

INFLUENCE OF AVOCADOS ON SERUM CHOLESTEROL

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PREFACE TO ARTICLE

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It is particularly important that the public know the nutritional value of the avocado, especially the oil content and the part it plays in our proper nutrition. Most people think of the avocado as fattening or have never heard much about this fruit. It is apt to be considered a luxury fruit. Even with potatoes and tomatoes selling for more per pound than avocados, it is difficult to impress the housewife with the fact that the avocado, with its greater proportion of vitamins, minerals, fat, carbohydrate, protein, and unnamed benefits, is a MUCH BETTER BUY for her family.

We need unsaturated fat in the nutritional processes of our body chemistry. It is especially important to see that we get the right kind of fat—that is, a liquid, unsaturated fat, not a hard saturated fat. As our studies proceed in reference to fat utilization in our blood and tissue chemistry, we are being informed that a fat, or oil, containing a high iodine number and a good degree of unsaturation, as expressed by this same iodine factor, is helpful, in a large part, in the control of cholesterol and phospholipid levels in the blood stream. Diets with a low fat content are not palatable or satisfying. This likable taste-factor, contributed by fats, can be found in the oil of the avocado fruit. It is not surprising that the avocado is sixth (1/6) in line of the sources of unsaturated fats. This fat in the avocado is compounded in the fruit in such a way that it becomes a very appetizing food, being enjoyed alone, in mixes, as a spread, as a garnish, and in salads. I have also eaten a half avocado, baked in the oven in casserole, with shrimp, which is delicious.

The avocado industry is fortunate to have in Dr. Wilson C. Grant, a well-qualified researcher and biochemist, who wishes to contribute to the research already done upon the unsaturated fats and the other elements of the avocado.

Dr. Grant's research and report on the serum cholesterol and phospholipids, and how the avocado can influence the reduction of cholesterol, should be read and reread and studied by doctors, dieticians, nutritionists, and housewives in particular.

Not only has the cholesterol and phospholipids content of the venous blood been evaluated before and after the use of the avocado, but Dr. Grant has shown that in a large percentage of people, a substantial reduction occurs in these fatty-esters by the

use of the avocado. Dr. Grant's factual contribution to the knowledge of the avocado and its oil and the anticholesterol properties, is another link in the investigation of the beneficial qualities of this wonderful fruit.

The avocado industry, especially, should thank Dr. Grant for his excellent studies and work, and an effort should be made to get his findings into the hands of every housewife.

In the past few years there has arisen an awareness of the influence of diet on serum cholesterol values. Much of this interest has been stimulated by the widely publicized discussions of the relationship between cholesterol and coronary disease. While it is not in the province of this present study to engage in this controversy, much of it has been reported in a voluminous literature (1, 2, 3, 4, 5, etc.). The influence of diet on serum cholesterol, on the other hand, has been amply demonstrated (5, 6, 7, etc.). Clinical investigation, for example, has shown that serum cholesterol tends to fall during periods of weight reduction particularly when produced by low fat diets (15).

Cholesterol levels are influenced by the degree of saturation of the constituent fatty acids of the diet. It is generally agreed that a diet composed exclusively or even largely of saturated fats, usually animal in origin, will produce a higher serum cholesterol than will one composed of unsaturated fats usually of vegetable origin (10, 11, 12, 13, for reviews see 5, 9). The most striking decreases in cholesterol values have been produced by diets whose fats have been entirely unsaturated in nature. However, partial substitution of unsaturated fats will also produce a drop in serum cholesterol values (7, 13, 14).

The degree of unsaturation of a fat is expressed by its Iodine Number. Some examples of pertinent fats are shown in Figure 1. The higher the number, the greater is the degree of unsaturation. It will be noted that although the Iodine Number of avocado oil is exceeded by that of several seed oils, it has a relatively high number.

FIGURE 1

Average Iodine Numbers of Certain Natural Oils (16)

Safflower	132
Soy Bean	130
Corn	120
Sesame	110
Cottonseed	108
Avocado	94 (17)
Olive	80
Lard	50
Beef Tallow	40
Butter	30
Coconut	8

At a practical diet level the act of substituting unsaturated vegetable fats for saturated animal fats is quite complicated and the results often unappetizing. Because of its content of unsaturated fats and palatable form, it was decided to use the avocado as a

means of partial substitution of unsaturated vegetable fat for ordinary mixed dietary fat.

Avocado Fat Composition. It is only recently that precise analyses of avocado lipids have been made. Unpublished analyses of modern techniques were kindly supplied by Judd C. Nevenzel of the University of California at Los Angeles. These have been combined with some from older studies and are presented in abbreviated form in Figure 2.

FIGURE 2
Fatty Acid Composition of Avocado Oil
(Percent of Total Fatty Acids)

Source Variety	California & Florida		California	
		Hass		Fuerte
Saturated				
Myristic	0.1	—		—
Palmitic	7.2	22.1		14.1
Stearic	0.6	0.7		0.2
Arachidic	trace	—		—
Unsaturated				
Palmitoleic	—	11.0		5.5
Oleic	80.9	51.9		70.7
Linoleic	11.2	14.3		9.3
Nonsaponifiable				
Material	1.6	—		2.0-4.0
Reference	(17)	(18)		(18)

Avocado in This Study. All avocados used in this study were supplied by the Calavo Growers of California. The Fuerte variety was used from February 1959 to May 1959 and the Hass was employed from June 1959 to September 1959. With one or two minor exceptions the shipments arrived in excellent condition.

For purposes of dietary calculations, it was necessary to know the weight of edible pulp and its total lipid content. Such measurements were made from time to time and a few representative values are presented in Figure 3. In our calculations we used 200 gm as the average weight of edible pulp in a single avocado. Using an approximate fat content of 20%, one whole avocado was regarded as supplying 40 grams of fat and 360 calories. Such a calculation ignores the few calories contributed by the protein and carbohydrate constituents. The fruit was consumed in a fresh and uncooked form.

FIGURE 3
Typical Average Values for Avocados in Study

Variety	Month	No. of fruit	Total Weight gm	Seed & Rind gm	Edible Pulp gm	Total Lipids Per cent
Fuerte	Jan.	3	295	86	209	21.8
Fuerte	Feb.	3	264	57	207	22.4
Fuerte	Mar.	3	281	66	215	22.9
Hass	Aug.	5	279	72	207	20.6

Subjects in Study. Sixteen patients in the Veterans Administration Hospital in Coral Gables, Florida, took part in this study. They were white males, aged 27 to 72 years and are summarized in Table I. A number of patients began the study but were unable to complete it for various administrative and medical reasons. The records of these latter patients are not included.

Five patients were on salt restricted diets in which the daily intake varied between 5 to 10 gm. per day. The diabetic patients (No. 9, 11, and 16, Table III) were given prescribed diets with respect to calories, fats, carbohydrates and protein which were maintained throughout the study.

The average avocado consumption by each patient per day is listed in Table I. The average daily fat consumption before and during avocado feeding is presented in Table III. It will be noted that in general the fat consumption during the avocado period exceeded that of the control period. This indicated that there was only partial substitution of avocado fat for ordinary dietary fat. In all calculations the fat content of one avocado was taken to be 40 grams.

Table I
PATIENTS IN AVOCADO STUDY

Patient No.	Age	Diagnosis	Avocados Per Day	Diet	Comments
1	45	Paranoid	1.5	Regular	
1			1.5	Regular	
2	38	Intervertebral Disc, Hernia	0.5	Regular	Surgical, in bed
3	63	Aortic Insufficiency	1.5	Low Salt	
4	39	Paranoid	1.0-1.5	Regular	
5	47	Paraplegic	1.5	Regular	
6	67	Auricular Fibrillation	1.5	Low Salt	
6			1.5	Low Salt	
7	62	Myocardial Infarction	1.5	Regular	
8	61	Trigeminal Neuralgia	1.5	Regular	Surgical, in bed
9	50	Diabetes	0.5	Diabetic	
10	27	Nephrosis	1.0	Low Salt	
11	64	Diabetes, Myocardial Infarction	0.75	Diabetic	In bed
12	48	Myocardial Infarction	1.5	Regular	
13	64	Pulmonary Embolism	1.5	Regular	
14	72	Arteriosclerosis	1.5	Low Salt	
15	67	Cirrhosis of Liver	0.5	Low Salt	In bed
16	65	Diabetes	0.5	Diabetic	

CONTROL PERIOD

Table II

Patient No.	Days	Total Cholesterol	Free Cholesterol	Cholesterol Esters	Phospholipids	Days	Total Cholesterol	Per Cent Change	P Value
1	19	367.0	97.0	270.0	14.6	33	236.7	-35.5	<0.01
1	35	346.7	91.2	251.9	14.65	40	256.0	-26.1	<0.01
2	21	296.0	92.0	205.0	11.6	16	169.0	-42.8	<0.01
3	56	267.0	71.5	195.5	16.2	24	198.6	-25.6	<0.01
4	27	249.0	63.0	185.8	10.6	35	179.8	-27.8	<0.01
5	15	215.6	60.6	155.0	11.0	29	171.6	-20.4	<0.02
6	44	270.6	69.3	201.3	12.8	56	196.0	-27.6	<0.01
6	35	255.8	63.3	192.5	13.5	67	206.6	-19.3	<0.01
7	19	331.0	90.8	240.2	16.7	72	302.3	- 8.7	<0.01
8	20	240.0	62.3	177.7	12.7	12	203.0	-15.4	<0.01
9	8	290.3	78.3	212.0	12.6	33	258.0	-10.9	N S
10	11	300.0	94.6	206.0	14.2	22	301.0	0.4	N S
11	18	259.0	72.2	186.8	11.1	39	235.5	- 9.1	N S
12	14	305.0	84.6	220.8	13.3	87	271.8	-10.9	N S
13	12	552.0	234.2	317.8	26.2	76	547.2	- 0.7	N S
14	10	271.0	67.4	203.4	12.2	24	253.1	- 6.6	N S
15	19	233.0	81.8	151.4	15.6	39	212.0	- 9.0	N S
16	14	299.0	85.6	213.6	12.4	11	254.0	-14.8	N S

AVOCADO FEEDING PERIOD

Table II

Free Cholesterol	Per Cent Change	P Value	Cholesterol Esters	Per Cent Change	P Value	Phospholipids	Per Cent Change	P Value
64.7	-33.3	<0.01	172.0	-36.3	<0.01	11.5	-21.2	<0.01
63.4	-30.4	<0.01	189.6	-35.7	<0.01	12.3	-16.1	<0.01
48.0	-47.8	<0.01	121.4	-40.8	<0.01	8.0	-31.0	<0.01
54.2	-24.2	<0.01	144.1	-26.2	<0.01	10.9	-32.7	N S
53.0	-16.2	<0.05	126.8	-31.7	<0.01	8.8	-16.9	<0.01
52.3	-13.8	N S	119.2	-23.2	<0.02	8.4	-23.6	<0.02
53.1	-23.4	<0.01	142.9	-29.0	<0.01	11.2	-12.5	0.02
53.9	-16.0	<0.01	152.7	-20.7	<0.01	11.2	-17.1	<0.01
81.5	-10.2	<0.01	221.0	- 8.0	N S	14.3	-14.4	<0.01
67.0	7.5	N S	134.0	-24.6	<0.01	10.0	- 2.1	N S
69.0	-11.9	<0.04	189.5	-10.6	N S	10.7	-15.0	<0.04
83.4	-11.8	N S	217.8	5.7	N S	10.8	- 2.8	N S
68.4	- 5.3	N S	167.1	-10.5	0.01	11.5	3.6	N S
73.8	-12.8	0.01	198.0	-10.3	N S	12.9	- 3.0	N S
217.8	- 7.0	N S	329.0	3.8	N S	27.7	5.7	N S
62.0	8.0	N S	190.1	- 6.1	N S	11.3	- 7.3	N S
86.3	5.5	N S	125.7	-17.1	N S	10.3	-34.0	N S
75.5	-11.8	N S	179.0	-16.2	N S	12.5	0.8	N S

Table III

Patient No.	CONTROL PERIOD				AVOCADO FEEDING PERIOD						
	Days	Fat Per Day	Calories Per Day	Body Weight	Days	Fat Per Day	Per Cent Change	Calories Per Day	Per Cent Change	Body Weight	Per Cent Change
1.....	22	57	2307	147	34	83	45.0	2577	11.7	143	-2.8
1.....	48	140	3323	145	43	127	- 9.3	2837	-14.6	143	-1.4
2.....	21	41	1179	147	13	72	95.6	1550	31.4	140	-4.8
3.....	56	70	1582	165	31	76	8.6	1657	4.7	161	-2.4
4.....	25	50	1237	156	36	59	18.0	1363	10.2	154	-1.2
5.....	13	94	2271		25	103	9.6	2161	- 4.9		
6.....	37	46	1251	143	41	98	113.0	1833	46.5	145	1.4
6.....	43	77	1980	146	76	90	23.4	1800	- 9.0	141	-3.4
7.....	14	44	1654	151	72	115	161.0	2706	3.1	152	0.7
8.....	20	25	1027	183	9	86	244.0	1666	62.0	186	1.6
9.....	8	71	1629	150	33	71	0	1629	0	150	0
10.....	12	85	2029	154	21	154	81.0	2965	46.1	154	0
11.....	17	60	1228	170	50	60	0	1228	0	162	-4.7
12.....	14			132	85	105		2052		133	0.8
13.....	12	71	1834	139	76	102	43.7	2336	27.3	140	0.7
14.....	8			131	25	105		1972		129	-1.5
15.....	19	27	838	160	39	38	40.8	891	6.3	154	-3.8
16.....	14	50	1200	130	20	50	0	1200	0	127	-2.3

Analytical Methods. Blood samples were drawn from all patients twice a week, on Mondays and Thursdays or on Tuesdays and Fridays, before breakfast between 7:30 and 8:00 A.M. Total ester and free cholesterol values were estimated in serum obtained from venous blood by the Sperry and Webb method (19) and phospholipids by the method of Zilversmit (20).

To estimate the total lipids of avocados, an aliquot of the pulp was extracted continuously with an alcohol-ether mixture and the lipids weighed after solvent removal. Fecal fats were measured on 24 hour -samples by the method of Zuckerman (21).

Total daily calories and fats were estimated by the subject and hospital Dieticians. This work was materially assisted by the use of mimeographed menus of each day's meals prepared in advance by the Dietetic Service. The quantity of each type of food consumed could thus be estimated in a uniform manner. Caloric values and grams of fat were calculated from standard charts or from chemical analyses.

Plan of Experiment. With the subject on a control diet without avocados, blood samples were drawn over an 8 to 56 day period. In some individuals relatively long control periods were required because of the fluctuations in daily cholesterol concentrations. When a reasonable constant set of control values was obtained, from 0.5 to 1.5 avocados per day were introduced into the subject's diet as shown in Table I. Blood samples were then drawn for from 12 to 87 days during the avocado feeding periods.

Results. Table II presents a summary of the average blood values of all subjects. Measurements made during the control period are compared with those taken during

the avocado feeding period. The percentage change and the probability by Wilcoxon Rank Test (P value) (22) are shown. Of the 16 subjects, 8 gave decreases in total cholesterol values of from 8.7 to 42.8 per cent. These changes from control values are statistically significant (see Table II). Although both free and ester forms decreased, changes in the esters generally exceeded those in the free form. Serum phospholipids decreased at the same time as did the cholesterol values. In no subject did the cholesterol or phospholipid concentrations rise significantly during the avocado feeding period. Such increases failed to occur in spite of appreciable increases in fat and calorie intake in certain patients, Number 10 for example.

In patients Numbers 1 and 6 at the end of the avocado feeding period a second control period was instituted to be followed by a second avocado feeding. Patient Number 1 was particularly interesting (Table III). It will be noted that fat intake during the first control and avocado periods was rather low and that it was elevated during the second control and avocado feeding periods. In both patients despite differences in fat consumption and total caloric intake between first and second series decreases in total cholesterol values were similar.

In order to illustrate the time sequence in the feeding trials, the total, free and ester cholesterol, and phospholipid values obtained from one subject are presented in Figure 4. It will be noted that the total serum cholesterol and phospholipid values began to fall within a week after the inclusion of avocados in the diet. Changes in the ester form were far more striking than those in free cholesterol.

In no subject was any unpleasant reaction observed that could be attributed to the feeding of avocados. It is of interest to note a favorable response reported by the paraplegic patient, Number 5. The hard fecal mass often found in such patients became softer and manageable during the avocado feeding.

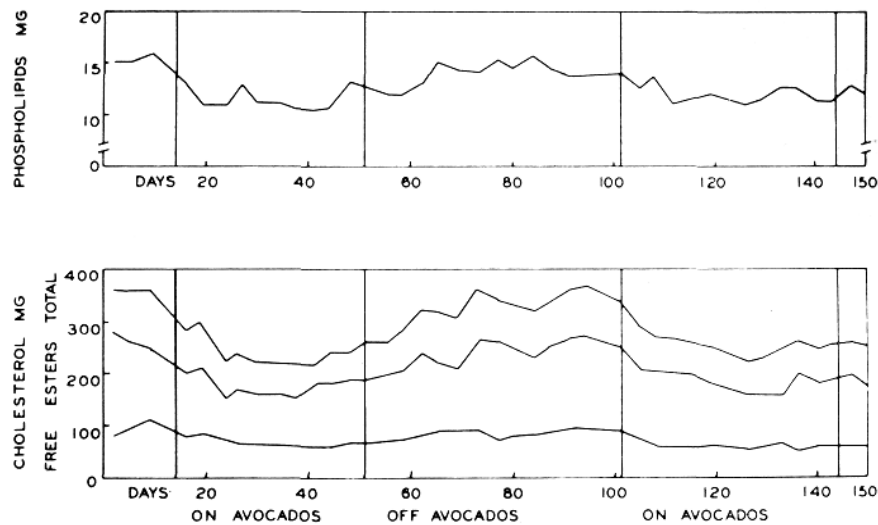


FIGURE 4

Discussion. The partial substitution of avocado lipids for mixed dietary lipids produced a significant decrease in cholesterol values in 8 of the subjects. As to the mechanism by which this hypocholesterolemia is accomplished, one can merely speculate. An obvious explanation lies in the unsaturated fatty acid content of avocado fat as was discussed previously. It has been suggested (23) that unsaturated fatty acids enhance the solubilizing, esterification and transport to the liver of cholesterol and thus promote its excretion by the liver and loss from the blood stream.

Another partial explanation involves the 1 to 4% nonsaponifiable portion of avocado lipid. This material appears to be a type of vegetable sterol or sitosterol. When 10 grams or more of certain sitosterols are fed daily to man, a decrease in serum cholesterol results (24). Sitosterols closely resemble cholesterol chemically and for this reason may inhibit the absorption of cholesterol by competition. If one uses 2 per cent non-saponifiable material as an average figure, an avocado containing 40 grams of lipid would have 0.8 grams of sitosterol. This relatively small amount of sitosterol may not be very effective by itself, but when combined with unsaturated fats it may be more active (17). It is possible, therefore, that the consumption of approximately 1 gram of sitosterol as it occurs in the avocado lipids may exert a small but appreciable influence on serum cholesterol values.

The third explanation for the observed cholesterol lowering is merely suggested but not demonstrated by this study. It will be noted in Table III that the average daily fat and calorie consumption tended to increase during the avocado feeding period, yet the body weights did not increase as expected. In fact, in several subjects the body weight declined from 1.5 to 4.8%. While this decrease in body weight is small, it raises the question of the availability of the fat calories in the avocado.

In an attempt to gain preliminary information concerning the degree of assimilation of avocados, the total fecal lipids were measured in samples collected over 24 hour periods (21). The total lipids excreted during the regular avocado feeding periods greatly exceeded those excreted during the control period (Figure 5). These data suggested that the avocado lipid is incompletely assimilated under the conditions of the experiment and therefore appears in the feces. A very brief report in the literature indicates that avocado oil is 82.5% assimilated (25). This figure would appear high from the data collected in this study. It is to be emphasized that avocado assimilation figures are outside the scope of this study and therefore incomplete. Despite the inadequacy of these measurements it is tempting to speculate that those subjects on an avocado diet were not only consuming unsaturated fats but were also on a relatively low fat diet.

FIGURE 5

Analyses of 24 hour stool samples			
	Stool Weight gm	Solids Per Cent	Total Fat gm
Patient 6			
Avocado	175	31.3	10.8
Control	120	25.0	2.8
Control	61	21.7	0.7
Avocado	224	17.3	6.1
Patient 9			
Avocado	116	29.5	9.3
Control	88	23.7	1.8
Control	109	24.6	2.1
Control	145	21.7	2.2
Patient 1			
Avocado	196	26.8	10.0
Control	192	15.3	2.2

In 8 of the subjects no consistent and significant changes in serum cholesterol values were observed. While there is at present no obvious explanation for the lack of response there are certain differences between the group responding and that not responding. Of those showing no change, three were mild diabetics (see Table I). Another subject in this group was hypercholesterolemic with total serum cholesterol values ranging between 500 and 600 mg. A fourth subject not responding was treated differently from all others in that the avocado was added to his diet without removing existing dietary fat. Despite the increased fat and calorie consumption, no change in serum cholesterol was noted.

SUMMARY

1. Sixteen male patients aged 27 to 72 years were given 0.5 to 1.5 avocados per day in partial substitution for dietary fat.
2. Serum total, free and ester cholesterol and phospholipids were measured twice a week during control and avocado feeding periods.
3. Of the 16 patients during the avocado feeding period, 8 gave significant decreases in total serum cholesterol of from 8.7 to 42.8 per cent and in phospholipids of from 12.5 to 21.0 per cent. Decreases in the ester form exceeded those in the free cholesterol.
4. Of the 8 patients whose cholesterol values were unchanged by avocado feeding, three were diabetics, one was hypercholesterolemic.
5. In no individual did cholesterol values rise during avocado feeding.

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