-fat and lard.

Although a seven-day experimental period is too short a time in which to make an accurate observation of the growth-promoting value of an oil, it is interesting to note the poor gain in weight (only 0.03 g. per g. of diet per rat) on the papaya seed oil diet. When these same animals received the butter-fat diet, they gained 0.1 g. per g. of diet per rat during the same period of time.

SUMMARY

Experiments have been conducted to determine the digestive coefficients of avocado oil (liquid fraction), papaya seed oil, and grapefruit seed oil. When fed at approximately a 10 percent level, all these oils were as well utilized by the rats as were the butter-fat and the lard. The animals rejected the *guanábana* seed oil altogether.