CAROTENE AND VITAMIN A METABOLISM

OF COLLEGE WOMEN

ON SELF-SELECTED DIETS

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# CAROTENE AND VITAMIN A METABOLISM OF COLLEGE WOMEN ON SELF-SELECTED DIETS

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# INTRODUCTION

Vitamin A and carotene balance studies have been the exception rather than the rule. Booher et al.(1939)[1] used dark adaptation as a means of measuring the individual's ability to use vitamin A and carotene. Five adult subjects were fed a basal weighed diet of ordinary food items adequate in all essentials except vitamin A. Before beginning the period, the subjects were given dark adaptation tests. It was found that the daily intake of vitamin A necessary for normal dark adaptation varies from 25 to 55 International Units per kilogram of body weight. Carotene in cottonseed oil was from 50 to 60 per cent as effective in supporting normal dark adaptation as vitamin A in cod liver oil.

LePage and Pett (1941)[2] showed that on receiving 10,000 International Units of vitamin A, three male subjects eliminated no free vitamin A in the feces. After the administration of 300,000 International Units, however, 0.46 per cent of the dose was found in the feces.

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[1] L. E. Booher, E. C. Callison, and E. M. Hewston, "An Experimental Determination of the Minimum Vitamin A Requirements of Normal Adults", Journal of Nutrition, XVII (1939), 317-331.

[2] G. A. LePage and L. B. Pett, "Absorption of Vitamin A", Journal of Biological Chemistry, CXLI (1941), 747-761.

In a study made by Wald et al.(1941)[3], it was found that the excretion of large doses of carotene and vitamin A ordinarily begins after 24 to 48 hours, rises to a maximum in 3 to 5 days, and ceases after 5 to 7 days. A single carotenoid determination in feces yields information, not on a single meal, but on ingestion over a considerable period of time. Even at the lowest intake levels, carotenoids seemed to be chiefly of dietary origin. In the lowest excretory levels the daily excretion was about 70 to 80 per cent of the intake.

Since vitamin A is insoluble in water, it could not be expected to be present in normal urine. Lawrie et al.(1941)[4] found no vitamin A in the urine of normal subjects. However, some vitamin A occurred in the urine of subjects having respiratory and kidney diseases. Excretion occurred infrequently in rheumatic diseases, heart diseases, diabetes, cancer, cerebral tumour, liver diseases, and thyroid diseases.

The object of this study is to determine the intake (in food) and output (in feces) of vitamin A and carotene of several groups of college women living in the Home Management House.

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[3] G. Wald, W. R. Carroll, and D. Sciarra, "The Human Excretion of Carotenoids and Vitamin A", Science, XCIV (1941), 95,96.

[4] N. R. Lawrie, T. Moore, and K. R. Rajagopal, "The Excretion of Vitamin A in the Urine", Biochemical Journal, XXXV (1941), 825-836.

## PROCEDURE

For calibration of standard carotene a mixture of 90 per cent beta and 10 per cent alpha carotene was dissolved in Skellysolve naphtha. Portions were diluted to give a curve on semi-logarithmic paper containing from 0.1 to 5.0 micrograms of carotene per milliliter. Ten milliliter Photelometric cells were used. The Cenco-Sheard-Sanford Photelometer was set at 100 with 10 milliliters of Skellysolve naphtha and readings taken on 10 milliliter portions of the standards, using a 410 millimicron filter. Micrograms of carotene were converted to International Units of vitamin A by dividing by the factor 0.6[5].

Vitamin A acetate was used for the calibration of vitamin A. The vitamin A acetate was dissolved in chloroform and a curve was plotted on semi-logarithmic paper from readings made on samples containing from 1.0 to 25.0 micrograms per milliliter. To 1.0 milliliter of each standard solution 4.0 milliliters of the reagent, 1,3-dichlorohydrin, were added. This was shaken and allowed to stand in a water

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[5]Marjorie Lesher, James Brody, Harold Williams, and Icie G. Macy, "Metabolism of Women During the Reproductive Cycle. X. The Utilization of Vitamin A During Lactation", Journal of American Dietetic Association, XXIII (1947), 211-217.

bath at 25° to 30° Centigrade for 2 minutes. The solution was then removed from the water bath and read in the Photelometer with a 550 millimicron filter. All test solutions read from the calibration curve were multiplied by 0.87, since vitamin A acetate is only 87% pure vitamin A. The results in micrograms were then multiplied by 4.3 to convert to International Units.[6]

From the macerated food of a known weight, a 20 gram sample was taken for analysis. For feces determinations only 5 grams of the wet feces were used. The sample was weighed into a 125-milliliter Erlenmeyer flask and 20 milliliters of absolute methanol and 5 milliliters of saturated potassium hydroxide were added. Contents were stirred with a glass rod until suspension was complete. The flask was heated on a water bath for 5 or 10 minutes, or until particles were disintegrated. The contents of the flask were cooled and transferred with 70 milliliters of water to a 500-milliliter separatory funnel. The first extraction was made with 35 milliliters of ethyl ether. Four more extractions were made, each with 25 milliliters of ethyl ether. If the last extraction was not colorless, additional extractions with 25 milliliter portions of ethyl

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[6] Marjorie Lesher, James Brody, Harold Williams, and Icie G. Macy, "Human Milk Studies. XXVI. Vitamin A and Carotenoid Contents of Colostrum and Mature Human Milk", American Journal of Diseases of Children, LXX (1945), 182-185.

ether were made until the ether remained colorless. Up to this point the procedure followed was largely that of Thompson et al.(1946)[7].

Lesher et al.(1947)[8] used petroleum ether instead of ethyl ether in order to prevent formation of an emulsion. Sodium sulfate, suggested by Wall and Kelley (1943)[9], was used in this study to prevent emulsification.

The ether extract was washed 5 times with 25 milliliter portions of water containing a small amount of sodium sulfate. The ether extract was then dried for 1 hour with anhydrous sodium sulfate.

The ether solution was evaporated to dryness to remove all ethyl ether and the residue redissolved in Skellysolve naphtha. This was transferred to a separatory funnel and extracted with 90 per cent methanol 3 times to remove xanthophylls.[10] The Skellysolve solution was washed with water plus a small amount of sodium sulfate to remove traces

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[7]C. R. Thompson, M. A. Ewan, S. M. Hauge, B. B. Bohren, and F. W. Quackenbush, "Chemical Determination of Vitamin A in Dried Whole Eggs", Industrial and Engineering Chemistry, Analytical Edition, XVIII (1946), 113-115.

[8]Lesher, op. cit.

[9]Monroe Wall and Edward Kelley, "Determination of Pure Carotene in Plant Tissues", Industrial and Engineering Chemistry, Analytical Edition, XV (1943), 18-20.

[10]Assoc. Off. Agr. Chem., Official and Tentative Methods of Analysis, 1940.

of methanol. The extract was made up to volume in a volumetric flask.

The chromatographic adsorption method of Zechmeister and Cholnoky (1941)[11] was used. The Skellysolve solution was passed through a column of finely pulverized activated alumina chromatographically. The column was made of a test tube about three-fourths of an inch in diameter with a piece of glass tubing attached to the bottom. A plug of cotton was placed in the bottom and about one and one-half inches of activated alumina packed dry. Skellysolve was passed through the column before and after elution of carotene.

Elution of carotene only was affected by passing a solution of 5 per cent acetone in Skellysolve through the column. The eluate of carotene was put in a 10 milliliter Photelometer tube and light transmission read through a 410 millimicron filter. Readings were compared with the standard.

The vitamin A fraction was eluted from the chromatograph with a 9:1 mixture of Skellysolve and methyl alcohol. The vitamin A was then added to the carotene and the combined solution evaporated to dryness. The residue was dissolved in chloroform.

To 1.0 milliliter of the chloroform solution containing vitamin A were added 4.0 milliliters of the vitamin A reagent,

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[11] L. Zechmeister and L. Cholnoky, Principles and Practices of Chromatography, pp. 248, 249.

glycerol 1,3-dichlorohydrin. (This reagent is used straight from the bottle.) This solution was shaken, placed in a water bath at 25° to 30° Centigrade, and read after six minutes with a 550 millimicron filter. The time allowed for reaction with the reagent is 6 minutes, for at that time both the carotene and vitamin A are stable. Readings were made against a blank of 2.0 milliliters of chloroform and 8.0 milliliters of glycerol 1,3-dichlorohydrin.

In their use of glycerol 1,3-dichlorohydrin as a reagent for vitamin A, Sobel and Werbin (1945)[12] found that 1 gamma of carotene gave a color reaction equivalent to that produced by 0.49 International Units of vitamin A. This correction was made on all solutions containing carotene.

The subjects for this study were all residents of the Home Management House, North Texas State College, at the time they participated in the study. The Home Management House is a duplex accommodating 14 girls, 7 on each side. The girls in each duplex have the same food supply. Therefore, an analysis of 1 day's food supply provided the intake of a number of girls at one time. Individual needs and preferences were permitted through the separate analysis of milk and by permitting the girls to eat sugar candies and carbonated beverages as desired. Coffee and tea, without cream, were permitted.

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[12] A. E. Sobel and H. Werbin, "Spectrophotometric Studies of a New Colorimetric Reaction of Vitamin A", Journal of Biological Chemistry, CLIX (1945), 681-691.

Weighed, eclipse, wide-mouth, quart size Ball* jars, containing a known amount of 1 per cent metaphosphoric acid, were used in collecting the food for each meal. (The metaphosphoric acid was for the purpose of preserving ascorbic acid, which was determined at the same time. The acid had no effect on the carotene and vitamin A determinations.) The servings of food were placed in the jar at the same time that the girls were served at the table. The milk sample was collected in a similar jar but only one-fourth of a glass was put in each day, giving one homogeneous milk sample for analysis. A record was kept of the number of glasses of milk consumed each day by each girl and suitable additions were then made to each individual's food intake to include the milk. The jars containing the meals were kept in the refrigerator until they could be collected for analysis. After weighing each jar, each meal was macerated in the Waring blendor and then the three meals were combined and macerated. Jars were kept in the refrigerator until the food was analyzed.

To mark the feces 0.5 gram of carmine was given in capsule form the night before the first meal of the test period and again following the last meal of the 5 day test period. In some instances meals were eaten outside the house. In this case duplicates of the foods eaten were collected in a glass jar containing metaphosphoric acid.

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*Furnished by the Ball Brothers Company.

Appropriate corrections were made for that individual's day's food intake. The feces were collected in weighed, pint size, wide mouth, Special Ball jars suitably labeled and numbered. The weight of each girl's moist feces was obtained, the total was macerated in the Waring blendor, and was kept in the refrigerator until carotene and vitamin A analyses could be made.

## DISCUSSION OF RESULTS

Recoveries for carotene and vitamin A, Table 1, made simultaneously on food samples ranged from 92 to 100 with an average of 97 per cent and from 85 to 106 with an average of 97 per cent, respectively.

The average daily carotene and vitamin A values of composite food samples representing the food consumed by 27 college women living in the Home Management House at North Texas State College are given in Table 2. These were studied as 6 different groups, the members of each group consuming the same foods for that period. Total vitamin A (carotene plus vitamin A) is given for comparison with the estimated values calculated from published tables. The total vitamin A of composite foods as determined in this study averages from 8658 to 26075 International Units per day, while the vitamin A estimated from published tables ranged from 4893 to 13762 International Units per day. In all cases the determined vitamin A was higher than the estimated vitamin A. This is understandable, since some of the foods consumed were not listed, the exact content of many prepared dishes such as meat loaf, potato salad, souffle and others was not known, and the exact weight of all the individual foods of the composite food samples was not known.

Table 1

CAROTENE AND VITAMIN A RECOVERIES

| Carotene | | | | | Vitamin A | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Determined in sample | Amount added | Total determined | Carotene recovered | | Determined in sample | Amount added | Total determined | Vitamin A recovered | |
| mcg. | mcg. | mcg. | mcg. | % | mcg. | mcg. | mcg. | mcg. | % |
| 33.0 | 18.0 | 49.5 | 16.5 | 92 | 79.7 | 50.0 | 133.0 | 53.3 | 106 |
| 48.0 | 24.0 | 72.0 | 24.0 | 100 | 104.7 | 100.0 | 189.0 | 84.7 | 85 |
| 20.5 | 30.0 | 50.0 | 29.5 | 98 | 114.8 | 75.0 | 191.4 | 76.6 | 102 |
| Average | | | | 97 | Average | | | | 97 |

Carotene comprised from 5 to 56 per cent of the total daily vitamin A intake in periods I, II, and IV. Only 3 girls, M.G.M., L.D.W., and M.J.C., in period III participated in the study. Two of these subjects ate two meals outside of the house, but since both girls ate the same foods the analyses were made together. The two meals eaten by the girl remaining at the house were also determined together. Since it was found that determinations made on one composite sample for the 5 day period agreed within 10 per cent of the total daily determinations, the remainder of the meals for that period were macerated and all analyses made on one composite sample. The food in periods V and VI was treated in the same way. Consequently, no daily values are shown for periods III, V, and VI. The average per cent of carotene in the total vitamin A for M.G.M. and for L.D.W. and M.J.C. for period III was 26 per cent for the former and 27 for the latter two. The average per cent of total vitamin A as carotene for periods V and VI was 41 and 28 per cent, respectively. For all periods the average carotene composition of the diet was 27 per cent of the total vitamin A.

The total vitamin A (carotene plus vitamin A) content of these diets may be compared with those of Lesher et al. (1947)[13]. The total estimated vitamin A content of the

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[13] Marjorie Lesher, James Brody, Harold Williams, and Icie G. Macy, "Metabolism of Women During the Reproductive Cycle. X. The Utilization of Vitamin A During Lactation", Journal of American Dietetic Association, XXIII (1947), 211-217.

Table 2

THE AVERAGE DAILY CAROTENE AND VITAMIN A CONTENT OF COMPOSITE FOOD SAMPLES CONSUMED BY COLLEGE WOMEN*

| Period | Day | Carotene | Vitamin A | Total Vitamin A | Estimated Vitamin A |
|---|---|---|---|---|---|
| | | I.U. | I.U. | I.U. | I.U. |
| I | 1 | 3393 | 11095 | 14488 | 10929 |
| | 2 | 789 | 5678 | 6467 | 2470 |
| | 3 | 450 | 4360 | 4810 | 3053 |
| | 4 | 1700 | 7740 | 9440 | 2043 |
| | 5 | 825 | 7258 | 8083 | 5970 |
| | Total | 7157 | 36131 | 43288 | 24465 |
| | Av/day | 1431 | 7226 | 8658 | 4893 |
| II | 1 | 5391 | 7504 | 12895 | 11506 |
| | 2 | 6760 | 34757 | 41517 | 13735 |
| | 3 | 1378 | 8179 | 9557 | 6657 |
| | 4 | 2493 | 9089 | 11582 | 5635 |
| | 5 | 1590 | 5498 | 7088 | 2396 |
| | Total | 17612 | 65047 | 82639 | 39929 |
| | Av/day | 3522 | 13010 | 16528 | 7985 |
| III Total (M.C.M.) | | 24404 | 69053 | 93457 | 33936 |
| | Av/day | 4881 | 13811 | 18691 | 6787 |
| Total (L.D.W. & N.J.C.) | | 24525 | 66784 | 91309 | 37618 |
| | Av/day | 4905 | 13357 | 18262 | 7524 |
| IV | 1 | 3550 | 9676 | 13226 | 10808 |
| | 2 | 9048 | 7065 | 16113 | 5477 |
| | 3 | 583 | 9575 | 10158 | 4552 |
| | 4 | 375 | 6328 | 6703 | 11145 |
| | 5 | 5579 | 21714 | 27293 | 14966 |
| | Total | 19135 | 54358 | 73493 | 46948 |
| | Av/day | 3827 | 10872 | 14699 | 9390 |
| V | Total (4 days) | 33252 | 46690 | 79942 | 55050 |
| | Av/day | 8313 | 11672 | 19985 | 13762 |
| VI | Total (4 days) | 29349 | 74950 | 104299 | 28235 |
| | Av/day | 7337 | 18837 | 26075 | 7059 |

*Milk is not included in these figures. For each glass of milk per day add 750 I. U. of vitamin A.

daily diets ranged from 0.91 to 13.3 milligrams or 3913 to 57190 International Units daily, with an average total of 2.95 to 3.20 milligrams or 12685 to 13760 International Units. Their total estimated vitamin A included vitamin A plus 75% of the carotene, whereas this study included 100% of the carotene. Lesher et al.(1947)[14] assumed carotene to be 75% active, while in this study it was endeavored to determine the activity of the total carotene by calculating the amount utilized by the body by comparing the fecal carotene with the intake. Total vitamin A for the daily diets of periods I, II, and IV in this study ranged from 6467 to 41517 International Units daily. Average total vitamin A for the six periods ranged from 8658 to 26075 International Units daily. Therefore, all of the total vitamin A values for average intakes of this study are higher than the former.

The food pattern of the self-selected diets eaten by these girls in the Home Management House follows:[15]

Breakfast

Fruit or Fruit Juice

Cereal

Eggs

Toast Butter Jelly

Coffee or Milk

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[14]Lesher, op. cit.

[15]For the detailed menus see Appendix.

Lunch

Meat or Substitute

Vegetable

Salad

Bread Butter

Dessert

Drink

Dinner

Meat or Substitute

Vegetable Vegetable

Salad

Bread Butter

Dessert

Drink

This pattern gives a heavier lunch plan than that consumed by many. It, however, is similar to the meal patterns the girls are accustomed to eating at the dormitories on the campus.

Individual differences in likes and needs were permitted by the separate analysis of the milk. The total milk consumption for each girl was added to the composite food sample (Table 2) before determining the daily averages shown in Table 3. For each glass of milk ingested per day 750 International Units of vitamin A was added. The milk

Table 3

AVERAGE DAILY CAROTENE AND VITAMIN A INTAKE AND EXCRETION IN FECES

| Subjects | Intake | | Fecal Output | | | |
|---|---|---|---|---|---|---|
| | Carotene | Vitamin A | Carotene | Vitamin A | Carotene | Vitamin A |
| | I.U. | I.U. | I.U. | I.U. | % | % |
| P.B.(4)* | 1431 | 7826 | 883 | 6178 | 62 | 79 |
| J.L.C.(7 1/2)* | 1431 | 8351 | 3798 | 5618 | 265 | 67 |
| L.M.H.(13)* | 1431 | 9176 | 1662 | 2916 | 116 | 32 |
| A.C.(2 1/3)* | 3522 | 13370 | 3479 | 787 | 98 | 5 |
| B.B.(12 1/2)* | 3522 | 14821 | 1855 | 3441 | 52 | 23 |
| J.B.(1)* | 3522 | 16160 | 1966 | 1876 | 56 | 12 |
| E.E.(7 3/4)* | 3522 | 14173 | 3828 | 1837 | 108 | 13 |
| F.B.(7 3/4)* | 3522 | 14173 | 2313 | 2252 | 65 | 16 |
| L.S.(12 1/2)* | 3522 | 14885 | 2393 | 1288 | 68 | 8 |
| L.D.W.(8)* | 4905 | 14557 | 5159 | 2455 | 105 | 17 |
| M.G.M.(14)* | 4881 | 15911 | 4435 | 4057 | 90 | 26 |
| M.J.C.(0)* | 4905 | 13357 | 4408 | 2521 | 89 | 19 |
| M.J.(1)* | 4394 | 8922 | 3109 | 8074 | 71 | 90 |
| P.A.(1)* | 4394 | 8922 | 7413 | 1353 | 169 | 15 |
| L.H.(10)* | 3827 | 12372 | 3997 | 1548 | 104 | 12 |
| G.R.(9)* | 2179 | 13889 | 2149 | 3527 | 98 | 25 |
| L.B.(10)* | 8313 | 13172 | 3973 | 1872 | 48 | 14 |
| E.M.R.(14)* | 8313 | 13772 | 6138 | 4586 | 74 | 33 |
| B.K.(6)* | 8313 | 12572 | 5507 | 0 | 66 | 0 |
| B.G.(9)* | 8313 | 13030 | 4361 | 3149 | 52 | 24 |
| D.B.(6)* | 8313 | 12572 | 2400 | 1670 | 29 | 13 |
| J.C.(7)* | 8313 | 12722 | 1874 | 634 | 23 | 5 |
| C.R.(13)* | 7337 | 20787 | 10463 | 1488 | 142 | 7 |
| M.R. (11)* | 7337 | 20487 | 4397 | 1027 | 59 | 5 |
| M.C.(12 1/2)* | 7337 | 19712 | 10208 | 4050 | 139 | 21 |
| F.D.(7 1/2)* | 7337 | 19962 | 5946 | 5880 | 81 | 29 |
| M.H.B.(8)* | 7337 | 20037 | 6772 | 2445 | 92 | 12 |

*Represents total number of glasses of milk consumed by the subject. For each glass, 750 I.U. of vitamin A was added to the day's vitamin A intake. No carotene was found in these samples of milk.

ingested ranged from 1 to 14 glasses during a period or from 1/5 to 2 4/5 glasses per day. The amount of milk consumed added appreciable amounts of vitamin A to the daily diet. For instance, the first 3 girls listed in Table 3 participated in the same study. Even so, their daily vitamin A intake varied, not because of meals eaten out, but because of the amount of milk ingested. L.M.H. consumed 13 glasses in the 5 day period as compared with P.B., who only consumed 4 glasses of milk during the same period of time. Their total daily vitamin A varied accordingly, 9176 as compared with 7826.

From Table 3 it will be seen that subjects D.B. and J. C. excreted 29 and 23 per cent of the carotene, respectively. This means they were able to absorb as much as 71 and 77 per cent of the carotene. Five of the 27 subjects excreted from 48 to 59 per cent; seven excreted from 62 to 81 per cent; and five others excreted 89 per cent or more. This means that 5 absorbed from 41 to 52 per cent, 7 from 19 to 38 per cent, and 5 others 11 per cent or less. The other 8 excreted a larger per cent than was taken in. The higher excretion of 108, 105, and 104 per cent of subjects E.E., L.D.W., and L.H. may be considered within the range of error. However, subjects J.L.C., L.M.H., P.A., C.R., and M.C. had excretions of 265, 116, 169, 149, and 139 per cent.

Wald, Carroll, and Sciarra (1941)[16] found that excretion of carotene begins after 3 to 5 days and ceases after 5 to 7 days. This delayed action may be the causal factor for the high excretion values observed for certain subjects in the present study.

One of the 27 subjects, B.K., with an absorption of 100 per cent, excreted no vitamin A in the feces. Five subjects excreted 10 per cent or less of the vitamin A, showing an absorption of 90 per cent or more. Ten excreted between 10 and 20 per cent, 6 between 20 and 30 per cent, and 2 between 30 and 40 per cent. The absorption of 10 subjects was between 80 and 90 per cent; of 6, between 70 and 80 per cent; of 2, between 60 and 70 per cent. Subjects M.J., P.B., and J.L.C. excreted 90, 79, and 67 per cent, giving absorptions of 10, 21, and 33 per cent. Only one of these three, J.L.C., was also among those excreting excessive amounts of carotene.

The absorption of vitamin A per day for the 27 subjects ranged from 848 to 19460 International Units. Absorption per kilogram ranged from 11.3 to 382.3 International Units; per centimeter, 5.2 to 126.5 International Units; per square meter of body surface, 540 to 12316 International Units. The ability to absorb vitamin A was unrelated to kilograms of body weight, per cent of overweight or

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[16]Wald, Carroll, and Sciarra, op. cit.

underweight, height in centimeters, and to square meters of body surface. No attempt was made to evaluate carotene in this manner.

From a balance standpoint all of the 27 college women on self-selected diets had a positive vitamin A balance, while all but 8 had a positive carotene balance. Five with negetive balances were exceedingly high and unrelated to the amount ingested.

## SUMMARY

The carotene and vitamin A intake and fecal output of a group of 27 college women on self-selected diets were determined by chemical analysis.

The average daily carotene and vitamin A content of the 6 periods studied ranged from 1431 to 8313 and from 7226 to 18837 International Units, respectively. The total vitamin A (carotene plus vitamin A) ranged from 8658 to 26075 International Units.

Two of the 27 subjects were able to absorb as much as 71 and 77 per cent of the carotene ingested. Five others absorbed from 41 to 52 per cent, seven, 19 to 38 per cent, 5 less than 11 per cent, and the other 8 excreted more than was consumed.

One of the 27 subjects absorbed 100 per cent vitamin A. Five absorbed 90 per cent or more, 10 between 80 and 90 per cent, 6 between 70 and 80 per cent, and 2 between 60 and 70 per cent. The other 3 subjects absorbed 10, 21, and 33 per cent of the vitamin A intake.

No relation was found between vitamin A absorption and kilograms of body weight, per cent of overweight or underweight, height in centimeters, or square meters of body surface.

# APPENDIX

Table 4

BASIC PHYSICAL AND CHEMICAL DATA OF SUBJECTS

| Subject | Age | Height | Weight | Predicted Normal wt.* | Underweight or Overweight | Chest Width | Hip Width | Body Surface |
|---|---|---|---|---|---|---|---|---|
| | | cm. | kg. | kg. | % | cm. | cm. | sq. m. |
| M.G.M. | 17 | 153.7 | 45.0 | 52.1 | - 13 | 24.0 | 27.0 | 1.38 |
| P.B. | 18 | 157.5 | 51.6 | 56.9 | - 9 | 20.6 | 30.4 | 1.49 |
| E.E. | 18 | 163.7 | 55.8 | 61.2 | - 8 | 21.3 | 32.1 | 1.59 |
| M.J. | 18 | 161.9 | 55.0 | 63.2 | - 13 | 25.5 | 31.6 | 1.57 |
| L.H. | 18 | 169.4 | 72.7 | 72.3 | 0 | 27.5 | 34.0 | 1.84 |
| B.K. | 18 | 166.9 | 56.6 | 72.3 | - 21 | 27.7 | 33.9 | 1.63 |
| C.R. | 18 | 160.0 | 61.4 | 65.9 | - 7 | 25.1 | 33.7 | 1.64 |
| B.G. | 18 | 166.3 | 78.6 | 79.1 | - 1 | 27.5 | 36.8 | 1.87 |
| L.B. | 18 | 156.3 | 51.4 | 65.0 | - 21 | 26.4 | 31.1 | 1.47 |
| G.R. | 19 | 158.4 | 65.4 | 70.0 | - 7 | 27.1 | 33.5 | 1.68 |
| M.J.C. | 19 | 158.4 | 64.5 | 66.3 | - 3 | 27.0 | 33.5 | 1.67 |
| J.B. | 19 | 151.2 | 47.7 | 50.3 | - 5 | 19.4 | 26.7 | 1.37 |
| L.D.W. | 19 | 161.2 | 50.8 | 64.1 | - 20 | 25.0 | 31.1 | 1.51 |
| D.B. | 19 | 146.3 | 59.8 | 64.1 | - 7 | 28.3 | 31.9 | 1.51 |
| M.C. | 19 | 159.4 | 50.5 | 63.6 | - 21 | 25.5 | 31.7 | 1.50 |
| M.R. | 19 | 153.8 | 50.9 | 62.7 | - 19 | 27.0 | 32.0 | 1.58 |
| B.B. | 20 | 156.9 | 57.7 | 58.7 | - 1 | 23.2 | 31.2 | 1.54 |
| F.B. | 20 | 151.2 | 46.8 | 49.2 | - 6 | 21.7 | 26.5 | 1.38 |
| L.S. | 20 | 161.9 | 51.3 | 57.4 | - 10 | 21.7 | 29.2 | 1.51 |
| M.H.B. | 20 | 161.9 | 51.4 | 64.5 | - 20 | 25.6 | 31.4 | 1.52 |
| J.C. | 20 | 153.1 | 49.5 | 57.4 | - 13 | 23.4 | 31.2 | 1.44 |
| E.M.R. | 20 | 164.4 | 50.5 | 60.0 | - 16 | 23.7 | 30.2 | 1.54 |
| J.L.C. | 21 | 165.0 | 62.7 | 60.6 | + 3 | 22.5 | 30.1 | 1.69 |
| P.A. | 21 | 165.0 | 66.7 | 74.1 | - 9 | 28.4 | 34.0 | 1.74 |
| L.M.H. | 22 | 162.5 | 56.3 | 60.1 | - 6 | 22.1 | 30.0 | 1.58 |
| F.D. | 22 | 163.1 | 56.7 | 65.4 | - 13 | 25.7 | 32.6 | 1.59 |
| A.C. | 33 | 156.9 | 72.2 | 61.2 | + 15 | 23.7 | 31.8 | 1.71 |

*As calculated from Stanford weight tables.

Table 4—Continued

| Vitamin A Absorbed | | | | | | | |
|---|---|---|---|---|---|---|---|
| Per day | Per kg. per day | Per cm. per day | Per sq. meter per day | Per Cent | Per cent per kg. | Per cent per cm. | Per cent per sq. m. |
| I.U. | I.U. | I.U. | I.U. | % | % | % | % |
| 11854 | 263.4 | 77.1 | 8589 | 74 | 1.64 | 0.48 | 53.6 |
| 1648 | 31.9 | 10.5 | 1106 | 21 | 0.41 | 0.13 | 14.1 |
| 12336 | 221.1 | 75.3 | 7758 | 87 | 1.56 | 0.53 | 54.7 |
| 848 | 15.4 | 5.2 | 540 | 10 | 0.19 | 0.06 | 6.3 |
| 10824 | 148.9 | 63.9 | 5882 | 88 | 1.21 | 0.52 | 47.8 |
| 12572 | 222.1 | 75.3 | 7713 | 100 | 1.77 | 0.59 | 61.3 |
| 19299 | 314.3 | 120.6 | 11767 | 93 | 1.51 | 0.58 | 56.7 |
| 9881 | 125.7 | 59.4 | 5284 | 76 | 0.97 | 0.45 | 40.6 |
| 11300 | 219.8 | 72.3 | 7687 | 86 | 1.67 | 0.55 | 58.5 |
| 10362 | 158.4 | 65.4 | 6168 | 75 | 1.14 | 0.47 | 44.6 |
| 10836 | 168.0 | 68.4 | 6488 | 81 | 1.25 | 0.51 | 48.5 |
| 14284 | 299.4 | 94.5 | 10426 | 88 | 1.84 | 0.58 | 64.2 |
| 12102 | 238.2 | 75.0 | 8014 | 83 | 1.63 | 0.51 | 54.9 |
| 10902 | 182.3 | 74.5 | 7219 | 87 | 1.45 | 0.59 | 57.6 |
| 15662 | 310.1 | 98.2 | 10441 | 79 | 1.56 | 0.49 | 52.6 |
| 19460 | 382.3 | 126.5 | 12316 | 95 | 1.86 | 0.62 | 60.1 |
| 11380 | 197.2 | 71.9 | 7389 | 77 | 1.33 | 0.49 | 50.0 |
| 11921 | 254.7 | 78.8 | 8638 | 84 | 1.79 | 0.55 | 60.8 |
| 13597 | 265.0 | 83.9 | 9005 | 92 | 1.79 | 0.57 | 60.9 |
| 17592 | 342.1 | 108.6 | 11573 | 88 | 1.71 | 0.54 | 57.9 |
| 12088 | 244.2 | 78.9 | 8394 | 95 | 1.91 | 0.62 | 61.7 |
| 9186 | 181.9 | 55.9 | 5965 | 67 | 1.32 | 0.41 | 43.5 |
| 2733 | 43.6 | 16.6 | 1617 | 33 | 0.52 | 0.20 | 19.5 |
| 7570 | 11.3 | 45.9 | 4350 | 85 | 1.27 | 0.51 | 48.8 |
| 6260 | 111.1 | 38.5 | 3962 | 68 | 1.21 | 0.42 | 43.0 |
| 14082 | 248.3 | 86.3 | 8856 | 71 | 1.25 | 0.43 | 44.6 |
| 12583 | 174.2 | 80.2 | 7914 | 95 | 1.31 | 0.61 | 55.5 |

# MENUS

## Group I

**Monday Nov. 18**

Breakfast - Tomato juice, oats with top milk, buttered toast, coffee or milk.
Lunch - Creamed asparagus on toast, stewed tomatoes, grape salad, Indian pudding.
Dinner - Meat loaf, spinach, mashed potatoes, lettuce salad, cake and peaches.

**Tuesday Nov. 19**

Breakfast - Fried eggs, toast and jelly, coffee or milk.
Lunch - Potato salad, meat loaf sandwiches, cake.
Dinner - Hamburgers, corn chips, lettuce, tomato and pepper salad, sweet roll, milk.

**Wednesday Nov. 20**

Breakfast - Cream of wheat with top milk, buttered toast, canned peaches, coffee or milk.
Lunch - Cheese toast, Harvard beets, green bean salad, prune whip, milk.
Dinner - Meat loaf, cabbage and carrot salad, parsley buttered potatoes, mince meat pie, coffee or milk.

**Thursday Nov. 21**

Breakfast - Cooked cereal with top milk, buttered toast and jelly, milk or coffee.
Lunch - Cream of onion soup, stewed fruit, bread and butter, cookies, milk.
Dinner - Hamburger patties, potato salad, tomatoes, lettuce, onions, chocolate pudding, milk.

**Friday Nov. 22**

Breakfast - Cooked cereal with top milk, coffee cake and apricots, buttered toast and jelly, coffee, milk.
Lunch - Cream of potato soup, Welsh rarebit, cabbage salad, chocolate pudding, milk.
Dinner - Baked ham, baked potatoes, green bean salad, biscuits, apricot whip, coffee.

## Group II

**Monday Dec. 2**

Breakfast - Grapefruit and orange juice, wheaties and bran, toast and coffee.
Lunch - Broiled cheese sandwiches, potato chips, apple, celery, raisin salad, chocolate cookies, milk.
Dinner - Spanish rice, spinach, apricot salad, chocolate drop cookies, coffee.

Tuesday Dec. 3
Breakfast - Orange juice, scrambled eggs, muffins, coffee.
Lunch - Salmon and apple salad, French fried potatoes, crackers, vanilla custard, hot tea.
Dinner - Liver, peas, carrot strips, cornbread sticks, gingerbread.

Wednesday Dec. 4
Breakfast - Apple sauce, oatmeal, muffins, coffee.
Lunch - Cream of potato soup, lettuce and tomato salad, crackers, sugar cookies, milk.
Dinner - Baked beans, sweet potatoes, apricot salad, cornbread, fruit cup, coffee.

Thursday Dec. 5
Breakfast - Grapefruit juice, scrambled eggs, cinnamon toast, coffee.
Lunch - Pea and cheese salad, mashed sweet potatoes, biscuits, peaches and cookies, coffee.
Dinner - Pork chops, baked potatoes, green beans, head lettuce salad, baked apples, coffee.

Friday Dec. 6
Breakfast - Prunes, wheaties, toast, coffee.
Lunch - Bakes beans, carrot and apple salad, toast, milk, peaches and cookies.
Dinner - Frankfurters, Spanish rice, slaw, biscuits, apple sauce and cheese, milk.

Group III

Monday March 17
Breakfast - French toast with syrup, grapefruit juice, coffee.
Lunch - Brown beans, carrot and beet salad, peanut butter and apple sandwiches, milk.
Dinner - Creamed eggs on toast, buttered rice, candied sweet potatoes, celery curls, apple pie, milk.

Tuesday March 18
Breakfast - Grapefruit juice, scrambled eggs, toast, coffee.
Lunch - Cream of tomato soup, buttered crackers, cabbage, apple, and celery salad, gingerbread with whipped cream, milk.
Dinner - Macaroni and cheese, green beans, Harvard beets, fresh spinach and egg salad, biscuits, butter, chocolate pinwheel cookies, hot tea.

Wednesday March 19
Breakfast - Tomato juice, cream of wheat, toast, coffee.
Lunch - Peanut butter and banana sandwiches, peanut butter and jelly sandwiches, stuffed eggs on wedges of lettuce, chocolate pinwheel cookies, milk.
Between meals - Peanut butter and jelly sandwich.
Dinner - Braised liver and onions, buttered carrots, rice, English pea salad with onion and cheese, biscuits, butter, orange tea cakes with 7-minute frosting, coffee.

Thursday March 20
Breakfast - Grapefruit, orange cloverleaf rolls, coffee.
Lunch - Meat cup filled with pinto beans, fruit cup, slices of tomato, carrot strips and celery, cornbread, apricot sponge, hot tea.
Dinner - Tomato juice cocktail, leg of lamb, parsley buttered potatoes, brussels sprouts, frozen fruit salad, hot rolls, butter, chocolate eclairs, coffee.

Friday March 21
Breakfast - Grapefruit juice, fried eggs, toast, coffee.
Lunch - Grilled cheese sandwiches, lettuce and tomato salad, carrot strips and celery, fruit cup, milk.
Dinner - Frito pie, pinto beans, cole slaw, Ritz crackers, baked apples, coffee.

Monday March 17 L.D.W. & M.J.C.
Lunch - Steak, green beans, potato salad, rolls, butter, chocolate ice cream.

Wednesday March 19 L.D.W. & M.J.C.
Lunch - Steak, potatoes, jello salad, butter, apricot pie.

Group IV

Monday March 17
Breakfast - Grapefruit halves, cream of wheat, toast, apple butter, milk.
Lunch - Lima beans with bacon, spinach, buttered carrots, rolls, ice box cookies, milk.
Dinner - Roast beef, potatoes, green beans, toast, devilled egg salad, ice box cookies, milk.

Tuesday
March 18

Breakfast - Tomato juice, scrambled eggs, toast, apple butter, milk.
Lunch - Tomato soup, crackers, egg and lettuce salad, gingerbread, milk.
Dinner - Mackeral salad, creamed potatoes, green beans, rolls, butter, fruit cup, cookies, iced tea.

Wednesday
March 19

Breakfast - Grapefruit juice, rolled oats, toast, apple butter, coffee.
Lunch - Egg in potato nests, green pepper and celery, English peas, rolls, butter, peppermint ice cream, ice box cookies, milk.
Dinner - Fruit juice cocktail, roast beef, buttered beets, potatoes, rolls, butter, congealed vegetable salad, lemon pie, coffee.

Thursday
March 20

Breakfast - Orange juice, malt o'meal, buttered toast, coffee.
Lunch - Bacon and egg sandwich, toast, English peas, cookies, milk.
Dinner - Liver and onions, cabbage slaw, gravy, rolls, butter, chocolate pudding, milk.

Friday
March 21

Breakfast - Grapefruit juice, scrambled eggs, biscuits, butter, apple butter, milk.
Lunch - Oatmeal souffle, boiled potatoes, spinach, prune salad, baked custard, hot tea.
Dinner - Sausage patties with macaroni and cheese, buttered broccoli, lettuce salad, upside down muffins, rolls, milk.

Group V

Monday
May 5

Breakfast - Orange juice, fried eggs, toast and jelly, milk or coffee.
Lunch - Beet and pea salad, toasted cheese sandwiches, spinach with grated eggs, stewed apricots, tea.
Dinner - Cabbage rolls, fried potatoes, celery and carrot strips, fruit salad, tea.

Tuesday
May 6

Breakfast - Grapefruit juice, scrambled eggs, butter and jelly, hot biscuits, coffee or milk.
Lunch - Navy beans and grated cheese, fresh spinach, hominy, apple sauce, buttered beets, tea.
Dinner - Fried fish, gravy, mashed potatoes, cabbage, apple salad, green beans, banana ice cream, tea.

Wednesday May 7
Breakfast - Grapefruit juice, French toast, syrup and jelly, milk.
Lunch - Baked ham, candied sweet potatoes, fresh spinach, grapefruit avacado salad, hot rolls, coffee ice cream, tea.
Dinner - Weiners in chili sauce, ranch style beans, candied yams, pineapple pie, hot rolls, milk.

Thursday May 8
Breakfast - Orange slices, coddled eggs, graham muffins, butter, jelly, milk or coffee.
Lunch - Potato salad in bologna cups, buttered squash, corn bread, lemon custard, tea.
Dinner - Fried liver, onion rings, corn cottage cheese salad, hot biscuits, prune whip, tea.

Group VI

Monday May 5
Breakfast - Grapefruit juice, rice with cream and sugar, buttered toast, milk or coffee.
Lunch - Escalloped potatoes, stewed cabbage, buttered beets, cottage cheese and egg salad, plain muffins, cup cakes with chocolate frosting, milk.
Dinner - Meat pie with catsup biscuits, English peas, corn, head lettuce salad, fruit salad, milk.

Tuesday May 6
Breakfast - Orange juice, grape-nuts flakes, bananas, milk or coffee.
Lunch - Vegetable soup, devilled eggs on lettuce cup, buttered toast strips, frozen fruit jello, milk.
Dinner - Broiled Spam, mashed potatoes, spinach, carrot and cabbage salad, buttered toast, peaches with whipped cream.

Wednesday May 7
Breakfast - Grapefruit halves, scrambled eggs, gravy, buttered toast, milk or coffee.
Lunch - Stuffed peppers, buttered carrots, hominy, tomato and lettuce salad, whole wheat muffins, oatmeal cookies, milk.
Dinner - Potato salad, green beans, carrot strips and tomato slices, buttered toast, brownies, tea.

Thursday May 8
Breakfast - Tomato juice, poached eggs on toast, jelly, milk or coffee.
Lunch - English pea salad, devilled eggs, carrot strips, toasted cheese sandwiches, peaches and whipped cream, milk or tea.
Dinner - Sauer kraut and weiners, fried potatoes, buttered beets, cottage cheese salad, raisin pie, hot biscuits, milk.

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