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COBALT METABOLISM OF YOUNG COLLEGE WOMEN
ON SELF-SELECTED DIETS

THESIS

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INTRODUCTION

Cobalt as a trace inorganic element has long been recognized according to Martin (1945)¹ as a nutritional essential in ruminants in whom cobalt deficiency is a typical anemia. For that reason emphasis has been placed upon studies with ruminants, since it seems logical to use a species for which cobalt is known to be essential.

The significance of trace amounts of cobalt in the therapy of iron deficiency anemias in man is also well known, Underwood (1937).² Sherman (1946)³ is of the opinion that cobalt is essential in the body, but as yet there is no consensus of opinion upon quantitative estimates.

Comar (1947)⁴ reported on tissue distribution and concentration of radioactive cobalt given by vein and orally to rabbits, swine, and young calves. No species difference of cobalt metabolism or distribution was noted. Young calves

¹C. J. Martin, "Diseases of Stock in Australia Caused by Deficiency of Cobalt and of Both Cobalt and Copper," Chemical Abstracts, XXXIX, Part 2 (1945), 3828.

²E. J. Underwood, "Cobalt Content of Iron Compounds and Its Possible Relation to Treatment of Anemia," Society for Experimental Biology and Medicine, XXXVI (1937), 296.

³Henry C. Sherman, Chemistry of Food and Nutrition, seventh edition, pp. 226-234.

⁴C. L. Comar and G. K. Davis, "Cobalt Metabolism Studies IV. Tissue Distribution of Radio Active Cobalt Administered to Rabbits, Swine, and Young Calves," Journal of Biological Chemistry, CLXX (1947), 379-389.

absorbed more from the intestinal tract than did older animals, but the tissue distribution was the same. About 65 per cent of the cobalt was ultimately excreted in the urine and about 30 per cent in the feces.

Greenberg (1943)⁵ also reports that urine was the chief pathway for the excretion of cobalt except when orally administered.

Comar (1947)⁶ also reported that when cows were injected with cobalt, large amounts appeared rapidly in the urine, indicating that urine is a major route of excretion for cobalt in the general circulation. The excretion values of the injected cobalt indicated that the animals do not store it and that cobalt should, therefore, be supplied more or less continuously in the diet for normal health of ruminants.

The analysis of cobalt in milk was reported by Underwood and Elvehjem (1938).⁷ Samples of milk were analyzed in duplicate for cobalt on five occasions. The results ranged from 8 to 16 micrograms of cobalt per liter, with a mean of

⁵D. M. Greenberg, H. D. Copp, and E. M. Cuthbertson, "The Distribution and Excretion, Particularly by Way of the Bile, of Iron, Cobalt and Manganese," Journal of Biological Chemistry, CXLVII (1943), 749.

⁶C. L. Comar, "The Internal Metabolism of Cobalt and Copper As Studied with Their Radioactive Isotopes," Proceedings of the Auburn Conference on the Use of Radioactive Isotopes in Agricultural Research, December 18-20, (1947), 137.

⁷E. J. Underwood and C. A. Elvehjem, "Is Cobalt of Any Significance in the Treatment of Milk Anemia with Iron and Copper," Journal of Biological Chemistry, CXXIV (1938), 419.

11 micrograms. The levels found are of interest in view of the claims of Wright and Papish (1929)⁸ and Blumberg and Rask (1933)⁹ that milk is "spectrographically free" of cobalt. Both Sylvester (1940)¹⁰ and Ahmad (1938)¹¹ also reported cobalt in milk. However, Ahmad's values were much higher than Sylvester's; Ahmad reported 6.0 micrograms in 100 grams of whole milk and 4.6 to 6.0 micrograms per 100 grams of powdered, skimmed milk, as compared with Sylvester's values of 0.01 micrograms per 100 grams of whole milk. Considerable variation also existed in the cobalt content of other foods analyzed. The values for beans and peas varied from 18.0 to 47.5 micrograms and 14.0 to 42.0 micrograms per 100 grams of dry material, respectively. Cereal grains, with the exception of three samples, ranged from 6.0 to 8.0 micrograms. Milling decreases the cobalt content of wheat, according to Sylvester (1940).¹² Straight grade flour contained 0.6 micrograms of cobalt per 100 grams; whereas whole wheat flour contained 5.0 micrograms of cobalt.

⁸N. C. Wright and J. Papish, "The Inorganic Constituents of Milk," Science, LXIX (1929), 78.

⁹H. Blumberg and O. S. Rask, "The Spectrographic Analysis of Milk Ashes," Journal of Nutrition, VI (1933), 285.

¹⁰N. D. Sylvester and L. H. Lampitt, "The Determination of Cobalt in Foods," Journal of the Society of Chemical Industry, LIX (1940), 57.

¹¹Basher Ahmad and E. V. McCollum, "The Cobalt Content of Some Food Materials from Different Parts of the United States," American Journal of Hygiene, XXIX (1939), 24.

¹²Sylvester and Lampitt, op. cit.

With the growing interest in cobalt as a result of its discovery in the B₁₂ molecule, this study was undertaken to determine the cobalt intake in food and milk, and the excretion of cobalt in the urine and feces of young college women living in the home management house and consuming a self-selected diet.

PROCEDURE

The subjects used in this study were young college women between the ages of seventeen and twenty-two years who were living in the Home Management House, North Texas State College, at the time of their participation in the study. Eleven girls lived in the house during March, and twelve lived there during May. It is a duplex accommodating seven girls on each side. Since all of the girls living on the same side of the duplex have identical food each day, the analysis of one day's food supply provided the intake of a number of girls at one time. The only difference between the diets of Studies I and II, and of III and IV, was in the quantity consumed and a different food supply. In this study, samples of all food, feces, and urine were analyzed for the weeks of March 12-16 and April 30-May 4.

A serving of each food from each meal similar in all respects to those eaten by the college women was collected in weighed, eclipse, wide mouth, quart-sized Ball jars containing a known amount of 1 per cent metaphosphoric acid. The servings were placed in the jar at the same time that the girls were served at the table. One-fourth glass of milk was collected daily in a similar manner, thus giving one homogeneous sample for analysis. A record was kept of the number of glasses of milk consumed by each girl each day,

since this was the only variable in the daily food intake. Suitable additions were made to each individual's food intake to include the milk. The jars containing the composite foods from each meal were kept in the refrigerator until analysis. After each jar had been weighed with the food to get the total weight of each meal, the food was macerated in the Waring Blendor, and the same fraction of the weight of each of the three meals of each day was removed, again macerated, and kept in the refrigerator until analyzed.

Carmine was administered as previously reported by Holt and Scoular (1948).¹³ The feces were collected directly into weighed, pint-size, wide-mouth Special Ball jars which were suitably labeled and numbered. The weight of each girl's moist feces was obtained, the total macerated in the Waring Blendor, and kept in the refrigerator until analyzed.

The twenty-four-hour collection of urine was made directly into four-liter amber bottles containing 30 milliliters of 1.5 normal sulfuric acid, 5 milliliters of toluene, and 1 milliliter of 8-hydroxyquinoline (91.45 grams of hydroxyquinoline in 100 milliliters of 95 per cent alcohol). All analyses were made according to the standard procedure of Yoe and Barton (1940).¹⁴

¹³Flowayne Holt and F. I. Scoular, "Iron and Copper Metabolism of Young Women on Self-Selected Diets," Journal of Nutrition, XXXV (1948), 717.

¹⁴John H. Yoe and Charles J. Barton, "Colorimetric Determination of Cobalt with Beta Nitroso Alphanaphthol," Industrial and Engineering Chemistry, Analytical Edition, XII (1940), 405.

A standard curve was established for cobalt, using a photoelectric photometer with samples varying from 0.1 micrograms to 0.6 micrograms of cobalt by the following procedure: Ten milliliters of ammonium citrate reagent were put in a 100 milliliter volumetric flask with a known amount of cobalt and made up to volume with distilled water. After this had been heated just to boiling, 25 milliliters of alpha-nitroso-beta-naphthol reagent were added, and the solution was allowed to stand for two hours before it was filtered. The filter paper and the precipitate were washed with a suitable volume of distilled water to free them as much as possible from the color of the reagent and dried at 100 C. in a hot air oven. All samples were analyzed without a separate determination for the cobalt in distilled water, since the same source of distilled water and the same amount were used in all samples. The precipitate was extracted from the filter paper, using chloroform in 10 to 15 milliliter portions until it was absolutely colorless. The volume of the extract was made up to exactly 100 milliliters with chloroform. The Cenco-Sheard-Sanford photometer was set at 100 with a blank solution and readings were taken on the standard solutions using a 515 millimicron green filter. The calibration curve for cobalt is shown in Figure 1.

From the macerated food of known weight, a 25-gram sample was taken for analysis. The sample was weighed into a 50 milliliter porcelain crucible and then ashed in the electric

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Fig. 1.---Calibration curve for cobalt

muffle at a temperature not exceeding 800 degrees centigrade. When ashed, the sample was allowed to cool, and 5 milliliters of concentrated HCl were added to dissolve the sample, then neutralized with NH_4OH . The solution of the sample was then made up to volume as described above.

The same procedure as described above was followed for the feces determinations.

Thirty milliliters were used for the determination of cobalt in urine. The sample was evaporated in the hot air oven to dryness, and the cobalt determined by the same procedure as that described for food.

Cobalt recoveries from food for Studies I, II, III, and IV range from 90 to 110, 90 to 99, 96 to 99, and 93 to 108 per cent, respectively, as shown in Table 1; from urine, 94 to 108, 92 to 105, 92 to 109, and 92 to 102 per cent, Table 2; and from feces, Table 3, 93 to 108, 93 to 105, 92 to 107, and 91 to 107 for each of the four periods.

TABLE 1
RECOVERY OF COBALT ON COMPOSITE FOOD SAMPLES^a

Subject	Cobalt in Sample	Amount of Cobalt Added	Cobalt in Sample Plus Added Cobalt	Per Cent Recovery
	Micrograms			
Study I	.142	.1	.252	110
	.126	.1	.231	105
	.135	.1	.239	104
	.131	.1	.223	92
	.137	.1	.227	90
Study II	.154	.1	.250	96
	.118	.1	.211	93
	.166	.1	.259	93
	.124	.1	.223	99
	.109	.1	.199	90
Study III	.114	.1	.210	96
	.142	.1	.241	99
	.140	.1	.236	96
	.162	.1	.259	97
	.112	.1	.210	98
Study IV	.105	.1	.210	105
	.143	.1	.236	93
	.135	.1	.235	100
	.165	.1	.260	95
	.142	.1	.250	108

^aEach study represents five days.

TABLE 2
RECOVERY OF COBALT ON URINE^a

Subject	Cobalt in Sample	Amount of Cobalt Added	Cobalt in Sample Plus Added Cobalt	Per Cent Recovery
	Micrograms			
Study I				
A.H.	.102	.1	.210	108
B.L.L.	.114	.1	.220	106
P.S.	.106	.1	.210	104
P.L.W.	.118	.1	.220	102
E.J.C.	.106	.1	.200	94
V.MC.	.110	.1	.208	98
Study II				
B.K.B.	.136	.1	.231	95
B.H.	.105	.1	.210	105
A.J.R.	.100	.1	.204	104
F.L.S.	.118	.1	.210	92
P.L.	.124	.1	.220	96
Study III				
E.M.B.	.118	.1	.210	92
J.M.	.118	.1	.227	109
M.M.	.132	.1	.240	108
B.S.	.126	.1	.220	94
K.W.	.106	.1	.209	103
B.W.	.106	.1	.200	94
Study IV				
P.B.	.116	.1	.120	94
P.Ba.	.129	.1	.227	98
P.E.	.106	.1	.208	102
N.M.	.102	.1	.200	98
R.P.	.116	.1	.208	92
S.S.	.110	.1	.208	98

^aEach study represents five days.

TABLE 3
RECOVERY OF COBALT ON FECES^a

Subject	Cobalt in Sample	Amount of Cobalt Added	Cobalt in Sample Plus Added Cobalt	Per Cent Recovery
	Micrograms			
Study I				
A.H.	.132	.1	.240	108
B.L.L.	.106	.1	.208	102
P.S.	.140	.1	.236	96
P.L.W.	.105	.1	.210	105
E.J.C.	.105	.1	.200	95
V.MC.	.100	.1	.193	93
Study II				
B.K.B.	.171	.1	.264	93
B.H.	.126	.1	.231	105
A.J.R.	.106	.1	.208	102
F.L.S.	.168	.1	.259	91
P.L.	.100	.1	.200	100
Study III				
E.M.B.	.106	.1	.198	92
J.M.	.138	.1	.240	102
M.M.	.152	.1	.259	107
B.S.	.152	.1	.245	93
K.W.	.157	.1	.240	93
B.W.	.121	.1	.217	96
Study IV				
P.B.	.166	.1	.264	98
P.Ba.	.143	.1	.250	107
P.E.	.168	.1	.259	91
N.M.	.152	.1	.259	107
R.P.	.103	.1	.210	107
S.S.	.121	.1	.220	99

^aEach study represents five days.

DISCUSSION

The daily cobalt intakes and excretions of twenty-five college women were determined during two periods in the late spring of 1951.

The daily cobalt intake from composite food is given in Table 4. The range in cobalt intake during each of these studies was 4.01 to 5.85, 4.50 to 7.88, 3.74 to 6.80, and 3.63 to 6.92 micrograms, respectively. The average daily intake was from 5.11 to 5.63 micrograms, with the lowest intake during Study I. Since identical menus were used in Studies I and II, and in Studies III and IV, this difference is attributed to a slightly lower food consumption by the group during Study I.

The average daily cobalt intake from milk in Studies I, II, III, and IV was 0.89 to 2.49, 0.0 to 2.34, 1.45, and 1.10 to 1.75 micrograms, respectively. The amount of milk consumed by the individual subjects varied from 0 to 2.5 cups, with an average of 1.04 cups per subject. The separate analysis of milk made it possible for individual needs and preferences to be met. Study III is the only one in which each subject in the group consumed the same amount of milk, namely, 1.02 cups. Therefore, these six subjects had identical daily cobalt intakes. The milk source of Study I and Study II, and

TABLE 4
DAILY COBALT INTAKE OF COLLEGE WOMEN ON SELF-SELECTED DIETS

Micrograms of Cobalt in Food										
Subject	Daily Composite Food Samples						Milk Composite		Average Total Daily Intake	
							Av. No. Cups/Day	Av. /Day		
	1	2	3	4	5	Total				
Study I										
A.H.	4.87	5.07	4.01	5.85	5.75	25.55	5.11	2.17	2.02 ^a	7.28
B.L.L.	4.87	5.07	4.01	5.85	5.75	25.55	5.11	2.49	2.50	7.60
P.S.	4.87	5.07	4.01	5.85	5.75	25.55	5.11	1.19	1.04	6.30
P.L.W.	4.87	5.07	4.01	5.85	5.75	25.55	5.11	0.94	0.75	6.05
E.J.C.	4.87	5.07	4.01	5.85	5.75	25.55	5.11	1.22	1.25	6.33
V.MC.	4.87	5.07	4.01	5.85	5.75	25.55	5.11	0.89	0.66	6.00
Average	4.87	5.07	4.01	5.85	5.75	25.55	5.11	1.78	2.00	6.89
Study II										
B.K.B.	4.58	4.50	7.88	6.77	4.42	28.15	5.63	2.29	2.04	7.92
B.H.	4.58	4.50	7.88	6.77	4.42	28.15	5.63	1.70	1.06	7.33
A.J.R.	4.58	4.50	7.88	6.77	4.42	28.15	5.63	0.00	0.00	5.63
F.L.S.	4.58	4.50	7.88	6.77	4.42	28.15	5.63	1.99	1.00	7.62
P.L.	4.58	4.50	7.88	6.77	4.42	28.15	5.63	2.34	2.02	7.97
Average	4.58	4.50	7.88	6.77	4.42	28.15	5.63	1.66	1.04	7.29

TABLE 4--Continued

Subject	Micrograms of Cobalt in Food										Average Total Daily Intake
	Daily Composite Food Samples						Milk Composite				
	1	2	3	4	5	Total	Av./Day	Av. No. Cups/Day			
Study III	3.74	6.27	5.99	6.80	3.44	26.26	5.25	1.45	1.02	6.70	
	3.74	6.27	5.99	6.80	3.44	26.26	5.25	1.45	1.02	6.70	
	3.74	6.27	5.99	6.80	3.44	26.26	5.25	1.45	1.02	6.70	
	3.74	6.27	5.99	6.80	3.44	26.26	5.25	1.45	1.02	6.70	
	3.74	6.27	5.99	6.80	3.44	26.26	5.25	1.45	1.02	6.70	
	3.74	6.27	5.99	6.80	3.44	26.26	5.25	1.45	1.02	6.70	
Average	3.74	6.27	5.99	6.80	3.44	26.26	5.25	1.45	1.02	6.70	
Study IV	3.63	5.71	4.96	6.92	4.89	26.11	5.22	1.32	1.02	6.54	
	3.63	5.71	4.96	6.92	4.89	26.11	5.22	1.10	1.00	6.32	
	3.63	5.71	4.96	6.92	4.89	26.11	5.22	1.11	1.00	6.33	
	3.63	5.71	4.96	6.92	4.89	26.11	5.22	1.32	1.02	6.54	
	3.63	5.71	4.96	6.92	4.89	26.11	5.22	1.32	1.02	6.54	
	3.63	5.71	4.96	6.92	4.89	26.11	5.22	1.75	1.06	6.97	
Average	3.63	5.71	4.96	6.92	4.89	26.11	5.22	1.58	1.04	6.54	

^aRepresents average daily milk consumed in cups.

of Study III and Study IV, was the same, but a variation in the cobalt content was observed, namely, from 0.4 to 0.408 during Studies I and II, and 0.424 to 0.448 micrograms during Studies III and IV. The cobalt values of whole milk in this study are lower than those reported by Ahmad (1938),¹⁵ namely, 6.0 micrograms per 100 grams, and higher than the 0.01 micrograms per 100 grams of whole milk reported by Sylvester (1940).¹⁶ Subject B.L.L. of Study I had the highest average daily milk intake, two and one-half cups or 2.49 micrograms of cobalt, of the twenty-three subjects. Although the cobalt content of the milk was slightly lower during this study, the amount of milk consumed made a definite contribution to the total cobalt intake of all the subjects. This influence is further illustrated by A.J.K., who consumed no milk (Study II), and whose average daily cobalt intake was 5.63 micrograms as compared with 7.29 to 7.97 for the other subjects during the same study.

The average total daily cobalt intake (food plus milk) during Studies I, II, III, and IV was 6.00 to 7.60, 5.63 to 7.97, 6.70, and 6.32 to 6.97, respectively. The average for Study II was higher than that of the other three studies; it was associated with the largest daily composite food intake of cobalt.

¹⁵Ahmad and McCollum, op. cit.

¹⁶Sylvester and Lampitt, op. cit.

The average total daily excretion for Studies I, II, III, and IV ranged from 1.64 to 8.65, 3.98 to 7.43, 3.82 to 5.11, and 3.50 to 6.36, respectively, with a mean average of 5.09 micrograms, Table 5.

The average daily urinary excretion of cobalt in Studies I and II ranged from 0.43 to 8.23, with an average of 4.75 micrograms; whereas the range for Studies III and IV was 3.24 to 5.72, with an average of 4.34 micrograms. The mean average urinary output was 67 per cent of the mean total daily intake. This percentage is in close agreement with that reported by Comar (1947)¹⁷ for animals, namely, 65 per cent.

The average daily fecal output for these studies was from 0.42 to 1.60, 0.26 to 1.07, 0.20 to 0.48, and 0.19 to 0.82 micrograms per day for each of the respective studies. The largest average daily fecal output was found during Study I; two subjects excreted more than 1 microgram, namely, 1.21 and 1.60. Only one other subject excreted as much, and this subject also consumed this same diet (Study II), varying only in amount and food source. This percentage of the mean average daily fecal output (7.5 per cent) was somewhat lower than the 30 per cent reported by Comar (1947).¹⁸

The percentage of the average daily cobalt intake which was absorbed ranged from 73 to 95, 85 to 95, 91 to 98, and 87

¹⁷Comar, op. cit.

¹⁸Ibid.

TABLE 5

COBALT METABOLISM OF COLLEGE WOMEN
ON SELF-SELECTED DIETS

Subject	Average Total Daily Intake	Average Daily Excretion			Average Daily Retention	Per Cent of Food Cobalt Absorbed*
		Urine	Feces	Total		
	Micrograms					
Study I						
A.H.	7.28	0.43	1.21	1.64	5.64	83
B.L.L.	7.60	8.23	0.42	8.65	-1.05	94
F.S.	6.30	3.72	0.46	4.18	2.12	93
P.L.W.	6.05	3.20	0.28	3.48	2.57	95
E.J.C.	6.33	6.58	0.49	7.07	-0.74	92
V.MC.	6.00	4.31	1.60	5.91	0.09	73
Average	6.59	4.41	0.74	5.15	1.44	85
Study II						
B.K.B.	7.92	3.52	0.46	3.98	3.94	94
B.H.	7.33	4.02	1.07	5.09	2.24	85
A.J.R.	5.63	5.35	0.26	5.61	0.02	95
F.L.S.	7.62	6.83	0.60	7.43	0.19	92
P.L.	7.97	5.81	0.40	6.21	1.76	95
Average	7.29	5.10	0.56	5.66	1.63	92
Study III						
E.M.B.	6.70	4.24	0.37	4.61	1.09	93
J.M.	6.70	3.43	0.39	3.82	1.88	93
M.M.	6.70	4.26	0.34	4.60	1.10	94
B.G.	6.70	3.99	0.48	4.47	1.23	91
K.W.	6.70	4.89	0.22	5.11	0.59	96
B.W.	6.70	3.77	0.20	3.97	1.73	98
Average	6.70	4.10	0.33	4.43	1.27	94
Study IV						
P.B.	6.54	4.31	0.38	4.69	1.85	94
P.Ba.	6.32	3.73	0.19	3.92	2.40	97
P.E.	6.33	3.24	0.26	3.50	2.83	96
N.M.	6.54	5.71	0.42	6.13	0.41	93
R.P.	6.54	5.54	0.82	6.36	0.18	87
S.S.	6.97	5.72	0.47	6.19	0.78	93
Average	6.54	4.58	0.42	5.13	1.24	93
Mean						
Average	6.78	4.55	0.51	5.09	1.39	91

* $\frac{\text{food intake} - \text{Co excreted in feces}}{\text{food intake}} \times 100 = \% \text{ absorbed.}$

to 97 per cent, with a mean average of 91 per cent. Subjects B.L.L. and E.J.C. of Study I exhibited an average daily cobalt retention of -1.05 and -0.74 micrograms, respectively. These two, however, showed 94 and 92 per cent of the food cobalt absorbed. It was assumed that these two subjects required more cobalt than did the other subjects. However, the lowest absorption values, 73 and 83 per cent, were associated with the lowest and highest retentions of Study I, 0.09 and 5.64 micrograms. These are also the lowest and the highest retentions for all four studies. Subject B.W. of Study III showed the greatest per cent of cobalt absorbed, namely, 98 per cent.

In general, the subjects did not show an increased retention of cobalt when this element was present in greater amounts in the diet, nor were the highest per cents of cobalt absorption associated with the higher intakes. The total urinary cobalt ranged from 0.43 to 8.23 micrograms, and the fecal cobalt from 0.19 to 1.60 micrograms. The excretion of cobalt was greater in the urine than that excreted in the feces. This is in accord with the findings of Comar (1947)¹⁹ and Greenberg (1943).²⁰

¹⁹Ibid.

²⁰Greenberg, op. cit.

SUMMARY

The cobalt intake in food and excretion in urine and feces of twenty-three college women on self-selected diets were determined chemically.

The average daily cobalt intake ranged from 5.63 to 7.97 micrograms.

The average daily urinary excretion of cobalt on these intakes was from 0.43 to 8.23 micrograms.

The average daily fecal output ranged from 0.19 to 1.60 micrograms.

The percentage of the average daily food cobalt absorbed ranged from 73 to 98 per cent.

The daily excretion of cobalt was less than the intake for twenty-one of the twenty-three subjects. From this study it is evident that college women absorb food cobalt to a high degree and that the intakes of the present study were sufficient for the majority of the subjects.

APPENDIX

DIRECTIONS FOR MAKING THE SOLUTIONS

Standard Stock Solution of Cobalt. 4.938 grams of cobalt nitrate hexahydrate were dissolved in enough water to make 500 milliliters. This solution contains 2.000 grams Co/liter.

Alpha-Nitroso-B-Naphthol Reagent. Prepared by boiling 1.0 grams compound with 200 milliliters of water and 10 milliliters 5 N Sodium Hydroxide, filtering and diluting to 2 liters. Must heat until compound is completely dissolved.

Ammonium Citrate Reagent. Contains 1000 grams Citric Acid crystals, 250 milliliters H_2O , 1000 milliliters ammonia solution.

Ammonia Solution. 100 milliliters of concentrated NH_4OH were diluted to 600 milliliters with distilled H_2O (sp. gr. 0.90).

TABLE 6

MENUS SERVED IN NORTH TEXAS STATE COLLEGE
HOME MANAGEMENT HOUSE DURING THE TWO
FIVE-DAY ANALYSIS PERIODS

Meal	Menu
Studies I and II	
Monday, March 12	
Breakfast	Bacon, scrambled egg, plain toast, grape jelly, pat of butter, coffee.
Lunch	Stuffed tomato with potted meat, cucumber, celery, mayonnaise, potato chips, toast, fruit cocktail, milk.
Dinner	Meat loaf, medium stuffed potato (cheese, butter, cream), tossed green salad, cornbread, butter, fudge cake, tea.
Tuesday, March 13	
Breakfast	Scrambled eggs, jelly, biscuits, orange juice, coffee, pat of butter.
Lunch	Cold meat salad (spam, celery, apple, mustard), tomato wedges, jello whip (apple, banana, cocoanut, pecans), cookies, cornbread, pat of butter.
Dinner	Baked chicken, dressing, green beans, giblet gravy, bread, cranberries, milk, butter.
Wednesday, March 14	
Breakfast	Grapefruit juice, French toast, sausage, jelly toast, coffee.
Lunch	Wilted spinach salad (bacon and egg), cheese toast, drop cookies, milk.
Dinner	Fried liver, French fried potatoes, English peas, mashed potatoes, cornbread, apple sauce, whipped cream, coffee.

TABLE 6--Continued

Meal	Menu
Thursday, March 15	
Breakfast	Orange juice, fried egg, bacon, toast, coffee.
Lunch	Cheese sandwich, potato chips, combination salad, apricots, cookies, milk.
Dinner	Weiners, kraut, lima beans, buttered beets, cornbread, butter, bread pudding, lemon sauce, milk.
Friday, March 16	
Breakfast	Bran flakes with milk, bacon, toast, butter, coffee.
Lunch	Corn soup, tomato salad, cornbread, butter, tea.
Dinner	Salmon croquettes, French fried potatoes, brocolli, Waldorf salad, cornbread, pineapple ice box pudding, coffee.
Studies III and IV	
Monday, April 30	
Breakfast	Mixed fruit juice, scrambled egg, sliced bacon, toast, coffee.
Lunch	Pimento cheese sandwich, potato chips, cole slaw, peach, cookies, milk.
Dinner	Broiled hamburger steak, creamed potatoes, spinach, apple and carrot salad, pineapple upside-down cake, cornbread.

TABLE 6--Continued

Meal	Menu
Tuesday, May 1	
Breakfast	V-8 juice, French toast, syrup, bacon, coffee.
Lunch	Celery soup, mixed green salad, cornbread, butter, tea.
Dinner	Beef and vegetable pie, mustard greens, pear rolled in graham crackers, bread, butter, milk, banana cream pie.
Wednesday, May 2	
Breakfast	Frozen orange juice, fried egg, Canadian bacon, bran muffin, butter, coffee.
Lunch	Tomato rarebit on toast, asparagus salad, mayonnaise, tea, tapioca pudding.
Dinner	Liver on rice, glazed carrots, lettuce wedge, French dressing, cornbread, individual pies, milk.
Thursday, May 3	
Breakfast	Bran flakes with milk, link sausage, toast, butter, coffee.
Lunch	Deviled ham sandwiches with hard-cooked egg, bread, celery, carrot stick, cucumber slices, pickle, radishes, butterscotch pudding, milk.
Dinner	Chipped beef and noodle casserole, green peas, jello salad (celery, nuts, cottage cheese), cornbread, tea, strawberry shortcake.

TABLE 6--Continued

Meal	Menu
Friday, May 4	
Breakfast	Grapefruit juice, poached egg, biscuits, butter, coffee.
Lunch	Pinto beans, cabbage slaw, sour cream dressing, cornbread, tea, bread pudding.
Dinner	Salmon loaf, green beans, mashed potatoes, carrot-raisin salad, whole wheat bread, milk.

TABLE 7
ORIGINAL READINGS AND DETERMINATIONS
OF COBALT IN FOOD

Day	Meal	Weight of Food	Cobalt						
			Sample I		Read- ing	Sample II		Aver- age	Re- covery
			Read- ing	Dilu- tion	Total	Read- ing	Dilu- tion	Total	
		Gm.			?			?	%
Study I	Breakfast Lunch Dinner	857.8	92	100	4.80	91.5	100	4.94	110
II	Breakfast Lunch Dinner	1002.5	94	100	4.97	93.5	100	5.17	105
III	Breakfast Lunch Dinner	741.9	93	100	4.01	93	100	4.01	104
IV	Breakfast Lunch Dinner	1109.6	93	100	5.99	93.5	100	5.72	92
V	Breakfast Lunch Dinner	1049.4	92.5	100	5.75	92.5	100	5.75	90
	Milk Av. for Period	1769.0	96.5	100	7.43	97	100	7.08	98

TABLE 7--Continued

Day	Meal	Weight of Food	Cobalt							Re- covery	
			Sample I			Read- ing	Sample II		Aver- age		
			Read- ing	Dilu- tion	Total		Dilu- tion	Total			
Study II		Gm.			γ			γ	γ	%	
	I	Breakfast Lunch Dinner	743.2	90.5	100	4.49	90	100	4.67	4.58	96
	II	Breakfast Lunch Dinner	954.4	95	100	4.50	95	100	4.50	4.50	93
	III	Breakfast Lunch Dinner	1183.9	89	100	7.81	88.5	100	7.95	7.88	93
	IV	Breakfast Lunch Dinner	1365.3	94	100	6.77	94	100	6.77	6.77	99
V	Breakfast Lunch Dinner	1078.1	96.5	100	4.53	97	100	4.31	4.42	90	
	Milk Av. for Period	1813.0	97	100	7.25	97	100	7.25	7.25	110	

TABLE 7--Continued

Day	Meal	Weight of Food	Cobalt						
			Sample I			Sample II			Average Recovery
			Reading	Dilution	Total	Reading	Dilution	Total	
		Gm.			7			7	%
Study III I	Breakfast Lunch Dinner	819.6	95.5	100	3.74	95.5	100	3.74	3.74 96
	Breakfast Lunch Dinner	1114.4	92	100	6.14	91.5	100	6.41	6.27 99
	Breakfast Lunch Dinner	1070.8	92	100	5.99	92	100	5.99	5.99 96
IV	Breakfast Lunch Dinner	1048.4	90	100	6.57	89.5	100	7.04	6.80 97
V	Breakfast Lunch Dinner	768.4	95	100	3.63	96	100	3.26	3.44 98
	Milk Av. for Period	1464.0	96	100	6.21	95	100	6.91	6.56 110

TABLE 7--Continued

Day	Meal	Weight of Food	Cobalt							Re- covery
			Sample I			Sample II			Aver- age	
			Read- ing	Dilu- tion	Total	Read- ing	Dilu- tion	Total		
Study IV		Gm.			2			2	2	%
	I	Breakfast Lunch Dinner	96	100	3.63	96	100	3.63	3.63	105
	II	Breakfast Lunch Dinner	91	100	5.85	92	100	5.57	5.71	93
	III	Breakfast Lunch Dinner	93	100	4.96	93	100	4.96	4.96	100
	IV	Breakfast Lunch Dinner	89	100	6.92	89	100	6.92	6.92	95
V	Breakfast Lunch Dinner	91.5	100	4.96	92	100	4.82	4.89	108	
	Milk Av. for Period	96	100	5.93	96	100	5.93	5.93	94	

TABLE 8
ORIGINAL READINGS AND DETERMINATIONS
OF COBALT IN URINE

Name	Days	Total Volume	Cobalt								Re- covery
			Sample I			Sample II			Aver- age		
			Read- ing	Dilu- tion	Total	Read- ing	Dilu- tion	Total			
Study I		Ml.			γ			γ	γ	%	
A.H.	5	4995	97	100	1.66	96.5	100	2.89	2.17	108	
B.L.L.	5	10830	95.5	100	41.15	95.5	100	41.15	41.15	106	
P.S.	5	5265	96	100	18.61	96	100	18.61	18.61	104	
P.L.W.	5	3995	95	100	15.38	94.5	100	15.85	15.61	102	
E.J.C.	5	9320	96	100	32.93	96	100	32.93	32.93	94	
V.MC.	5	5890	96	100	20.81	95.5	100	22.38	21.59	98	
Study II											
B.K.B.	5	3880	93	100	17.46	92.5	100	17.71	17.58	95	
B.H.	5	5720	96	100	20.21	96.5	100	20.02	20.11	105	
A.J.R.	5	8025	97	100	26.75	97	100	26.75	26.75	104	
F.L.S.	5	8680	95	100	34.14	95	100	34.14	34.14	92	
P.L.	5	7035	94	100	29.07	94	100	29.07	29.07	96	
Study III											
E.M.B.	5	5387	95	100	21.18	95	100	21.18	21.18	92	
J.M.	5	4363	95	100	17.16	95	100	17.16	17.16	109	
M.M.	5	4803	93.5	100	20.65	93	100	21.91	21.28	108	
B.S.	5	3875	93.5	100	19.99	94	100	19.85	19.92	94	
K.W.	5	6925	96	100	24.46	96	100	24.46	24.46	103	
B.W.	5	5340	96	100	18.87	96	100	18.87	18.87	94	

TABLE 8--Continued

Name	Days	Total Volume	Cobalt							Re- covery
			Sample I			Sample II			Aver- age	
			Read- ing	Dilu- tion	Total	Read- ing	Dilu- tion	Total		
Study IV		Ml.			γ			γ	γ	%
P.B.	5	5666	95	100	22.29	95.5	100	21.53	21.91	94
P.Ba.	5	4340	93.5	100	18.66	93.5	100	18.66	18.66	98
P.E.	5	4580	96	100	16.18	96	100	16.18	16.18	102
N.M.	5	8355	97	100	27.85	96.5	100	29.24	28.54	98
R.P.	5	6530	95	100	28.35	95.5	100	27.14	27.74	92
S.S.	5	7805	96	100	27.57	95.5	100	29.65	28.61	98

TABLE 9

ORIGINAL READINGS AND DETERMINATIONS
OF COBALT IN FECES

Name	Days	Total Weight	Cobalt							Re-covery
			Sample I			Sample II			Aver-age	
			Read-ing	Dilu-tion	Total	Read-ing	Dilu-tion	Total		
		Gm.			γ			γ	γ	%
Study I	9	1154.7	93	100	6.23	93.5	100	5.95	6.09	108
	6	502.0	96	100	2.12	96	100	2.12	2.12	102
	4	422.0	92	100	2.36	92	100	2.36	2.36	96
	4	339.1	96	100	1.44	96.5	100	1.42	1.43	105
	7	583.6	96	100	2.47	96.5	100	2.45	2.46	93
	15	2006.9	97	100	8.02	97	100	8.02	8.02	93
Study II	1	345.9	88	100	2.36	88	100	2.36	2.36	93
	12	1058.7	94	100	5.25	93.5	100	5.46	5.35	105
	2	305.8	96	100	1.29	96	100	1.29	1.29	102
	4	451.7	89	100	2.98	88	100	3.09	3.02	91
	4	495.2	97	100	1.98	97	100	1.98	1.98	100
Study III	3	432.6	96	100	1.83	96	100	1.83	1.83	92
	4	359.6	92	100	2.01	92.5	100	1.97	1.99	102
	5	345.3	90	100	1.37	91	100	2.03	1.70	107
	4	397.6	90	100	2.50	91	100	2.34	2.42	93
	3	173.2	90	100	1.09	90	100	1.09	1.09	93
	3	208.2	94	100	1.03	94.5	100	0.99	1.01	96

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