FLORIDA STATE COLLEGE FOR WOMEN

CHEMICAL COMPOSITION AND VITAMIN B CONTENT OF THE TRAPP AND WEST INDIAN SEEDLING AVOCADOS, VARIETIES OF THE WEST INDIAN RACE

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CHEMICAL COMPOSITION AND VITAMIN B CONTENT OF THE TRAPP AND WEST INDIAN SEEDLING AVOCADOS, VARIETIES OF THE WEST INDIAN RACE.

This investigation was prompted by the fact that there is available very little data on the chemical composition and vitamin content of the West Indian race of avocado, the type very largely grown in Florida. The most extensive studies that have been reported have been ~~work~~ made in California on the Guatemalan and Mexican races of avocado (1). Since the avocado is being grown extensively in Florida and is widely used as an article of food, a knowledge of the protein, fat, carbohydrate, mineral and vitamin content of the different varieties of the West Indian race is most important.

Part I.

CHEMICAL COMPOSITION.

Review of Literature.

In 1901, Woods and Merrill (2) reported the analysis of three fruit grown in Florida and representing three distinct varieties. The pulp of these was mixed and analyzed as one. It showed moisture, 81.10%; protein, 1.00%; fat, 10.20%; carbohydrate, 6.80%; and ash, 0.90%. In 1902, Miller (3) reported

the results of an analysis of one avocado grown in Florida, the variety of which was unknown, as follows:- moisture, 72.77%; protein, 2.18%; fat, 17.26%; crude fiber, 1.87%. Merrill (4) in 1908 found for one West Indian avocado, skin, 11.00%; seed 24.00%; pulp 65.00%; moisture, 77.18%; protein 1.14%; fat, 13.78%; and ash 0.76%. Jaffa and Goss (5) in 1923 reported for one Trapp, grown in Florida, moisture, 77.66%; protein, 1.61%; fat, 9.80%; and ash, 0.85%. In 1923, Cardenas and Moreno (6) reported the analyses of two varieties grown in Cuba, the green and the purple, so-called. The green variety showed moisture, 71.00%; protein, 1.71%; fat, 20.90%; crude fiber, 2.10%; and ash, 1.33%. The purple showed moisture 73.50%; protein, 2.00%; fat, 18.00%; crude fiber, 2.10%; and ash, 1.25%.

The results of these analyses are summarized in Table I.

Table I.

Reports of Analyses of Avocados Grown in Florida.

Investigators	Number of fruit	Variety	Moisture	Protein	Fat	Crude fiber	Ash
		%	%	%	%	%	%
Woods & Merrill(2)	3	Unknown	81.10	1.00	10.20		0.90
Miller (3)	1	Unknown	72.77	2.18	17.26	1.87	1.45
Merrill (4)	1	West Indian	77.18	1.14	13.78		0.76
Jaffa & Goss (5)	1	Trapp	78.66	1.61	9.80		0.85
Cardenas and Moreno (6)		Cuban (green)	71.00	1.71	20.90	1.60	1.33
		Cuban (purple)	73.50	2.00	18.00	2.10	1.25

Experimental Work.

The fruit used in this investigation was obtained from Mr. W. J. Krome, of Homestead, Florida. The first lot, West Indian Seedlings, Grade 2, was received September 5, 1924. The fruit was stored in the refrigerator for one week before samples were dried for analysis. Not all the avocados were used for the analysis. Portions of different ones were mixed, and samples taken from the mixture, thus giving an average

for the lot. A second lot was received September 12, 1924. These were Trapps, Grade 2, which Mr. Krome stated were "the very first to reach edible maturity." These were stored in the refrigerator for ten days before samples were dried for analysis. The samples were obtained similarly to those from the first lot, so that the results represent an average of many, rather than of an individual fruit. On October 30, 1925, one half dozen each of the Trapp and West Indian Seedlings, Grade 1, were received. Each individual fruit was dried for analysis. The drying process was begun as soon as the fruit reached the laboratory. The last fruit was dried on November 9. In the meantime, the fruit was stored in the refrigerator. The fruit was sound with no deterioration or discoloration of the edible material. The pulp was soft and cream-yellow in color. The color of the skin of the Trapp was yellowish green, while that of the Seedling was darker green. The skin of each variety was easily removed, with no adhering pulp.

EDIBLE PORTION, SKIN, AND SEED:- The fruit was weighed, cut in half, seed removed, and the pulp removed from the skin. The weights of seed and skin were determined

and the weight of edible portion was found by difference. From these weights, the percentages of skin, seed, and edible portion were calculated.

The methods of analysis of the Association of Official Agricultural Chemists (7) were used, with the exception of calcium, which was determined by McCrudden's Volumetric method (8). All determinations were done in duplicate.

MOISTURE:- Samples of the pulp, taken from different parts of the fruit to secure an average sample, were dried to constant weight in weighed silica dishes. The drying was done in an electric oven at 70°C, and in vacuo. The results by both methods were the same. From the weight of the dried residue, the percentage of moisture was determined. The remainder of the fruit was dried in the electric oven at 70°C, for the protein, fat, carbohydrate, crude fiber and ash determinations.

PROTEIN:- Moisture free samples were placed in 500 cc. Kjeldahl flasks. About 25 cc. of concentrated sulphuric acid and 0.2 grams of crystallized copper sulphate were added. This was heated at a low temperature, gradually

increased, until the mixture was boiling. Boiling was continued until digestion was complete, as shown by colorless solution. The flame was then removed. After the solution had cooled, 200 cc. of water were added and the flask connected with a condenser. Fifty cubic centimeters of concentrated sodium hydroxide solution were added. This alkali was allowed to run down the side of the flask, in order to prevent too rapid mixing. The contents were then mixed by gentle rotation of the flask and the ammonia distilled off. The distillate was collected in a known quantity of tenth-normal sulphuric acid. The excess acid was titrated with tenth-normal sodium hydroxide and the volume of acid neutralized by the ammonia found. One cubic centimeter of tenth-normal sulphuric acid was equivalent to 0.0014 grams nitrogen. The usual factor of 6.25 was used to convert nitrogen to protein.

FAT:- Fat was determined by the extraction of a moisture-free sample, for eighteen hours, with anhydrous ether in the Soxhlet extractor.

CRUDE FIBER:- A fat-free, moisture- free sample was placed in a 500 cc. Erlenmeyer pyrex flask, with Hopkins reflux condenser. The flask was heated for thirty

minutes with 200 cc. of 1.25% sulphuric acid. The residue was filtered and washed until neutral and rinsed back into the flask with 200 cc. of 1.25% sodium hydroxide. After boiling for thirty minutes, the residue was filtered on a tared, ashless, filter paper, washed, and dried to constant weight. It was then ignited in the electric furnace and weighed again. The loss in weight was considered as crude fiber.

ASH:- A fat-free, moisture-free sample in a weighed silica dish was ignited in the electric furnace. From the weight of the residue, the percentage of ash was calculated.

CARBOHYDRATE:- Carbohydrate was determined by difference.

ANALYSIS OF ASH:- The ash was put into solution with hydrochloric acid, sp. gr. 1.18, and water. It was boiled with nitric acid, sp. gr. 1.54, to oxidize any ferrous iron which might be present.

PHOSPHORUS:- After cooling, the solution was neutralized with ammonium hydroxide, sp. gr. 1.54. The phosphate was precipitated with ammonium molybdate solution. After standing twelve hours, the precipitate was filtered, washed, dissolved, in tenth-normal NaOH, and the resulting solution titrated with

tenth-normal sulphuric acid. One cubic centimeter of the alkali was equivalent to 0.00102gm phosphorus.

IRON:- The filtrate from the ammonium phosphomolybdrate precipitation was made alkaline with ammonium hydroxide, sp. gr. 0.9. After standing over night, the ferric hydroxide was filtered, washed, redissolved in nitric acid, sp. gr. 1.54, and reprecipitated with ammonium hydroxide. The precipitate was filtered, washed, ignited, and weighed as iron oxide. The ignited precipitate was fused with fused potassium sulphate and allowed to cool. Five cubic centimeters of sulphuric acid, sp. gr. 1.84, were added and the mixture heated. After cooling, the solution was transferred to an Erlenmeyer flask. About 25 cc. of water was added, the solution digested, the iron reduced with zinc to ferrous iron, and the solution titrated with 0.0181 N. potassium permanganate. One cubic centimeter of the potassium permanganate solution was equivalent to 0.001014 gram of iron.

CALCIUM:- Calcium was precipitated from the filtrate after the removal of iron, as calcium oxalate. The oxalate precipitate was carefully washed and transferred back to the beaker. After adding 10 cc. of sulphuric acid,

the solution was titrated while hot, with 0.0597 N potassium permanganate. One cubic centimeter of the potassium permanganate is equivalent to 0.0012 gm. calcium.

MAGNESIUM:- The filtrate from the calcium precipitation was evaporated to dryness on the water bath and the residue heated, to expel the ammonium salts. After all ammonium salts were removed, water and hydrochloric acid, sp. gr. 1.18, were added and the solution filtered. The filtrate was cooled and disodium hydrogen phosphate was added. Ammonium hydroxide, sp. gr. 0.9, was added, until the solution was alkaline. After standing twelve hours, the precipitate of magnesium ammonium phosphate was filtered, washed, dried, ignited, and weighed as magnesium pyrophosphate, from which the percentage of magnesium was calculated.

Discussion of Results.

EDIBLE PORTION, SEED AND SKIN:- Forty-nine avocados, West Indian Seedlings, Grade 2, received September 5, 1924, ranged in size from 418 grams to 294 grams, with an average weight of 339 grams. The seeds averaged 25.30% of the weight of the fruit; the skin, 10.70%; and the edible portion 64.00%. Forty-one Trapps, Grade 2, received September 12, 1924,

ranged in size from 410 grams to 240 grams, with an average of 324 grams. The seeds averaged 37.00%, of the weight of the fruit, the skin 9.60%, and the edible portion, 53.40%. The six Trapps Grade I, received November 2, 1925, ranged in size from 701 grams to 456 grams, with an average of 561 grams. The seed averaged 19.33% of the weight of the fruit; the skin 8.61% and the edible portion 72.06%. The six West Indian Seedlings, Grade I, ranged in weight from 624 grams to 457 grams, with an average of 517 grams. The seeds averaged 21.19% of the weight of the fruit; the skins, 9.00%, and the edible portion, 69.81%. These results are summarized in Table II.

Table II.

The Percentages of Seed, Skin, and Edible Portion.

Number of Avocados	Grade	Weight Average	Seed	Skins	Edible portion
		gms	%	%	%
49	Seedling,No. 2	339	25.30	10.70	64.00
51	Trapp, No. 2	324	37.00	9.60	53.40
6	Trapp, No.I	561	19.33	8.61	72.06
6	Seedling,No.I	517	21.19	9.00	69.81
Average	Grade 2		31.15	10.15	59.20
Average	Grade I		20.26	8.80	70.94
Average	Trapp I&2		28.17	9.10	62.73
Average	Seedling I&2		23.60	9.85	66.52
GENERAL AVERAGE (Omitting Trapp 2)			21.94	9.43	68.95

From the table it can be seen that there is fairly close agreement in the percentages of seed, skin, and edible portion, except for the Trapps, Grade 2, which were in the earliest stage of edible maturity. There is still closer agreement in the figures if we compare only Grade 1 of the two varieties.

Results of analyses for moisture, protein, fat, carbohydrate, crude fiber, and ash are summarized in Table III.

Table III.

Composition of the Trapp and Seedling Varieties of Avocado.

Avocado	Date	Moisture	Protein	Fat	Carbohydrate	Crude fiber	Ash	Calorie per lb.
		%	%	%	%	%	%	
Average-49 Seedling, Grade No.II.	Sept.5,1924	83.92	1.12	9.45				
Average, 51 Trapps, Grade No. II.	Sept. 12, 1924	87.38	0.63	4.47				
Trapp Grade No. I.	Nov.1925	83.79	1.09	5.96	7.04	I.05	1.07	
		80.51	1.30	7.43	7.96	1.62	1.16	
		85.40	1.08	5.86	5.47	1.21	0.98	
		82.58	1.13	7.25	6.93	1.14	0.97	
		84.19	1.35	5.73	6.72	1.00	1.01	
		84.45	1.02	6.37	6.29	0.94	0.93	
Average		83.49	1.16	6.43	6.72	1.16	1.02	
Seedlings Grade No.II.	Nov,1925	81.64	1.09	8.71	6.51	0.96	1.09	
		81.67	1.12	7.96	6.79	1.31	1.15	
		80.68	1.21	8.23	7.55	1.34	0.99	
		82.40	1.07	8.63	5.90	1.19	0.81	
		81.18	1.18	7.89	7.59	1.15	1.01	
		82.32	1.11	7.15	1.20	1.06	7.16	
Average		81.65	1.13	8.09	6.92	1.19	1.02	
GENERAL AVERAGE (Omitting Trapp No.2		83.02	1.14	7.33	6.82	1.17	1.02	444.06

A study of Table III shows a very close agreement in the composition of the different avocados, with the exception of Trapps, Grade No. II. These were in the very earliest stage of edible maturity which may account for their high moisture, low fat and protein content. This is in agreement with the results of the California studies (1) which show that the fat increases and moisture decreases with increase in maturity.

Omitting the analysis of Trapps, Grade No. II, the average of 1.14% for protein, 6.82% for carbohydrate, 1.17% for crude fiber, 1.02% for ash may be taken as representative of the protein, carbohydrate, crude fiber, and ash content of mature West Indian Avocados.

There appears to be greater variation in the moisture and fat content. A higher moisture content accompanies a lower fat content. Percentage for moisture varies from 81.65% to 83.92% with an average of 83.00%; percentage of fat varies from 6.43% to 8.09%, with an average of 7.33%.

Table IV gives the results of the ash analysis for Grade I avocados, calculated as percentage of total ash. Table V gives the results of the ash analysis, calculated in grams per 100 grams of fresh avocado. Due to the small amount of ash, it

was necessary to combine the ash of two avocados for each sample.

Table IV.

Percentage of Phosphorus, Iron, Calcium, and Magnesium in the Total Ash.

Avocado	P	Fe	Ca	Mg
	%	%	%	%
Trapp	4.66	0.71	3.57	3.79
Grade No. I.	6.23	0.94	3.76	3.30
	4.05	0.46	3.94	2.87
Average	4.98	0.73	3.75	3.32
Seedlings, Grade No. I.	4.92	0.42	4.04	3.73
	4.87	0.52	4.06	3.50
	4.30	0.68	3.08	4.75
Average	4.69	0.54	3.73	3.94
GENERAL AVERAGE	4.83	0.63	3.74	3.63

Table V.

Mineral Elements, in 100 grams Fresh Avocado.

Avocado	P	Fe	Ca	Mg
	Grams	Grams	Grams	Grams
Trapp, Grade No. I.	0.0517	0.0079	0.0396	0.0375
	0.0611	0.0092	0.0367	0.0317
	0.0393	0.0046	0.0382	0.0279
Average	0.0507	0.0072	0.0381	0.0323
Seedlings, Grade No. I.	0.0551	0.0047	0.0422	0.0418
	0.0438	0.0047	0.0365	0.0315
	0.0443	0.0067	0.0317	0.0488
Average	0.0477	0.0054	0.0368	0.0407
GENERAL AVERAGE	0.492	.0063	.0374	.0365

A comparison of the nutritive value of the avocado with that of other fruits is of interest. In most fruits the amount of moisture is high, averaging about 83.00%, a value corresponding closely to that found for the avocado. The fat furnishes approximately two thirds of the calories of the avocado, while in most fruits and vegetables it is quite low. The protein content of most fruits is low (9), apples and pineapples average about 0.4%; oranges and peaches average about 0.75%; and bananas and apricots about 1.20%. The avocado falls but little lower than the highest of these. The coconut seems to compare more closely with the avocado in the distribution of its calories than any other food we have found. The calorie values of coconut and dried avocado agree very closely.

The calcium content is low. It compares with the figures for the refined cereals. The phosphorus content is within the range of most fruits and vegetables. The iron content is high. It is almost twice as high as spinach which is recognized as one of our richest plant sources, and approaches egg-yolk in its iron value.

SUMMARY.

1. Fifty-one Trapps, Grade 2, in the earliest stages of maturity, forty-nine Seedlings, Grade 2, and twelve Grade I Trapps and Seedlings in the latest stages of maturity were used in the study of the percentage of edible portion, seed, skin, moisture, protein, fat, carbohydrate, crude fiber, and ash.

2. The percentage of edible portion for Grade I varies from 69.81% to 72.06% with an average of 70.49%; Grade 2 Seedlings, the edible portion was 64.00%. Grade 2 Trapps, it was 53.40. The average of edible portion in mature fruit is approximately 68.95%. The percentage of skin for all grades averages 9.43%. The percentage of seed for Grade I, varies from 21.19% to 19.33%; with an average of 20.26%; in Grade 2 Seedlings, the seed was 25.30%; in Grade 2 Trapps, it was 37.00%. The average seed in mature fruit is approximately 21.94%.

3. The percentage of moisture for mature fruit ranges from 81.65% to 83.92%, with an average of 83.02%; protein varies from 1.12% to 1.16% with an average of 1.14%; fat, 6.43% to 8.09%, with an average of 7.33%; carbohydrate, 6.72%, to 6.92% with an average of 6.82%; crude fiber, 1.16% to 1.19%, with an average of 1.17%, and ash, 1.02%.

4. An analysis of the ash, calculated on the basis of grams per 100 grams fresh avocado, shows the following:- Phosphorus, 0.0477 to 0.0507, average 0.0492; Iron, 0.0054 to 0.0072, average 0.0063; Calcium, 0.0368 to 0.0381, average 0.037; and Magnesium, 0.0323 to 0.0407, average 0.0365.

5. A comparison with results obtained in California (10) shows the Florida avocado is somewhat higher in moisture and lower in fat and protein. In carbohydrate and ash, they compare very closely. Our results for calcium, magnesium, and phosphorus compare closely with the California avocado, while the iron is approximately one-half.

Part II.

VITAMIN B CONTENT.

In 1922, Santos (11) reported that rats which had been declining in weight, due to a lack of vitamin B, easily recovered on administration of daily doses of fat-free dried avocado, type unknown, in the proportion of 0.50 to 1.0 gram, fed in addition to the standard ration. He found 0.10 gram insufficient and 0.40 gram just enough for maintenance but not for complete recovery of weight.

Procedure.

Sherman's (12) quantitative method for the study of vitamin content was closely followed. White rats were used as the experimental animals. They were placed on the experimental diet at the age of twenty-eight days, at which time they weighed between 40 and 60 grams. The experimental period continued for eight weeks covering the time of most rapid growth. Eight animals were placed on each diet studied. The animals all came from mothers on a diet consisting of a mixture of one-third dried whole milk, and two-thirds ground whole wheat, with the addition of sodium chloride to the amount of 2% of the weight of the wheat (13). Each animal was kept in a wire cage with raised screen floor, so that it did

not have access to its feces (14). No bedding was used. Fresh distilled water and basal diet were given ad libitum; the food which furnished the vitamin B was, wherever possible, fed separately. The cages were cleaned daily. The animals were weighed every seventh day, and the amount of food consumed was determined for the same interval.

The basal diet, lacking in vitamin B, but containing all other essential food factors, has the following composition: purified casein, 18%; butter fat, 10%; Osborne and Mendel salt mixture 4% (15); starch, 68%. The casein was purified with alcohol by the procedure outlined by Sherman and Spohn (11). This diet was shown to be B-free by feeding it to a group of seven animals. The individual records of these are shown in Table VI.

Table VI.

Weight and Food Consumption of Rats on Basal Diet.

Animal	Initial wt.	Final wt.	Gain	Basal Diet Eaten
	grams	grams	grams	grams
1021 F	62	55	-7	166
1022 F	68	50	-18	166
1023 F	60	50	-10	166
1024 M	64	50	-14	166
1345 F-	32	26	-6	122
1346 M	40	42	+ 2	122
1347 F	40	43	+ 3	122
AVERAGE	52	45	-7	147

The basal diet, with yeast added as a source of vitamin B, was fed to a group of 3 animals as a control diet. The individual records of these are shown in Table VII.

Table VII.

Weight and Food Consumption of Animals on Basal Diet Plus Yeast.

Animal	Initial wt.	Final wt.	Gain	Total Food
	grams	grams	grams	grams
1108 M	50	222	172	690
1109 F	44	172	128	690
1110 F	44	166	122	690
AVERAGE	53	127	141	690

Experimental Results.

FRESH AVOCADO:- Fresh avocado was fed in daily doses of 5, 7.5 and 10 grams. The weighed portions of avocado were placed in the cage each morning and the food jar removed until the avocado was eaten. The animals receiving 5 gram portions ate them immediately. For most of the others it was necessary to mix the avocado with the basal diet. Only a few of those receiving the larger doses ate the entire amounts so that the results of these are less reliable. Four of the animals receiving 7.5 grams daily eat practically all of the avocado and only these animals are considered in the final comparison.

Eight animals on basal diet plus 5 grams fresh avocado made an average gain of 44 grams, with a basal food consumption of 384 grams. This represents a gain 31% of the total gain of the animals on the control diet. It required 44 calories of food for each gram of weight gained. These results are summarized in Table VIII.

Table VIII.

Basal Diet Plus 5 grams Fresh Avocado.

Animal No.	Initial wt.	Final wt.	Gain	Basal Diet Eaten
	grams	grams	grams	grams
1064 F	47	81	51	359
1065 M	49	94	45	374
1072 F	57	102	45	373
1073 M	62	114	52	386
1074 F	57	85	28	405
1086 M	46	93	47	389
1087 M	48	98	50	375
1101 M	44	82	38	406
AVERAGE	52	96	44	384

Nine animals on the basal diet plus 7.5 grams made an average gain of 44 grams with a basal food consumption of 324 grams. However, 5 of these animals did not eat all the

avocado furnished daily. When we study the gain in weight of the four animals which did eat 7.5 grams, we find that they made an average gain of 59 grams, with a basal food consumption of 388 grams. This is about 42% of the total gain of the animals on control diet. It requires 36 calories of food for each gram of weight gained. These results are summarized in Table IX.

Table IX.

Basal Diet Plus 7.5 grams Fresh Avocado.

Animal	Initial wt.	Final wt.	Gain	Basal Diet Eaten
	grams	grams	grams	grams
1114 F	46	74	28	284
1115 M	52	89	37	318
1116 F	45	70	24	277
1117 F	42	77	35	287
1118 F	44	78	34	290
* 1119 M	63	108	45	309
* 1120 F	62	130	68	483
* 1121 F	54	122	68	360
* 1122 F	62	116	54	454
AVERAGE (9)	52	96	44	324
*AVERAGE (4)	60	119	59	388

Since there was difficulty in getting the animals to eat large amounts of avocado, it was thought that the high fat content might be responsible. Working on this assumption, basal diet No. 3 was constructed in which butter fat was omitted entirely. Experiments in this laboratory (16) have shown that the avocado furnishes ample vitamin A

in doses as low as 3 grams fresh weight, so that the butter fat is not needed as a source of this vitamin. The salt mixture was increased from 4% to 6% and the protein increased to offset the small amount of diet eaten.

Eight animals were placed on this diet plus 10 grams avocado. The reduction in fat did not improve the food consumption. Both the avocado and the basal diet were poorly eaten. The results are summarized in Table X. These have not been analyzed in detail for they are of no value.

Table X.

Basal No. 3 Plus 10 grams Fresh Avocado.

Animal	Initial wt	Final wt.	Gain	Basal Diet Eaten
	grams	grams	grams	grams
1151 F	54	74	20	105
1152 M	62	78	16	115
1153 M	64	66	2	99
1154 F	56	74	18	110
1156 F	46	90	44	141
1157 M	49	53	4	64
1169 F	48	55	7	67
AVERAGE	54	70	16	100

Since the total food consumption was low on the diets to which large amounts of avocado were added, the basal diet was varied in several ways in an attempt to improve this condition.

The variations of the basal diet are shown in Table XI.

Table XI.

Variations in Basal Diet.

	Basal No. 1	Basal No. 2	Basal No. 3	Basal No. 4.	Basal No. 5.	Basal No. 6
	%	%	%	%	%	%
Casein	18	21	27	22	24	26
Butterfat	10	5	—	10	10	10
Salt Mixture	4	4	6	4.8	5.3	5.6
Starch	68	70	67	63.2	60.7	58.4

Basal Diet No. 2 was designed to give less fat, to allow for the addition of the avocado fat. The results of feeding 5 grams of fresh avocado plus the Basal diet No. 2 are summarized in Table XII.

Table XII.

Basal Diet No. 2, Plus 5 grams Fresh Avocado.

Animal No.	Initial wt.	Final wt.	Gain	Basal Diet Eaten.
	Grams	Grams	Grams	Grams
1146 M	42	66	24	167
1147 F	40	68	28	204
1149 M	50	70	20	222
1150 F	44	44	0	148
1159 M	47	116	69	212
1160 F	48	100	52	204
1161 M	54	126	72	271
AVERAGE	46	82	36	200

Basal Diet No. 4 to which 5 grams fresh avocado were added, Basal Diet No. 5 to which 7.5 grams were added, and Basal Diet No. 6 to which 10 grams were added, were so prepared that the protein and ash content bore the same relation to total calories as in the control diet. Table XIII summarizes the results of feeding Basal Diets No. 4, 5, and 6 with varying amounts of avocado.

Graphs I, II, and III, show the average growth curves on varying amounts of avocado. The final comparisons are

GRAPH I

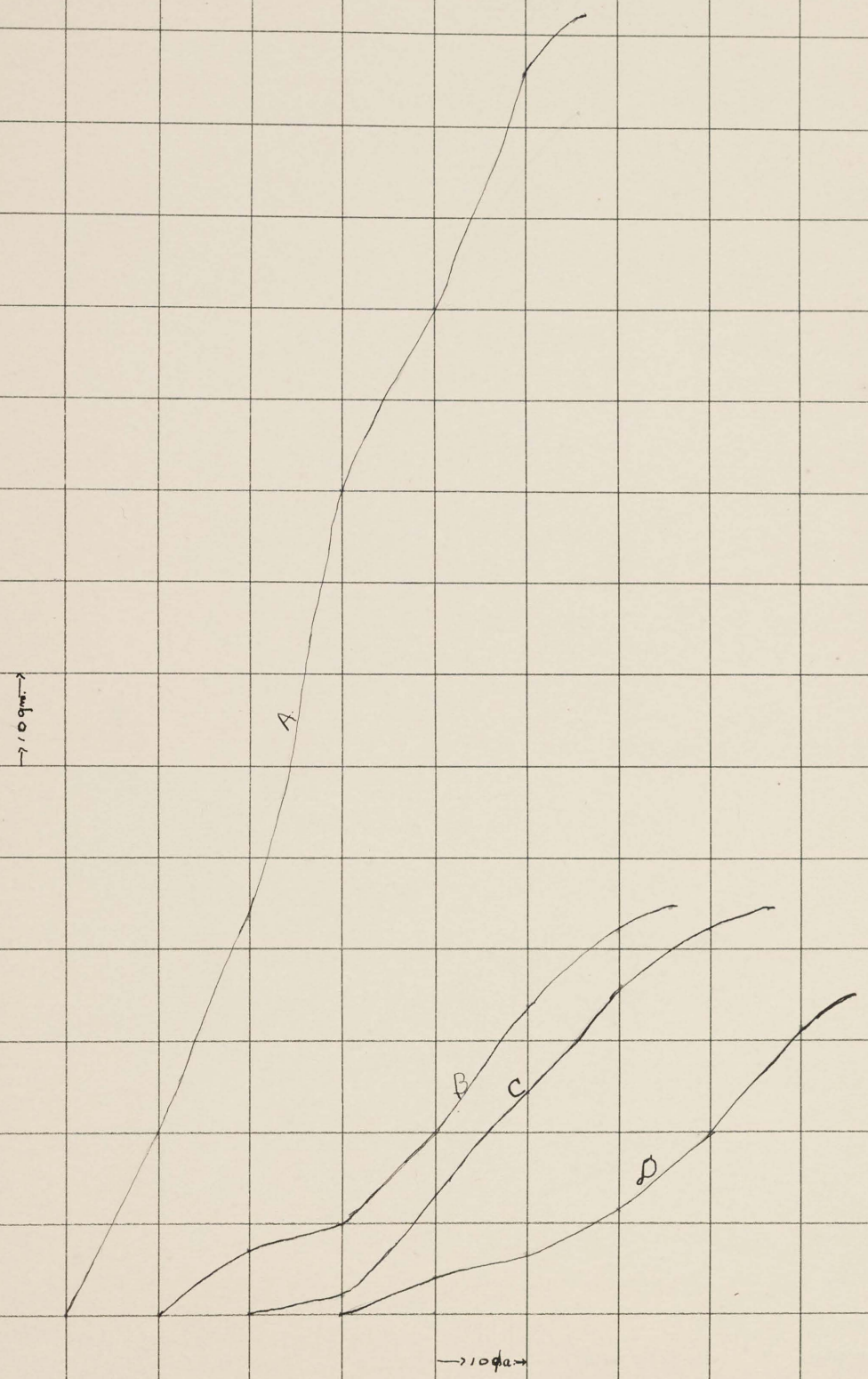
Basal Diets Plus 5 grams Fresh Avocado

A. Control diet

B. Basal diet No. 1

C. Basal diet No. 4

D. Basal diet No. 2



GRAPH II

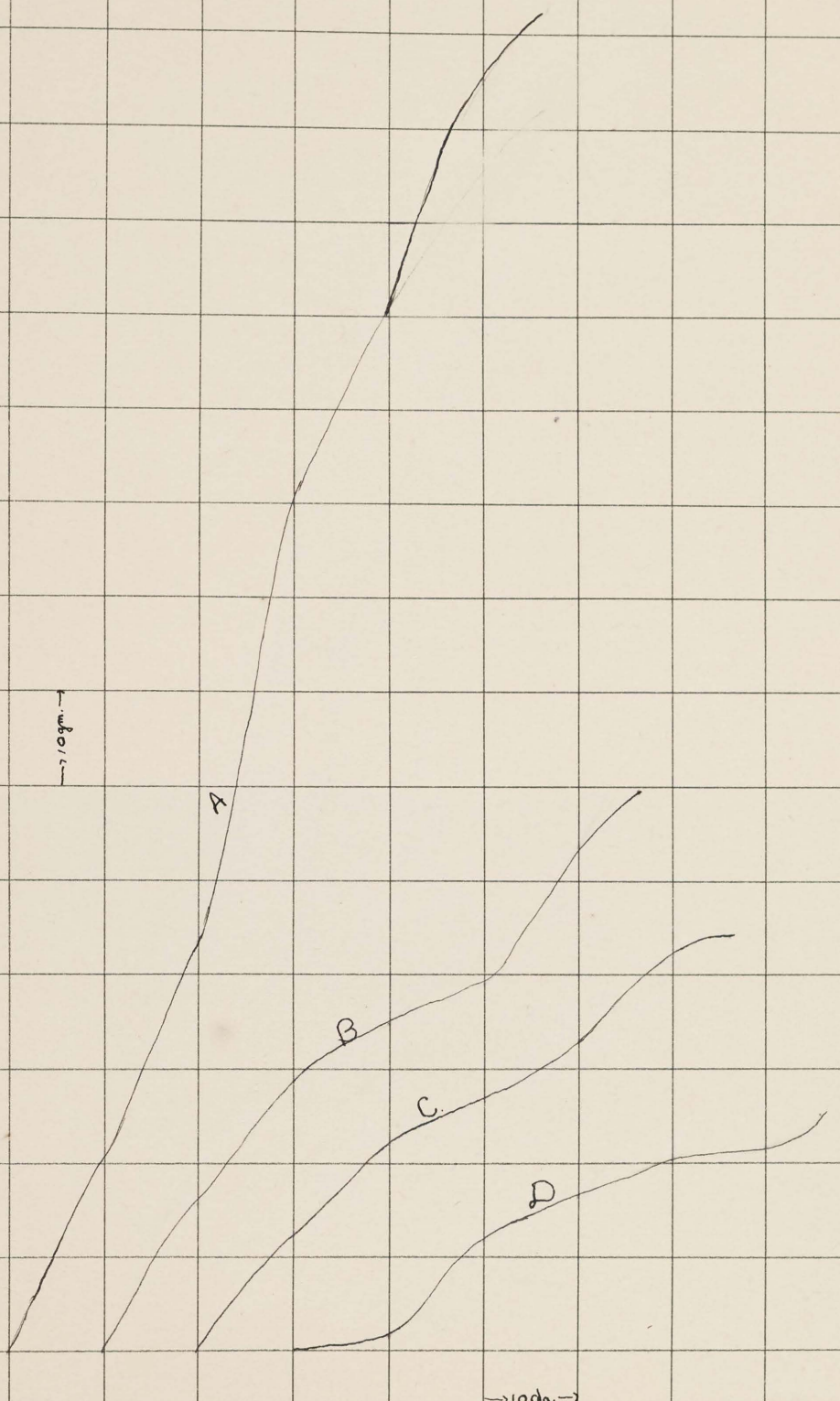
Basal Diets Plus 7.5 grams Fresh Avocado

A. Control diet

B. Basal diet (4 rats)

C. Basal diet (7 rats)

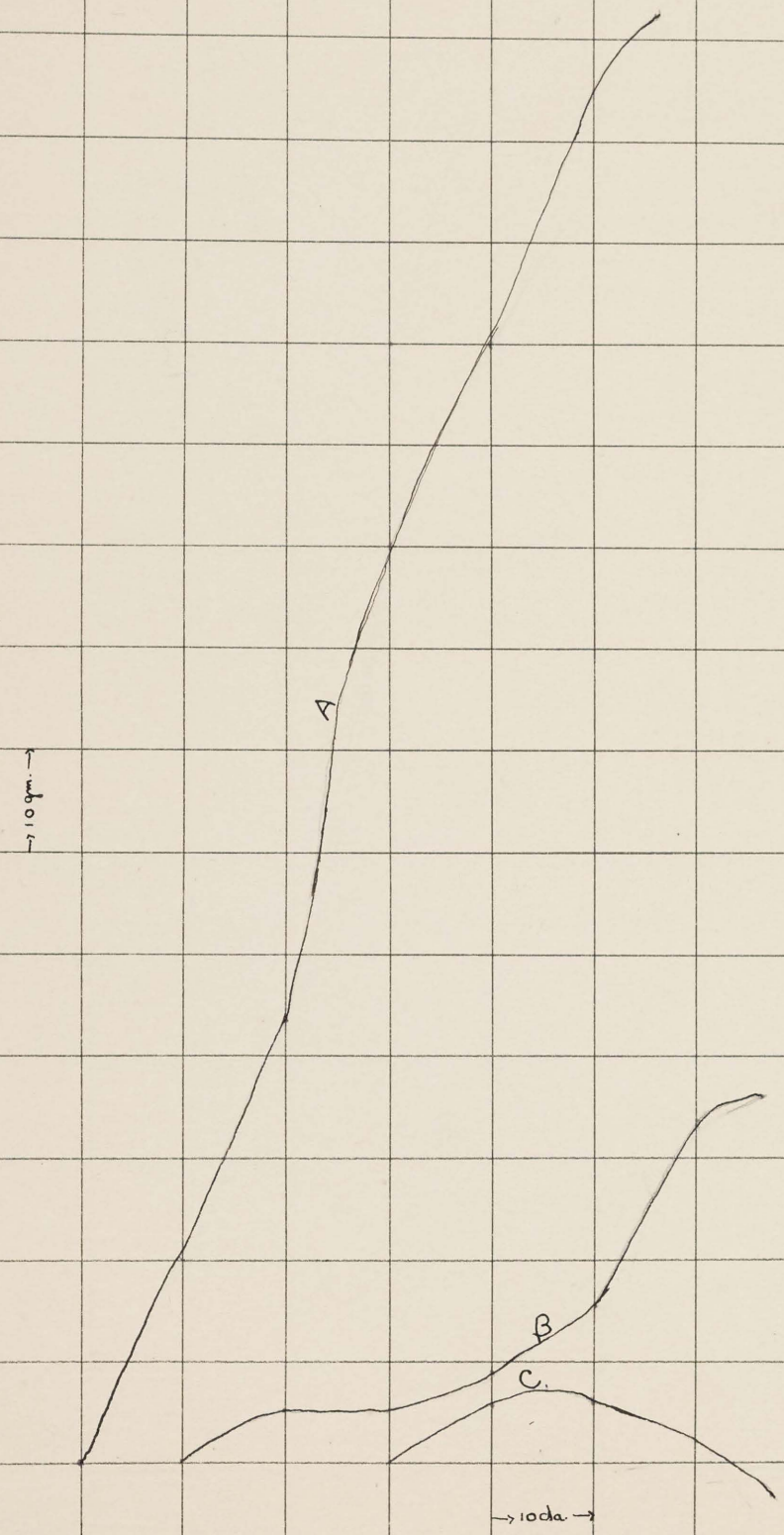
D. Basal diet No. 5



GRAPH III

Basal Diets Plus 10 grams Fresh Avocado

A. Control diet
B. Basal No. 3
C. Basal No. 6



GRAPH IV

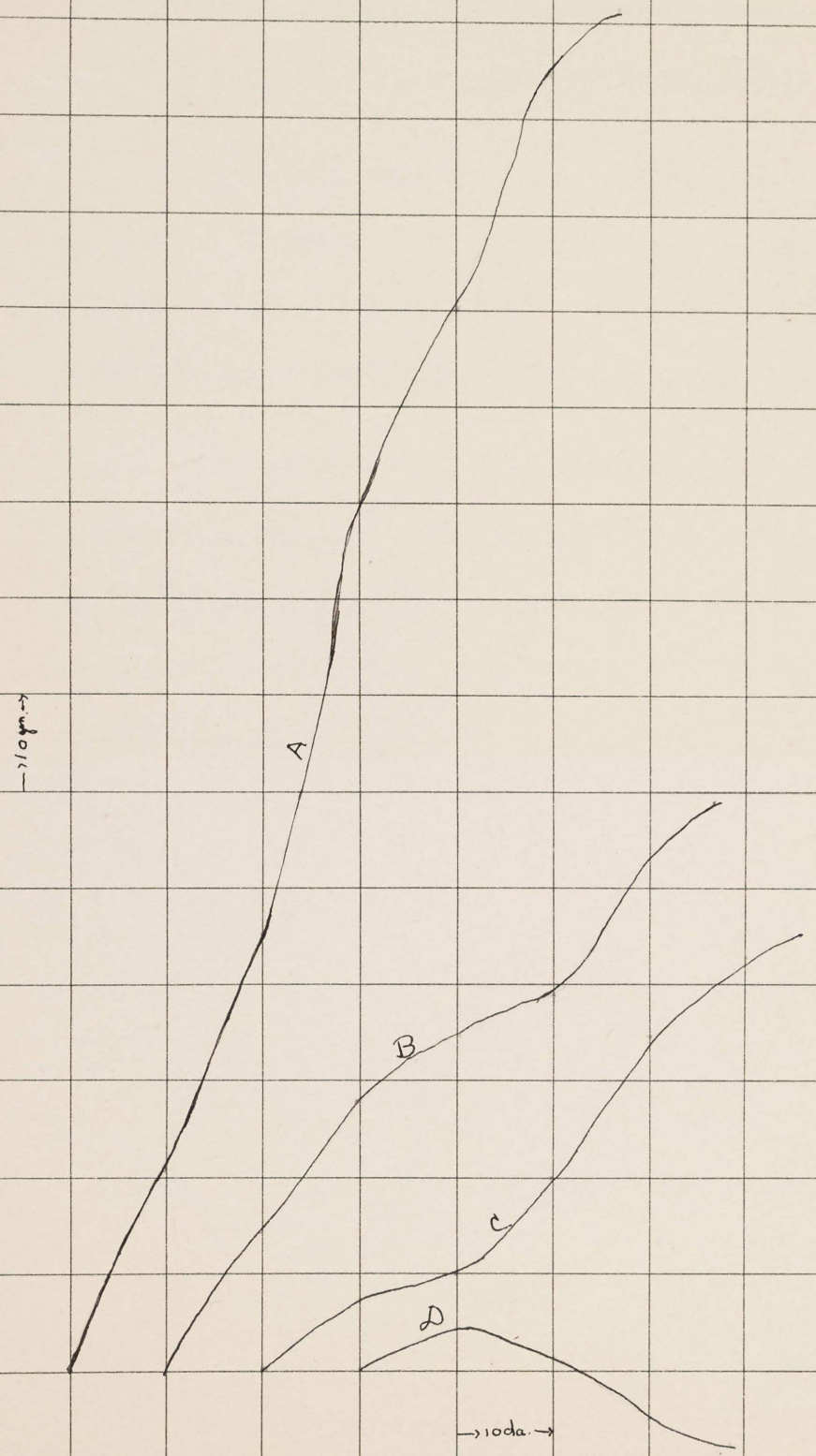
Basal Diet Plus Fresh Avocado

A. Control diet

B. Basal diet plus 7.5 gms.

C. Basal diet plus 5.0 gma.

D. B-free diet.



shown in Graph IV. In the growth curve of the animals receiving 7.5 grams daily, only those animals which ate all of their daily allowance were considered. Animals receiving 10 grams are not considered.

It would seem that the failure of the rats to grow on 10 grams is to a large extent due to their refusal to eat the large amount of the avocado and to their low basal food consumption.

It will be seen that 7.5 grams stimulates growth to a greater degree than 5 grams. The animals on the higher amount made a gain of 42% of that of the control animals, while those on the smaller amount made a gain of only 31%.

DRIED AVOCADO:- Avocado, dried in the electric oven at a temperature of 70°C., was fed in daily doses of 0.2, 0.4, 0.5, 0.7 and 1.0 gram. One gram of the dried avocado was equivalent to 6.97 grams of fresh avocado. On this basis, the daily doses of dried avocado were equivalent respectively, to 1.4, 2.8, 3.5, 4.9 and 6.97 grams of fresh avocado.

The weighed amounts of dried avocado were mixed with weighed amounts of the basal diet. In order to prevent the animals from picking out the basal diet, leaving the avocado uneaten, the avocado was moistened with water and thoroughly mixed with this basal diet. Less diet was mixed with the avocado than the animal was expected to eat during the day. If this amount was eaten before the end of the day, more was given. In this way, the animal was forced to eat the avocado in the first portion of the day's food but was not restricted in the total amount. Dried avocado has a very characteristic taste and odor. In amounts up to 0.5 gram this did not affect the amount of food eaten. However, in amounts of 0.7 and 1.0 gram, it did. The animals getting 0.5 gram, or less, ate that amount each day regularly. Those getting larger amounts ate their total allowance within the seven day interval but they did not eat their daily

allowance each day. This irregularity, together with the lowered basal food consumption, probably accounts for their failure to grow.

Tables XIV, XV, XVI, XVII, AND XVIII, summarize the gains of the individual rats in the groups receiving 0.2, 0.4, 0.5, 0.7, and 1.0 gram. Graph V shows the growth curves of the animals receiving 0.5 or less. The results of feeding 0.7 and 1.0 gram are influenced by the low food consumption and are not considered of value. These are not included in the final comparison. Their growth curves are shown in Graph VI.

Table XIII.

Basal Diets 4, 5, and 6, with Varying Amounts of Avocado.

Basal Diet No 4 Plus 5 grams fresh avocado					Basal Diet No. 5 Plus 7.5 grams fresh avocado					Basal Diet No. 6 Plus 10 grams fresh avocado				
Animal	Initial weight	Final weight	Gain	Basal Diet eaten	Animal	Initial weight	Final weight	Gain	Basal Diet Eaten	Animal	Initial weight	Final weight	Gain	Basal Diet Eaten
	grams	grams	grams	grams		grams	grams	grams	grams		grams	grams	grams	grams
1177 F	50	92	42	184	1181 M	56	74	18	132	1194 F	64	70	6	59
1178 F	57	116	59	212	1182 F	50	76	26	112	1195 M	56	58	2	50
1179 M	48	86	38	163	1183 F	48	84	36	139	1196 F	66	66	0	44
1180 F	48	84	36	173	1184 M	52	80	28	153	1197 M	68	54	-14	35
AVERAGE	56	95	44	183		51	78	27	134		63	62	-1	47

Table XIV.

Basal Diet Plus 0.2 gram Dried Avocado.

Animal No.	Initial wt.	Final wt.	Gain	Basal Diet Eaten
	Grams	Grams	Grams	Grams
1093 M	48	48	0	238
1094 M	48	44	-4	237
1095 F	52	48	-4	237
1096 M	50	56	6	279
1097 M	50	52	2	287
1098 M	48	48	0	268
1099 F	44	45	1	230
1100 F	44	42	2	232
AVERAGE (8)	48	49	1	249

Table XV.

Basal Diet Plus 0.4 gram Dried Avocado.

Animal No.	Initial wt.	Final wt.	Gain	Basal Diet Eaten
	Grams	Grams	Grams	Grams
1014 F	50	76	26	239
1015 M	50	96	46	257
1016 M	52	108	56	320
1043 F	62	114	52	319
1044 F	54	78	24	303
1045 F	56	72	16	289
1046 M	58	75	17	286
AVERAGE	54	88	34	288

Basal Diet Plus 0.5 gram Dried Avocado.

Animal No.	Initial wt.	Final wt.	Gain	Basal Diet Eaten.
	grams	grams	grams	grams
1014 F	50	76	26	239
1015 M	50	96	46	257
1016 M	52	108	56	320
1043 F	62	114	52	319
1044 F	54	78	24	303
1045 F	56	72	16	289
1046 M	58	75	17	286
AVERAGE 6	54	88	34	288

Table XVII.

Basal Diet Plus 0.7 gram Dried Avocado.

Animal No.	Initial wt.	Final wt.	Gain	Basal Diet Eaten
	grams	grams	grams	grams
1123 F	70	86	16	354
1124 F	72	88	16	341
1125 M	69	72	3	296
1127 M	68	77	-9	253
1129 M	68	60	-6	293
1131 M	76	70	-6	297
1133 F	56	68	12	297
1134 F	66	87	21	302
AVERAGE (8)	67	76	9	301

Table XVIII.

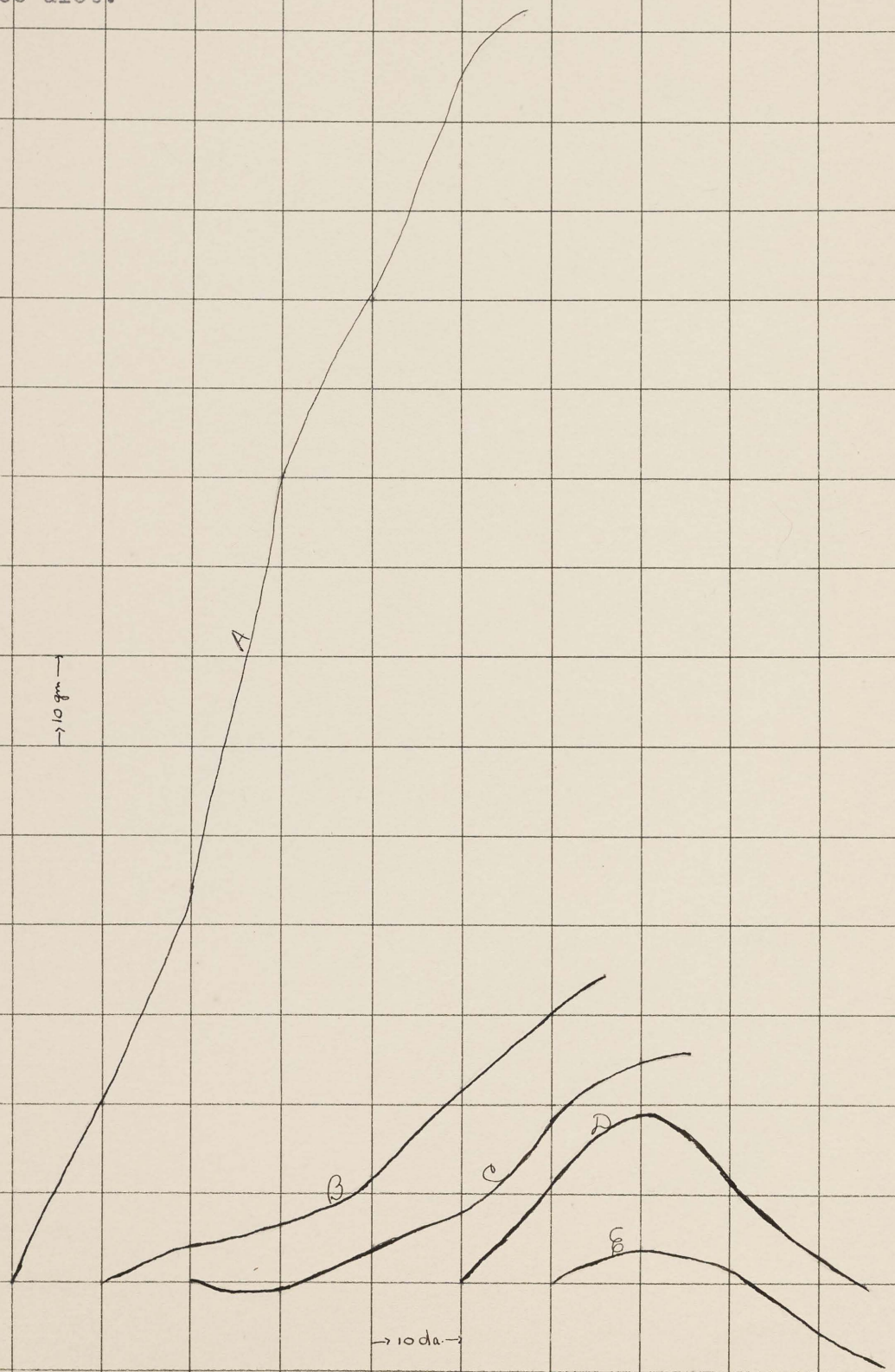
Basal Diet Plus 1.0 Gram Avocado.

Animal No.	Initial wt.	Final wt.	Gain	Basal Diet Eaten
	grams	grams	grams	grams
1067 M	50	70	20	287
1069 M	56	93	8	252
1071 M	58	66	8	252
1102 M	42	56	14	288
1104 M	48	72	24	330
1070 F	63	96	33	305
1068 F	60	104	44	310
1103 F	46	70	24	331
AVERAGE (8)	53	78	25	302

GRAPH V

Basal Diet Plus Dried Avocado

A. Control diet
B. Basal diet plus 0.5 gm.
C. Basal diet plus 0.4 gm.
D. Basal diet plus 0.2 gm.
E. B-free diet.



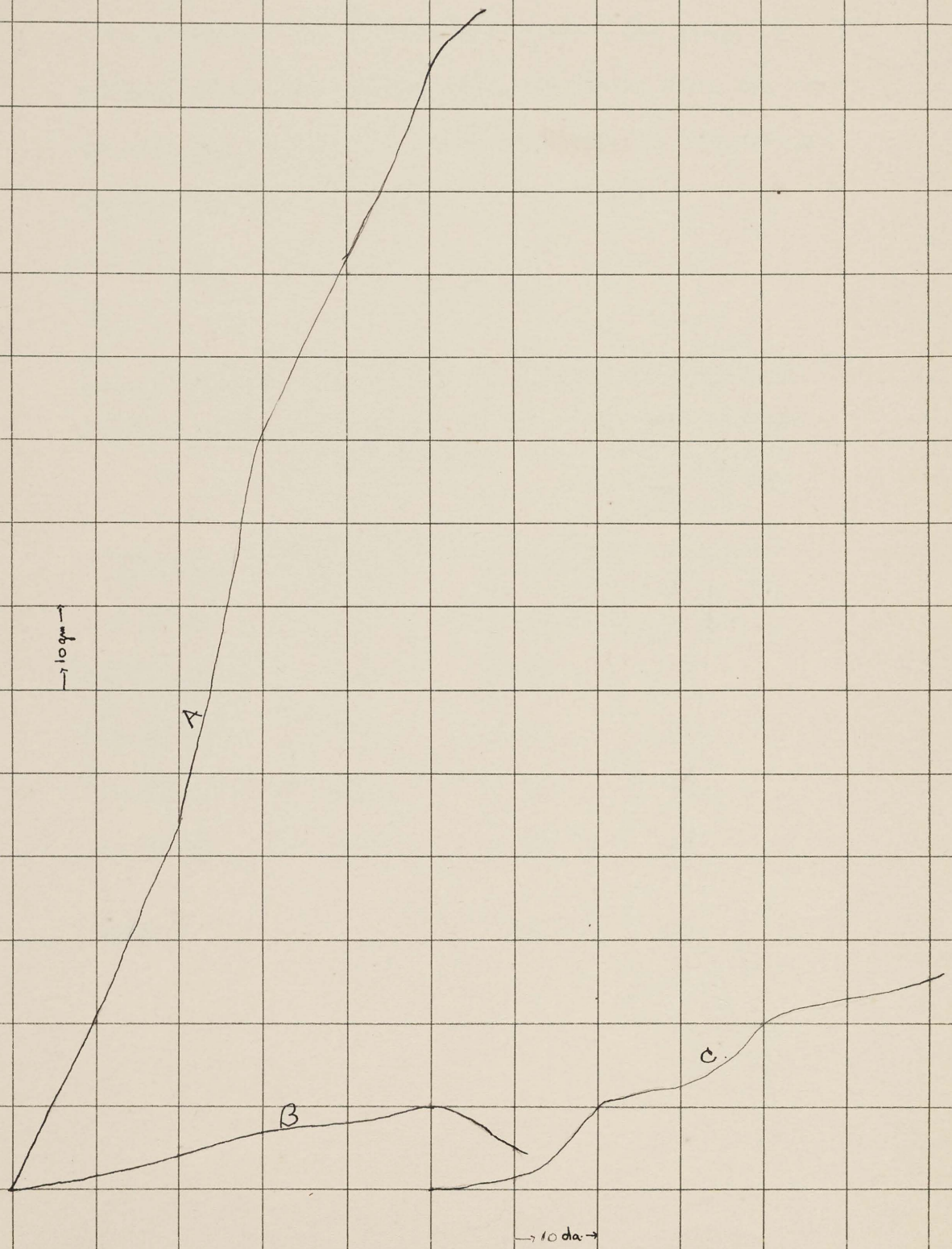
GRAPH VI

Basal Diet Plus 0.7 and 1.0 gm. Dried Avocado

A. Control diet

B. Basal diet plus 0.7 gm.

C. Basal diet plus 1.0 gm.



It is interesting to note further that with the larger amounts of avocado, the animal was able to make more efficient use of the food eaten. The larger the proportion of avocado in the diet, the fewer were the number of calories required for each gram gain in body weight. These results are summarized in Table XIX.

Table XIX.

Growth of Animals on Varying Amounts of Avocado.

Avocado as fed	Equivalent in Fresh Avocado	Average Gain	Gain expressed in per cent of gain of controls	Calories required per gram gained
grams	grams	grams	%	Cal.
0.2 dried	1.4	1		
0.4 dried	2.8	27	19	51
0.5 dried	3.5	34	19	41
5.0 fresh	5.0	44	31	44
7.5 fresh	7.5	59	42	36
CONTROL	—	141	100	21

No conclusion can be drawn as to the destruction of vitamin B in the drying process. The smallest amount of fresh avocado fed was 5 grams, which is equivalent to 0.7 gram dried. The animals did not eat completely the 0.7 gram dried, so that the results can not be compared.

It is very difficult to compare avocado with other common food materials as a source of vitamin B as the technique employed in the study of the vitamin has changed markedly in the last few years. However, there are available a few figures for vegetables and fruits which seem to have been tested in a manner similar to that used in the present study.

Osborne and Mendel (17) found that 2.2 grams of asparagus, between 10.8 and 17.2 grams of celery, 11 grams of lettuce and 2.7 grams parsley gave approximately normal growth. Acuña (8) found that 10 grams of banana supported normal growth. Comparing the avocado with these foods, we find that it is about two-thirds as potent as celery, the least potent of these. Osborne and Mendel (19) found that 5 grams of apple or pear prevented beri-beri in rats. Since 5 grams of avocado gave a gain 30% of the normal, it would seem that it is a better source than apple or pear.

SUMMARY.

1. Ninety-five white rats were used in a study of the vitamin B content of the Seedling and Trapp varieties of avocado. Twelve groups of rats were given a B-free basal diet, with additions of avocado. The fresh avocado was fed in amounts of 5, 7.5, and 10 grams daily, and the dried in daily doses of 0.2, 0.4, 0.5, 0.7 and 10 grams.

2. Animals receiving daily 5 grams fresh avocado made a gain 31% of that of the control animals, whereas those receiving 7.5 grams made a gain 42%. The results of feeding 10 grams were not considered of value.

3. Animals receiving daily, 0.2 gram of dried avocado died, after developing symptoms characteristic of a vitamin B deficienty. Animals receiving 0.4 gram made a gain of 19% of that of the control animals; those receiving 0.5 gram made a gain of 24%. Animals fed 0.7 gram and 1.0 gram failed to eat the avocado so that the results are not considered of value.

4. Avocado seems to furnish a moderate ~~source~~ amount of vitamin B, although it does not equal some of the richer sources.

5. No conclusions can be drawn as to the destruction of the vitamin on drying.

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