THE EFFECT OF COOKING ON THE VITAMIN A VALUE OF
TWO DEHYDRATED SWEET POTATO PRODUCTS

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THE EFFECT OF COOKING ON THE VITAMIN A VALUE OF TWO DEHYDRATED SWEET POTATO PRODUCTS

THESIS

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CHAPTER I

INTRODUCTION

The present war has greatly promoted the use of dried and dehydrated products. Of the dehydrated products sweet potatoes are one of the most valuable. The dehydrated sweet potato requires little volume in shipping and in storage space. Loss due to spoilage is eliminated and culls which are suitable for dehydrating but have little value for other purposes can be used. Dehydrated sweet potatoes can also be mixed with feeds to make a complete ration for farm animals. It is important to humans in that it is an excellent source of the pro-vitamin A, carotene.

Fraps and Treichler,[1] 1933, tested the Puerto Rico variety of sweet potato for loss of vitamin A during drying. They reported that the vitamin A loss during drying was approximately 29 per cent for sweet potatoes, as compared with 80 per cent in dried carrots and a 65 per cent loss in dried spinach.

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[1] G. S. Fraps and Ray Treichler, "Losses of Vitamin A in Drying Fresh Raw Carrots, Sweet Potatoes, and Canned Spinach," Journal of Agricultural Research, XLVII (1933), 539-541.

By using the photoelectric colorimetric method of analysis, Lease and Mitchell,[2] 1940, found that sweet potato flour prepared from Puerto Rico sweet potato contains an average of 130 micro-grams carotene per gram (217 International Units of vitamin A per gram).

From a biological study of dehydrated sweet potato made from freshly harvested crops of Puerto Rico variety, James,[3] 1941, reported that one gram of dehydrated sweet potato contains not less than 130.2 International Units of vitamin A per gram.

Using this same method of biological assay, Dozier,[4] 1941, presented data to show that one gram dehydrated sweet potato made from stored sweet potatoes furnish no less than 102 International Units of vitamin A.

Continuing this study of the vitamin A content of dehydrated sweet potato flour, Ballew,[5] 1942, reported 126.5

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[2]E. J. Lease and J. H. Mitchell, "Bio-Chemical Nutritional Studies of Dehydrated Sweet Potato," South Carolina Agricultural Experiment Station Bulletin 329, (1940), p. 12.

[3]Catherine James, "Vitamin A Content of Dehydrated Sweet Potato Made from the Freshly Harvested Puerto Rico Variety," (Unpublished Master's Thesis, Department of Home Economics, North Texas State Teachers College, 1941).

[4]Vera Dozier, "Vitamin A Content of Dehydrated Sweet Potatoes Made from Stored Sweet Potatoes," (Unpublished Master's Thesis, Department of Home Economics, North Texas State Teachers College, 1942).

[5]Jewell E. Ballew, "Biological Assay of Vitamin A of Certain Texas Foods," (Unpublished Master's Thesis, Department of Home Economics, North Texas State Teachers College, 1942).

International Units per gram for the freshly harvested and 90.2 International Units per gram for the stored product.

Wilson and Masters,[6] 1940, reported that sweet potato flour prepared from the Puerto Rico variety will contain from 120 to 160 International Units of pro-vitamin A per gram when using Snells'[7] antimony trichloride colorimetric method of analysis.

The dehydrated sweet potato is not only an excellent source of vitamin A but its uses in cooked products produces many interesting combinations. Many recipes containing sweet potatoes have been used because the addition of water makes it possible to substitute it for raw sweet potatoes in long used recipes. However, many new recipes have been developed to simplify the handling of the dehydrated product.[8]

Lewis,[9] 1942, using the biophotometer, made a study to determine if the addition of sweet potato flour as a source

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[6]Gilbert C. Wilson and W. N. Masters, "Sweet Potato Dehydration," Chemurgic Series, Bulletin No. 2, (August, 1940), Published by North Texas State Teachers College.

[7]Foster Dee Snell and Cornelia F. Snell, Colorimetric Method of Analysis, II, 617-621.

[8]Under the direction of Jessie E. Acker, the Home Economics Department at North Texas State Teachers College have worked out and tested many palatable recipes using sweet potato flour.

[9]Amber Loreta Lewis, "A Study of the Effect of Feeding High Vitamin A Foods upon the Dark Adaptation of College Girls," (Unpublished Master's Thesis, Department of Home Economics, North Texas State Teachers College, 1942).

of vitamin A to the daily diet improves the dark adaptation of college-age girls. In this study the commercial sweet potato flour called "Vita-Yam"[10] was used in the preparation of candy and cookies, which were added to the daily diet as the added source of Vitamin A.

These data gave evidence of improved dark adaptation when supplements of vitamin A were given in the form of "Vita-Yam" candy and cookies. The evidence presented showed that "Vita-Yam" candy seemed to be more valuable in improving the dark adaptation of these students than the "Vita-Yam" cookies. This result suggests that the difference may be due to the cooking processes.

Parsons and co-workers,[11] 1931, using the early biological method for the determination of vitamin A values of Steenbock and Coward,[12] made a study of the loss of vitamin A during the baking of thin butter cookies. They concluded that the destruction of vitamin A during the baking of the cookies was not extensive.

The purpose of the present study is to determine the effect of cooking on the vitamin A value of "Vita-Yam" candy and cookies.

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[10] "Vita-Yam", Dehydrated Sweet Potato Pulverized, Manufactured by Gilbert C. Wilson Laboratories, Denton, Texas.

[11] Helen T. Parsons, Ina Stevenson, Iva Mullen, and Carolyn Horn, "Loss of Vitamin A during the Baking of Thin Butter Cookies," Journal of Home Economics, XXIII (1931), 366-372.

[12] H. Steenbock and K. H. Coward, "The Quantitative Determination of Vitamin A," Journal of Biological Chemistry, LXXII (1927), 765-779.

CHAPTER II

PROCEDURE

The biological method of analysis was used in the present study to determine the effect of cooking on the vitamin A value of "Vita-Yam" cookies and "Vita-Yam" candy.

Albino rats of known nutritional history[1] were used in the experiment. The growth rate of the animals was uniform due to previous inbreeding which was continued when the animals were moved to the present stock colony. The same stock diet was maintained. The stock ration consisted of:

Ground whole wheat	600 grams
Whole milk powder	250 grams
Meat concentrate	140 grams
Salt	5 grams
$CaCO_3$	5 grams

The lactation diet consisted of:

Ground whole wheat	500 grams
Whole milk powder	250 grams
Meat concentrate	140 grams
Yeast -- A, B, strain C	100 grams
Salt	5 grams
$CaCO_3$	5 grams

These diets were supplemented with lettuce and cod liver oil, fed daily. Distilled water was available at all times.

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[1]Original stock colony was secured from Dr. Jet C. Winters of the University of Texas.

The experimental animals used in this study were allowed a lactation period of twenty-one days or until they reached the weight of thirty-five grams, which never exceeded twenty-five days. The average weaning weight of the animals in the present study was 40.5 grams with a range of 35 to 67 grams. Only four animals weighed over 50 grams. This greater variance in weight was due to an unavoidable delay in placing the animals on the depletion diet when they were of suitable weight at twenty-one days of age and were allowed a prolonged lactation period of a total of twenty-five days. The results of these four animals are included because they compare favorably with those of the other animals.

When weaned, the rats were placed in individual wire cages with raised wire bottoms. Distilled water was available at all times. Care was exercised in maintaining cleanliness of cages and food and water cups throughout the experiment.

The experimental procedure used was that outlined by Sherman and Munsell,[2] 1925, and modified by Swanson, Stevenson, and Nelson,[3] 1938. It was necessary to make a change in the latter method as the present stock colony would not

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[2]H. C. Sherman and H. E. Munsell, "The Quantitative Determination of Vitamin A," Journal of American Chemical Society, XXXXVII (1925), 1639-1646.

[3]Pearl Swanson, Gladys Stevenson, and P. M. Nelson, "A Method of Increasing Precision in Vitamin A Assay," Journal of Nutrition, XV (1938), 103-123.

permit the use of females alone. In so far as possible an equal distribution of males and females was made in each group.

A basal vitamin A-free diet was fed ad libitum to deplete the animals of their vitamin A stores. The depletion diet consists of:

Casein (vitamin-free)	18 per cent
Hydrogenated lard[4]	22 per cent
Cornstarch	56 per cent
Osborne and Mendel salt mixture[5]	4 per cent
Yeast (8 per cent of diet -- ½ of which was irradiated)[6]	

Fat was used in the basal diet to prevent xerophthalmic symptoms due to irritation from food dust. Clix was used because Swanson et al,[7] 1938, reported that smaller increments of growth were observed in the depletion period with this fat in the ration than when Crisco was employed.

The Osborne and Mendel salt mixture[8] used in the diet consisted of:

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[4]Clix, courtesy of the Cudahy Packing Company, Chicago, Illinois.

[5]G. H. Osborne and H. S. Mendel, "Nutritive Factors in Animal Tissues," Journal of Biological Chemistry, XXXII (1917), 317.

[6]Swanson, Stevenson, and Nelson, op. cit., p. 105.

[7]Ibid.

[8]See footnote 5, above.

$CaCO_3$	134.8	grams
$MgCO_3$	24.2	grams
Na_2CO_3	34.2	grams
K_2CO_3	141.3	grams
H_3PO_4	103.2	grams
HCl	53.4	grams
H_2SO_4	9.2	grams
Citric Acid + H_2O	111.1	grams
Ferric Citrate 1½ H_2O	6.34	grams
KI	0.020	grams
$MnSO_4$	0.079	grams
NaF	0.248	grams
$K_2Al_2(SO_4)_2$	0.0245	grams

Stationary weight which did not vary plus or minus four grams in four days[9] and incipient symptoms of xerophthalmia were criteria for determining the end of the depletion period. Incipient symptoms of xerophthalmia were described by Swanson et al,[10] 1938, as characterized by a slight swelling of the eyelids or a small exudate in the corner of the eye. Munsell,[11] 1938, found that xerophthalmia symptoms may or may not be present along with stationary or declining weight which signifies the end of the depletion period.

The time required for depleting the animals of their vitamin A stores ranged from twenty-four to thirty days with an average time of twenty-six days. This exceeds by two days the average time Swanson, Stevenson, and Nelson,[12] recommended

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[9] Swanson, Stevenson, and Nelson, op. cit., p. 106.

[10] Ibid., p. 107.

[11] H. E. Munsell, "Vitamin A Methods of Assay and Sources in Food," Journal of American Medical Association, CXI (1938), 245-252.

[12] Swanson, Stevenson, and Nelson, op. cit., p. 106.

for females on the basis of persistence of cornified cells in vaginal smears. Goss and Guilbert,[13] 1939, reported that vaginal smears became continuously cornified at an average of 53.1 days of age and 165 grams weight when placed on a depletion diet at twenty-one days of age. In the present study the average weight of the animals at the end of the depletion period was 90 grams for males and 72 grams for females. The growth rate of males is greater than that of females, as shown by Donaldson[14] in 1942.

The assay technique used is based on the comparison of the growth rate of Albino rats. After depleting the animals of their vitamin A stores, the growth of animals fed weighed amounts of test substances is compared with that of animals fed graded amounts of vitamin A in the form of a standard reference oil.[15]

A total of sixty-five animals were used in the present study from November, 1942, to July, 1943. Upon depletion, each animal was assigned to one of the nine groups, making each group as comparable as was possible in weight, sex, and litter-mates.

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[13] H. Goss and H. R. Guilbert, "The Minimum Vitamin A and Carotene Requirements of the Rat," Journal of Nutrition, XVIII (1939), 169-179.

[14] Henry Donaldson, The Rat-Data and Reference Tables, Edited by H. Donaldson, Philadelphia, Pennsylvania, (1924), p. 177.

[15] Reference Cod Liver Oil secured from United States Pharmacopeia Reference Standards, 43rd Street and Woodland Avenue, Philadelphia, Pennsylvania.

Due to loss of moisture during the cooking process, the weight of the dose of cooked candy and baked cookies was smaller than that of uncooked candy and raw cookie dough. The amount of cooked product given was a factor calculated on the basis of weight equivalent to the given weight of the uncooked or raw product.

The supplements were fed daily, six days a week, as follows: group one, (three males and three females), 5.3 grams of uncooked "Vita-Yam" candy; group two, (three males and two females), an average amount of 4.58 grams of cooked "Vita-Yam" candy, pulverized; group three, (three males and two females), an average of 2.97 grams of baked "Vita-Yam" cookies, pulverized; group five, (two males and four females), one gram of "Vita-Yam"; groups six, seven, eight, and nine were fed levels of cod liver oil diluted with cottonseed oil in amounts of 80, 96, 112, and 128 International Units, respectively. Due to an erratic response of unknown cause, the data collected on the thirty-three animals placed in groups six, seven, eight, and nine could not be used. Since the purpose of this study is to determine the effect of cooking upon two "Vita-Yam" products, a composite graph of the growth increments of the stock animals obtained from a two-year period of time was used. (This graph shows the growth increments of animals fed different levels of reference cod liver oil as summarized from data reported by Ballew,[16] Dozier,[17] and James.[18])

As negative controls, four animals were kept on the vitamin A-free basal diet without supplement from the time of weaning to the end of the test period. All animals used in the present study were weighed daily, six days a week, from the time of weaning to the end of the test period.

In 1938, Swanson _et al_[19] found that the uniformity and thence the reliability of the assay had been increased by the shortening of the test period from eight to five weeks. In 1940, Swanson and co-workers[20] gave evidence to show that the results obtained from a five weeks' test period were practically identical to those obtained from an eight weeks' assay. Consequently, the data in the present study are based on a five weeks' test period.

The dehydrated sweet potato used in this study was a commercial product called "Vita-Yam."[21] Since "Vita-Yam" is a commercial product, the age and variety of the samples were

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[16]Ballew, _op_. _cit_., pp. 17-18.

[17]Dozier, _op_. _cit_., p. 20.

[18]James, _op_. _cit_., pp. 13-14.

[19]Swanson, Stevenson, and Nelson, _op_. _cit_., pp. 103-123.

[20]Pearl Swanson, Gladys Stevenson, E. S. Haber, and P. Mabel Nelson, "Effect of Fertilizing Treatment on Vitamin A Content of Sweet Potatoes," _Food Research_, V (1940), 433.

[21]See footnote 8, Chapter I.

unknown. Twelve one-pound cartons of "Vita-Yam" were purchased, thoroughly blended in a large container in order to obtain a more uniform sample, and stored in the original one-pound containers in a cool, dry place.

Due to the rationing of sugar, substitutes were made for part of the sugar in the candy and cookie recipes. A simple cookie recipe, adjusted for dehydrated sweet potato,[22] was used. The ingredients were weighed each time in the preparation of the cookie dough, as follows: 100 grams shortening, 44 grams sugar, 75 grams white cornsyrup, 140 grams "Vita-Yam," 20 grams water, 2 grams vanilla, 74.4 grams white flour (wheat), 1 gram salt, 0.6 grams soda, and 8 grams baking powder. To guard against an extraneous source of vitamin A, water was substituted for milk and only the white of the egg, which was carefully separated from the yolk, was used.

A fresh preparation of the cookie dough was mixed every two weeks. By weight, one-half of the cookie dough was removed, placed in a tightly closed container, and stored in an electric refrigerator. The second half of the cookie dough was chilled in the refrigerator for one day, then rolled out and baked. The thickness of the cookies were

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[22]Soft Cookie Recipe, (Unpublished recipe adjusted for dehydrated sweet potato in the Department of Home Economics, North Texas State Teachers College).

kept uniform by rolling the dough between a frame made from wood cut three-sixteenths of an inch thick. The edges of the rolling pin were rolled on the frame, which was placed on a dough board. A cookie cutter two inches in diameter was used. An attempt was made to use the same amount of flour each time in rolling the dough.

The cookies were baked at a temperature of 400° Farenheit for eight minutes. The temperature was set by means of an oven thermostat and checked by means of a calibrated oven thermometer.

In 1931, Parsons et al[23] reported that if cookies were allowed to cool for 15 minutes at room temperature, pulverized in a mortar, and stored in a tightly closed container, practically no shift in weight occurred thereafter, even though the container was opened for removing doses. Consequently, the "Vita-Yam" cookies were allowed to cool for 15 minutes, then pulverized in a mortar. The pulverized cookies were stored in a tightly closed container in an electric refrigerator. Since there was practically no shift in weight, a factor could be calculated at once after each baking for determining the dosage of the individual baked cookies equivalent to a given weight of dough. The difference in the dose of the baked cookie did not vary more than a plus or minus

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[23]Parsons, Stevenson, Mullen, and Horn, op. cit., p. 367.

0.02 grams. This difference could probably be accounted for, in part, by the varying amount of flour incorporated in rolling the dough.

In preparing the "Vita-Yam" candy,[24] the ingredients were weighed each time, as follows: 396 grams of molasses, 200 grams of sugar, 240 grams of white cornsyrup, 200 grams of "Vita-Yam," and 24 grams of shortening. A fresh preparation of candy mixtures was mixed every two weeks. By weight, one-half of the mixture was removed, placed in a tightly closed container, and stored in an electric refrigerator. In order that the cooked candy could be pulverized in a mortar, the second half of the candy mixture was cooked to a temperature of 460° Farenheit, which exceeds by 10° Farenheit the temperature attained by Lewis[25] in feeding human subjects. It was necessary to stir the candy to keep it from scorching. The average time for cooking was 14 minutes.

The cooked candy was poured onto a china plate, which was slightly greased with shortening, and allowed to cool at room temperature. When thoroughly cool, the candy was pulverized and stored in a tightly closed container in the electric refrigerator. As for the baked cookies, a factor was calculated for determining the dosage of the individual

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[24]Lewis, Molasses Stacks, op. cit., p. 73.

[25]Private Correspondence.

batches of cooked candy equivalent to a given weight of raw mixture. The difference in the dose of cooked candy did not vary more than a plus or minus 0.01 gram.

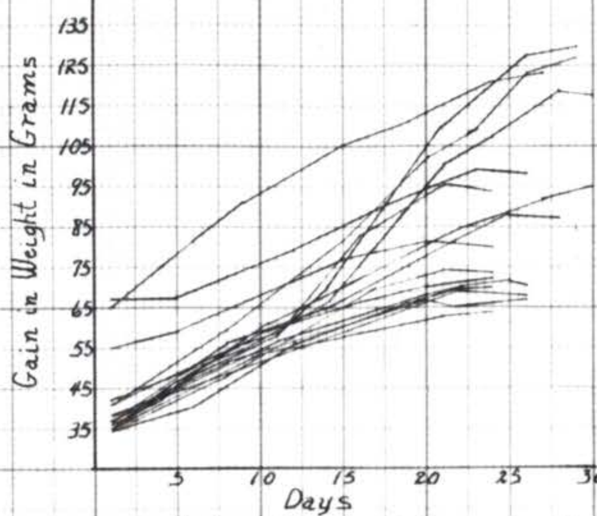
The same equipment, utensils, and brands of ingredients were used each time in the preparation of the candy and cookies.

CHAPTER III

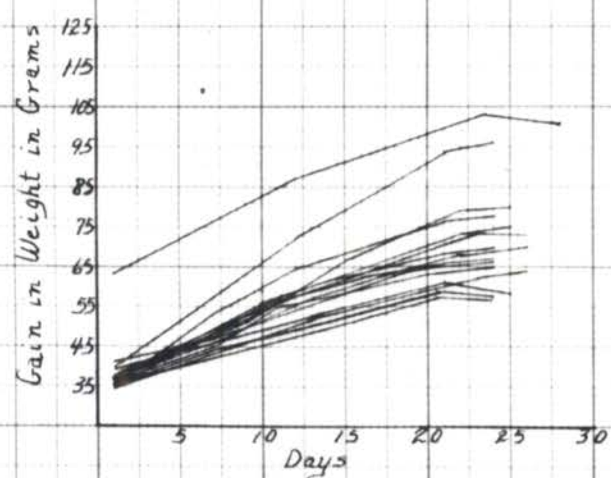
DISCUSSION OF RESULTS

Although sixty-five animals were used in this study, the results of only thirty-two are reported, since the growth response of the thirty-three animals fed reference oil was irregular. No definite cause has been found to explain the erratic response of those animals fed different levels of reference cod liver oil, which was diluted with cottonseed oil.

Figure 1 shows the growth response of seventeen males and fifteen females during the depletion period. The depletion period is the time required to deplete weaned animals of their vitamin A stores when fed a vitamin A-free diet. The end of the depletion period was determined by stationary or slightly declining weight, as is evident in the growth curves of the animals in Figure 1. The males required a longer time for depletion than the females. The average time required for depleting the males of their vitamin A stores was twenty-six and three-tenths days, with a range of twenty-four to thirty days, while the average time required for depleting the females was twenty-five days, with a range of twenty-four to twenty-eight days.



Depletion Curves of Seventeen Males



Depletion Curves of Fifteen Females

Fig 1.--Depletion curves of seventeen male and fifteen female rats

When comparing the growth curves of the males and females (Figure 1), the males show a slightly greater growth increment than the females. The average weight of the males at the end of the depleting period was 90 grams, with a range of 64 to 130 grams. The average weight of the females at the end of the depletion period was 72 grams, with a range of 57 to 102 grams. Although individual variations are evident in the growth curves, the trend is toward a straight line. However, as shown in Figure 1, the males show a greater variation in growth than the females.

When the test animals were depleted of their vitamin A stores, they were assigned to one of five groups and fed vitamin A supplements for a period of five weeks. The supplements were fed as follows: group one, 5.3 grams of uncooked "Vita-Yam" candy; group two, 4.58 grams of cooked "Vita-Yam" candy, pulverized; group three, 3.5 grams of raw "Vita-Yam" cookie dough; group four, 2.97 grams of baked "Vita-Yam" cookies, pulverized; and group five, 1.0 gram of "Vita-Yam," as purchased. The amounts of candy and cookies fed were equivalent to one gram of dry "Vita-Yam."

The given amounts were fed daily, six days a week. Since the animals did not eat all of the supplement every day and an occasional spillage occurred, it was necessary to weigh back the dose each day and to determine an average for each rat from the amount eaten. The average amount of vitamin A supplement eaten daily by each rat is shown in Table 1. The gain in weight of the males increased in proportion to the increase in amount of supplement consumed. The same is true for females. However, the increase in weight is not in proportion to the amount of supplement eaten when sex is disregarded, because the growth increment of males is greater than that of females.

Three males in group one, consuming an average of 1.43 grams of uncooked candy, showed an average total of gain of 71 grams and an average total daily gain of 2.02 grams, while three females, consuming an average of 1.64 grams, made a total gain of 64 grams, with a daily gain of 1.95 grams. It is evident from these figures that even though the females in this group consumed a slightly higher average amount of uncooked candy, the males showed a greater gain in weight.

Group two, in contrast to group one, was fed pulverized cooked "Vita-Yam" candy. The amount consumed ranged from 1.11 to 2.04 grams. Two females, consuming an average of 1.39 grams of cooked candy, showed an average total gain of 68 grams and an average daily gain of 1.95 grams, while three males, consuming an average of 1.87 grams of cooked candy, showed a total gain of 78 grams and daily gain of 2.22 grams.

The animals in group three consumed a range of 2.67 to 3.50 grams of raw "Vita-Yam" cookie dough. All animals except one female consumed 3.50 grams daily. Three females,

TABLE 1

SUMMARIZED RECORDS OF RATS RECEIVING VITAMIN A SUPPLEMENTS

Rats	Sex	Basal Diet Plus Average[a] Amount of Vitamin A Supplement Consumed Daily	Weaning Weight in Grams	Weight in Grams after Depletion Period	Weight in Grams of Animals at End of Vitamin A Supplementary Feeding Period: Weight at End of 35 Days	Total Gain in Weight	Average Daily Gain
		GROUP I					
1	♀	2.20 gm. U. Candy[b]	35	80	182	102	2.90
2	♀	1.86 gm. U. Candy	37	70	139	69	1.97
3	♀	1.04 gm. U. Candy	35	67	101	34	0.97
4	♂	1.80 gm. U. Candy	65	124	226	102	2.90
5	♂	0.74 gm. U. Candy	41	126	170	44	1.26
6	♂	1.74 gm. U. Candy	37	88	154	66	1.90
		GROUP II					
1	♀	1.66 gm. C. Candy[c]	41	67	126	59	1.70
2	♀	1.11 gm. C. Candy	36	67	144	77	2.20
3	♂	1.73 gm. C. Candy	67	98	168	70	2.00
4	♂	2.04 gm. C. Candy	42	118	208	90	2.57
5	♂	1.85 gm. C. Candy	35	70	143	73	2.09
		GROUP III					
1	♀	3.50 gm. U. Cookie[d]	35	64	127	63	1.80
2	♀	2.67 gm. U. Cookie	35	57	104	47	1.34
3	♀	3.50 gm. U. Cookie	39	95	135	40	1.14
4	♂	3.50 gm. U. Cookie	37	70	141	71	2.03
5	♂	3.50 gm. U. Cookie	42	130	204	64	1.83
6	♂	3.50 gm. U. Cookie	35	85	108	23	0.66

TABLE 1 -- Continued

Rats	Sex	Basal Diet Plus Average Amount of Vitamin A Supplement Consumed Daily	Weaning Weight in Grams	Weight in Grams after Depletion Period	Weight in Grams of Animals at End of Vitamin A Supplementary Feeding Period		
					Weight at End of 35 Days	Total Gain in Weight	Average Daily Gain
		GROUP IV					
1	♀	0.74 gm. C. Cookie[e]	38	73	150	77	2.20
2	♀	1.13 gm. C. Cookie	36	67	148	81	2.30
3	♂	1.82 gm. C. Cookie	39	66	150	84	2.40
4	♂	1.63 gm. C. Cookie	37	96	143	47	1.31
5	♂	1.31 gm. C. Cookie	35	74	144	70	2.00
		GROUP V					
1	♀	1.00 gm. D. S. P.[f]	63	102	163	61	1.74
2	♀	1.00 gm. D. S. P.	39	60	107	47	1.34
3	♀	0.70 gm. D. S. P.	36	80	115	35	1.00
4	♀	1.00 gm. D. S. P.	36	75	123	48	1.37
5	♂	1.00 gm. D. S. P.	38	66	144	78	2.23
6	♂	1.00 gm. D. S. P.	35	64	149	85	2.43

[a]Because the animals did not eat all of the supplement given daily and an occasional spillage occurred, it was necessary to weigh back the supplement each day and to determine an average for each rat from the amount consumed.

[b]Uncooked Candy, a "Vita-Yam" product.

[c]Cooked Candy, a "Vita-Yam" product.

[d]Uncooked Cookie, a "Vita-Yam" product.

[e]Baked Cookie, a "Vita-Yam" product.

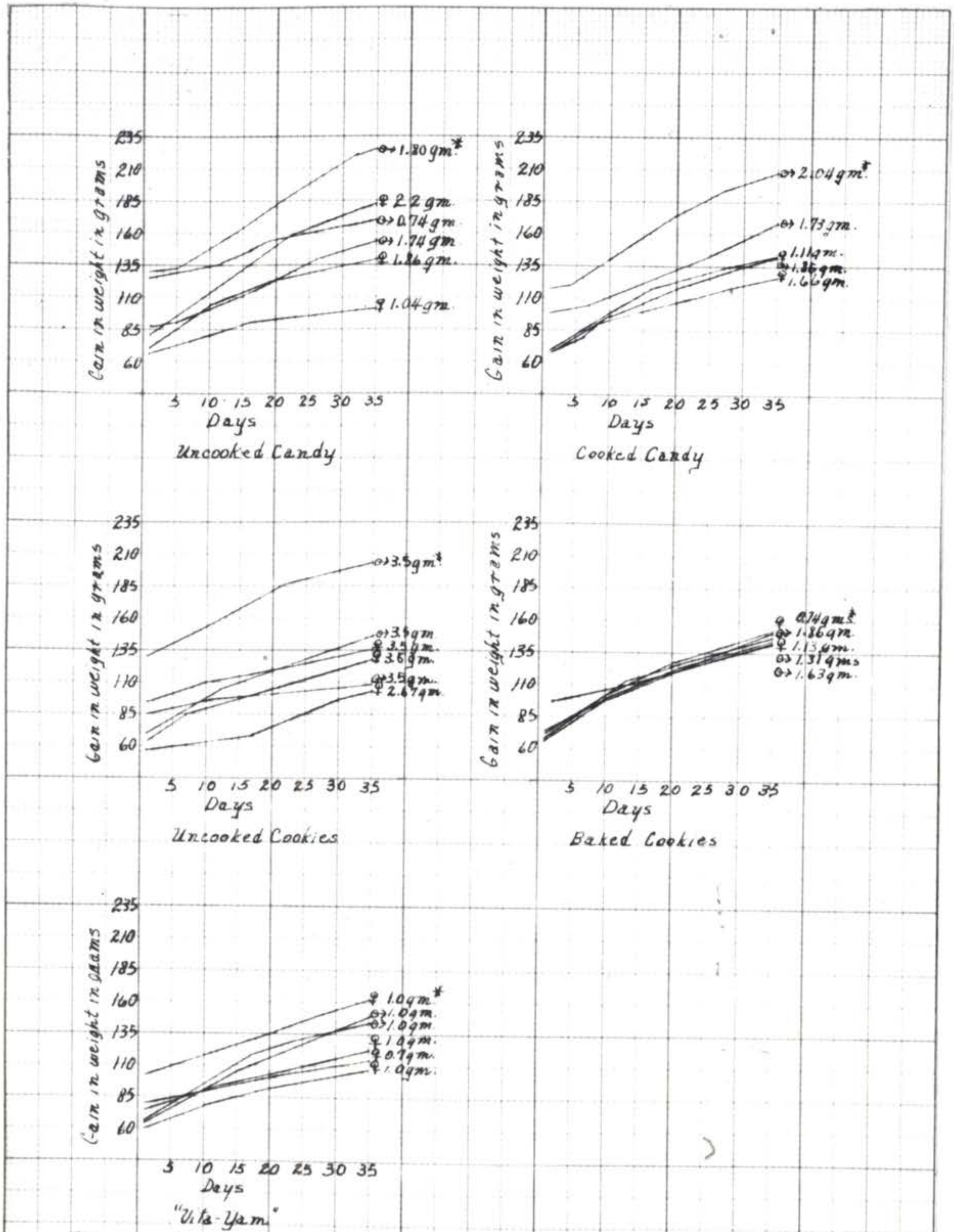
[f]Dehydrated Sweet Potato, "Vita-Yam."

consuming an average of 3.22 grams of cookie dough daily, showed an average total gain of 50 grams and an average daily gain of 1.43 grams, while three males, consuming an average of 3.50 grams of cookie dough, showed total gain of 53 grams and a daily gain of 1.51 grams.

Group four, fed pulverized baked "Vita-Yam" cookies, consumed a range of 0.74 to 1.82 grams daily. Two females, consuming an average of 0.94 grams of baked cookies, showed an average total gain of 2.25 grams, while three males, consuming an average of 1.59 grams of baked cookies, showed a total gain of 67 grams and a daily gain of 1.90 grams. In this group the average gain in weight for the females was greater than that for the males, even though the initial weight and age at the time of weaning was approximately the same. This can be partially accounted for, in that male four showed a much smaller gain in weight than the other animals in the group, although he consumed next to the highest quantity of baked cookies, namely, 1.63 grams. Omitting this male from the average, the other two males showed results very similar to those of the females consuming an average of 1.57 grams of baked cookies, the two males showing an average total gain of 2.20 grams.

Group five was fed the commercial dehydrated sweet potato called "Vita-Yam," unchanged. Only one animal from the group of six failed to eat the one-gram dose of "Vita-Yam" fed daily. Consuming an average of 0.925 gram of "Vita-Yam," four females showed an average total gain of 48 grams and an average daily gain of 1.38 grams, while two males, consuming an average of 1.0 gram of "Vita-Yam," showed a total gain of 82 grams and a daily gain of 2.33 grams. The one gram dose of dehydrated sweet potato fed is the amount that other workers have fed when determining vitamin A value.

The individual growth curves of the animals during the five weeks' test period of vitamin A supplementary feeding are shown in Figure 2. With a few exceptions, animals of like sex in each group showed an increase in growth increment in proportion to an increase in the amount of supplement consumed daily. It is also evident in Figure 2 that the growth curves of the animals fed uncooked candy and uncooked cookies show greater variation than those fed cooked candy and baked cookies. The final weight of the animals fed uncooked candy showed a variation of plus or minus 63 grams at the end of the test period, while the final weight of the animals fed cooked candy showed a variation of plus or minus 41 grams. The variation in weight at the beginning of the test period was plus or minus 39 grams for the animals fed uncooked candy and plus or minus 26 grams for those fed cooked candy. The animals fed uncooked cookies showed a variation in weight of plus or minus 50 grams at the end of the test period, while the animals fed baked cookies showed



*The number at the right of each growth curve shows the daily amount of vitamin A supplement consumed by that rat.

Fig. 2.--Growth curves of animals fed uncooked "Vita-Yam" candy, cooked "Vita-Yam" candy, uncooked "Vita-Yam" cookies, cooked "Vita-Yam" cookies, and "Vita-Yam".

a variation in weight of plus or minus 3.5 grams. The variations in weight at the beginning of the test period were plus or minus 37 grams for the animals fed uncooked cookies and plus or minus 15 grams for the animals fed baked cookies. Although the animals fed uncooked products showed a greater variation in weight at the beginning of the test period than those fed the uncooked products, the variation was still greater for the animals fed the uncooked products at the end of the test period.

To prove that the increase in weight of the animals fed "Vita-Yam" products was due to the vitamin A in the "Vita-Yam," four animals were kept on the vitamin A-free basal diet during the entire nine weeks' experimental period, as negative controls. The growth curves of these animals were very similar to those of the other animals during the depletion period. Receiving no supplement at the end of the depletion period, the weight of these four animals remained practically stationary throughout the five-weeks' test period. Therefore, the consistent gain in weight of the animals fed "Vita-Yam" products indicates that the gain was due to the vitamin A in the "Vita-Yam."

In Table 2 the average gain in weight of each group of rats during the five weeks' test period is shown. Since each vitamin A supplement did not contain the same amount of "Vita-Yam" and "Vita-Yam" is the only source of vitamin A,

TABLE 2

THE AVERAGE GAIN IN WEIGHT OF EACH GROUP OF RATS DURING THE FIVE WEEKS' FEEDING OF VITAMIN A SUPPLEMENTS

Group	Average[a] amount of supplement consumed daily	Per cent of "Vita-Yam" in supplement	Average gain in grams of rats in each group	
			Total	Daily
I	1.56 gm. U. Candy[b]	18.868	69.5	1.98
II	1.68 gm. C. Candy[c]	21.834	74.0	2.11
III	3.36 gm. U. Cookie[d]	28.574	51.3	1.47
IV	1.33 gm. B. Cookie[e]	33.670	71.8	2.04
V	0.95 gm. D. S. P.[f]	100.000	59.0	1.70

[a]See asterisk, Table 1.

[b]Uncooked Candy, a "Vita-Yam" product.

[c]Cooked Candy, a "Vita-Yam" product.

[d]Uncooked Cookie, a "Vita-Yam" product.

[e]Baked Cookie, a "Vita-Yam" product.

[f]Dehydrated Sweet Potato, "Vita-Yam."

the results cannot be discussed according to grams of supplement eaten without regard to the per cent of "Vita-Yam" in the supplement. Using per cent, the amount of "Vita-Yam" can be calculated in grams for each amount of supplement eaten.

Group one consumed an average of 1.56 grams of uncooked "Vita-Yam" candy daily, or 0.294 grams of "Vita-Yam" and showed an average daily gain of 1.98 grams. Group two consumed an average of 1.68 grams of cooked "Vita-Yam" candy daily, or 0.366 grams of "Vita-Yam" and showed an average daily gain of 2.11 grams. Although group two showed a higher average daily gain in weight than group one, group one consumed more "Vita-Yam." Comparing gain in weight with amount of "Vita-Yam" consumed, it may be concluded that the cooking of "Vita-Yam" candy shows little or no effect on the vitamin A value.

Group three consumed an average of 3.36 grams of raw cookie dough daily, 0.96 gram of "Vita-Yam" and showed an average daily gain in weight of 1.47 grams, as compared with group four's consumption of 1.33 grams of baked cookies daily, or 0.348 gram of "Vita-Yam" and a daily gain of 2.04 grams, although group four consumed almost two-thirds less "Vita-Yam" than group three, the average daily gain of group four was approximately twice as great. From these data it may be concluded that the baking of the "Vita-Yam" cookies increases the availability of the vitamin A. Since there was no other data available on the effect of baking upon cookies prepared with dehydrated sweet potatoes, the results obtained in this study cannot be compared. However, Parsons,[1] 1931, reported that the loss of vitamin A during the baking of thin butter cookies was not extensive. MacLeod and Utley,[2] 1938, reported that

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[1]Parsons, op. cit., p. 372.

[2]F. L. MacLeod and Evelyn Utley, "The Vitamin A Values of Sweet Potato, Turnips, and Carrots," Tennessee Agricultural Experiment Station, (1938), pp. 34-35.

the cooking of sweet potatoes increased the vitamin A content two-fold.

The effect of the two methods of cooking, moist heat and dry heat, upon the vitamin A value of "Vita-Yam" are apparently the same. The group of animals fed cooked candy (moist heat) showed an average daily gain of 2.11 grams and received 0.366 grams of "Vita-Yam" when they consumed an average of 1.68 grams of the candy daily. The group of animals fed baked cookies (dry heat) showed an average daily gain of 2.04 grams and received 0.366 grams of "Vita-Yam" when they consumed an average of 1.33 grams of the cookies daily. The relation of the average daily gain in weight to the amount of "Vita-Yam" received is approximately the same for each group. These results indicate that the type of heat did not differ greatly in its effect on the vitamin A value of "Vita-Yam."

Since the results of the animals fed reference oil in this study could not be used, a composite graph, Figure 3, of the growth increments of the same stock animals fed different levels of reference oil over a period of two years was used. The amount of reference oil fed ranged from 55.1 to 227.6 International Units of vitamin A. Data from twelve groups of animals are included, with three males and three females in each group. The biological method of assay used in the collecting of the data was the same as was used in the present study. Since the same stock animals were used and

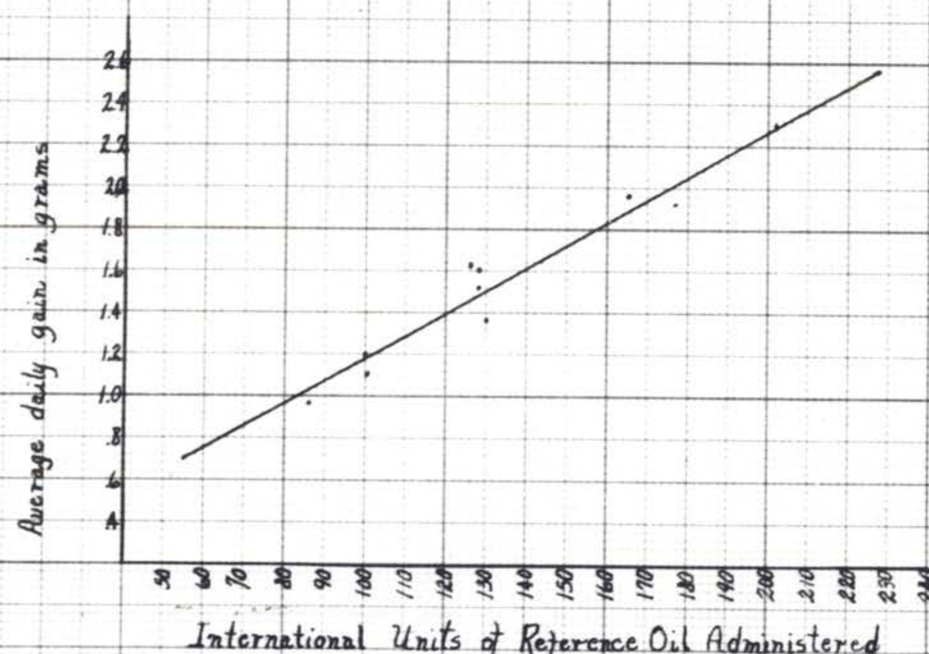

Fig. 3.--Average daily gain in weight of rats fed graded amounts of reference cod liver oil (summarized from data reported by Ballew, Dozier, and James).

the growth rate was uniform, the data can be used to predict reliable vitamin A values for the test substances in the present study.

In Table 3 the approximate International Units of vitamin A in a given amount of supplement are predicted. Because of the fact that the range of the amount of test substance eaten by the animals in each group are large, the results obtained from those animals that consumed like quantities of the same supplement were averaged and a vitamin A value predicted for each level. The vitamin A values were predicted from data in Figure 3 on the basis of average daily gain in weight. Since "Vita-Yam" was the only source of vitamin A in the candy and cookies, it was necessary to calculate the grams of "Vita-Yam" in each level of supplement in order to compare one supplement with another.

In group one, one male and one female consumed an average of 0.89 gram of uncooked candy which contained 0.168 gram of "Vita-Yam." Since their average daily gain was 1.11 grams, a value of 85 International Units was predicted from Figure 3. For 1.80 grams of uncooked candy containing 0.339 grams of "Vita-Yam," consumed by two males and one female with an average daily gain of 1.80 grams, a value of 157 International Units of vitamin A was predicted. One female consumed 2.20 grams of uncooked candy containing 0.415 grams of "Vita-Yam" and showed an average daily gain of 2.90 grams, which gave a vitamin A value of 260 International Units.

TABLE 3

AVERAGE DAILY GAIN OF RATS THAT CONSUMED LIKE QUANTITIES OF VITAMIN A SUPPLEMENTS, PREDICTED INTERNATIONAL UNITS OF VITAMIN A[a] IN SUPPLEMENTS, AND AMOUNT OF "VITA-YAM" IN SUPPLEMENT[b]

Rats: No. of Males	Rats: No. of Females	Amount of Supplement Consumed	Average Daily Gain in Grams	Predicted Vitamin A Value[a] in I. U.[c]	Amount of "Vita-Yam" in Supplement[b] in Grams
		GROUP I			
1	1	0.89 gm. U. Candy[d]	1.11	85	.168
2	1	1.80 gm. U. Candy	1.80	157	.339
..	1	2.20 gm. U. Candy	2.90	260	.415
		GROUP II			
..	1	1.11 gm. C. Candy[e]	2.20	194	.242
2	1	1.75 gm. C. Candy	2.00	176	.392
1	..	2.04 gm. C. Candy	2.57	204	.445
		GROUP III			
..	1	2.67 gm.U.Cookie[f]	1.34	106	.763
3	2	3.50 gm.U.Cookie	1.45	130	1.000
		GROUP IV			
..	1	0.74 gm.B.Cookie[g]	2.20	194	.249
1	1	1.22 gm.B.Cookie	2.15	186	.411
1	..	1.82 gm.B.Cookie	2.40	212	.808
		GROUP V			
..	1	0.70 gm. D.S.P.[h]	1.00	84	.700
2	3	1.00 gm. D.S.P.	1.82	158	1.000

[a]Vitamin A values predicted from Figure 1.
[b]Calculated from per cent of "Vita-Yam" in recipe.
[c]International Units.
[d]Uncooked Candy, a "Vita-Yam" product.
[e]Cooked Candy, a "Vita-Yam" product.
[f]Uncooked Cookie, a "Vita-Yam" product.
[g]Baked Cookie, a "Vita-Yam" product.
[h]Dehydrated Sweet Potato, "Vita-Yam."

In group two, one female consumed 1.11 grams of cooked candy containing 0.242 grams of "Vita-Yam." Since their average daily gain was 2.20 grams, a vitamin A value of 194 International Units was predicted. The amount of 1.75 grams of cooked candy containing 0.392 gram of "Vita-Yam" consumed by two males and one female, contained a predicted vitamin A value of 176 International Units. For 2.04 grams of cooked candy containing 0.445 grams of "Vita-Yam," consumed by one male, a vitamin A value of 204 International Units was predicted.

In group three, for 2.67 grams of uncooked cookies containing 0.763 gram of "Vita-Yam," consumed by one female, a vitamin A value of 106 International Units was predicted. For 3.5 grams of uncooked cookies containing 1.0 gram of "Vita-Yam," consumed by three males and two females, a vitamin A value of 130 International Units was predicted.

In group four, 0.74 gram of baked cookies containing 0.249 gram of "Vita-Yam," consumed by one female, gave a predicted vitamin A value of 194 International Units. For 1.22 grams of baked cookies, consumed by one male and one female, a vitamin A value of 186 International Units was predicted. For 1.82 grams of baked cookies containing 0.808 gram of "Vita-Yam," consumed by one male, a vitamin A value of 212 International Units was predicted.

In group five one female consumed 0.70 gram of "Vita-Yam" daily. The vitamin A value predicted was 84 International

Units. Two males and three females consumed 1.0 gram of "Vita-Yam" daily. The vitamin A value predicted for one gram of "Vita-Yam" on the basis of average daily gain in weight as compared to daily gain in weight of animals fed reference cod liver oil (Figure 3), was 158 International Units.

James,[3] 1941, reported one gram of dehydrated sweet potatoes, prepared from freshly harvested crops of Puerto Rico variety, contained not less than 130.2 International Units of vitamin A. Ballew,[4] 1942, reported that one gram of dehydrated sweet potatoes made from freshly harvested crops contained 126.5 International Units of vitamin A. The vitamin A value of one gram of "Vita-Yam" obtained in the present study is slightly higher than that reported by James and Ballew. Although the age and variety of the sample of "Vita-Yam" used in the present study was unknown, the color was compared with the samples of dehydrated sweet potato used by James and Ballew and was found to be much deeper in color, which may account, in part, for the higher value received in the present study. Steenbock and Sell,[5]

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[3]James, op. cit., p. 23.

[4]Ballew, op. cit., p. 27.

[5]H. Steenbock and M. T. Sell, "Fat-Soluble Vitamin A. Further Observations on the Occurrence of the Fat-Soluble Vitamin with Yellow Plant Pigments," Journal of Biological Chemistry, LI (1922), 63-76.

1922, reported that the amount of vitamin A in sweet potatoes varied with depth in color. MacLeod, Armstrong, Heap, and Tolbert,[6] 1935, studied five varieties of sweet potatoes and reported that the deeply pigmented varieties, Nancy Hall, Puerto Rico, and Yellow Jersey, gave better growth response in test animals than the light colored varieties, Triumph and Southern Queen, which did not support growth in test animals when fresh. These authors also reported that the vitamin A value of sweet potatoes increased during a storage of two months.

Wilson and Masters,[7] 1940, reported that the Puerto Rico variety of dehydrated sweet potatoes will contain from 120 to 160 International Units of pro-vitamin A per gram when using Snells'[8] antimony trichloride method of analysis. Although different methods of analysis were used, the value obtained in the present study is within the range reported by Wilson and Masters.

From the foregoing data, it is apparent that the cooking of candy and cookies prepared with "Vita-Yam" increases the availability of vitamin A in the "Vita-Yam." The vitamin A

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[6]F. L. MacLeod, M. R. Armstrong, M. E. Heaps, and L. A. Tolbert, "Vitamin Content of Five Varieties of Sweet Potatoes," Journal of Agricultural Research, L (1935), 181-187.

[7]Wilson and Masters, op. cit.

[8]Snell and Snell, op. cit.

value of cookies when baked increases approximately two-fold. Although cooked and uncooked candy showed approximately the same results, the predicted vitamin A value was almost twice as much as that predicted for dry "Vita-Yam." The vitamin A value predicted for raw cookie dough compares similarly with that predicted for the dry "Vita-Yam."

The fact that raw "Vita-Yam" candy produced better growth in the rats than raw "Vita-Yam" cookie dough may be due to the other ingredients used in the recipes. The candy recipe was composed of food stuffs that do not require heat to make them more easily digested, whereas the cookie recipe contained starch (wheat flour), which is more readily digested when cooked. This may also account for the fact that baked cookies produced better growth than the raw cookie dough.

CHAPTER IV

SUMMARY

The biological method of assay was used to determine the effect of cooking on the vitamin A value of two dehydrated sweet potato products.

Candy and cookies, prepared using the commercial dehydrated sweet potato called "Vita-Yam," were fed raw and cooked. "Vita-Yam," as purchased, was also fed.

Data are presented to show that cooking apparently increased the vitamin A value of "Vita-Yam" and that the vitamin A value of cooked "Vita-Yam" candy and baked "Vita-Yam" cookies are approximately the same. It may also be concluded that the "Vita-Yam" in raw candy is more available than that in raw cookie dough.

The sample of dry "Vita-Yam" tested contained 158 International Units of vitamin A per gram.

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