A DETERMINATION OF CALCIUM IN THE DIETS OF A COOPERATIVE HOUSE AND A DORMITORY AT OREGON STATE COLLEGE

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INTRODUCTION

A growing interest in the food value of the diets provided girls living in the cooperative houses and dormitories at Oregon State College has been stimulated by a study made in 1939-40. The financial management of the five cooperative houses was studied in detail by Nolma L. Saylor, (32) and food expenditures were analyzed on the basis of the percentage of a dollar recommended by Stiebeling and Ward (40) to be spent on each food group. Results of the study raised the question as to the possibility of a low expenditure in the milk, cream, and cheese group. Percentages spent on this group ranged between 14.19% and 22.71% as compared with Stiebeling and Ward's standard of 25-30%. In order to discover what amounts of calcium the dietary might actually contain, this study was made to determine through chemical analysis the calcium content of the diets of a cooperative house and a dormitory. Margaret Snell Hall was selected because of the convenience in relationship to the Home Economics Building and because a smaller number of girls are served there than at Waldo Hall. The Pines was the cooperative house selected.

Purpose of the Study

1. To analyze for calcium the food, excluding milk, cream, and cocoa, which was served to each girl during a period of one week at a cooperative house and a dormitory.

2. To analyze separately for calcium the milk, cream, and cocoa that were served to one girl.

3. To compare the amount of calcium provided with and without the use of milk as a beverage.

4. To estimate whether the amount provided contained adequate calcium to meet the dietary standards.

REVIEW OF LITERATURE

Physiology

McCollum (20) states that the prominent part which calcium plays in bodily functions was recognized by Parey as long ago as 1649. Since that time there has accumulated a wealth of information dealing with the many phases of calcium metabolism and its related problems.

Of the mineral elements which are present in the human body, calcium is found in the largest quantities. (37) About 2% of the total body weight, or between 1400 and 2000 gms. of calcium may be contained in the average adult human body (20). Its distribution is very uneven,

for over 99% is found in combination with phosphorus in the skeletal system (35). The small remaining fraction is essential to the normal functioning of blood, muscles, and nerves (33).

Whether or not there is a daily intake of calcium, the body will continue to excrete a certain amount of the mineral each day. It has been shown by metabolism studies that there are many factors which will add to or subtract from the body's calcium supply. A low calcium intake, pregnancy, lactation, ingestion of acids, and administration of parathyroid extract are examples of influences which increase the demand upon the body's store of calcium (1).

Since there is a constant excretion of calcium from the body, Bauer, Aub, and Albright (1) raised the question whether there is a special storehouse for calcium, or whether the whole body is at the mercy of these factors. Eight rabbits were placed upon a high calcium diet, some receiving parathyroid extract to cause calcium excretion. It was found that the bones of the control animals contained more trabeculae, while in neither group were the cortical shafts of the bones affected. These results and those of subsequent studies on kittens bore out their theory that the bone shaft serves as the mechanism for body support; while the trabeculae of the bones, being less stable, act as a reserve supply of readily

available calcium, besides being a support against tension of muscles.

Being situated at the epiphyseal ends of the bones, the trabeculae are more easily accessible to the blood. Their position facilitates the deposit of calcium when an excess is present, and the withdrawal of calcium during times of calcium demand. A negative balance of calcium will deplete the trabeculae while a positive balance will increase them. Being extremely important in maintaining the body structure, the bone shafts are thus protected. It is when exceptionally heavy demands as in growth and stress deplete the trabeculae that the bone shafts are forced to meet the demands for calcium. Such depletion may result in rickets or osteomalacia.

The matured skeletal framework of the body should not be thought of as solid and unchanging. Shohl (57) states, "The idea that bone is an inert mass of lime salts is rapidly giving way to newer knowledge. Bone is a vascular structure, and the minerals may be readily removed by the action of the osteoclasts or bone destroying cells and the ions transferred to the blood." Supplementing the findings that the trabeculae function as a readily available reserve supply of calcium, Shohl continues, "Aub and Calhoun have shown further, from studies with both madder root and radium that material

originally deposited almost wholly in the trabeculae is gradually disseminated. Radium over the course of years finally becomes evenly distributed throughout the bone shaft, which could happen only by the dissolution and rearrangement of the material in the trabeculae."

None the less important is the small fraction of the body's calcium left for functions other than skeletal framework. In blood, calcium is found almost wholly in the serum (37) and is essential for normal clotting (33). It is regulated mainly by parathyroid hormone (37).

The normal function of vitamin D is to keep the calcium/phorphorus ratio toward normal. With an excess of the vitamin comes an elevation of serum calcium; and with an absence of vitamin D, and long-continued low calcium, there will be a decrease in serum calcium.

Besides controlling the coagulation power of the blood, calcium preserves the normal response of nervous tissue to stimuli, and controls the contractility of muscles, particularly the rhythmic beat of the heart (30). Increased irritibility of muscle is caused by an increase in potassium or diminution in calcium in the fluid bathing it (37). Sodium, magnesium, and hydrogen also influence irritibility; sodium and potassium counteracting many of the effects of magnesium and calcium. Thus, many complicating factors influence the presence and functioning of calcium in the body.

Deficiency of Calcium

Improper calcium metabolism can cause serious bodily defects. Sherman (35) states, "According to Park's definition which has been generally accepted, rickets is a condition in which the mineral metabolism is disturbed in such a way that calcification of the growing bones does not take place normally."

More than one type of the disease has been described. With a normal content of calcium in the blood but a subnormal phosphorus (phosphate ion) content, low-phorphorus rickets results. With a normal content of phosphorus in the blood but a subnormal calcium content "there results a similar gross abnormality but a somewhat different histology of the bones," (35) low-calcium rickets. The latter is often accompanied by tetany, a condition which is probably due to a subnormal concentration of calcium in the blood. A third type of rickets sometimes called osteoporosis is the result of a reduction of both calcium and phosphorus below normal concentrations in the blood.

Generally rickets occurs during the period of most rapid bone growth, from the 6th to the 18th month of age. It occassionally occurs later, though it is termed osteomalacia in adolescence and mature life (37). The outstanding features of the latter disease are bone softening and deformity; it affects mainly pregnant and lactating women (20).

Rose (30) remarks that, "Inasmuch as rickets is a disease in which the bones are deficient in calcium, a very natural notion was widespread that administration of calcium should cure it. However, dosage with calcium generally gave disappointing results and rickets sometimes developed when children were fed liberally on cow's milk, rich in calcium."

There are many other important influencing factors. However, lack of exposure to the sunlight or a diet deficient in vitamin D is the primary cause of the defect (37). Except when the mineral supply is very deficient, vitamin D can prevent any of the three types of rickets by keeping normal the concentrations of calcium and phosphorus in the blood (35). Correction of the bone lesions and the underlying condition is possible when vitamin D or ultra-violet light irradiation is given in adequate amounts (37).

Retention

Recognition of the important role played by body tissues and the skeletal system in the calcium metabolism of the body leads to the realization that in order to maintain strong, well-formed bones and teeth, the daily calcium intake must at least balance, and for growth must exceed the daily excretion. Simply ingesting the

amount of calcium thought to balance excretion is not enough to consider. The assimilation and retention of the calcium by the body is of great importance, as is the degree of availability of the calcium in the foods taken.

Experiments to demonstrate when the rise in blood calcium appears following calcium intake have been reported by Kahn and Roe (13). The normal blood calcium level was determined in healthy men. Effects of doses of calcium lactate were tested for the best assimilation as measured by amount and time during which the blood calcium level was increased. With 5 gms. calcium lactate, hourly blood tests showed a blood calcium level 80% above normal between six and seven hours after the test dose was given. The high level was sustained for nine hours in contrast to four, and one and one-half hours in the 20 and 2 gm. doses, respectively. The optimal dose was 5 gms. calcium lactate. With 20 gms. there was increased irritation of intentinal mucosa causing a shorter period of raised blood calcium, while 2 gm. was insufficient. Kahn and Roe (13) concluded that "calcium is absorbed from the intestinal tract just like any other diffusible substance."

Such assimilation would be the ideal especially for therapeutic treatments. However, in normal intakes other

factors have been shown to affect utilization. The effects of acid-forming and base-forming diets on calcium, phosphorus, and nitrogen retention of children have been studied by Davis (10). During eight periods with intervals of three or four days between, natural diets were given to four boys and eight girls between seven and 12 years of age. Food aliquots and urine samples were tested for pH, and their reactions during each given period checked against each other. The diets planned to give basic reactions gave the highest retentions of all of the elements, calcium, phosphorus, and nitrogen, but the three acid diets gave equally high calcium and phosphorus retentions. Davis stated, "Only with calcium was an outstanding effect of the reaction of the diets obvious in the paths of excretion of the three elements. With the basic diet the excretion of calcium increased in the stool and at the same time decreased in the urine, with the result that the total output of calcium was approximately constant with both acid and basic diets." Results demonstrated, that "the retention of calcium was uniform and apparently not influenced by the reaction of the diets."

In studies on humans nutritionists have made use of the knowledge that excretion of calcium will continue even without a daily intake of the mineral. Metabolism studies

measuring the intake and the excretion of calcium have been made in order to determine the normal balance between the two.

Summarizing the findings of recent studies, Leitch (17) concluded that "two levels of intake might be found, one below which output would always exceed intake, and one above which the chances of a positive or a negative balance would be equal.... Those two might or might not coincide."

In determining the influence of cereals upon the retention of calcium and phosphorus, Burton (4) conducted metabolism studies on children and adults. Both showed higher retentions on the diet providing calcium in the form of wheat than in the diet containing oats.

The Council on Foods of the American Medical Association (8) has reported on the alleged decalcifying effect of cereals. Rickets in dogs was made more severe by McCollanby in 1921 when the diet was increased in oatmeal and decreased in milk. It was suggested that a toxamine in the cereal was the cause and that irradiation of the cereal might overcome it. Later it was shown that oatmeal boiled in 1% hydrochloric acid had no toxamine. The ratio of the amount of calcium to phosphorus supplied by the diet is accepted as normal when it is 1/1 or 2/1, and a lowered amount of phosphorus will cause the low-

phosphorus rickets. In some grains phosphorus exists as phytin, a form poorly utilized by rats and man. Thus, there is a smaller amount of available phosphorus and the ratio of calcium to phosphorus is changed. When the phytin is hydrolyzed by intestinal bacteria or treated with 1% hydrochloric acid, the amount of available phosphorus is increased so that the calcium/phosphorus ratio is changed toward normal. No good evidence was found for the existence of a decalcifying factor in cereals, but the available phosphorus, being low, altered the calcium/phorphorus ratio.

The Council on Foods of the American Medical Association concluded that "grain products not treated with vitamin D are wholesome foods." There is no need "to irradiate cereals or to add vitamin D substances to cereal products intended for general human consumption, in order to overcome the harmful effects of a hypothetical toxamine."

Dietary Studies

Another method used in showing the effect of adding certain foods to the basic diet is in large scale feeding experiments where the improvement in growth rate and physical status of children is measured.

A study of this type was conducted in England by M. C. Corry Mann (19), who measured over a two-year period the growth of boys as affected by supplements of milk, butter, margarine, casein, water cress, and sugar. About 350 boys living in an institution were divided into comparable groups of thirty to forty, each group living in a separate cottage. Measurements of growth in height and gain in weight showed that every supplement caused better growth than that of the controls who received only the regular diet. A pint of milk added to the basic institution diet gave the greatest improvement, with an increase over the control group of 3.13 lbs. and 0.79 inch in a year. Results indicated that the diet of the institution was somewhat low in almost every requirement. Milk, providing the largest number of them, gave the greatest improvement.

To check results of the study made in England, another large-scale test was carried out by Orr (24) and during the second year by Leighton and Clark (16). In contrast to the exact conditions and controlled diet of the former study, the Scotland experiment used as a basis the varied diet of the working-class household. The elementary school children in seven cities were divided into groups. One was given whole milk; a second, separated milk; a third, biscuit of the same calorie value

as the separated milk; and a fourth group received no supplement. Growth and gains in weight closely approximated the results of the study by Mann. During the first seven-months' experiment, there was an average monthly increase of 0.17 inch and 0.42 lb. in the non-milk groups; and a 0.21 inch and 0.52 lb. gain in the milk groups, an increase in height and weight 20% greater than that in the non-milk groups. During the second period, the average increase in weight of the milk-fed groups over the non-milk fed groups was 45.37%, while the increase in height was 23.5%. Leighton and Clark concluded, "No great difference was noticed between the whole milk and the separated milk groups".... "The value of an additional milk ration to that already taken at home is clearly demonstrated for all ages of school children."

The effect of a milk supplement on the physical status of institutional children has been studied also by Roberts (27). Over a period of a year, the growth of three groups of institutional children was followed. The control group received no supplement to the institutional diet; another received daily one pint-equivalent of evaporated milk; another received an equal amount of irradiated evaporated milk. The results, compared as groups or as matched trios, showed most favorable growth from the plain milk group, and somewhat lesser amounts

from the irradiated milk group. "By all methods of comparison the growth of the children given a supplement exceeded that of the controls," reported Roberts.

To study the effect of improvement of diet on development of bone, MacNair and Roberts (18) reported on data obtained on the institutional group just mentioned. At the beginning and the end of the year, roentgenograms of the wrist of each child were taken and finally compared by using the norms developed for the Carter index which relates the area of bone of the wrist already ossified to the area to be ossified. There was no significant difference between the two groups receiving milk, but they both showed somewhat greater progress than did the control group. MacNair and Roberts remarked, "Though all groups at the outset were retarded in respect to the Carter norms and were still retarded at the end of the study, both the groups given a supplement reduced their deficits to a greater degree than did the control group."

Another phase of the study on institutional children deals with the progress of dental caries. Complete records on 106 children were obtained by Roberts, Englebrecht, Blair, Williams, and Scott (29). The children's teeth were scored on a seven-point rating scale, roentgenograms were taken, and cavities were charted. Comparisons of the tests made at the beginning

and the end of the year indicated that all of the children showed extremely progressive caries. Scores showed small and statistically insignificant differences, yet Roberts and co-workers found a "consistent tendency for the progress of caries to be slightly less for the children given a supplement than for the control children." Results indicated that other factors also were involved.

A number of supplementary feeding studies have been made to compare the value of milk and oranges (5,22,23).

Chaney's (5) study showed that children do not always make the most improvement on a milk supplement. Her subjects, under-weight children, were given their choice of a mid-morning lunch of orangeade, milk, an orange, or milk and an orange. Those taking no lunch were used as controls. Those who received an orange each day made better gains than those taking milk. The explanation was suggested that the home diets were adequate in milk, but low in vitamin C-containing foods. The milk and orange supplement caused slightly higher gains than milk alone, but somewhat lower gains than orange juice. The reason put forth was the possibility of the retarding effect of milk upon the appetite for the next meal.

Using 67 normal school children on a house diet, Morgan, Hatfield, and Turner (22) studied the effects of one-half pint of milk, one orange, and four pulled figs

as daily supplements. An average of several physical tests showed the orange group rated first; the fig, and milk groups followed; and the control group was last. However, the gross average gain in pounds was largest for the milk group, while the percentage gain in weight above that expected was largest for the orange and milk groups. There is the possibility that the basic ash of oranges changed the acid reaction of the house diet and the antiscorbutic reaction was a necessary supplement to it. Since one quart of milk per child per day was included in the house diet, it was hardly to be expected that unusual gains would be promoted by the milk supplement.

Morgan and Warren (23) have reported an experiment which compared the increase in growth of four groups of public school children given small supplementary feedings. Each school day during ten weeks, the groups were given either one-half pint milk, one orange, a small cracker sandwich, or no supplement. At the end of the study, changes in height and weight were noted. The milk and cracker groups gained in weight at similar rates, while with the orange group, the gains were somewhat less. None of the groups made strikingly different gains in height.

Morgan and Warren commented that "these children seemed to profit by additional calories as to weight, but to obtain in addition stimulation to height and skeletal growth from the added orange juice and milk." It was recommended that a school planning to add a supplementary lunch should compare the growth of the school children during eight to twelve weeks while three or four kinds of supplements were given. Thus, the food causing greatest improvement could be given as a supplement to the home diet.

In four Massachusetts schools, 760 children were tested by Wait and Cowing (42) for the effect of a mid-morning lunch. Pasteurized milk, reconstituted evaporated milk, tomato concentrate, and a mixture of evaporated milk and tomato concentrate were given to separate groups, another group being used as a control. A definite improvement was observed in the groups receiving milk, or tomato concentrate and milk, while there was less improvement with the feeding of the tomato concentrate. However, there was no increase noted in the rate of growth in height; nor was there a decrease in the incidence of dental caries. The evidence showed that the dietary habits of the families could be improved most effectively by a mid-morning lunch of milk, but tomato concentrates or both supplements together were beneficial.

A comparison of the influence of evaporated and commercially pasteurized milk on the calcium, phosphorus, and nitrogen metabolism of four children and three adults was made by Willard and Blunt (43). Two tests were run. The first was on two girls, eight and 12 years of age, and two young women; the second was on two boys, three and four years of age, and two women, one of whom was repeating the test. The basal diet was given for a three-days' preliminary period, after which collections of food, urine, and feces were made for three or four days for analysis.

All of the children showed positive calcium balances of 0.11 to 0.04 gm. calcium per day. Their diet with evaporated milk showed a higher calcium retention in three of the four children. One-half of the calcium balances of the adults favored evaporated milk while half favored pasteurized. From the results of the study Willard and Blunt concluded that the "evaporated milk appeared to be slightly superior to pasteurized milk." Both were judged satisfactory sources of calcium, phosphorus, and nitrogen.

Another study which compared the availability of calcium and phosphorus from raw, pasteurized, evaporated, and dried milks was made by Kramer, Latzke, and Shaw (15). During the first of three experimental periods, two boys and three girls between seven and 12 years of age were given a diet which provided amounts of calcium and phosphorus below the adequate for optimum storage.

Fresh raw milk was used as a standard, 625 gms. per day or equivalent amounts of dried milk being provided. The children showed good storage of calcium with fresh milk, but with dried milk they showed 53 to 71% as much storage as with fresh milk although 94.5% as much calcium was furnished.

During the second period four women on the diet were given 222 gms. of fresh milk or its equivalent in other forms, but during the third period 260 gms. of fresh milk were given to four women. On dried milk and pasteurized milk, calcium retentions were lower than those made on fresh milk. When calcium was provided by evaporated rather than fresh milk, calcium balances were higher in four of the six subjects, while in the third period distinctly better calcium balances were shown on evaporated milk than on fresh milk.

To determine the optimum amount of calcium which children three to five years of age should retain, Daniels, Hutton, Knott, Everson, and Wright (9) made a metabolism study on two girls and eight boys from an orphanage and country home. During several dietary regimens, the same children were given milk and vitamin D in varied amounts. Following a three-day preliminary period, five-day collections of food, urine, and feces were made for analysis. Daniels and co-workers reported that results of the study indicated "one pint of milk

will supply sufficient calcium for the normal child between three and five years of age, provided the diet furnishes enough protein, phosphorus and vitamins from other sources. One pint of milk when included in a diet which supplies approximately 23% of its calcium from other sources, will supply enough calcium for normal children of the ages studied when a sufficient amount of vitamin D or sunshine is allowed." It was found that normal children between three and five years of age retained from 3 to 10 mg. of calcium per kilogram on this diet. The suggestion was made that in some of the previous investigations the subjects showed high retentions of the constitutents studied because they were more or less depleted in the substances being tested.

Roberts, Carlson, and MacNair (28) have reported upon the supplementary value of dry skim milk in institution diets. They suggested that a dry milk supplement might well be used to increase the food value of an institution diet at a relatively low cost. In order to determine the practicability of such a use of dry milk in an institution for children, and to measure the effect upon the food value of the children's diets, Roberts and co-workers compared two similar institutions. Each was supplying its 25 to 30 children with one pint of milk per person per day. For the first 13 days the dietary of each house was studied by computing the food value of the diet of each

child from the weights of the foods consumed. The children in each house were measured for height and weight, and medical and dental examinations were made. For three months a five-pound can of dried skim-milk powder was provided each day for one of the houses where it was used in recipes in the reconstructed milk or the powdered form. In three months 237.6 pounds, or the equivalent of 1210 quarts of liquid skim-milk were used. A recheck of the diets, and physical condition of the children was then made in each house. Comparisons of food value of the diets before and after the experimental period were made in order to determine whether the added intake of dried milk lowered the intake of other foods or the use of the whole milk. When the first and second studies of food value were compared, the children in the control house showed some intakes higher and some lower for calories, calcium, and protein. The children in the experimental house showed some higher and some lower intakes for calories, but for milk consumption they showed an increased intake of one-third quart for 28, and more than one-third for eight. Roberts stated, "These additions were sufficient to bring the total calcium of all of 32 children up to the commonly advocated 1.0 gm. standard.... The provision of dry skim milk to this institution made little change in the calories ingested by the children; it did, however, make significant additions to the total milk

solids consumed and hence to the calcium and protein.... at the negligible cost of not over 50 cents to 75 cents per day for an institution of the size studied.

The study made by Sherman, Gillett, and Pope (36) in 1918 was made on women to determine the effect of the monthly cycle upon phosphorus and calcium metabolism, and to furnish data upon the quantities of phosphorus and calcium required in normal human nutrition. Prearranged uniform diets, low in calcium and phosphorus, were given during ten successive periods of three days each, and intake and output of nitrogen, phosphorus, and calcium were determined quantitatively. Results indicated that women have no distinct monthly cycle in the metabolism of nitrogen, phosphorus, and calcium. The output of any of these elements in the menstrual flow is not sufficient to change the average daily requirement.

Protein, calcium, and phosphorus intakes of twenty-five college women were studied by Kramer, Evers, Fletcher, and Gallemore (14). "Unless the intake is at a very low level," they stated, "the normal adult tends to adjust nitrogen and mineral metabolism to his supply, so that determinations of the amounts eliminated indicated the amounts contained in the diet." Therefore, the subjects, on their usual freely chosen diets, made complete urine and feces collections during four days in the fall, and four days in the winter. The nitrogen, calcium, and phosphorus outputs were an indication of dietary intake.

Kramer and co-workers stated that "calcium figures showed more than half the subjects were using at least 1 gm. of calcium per day. Only one showed a figure below the requirement of 0.45 gm. for calcium."

A male adult was the subject of the study by Hart, Tourtellotte, and Heyl (12) who stated their objective to find "whether or not cod liver oil or irradiation will produce an appreciable storage on an acidotic, calcium-deficient diet." For three months, twenty-five experimental periods of five days were carried out, with rest intervals of a week. There was no increased tendency to retain calcium, phosphorus, or magnesium as a result of daily irradiation for twenty days, nor was there any similar tendency to retention with 12 cc. cod liver oil given per day.

The question raised by Pierce, Daggs, Messervey, and Simcox (26) concerns the availability of added substances in fortified foods for use by the human body. Six boys and four girls of pre-school age, saturated with calcium and phosphorus, were given a basal diet containing approximately 50 mg. of calcium per kilogram of body weight per day. Milk supplied 80% of the total calcium ingested while food solids supplied the remainder. During the experimental period the 200 mg. of milk calcium was replaced by 200 mg. of calcium in fortified cereals. Calcium and phosphorus storage during the first period

was significantly better when supplied partly by cereal, but during the second period retention and, therefore, availability were the same. Pierce and co-workers found a final analysis of results showed no significant difference between the retentions of calcium and phosphorus regardless of the salt used.

Requirement

Over a period of years more and more workers have contributed to the knowledge of the calcium requirement of man.

In 1920 Sherman (34) analyzed the findings of 97 calcium-balance experiments then available on subjects about equally divided between men and women. Calculated on the basis of 70 kilograms of body weight, the results showed calcium outputs ranging from 0.27 to 0.82 gm. with a mean maintenance requirement of 0.45 gm. of calcium per day.

Regarding these figures, Sherman (35) later commented, "This estimate of average requirement was not changed by subsequent studies of the relation of vitamin D to calcium metabolism. It is also not significantly changed by the accumulation of further studies of the calcium balance as influenced by the level of intake."

Steggerda and Mitchell (38) have reported on the calcium requirement of adult man and the utilization of

the calcium in milk and in calcium gluconate. During forty-three 4-day periods, the subject was given a low-calcium diet which provided daily 195 mg. of calcium. Supplements of calcium in the form of skim milk powder or of calcium gluconate were added to the diet in graded amounts, and the calcium level was determined on each level in order to discover how much calcium in the two forms would be required for calcium equilibrium.

The equation used by Steggerda and Mitchell was derived by Mitchell and Curzon (21) "to describe the average relationship in adult human subjects between the output of calcium and its intake....

$$Y = 0.6826X + 30.0940$$

"where y is the calcium output in mg. per kilogram of body weight per day and x is the intake of calcium expressed in the same fashion. In the experiments reported above, the average body weight of the subject in the three experimental periods in which no calcium supplement was added to the basal diet was 81.1 kilograms. His average daily intake of calcium per kilogram was therefore

$$195 \div 81.1 = 2.40 \text{ mg.}$$

His average output on the same basis was $304 \div 81.1 = 3.75$ mg. Placing the former value for x in the above equation, gives a value for $y = 4.73$ mg., about 26% higher than the observed output, 3.75 mg. per kilogram--the coefficient

of x in this equation indicates an average utilization of 32% ([1-0.6826] x 100 = 31.74) of the dietary calcium."

For calcium equilibrium the subject required 540 mg. of calcium in skim milk powder or calcium gluconate in addition to 195 mg. of calcium in the basal diet, the total required being 735 mg. of calcium. Expressed as weight of calcium per kilogram of body weight, the requirement for equilibrium is about 9.2 mg., a figure close to the average of 9.75 mg. derived by Mitchell and Curzon from available data in the literature. Results of the study demonstrated that the calcium of skim milk powder or calcium gluconate were utilized equally well to the extent of 20%.

Later Steggerda and Mitchell (39) reported upon the calcium requirement of adult man and the utilization of the calcium in milk. A basal diet containing 203 mg. of calcium per day was given to nine male adults. An adjustment period of four to five days was followed by four-day periods in which feces and urine collections were made. Milk supplements of liquid skim, dried skim, liquid whole, homogenized milk and "dried milk solids" were given for calcium equilibrium in succeeding periods. Results of the study showed that there was an average utilization of 29% of the calcium in all forms of milk. Steggerda and Mitchell commented, "The results of this

experiment do not afford any basis for assuming differences in the biological value of calcium among the different milk products tested." The average calcium requirement was calculated to be 9.55 mg. per kilogram of body weight or 357mg. per square meter of body surface.

Because milk is highly rated for its richness in calcium, Breiter, Hills, Dwight, McKay, Armstrong, and Outhouse (3) studied the ability of four women and three men to utilize the calcium of milk. During five day periods the subjects were given a basal diet designed for a negative calcium balance, and the test food, milk or calcium acid phosphate, was given on a low level so that the balances would still be negative. Thus, when a smaller deficit was present, the calcium in the test food was utilized. Concerning the results obtained, Breiter and co-workers wrote "the wide disparity in the values obtained with these adults--and with the children previously studied for utilization of milk calcium--is good evidence that it is not the form in which calcium occurs in a given food which determines its availability." The average utilization of calcium in milk for all periods was 24.2%. Some used 20% or less, while others used 30% or more.

Breiter and co-workers continued, "If the state of calcium (i.e. whether or not it is ionized) does not

determine the rate of utilization, than one would expect all species and all members of a given species to make use of identical portions of the calcium in a specific food. Obviously, the factor which governs the degree of utilization must be situated in the body, but whether it controls the absorption of calcium from the intestines or whether it regulates the disposition of the absorbed calcium into the skeletal tissue is not known."

Studying further the work by Breiter and co-workers, Outhouse, Breiter, Rutherford, Dwight, Mills, and Armstrong (25) placed four women and three men on a basal diet which provided 270 mg. of calcium per day, with a supplement of milk sufficient for calcium equilibrium.

The calcium requirement was calculated by the following formula:

$$\text{Ca requirement} = \text{Ca intake} \pm \left(\frac{\text{Ca balance}}{\% \text{ utilization of Ca of milk}} \times 100 \right)$$

The average requirement for the seven adults on the study was 662 mg. or 10.7 mg. per kilogram of body weight.

A comparison of figures obtained by various workers concerning daily calcium requirement of man shows their range and the means by which they are generally expressed.

Sherman's (34) average minimum requirement on the basis of 70 kilograms of body weight was 0.45 gm. of calcium "per man per day," or 6.42 mg. per kilogram of body weight. An increase of 50% added to the minimum requirement gave 0.68 gm. per day, a value which has

generally been regarded as standard (20).

In 1936-37 in a review of findings recorded by different workers, Leitch (17) recalculated the available experimental data for 400 women and by a different method of interpretation estimated the maintenance requirement of calcium for women as 0.55 gm. daily. She also recommended that the daily intake be higher than this.

The study published in 1939 on present day diets in the United States by Stiebeling and Coons (41) contains specifications for diets rated good with daily allowances of calories and certain important nutrients. The suggested allowance for girls 14 to 19 years of age is 1.00 gm. calcium per day; and for women 20 years of age and over, .88 gm. calcium per day.

The man studied in 1939 by Steggerda and Mitchell (38) attained equilibrium on 735 mg. of calcium or about 9.2 mg. per kilogram of body weight. Steggerda and Mitchell compare their figure with the average of 9.75 mg. per kilogram derived by Mitchell and Curzon (21) in 1939.

The study in 1941 by Steggerda and Mitchell (39) on nine male adults gave a calcium requirement of 9.56 mg. per kilogram of body weight, or 357 mg. per square meter of body surface.

The figures presented in 1941 by Outhouse (25) and co-workers after a study on seven adults show an average

requirement of 662 mg. or 10.7 mg. per kilogram per day.

The Committee on Food and Nutrition of the National Research Council (7) in May 1941 set up recommended daily allowances for the various dietary essentials. The recommended daily standard of calcium is listed as 1.0 gm. for the girl 16 to 20 years of age, and 0.8 gm. for the average 58 kg. woman.

Food Sources

According to the figures given by Rose (31) for the calcium content of milk, three cups of milk will supply 0.8 gm. of calcium, and one quart of milk will supply 1.0 gm. of calcium. The following foods which are excellent or good sources of calcium have been listed by Chatfield and Adams (6). Milk and green leafy vegetables rate highest in importance.

Excellent

Amaranth
Broccoli
Chard
Buttermilk
Cabbage:
 Savoy and nonheaded Chinese, nonheaded varieties including tendergreens
Cheese:
 American or Cheddar, Swiss
Clams
Collards
Cress, garden
Dandelion greens
Kale
Milk, whole or skimmed; evaporated, condensed and dried

Good

Almonds
Artichoke, globe or French
Beans, common, kidney; dry or fresh, shelled; also snap or string
Burdock, roots
Cabbage, headed, especially green
Carrots
Coleriac
Celery
Cheese, cottage
Chickpeas, whole
Chicory, leaves
Cottonseed flour
Crabs
Cream
Eggs, whole
Endive or escarole

Molasses
Mustard greens
Orach
Sesame seed
Tendergreens
Turnip tops
Watercress

Egg yolk
Figs, dry
Kohlrabi
Leeks
Lettuce, head or leaf
Lobster
Maple sirup
Okra
Oysters
Parsnips
Romaine
Rutabagas
Sorgo sirup
Soybeans, dry or as green vegetable
Soybean flour
Sweetpotato tops
Turnips
Vegetable-oyster or salsify

Regarding the list, Chatfield and Adams wrote, "Certain plant foods, the calcium content of which was high enough to justify inclusion in this list, have been omitted because of their oxalic acid content. Beets, beet greens, dock, rhubarb, spinach, and New Zealand spinach were left out on this account. If a food contains enough oxalic acid to combine with all of its calcium to form calcium oxalate, the evidence seems to show that the calcium is of little or no use to the body."

EXPERIMENTATION

The Pines

During one week starting Sunday morning, February 2, and ending Saturday evening, February 8, 1941, 12, or approximately one-third of the girls at The Pines

cooperative house kept daily records of the quantities of each food they ate. They were selected on the basis of being willing to cooperate with the study and being representative of the girls in food habits, age, academic class, and school. Table I contains these individual data regarding the girls. The girls were not encouraged to change their habits in any way but were urged to continue to eat their meals in the usual manner. They were asked to eat all meals at the house unless some exceptional occurrence prevented their doing so, and their records were used to determine whether the food served was actually consumed. In order to simplify the recording, the girls keeping records sat at the table in a group. Foods were recorded in cups, teaspoons, or tablespoons. Milk was recorded in cups or fractions of cups; cream in cups, or in teaspoons when used in coffee. Menus for the week are given in the appendix.

TABLE I

INDIVIDUAL DATA REGARDING GIRLS WHO KEPT FOOD RECORDS AT THE PINES

Subject	Age	Weight	Height	Acad. Class	School
VA	24	107	5'	Grad.	H. Econ.
JD	19	123	5'5⅜"	Fr.	Sci.
JG	20	150	5'7⅜"	Soph.	H. Econ.
MH	18	125	5'7⅜"	Fr.	H. Econ.
WK	19	152	5'9⅜"	Soph.	H. Econ.
JK	21	162	5'4"	Jr.	Educ.
GL	22	135	5'7⅜"	Fr.	Art & Arch.
DP	18	164	5'6"	Fr.	Low. Div.
AS	23	125	5'6"	Jr.	H. Econ.
LS	21	133	5'5⅛"	Jr.	H. Econ.
MLS	22	100	5'1⅜"	Jr.	H. Econ.
MW	22	114	5'3⅜"	Sr.	Sec. Sci.

During the same week, February 2 to February 8, 1941, that the girls were recording the quantities of all foods eaten, duplicate samples were taken of each meal served to the girls at The Pines. Since all meals were served from the kitchen, one extra plate of the main dish, salad, and dessert was served. From the plates set out, one was picked at random and used for the analysis. All foods on the plate were weighed separately on a dietetic balance and then placed in a quart jar. The recorded weights of the foods were used later in rough calculations prior to the analysis.

In order to arrive at an average serving of bread, the number of slices of bread was divided by the number of girls present for the meal. That average amount of bread was weighed and added to the food for the meal.

Since hot cereal was served at The Pines, the serving of cereal for the day was collected separately. From the records it was found that on only one day was there a sufficiently large number of girls who kept records taking cereal to make a separate analysis of it advisable. Also, the amount of calcium present in the cereal consumed by a few of the girls keeping records was not included, as the amount was too small to measure.

An essential part of the study was the separate collection and analysis of the milk and cream used. Because of the high calcium content of milk and cream, and

because individual likes and dislikes vary greatly the amounts consumed, the calcium content of diets can be raised or lowered considerably by their use or omission.

Milk and cream samples were collected every other day, or four out of the seven days. The weight of one cup of milk was recorded, and a portion of it was stored in a pint jar. The weight of one-fourth cup of cream was recorded and a sufficient amount for analysis was stored.

Cocoa was made at The Pines by adding chocolate syrup to milk. Therefore, either the amount of milk used was recorded as milk, or the amount of cocoa with the proportionate amount of milk. The girls' records of quantities of milk and cream consumed were used in the calculation of the amounts of calcium each girl received from this part of their daily food.

Milk and cream samples were stored in a refrigerator in the collection jars until drying was feasible. The milk was weighed out on a torsion balance into two clean dry evaporating dishes, approximately half of the milk in each dish. Cream was weighed out in the same manner.

Approximately one day was required to evaporate the samples over a steam bath, after which the ashing of the milk and cream samples was accomplished at dull red heat in a muffle furnace. Several hours brought the samples to a white flaky ash which was covered and stored for analysis.

Breakfast, lunch, and dinner samples collected each day were temporarily stored in a refrigerator. In order to obtain a representative sample of the food served during one day, an adaption of Blair's (2) method of sampling was used. The day's food was put through a food chopper which was then cleaned thoroughly with a rubber scraper and washed with distilled water. Washings were added to the composite. The jars and utensils were cleaned similarly, with washings added to the composite. The composite was thoroughly mixed to make a representative sample more easily obtainable, marked with the date collected, and stored in the refrigerator until it could be dried.

Before drying, the composite was again thoroughly mixed to insure a representative sampling of the material when dry. Containers for the composite were thoroughly cleaned, dry evaporating dishes, the weights and numbers of which were all recorded before use. After one or two days on the steam bath the drying was completed in an electric oven thermostatically controlled at 60°C. Several days in the oven dried the composite thoroughly, forming a brittle brown material. When dried, each evaporating dish was again weighed on the torsion balance. The dried material from each collection day was stored in an air-tight quart jar, and aliquots were taken for analysis.

Calculations to estimate the amount of calcium contained in the total composite for each day were made by using Rose's "Laboratory Handbook for Dietetics (31)". An amount estimated to contain between 0.05 and 0.1 gms. of calcium was weighed out on the torsion balance into a clean evaporating dish. Duplicate samples from the composite for each day were placed in separate evaporating dishes for ashing and analysis.

Margaret Snell Hall

From the 150 girls living at Margaret Snell Hall, ten volunteers were selected on the basis of being willing to cooperate with the study, and being representative of the girls in food habits, age, academic class, and school. Table II contains these individual data regarding the girls. During one week starting Sunday morning, February 16, and ending Saturday evening, February 22, 1941, the girls sat together at one table and recorded all foods and beverages consumed. They were encouraged to follow their regular habits of taking meals. However, since these ten girls were the representative sample of the entire hall, they were asked to take all their meals at the Hall, unless some exceptional occurence prevented their doing so. Menus for the week are given in the appendix.

TABLE II

INDIVIDUAL DATA REGARING THE GIRLS WHO KEPT FOOD RECORDS AT MARGARET SNELL HALL

Subject	Age	Weight	Height	Acad. Class	School
VB	18	123½	5'3"	Fr.	H. Econ.
MF	20	143	5'7"	Soph.	Low. Div.
MN	22	125	5'5½"	Sr.	H. Econ.
AR	20	128	5'4"	Soph.	H. Econ.
VSI	20	124	5'4"	Fr.	Soc. Sci.
VSL	23	128	5'1½"	Jr.	H. Econ.
FT	22	118	5'6-3/4"	Sr.	Soc. Sci.
MT	18	124	5'4"	Soph.	H. Econ.
JT	20	118	5'3/4"	Jr.	H. Econ.
RV	19	131	5'4½"	Fr.	H. Econ.

The food management of a large hall is necessarily different from that of a house group. The food at Snell Hall was brought to each table by waitresses, rather than being served from the kitchen. The casserole dishes held enough for the ten girls who were served by one of the girls at the table. The empty casseroles were then refilled in the kitchen.

Since the extra plate for analysis could not be taken from the casseroles served at the table without reducing the amount left for the girls, the plate was served in the kitchen. In order to be sure that the extra plate was served as nearly like the plates given the girls, the service in the dining room was observed before the extra plate was filled.

The average serving of bread was determined by dividing the number of slices taken, by the number of girls at the table for that meal. This fraction of a slice was weighed and added to the food for that meal.

After collection, the food for each day was treated by the method described above.

Milk and cream samples were collected in the same manner as those at The Pines, collections being made every other day, or four days out of the seven. However, rather than weighing one-fourth cup of cream, it was weighed in teaspoons because the girls measured cream only by that method for their records; and a sufficient amount for

analysis was stored. At Snell Hall cocoa was prepared in quantity so that the amount of milk taken by an individual was not known. Consequently, a cup of cocoa was weighed and analyzed separately on each of the four days.

Milk, cream, and cocoa were prepared for analysis in the same manner as those from The Pines. In some instances, however, the milk had curdled before they could be dried. These samples were weighed into only one evaporating dish, and after ashing, dissolving and making up the solution to volume, aliquots were measured for analysis.

Analysis for Calcium

The ash was dissolved in dilute hydrochloric acid, heated to boiling, and filtered while hot through No. 44 or No. 40 Whatman ashless filter paper and washed with hot water until blue litmus showed the absence of acid. Each sample which was ashed without a duplicate was dissolved in the same manner, the filtrate made up to 250 ml., and 100 ml. aliquots used for analysis. The ashed samples were analyzed for calcium according to an adaptation of the McCrudden method used in this laboratory as follows:

The dissolved solution was made just alkaline using concentrated ammonium hydroxide and then just acid with molar hydrochloric acid. To this solution 3.5 ml. of molar hydrochloric acid and 10 ml. of 2.5% oxalic acid were then

added. The solution was boiled and an excess of 3% ammonium oxalate added to the boiling solution. When the mixture was cold, 8 ml. of 20% sodium acetate were added slowly with vigorous stirring. The precipitate of calcium oxalate was allowed to stand overnight at room temperature and then filtered on No. 44 or No. 40 Whatman ashless filter paper, washed with 0.5% ammonium oxalate solution until free from chloride ion, and washed three times with cold water, filling filter half full. A hole was made in the paper, the precipitate washed into a beaker with about 200 ml. water; 10 ml. concentrated sulfuric acid added and the solution heated to boiling. It was then titrated with standard potassium permanganate solution; after the end point was reached the filter paper was added, and the end point again reached. Blanks, using the same amount of water and acid, were subtracted from the values thus obtained.

Preparation of Solutions

1. Molar hydrochloric acid: 82.3 ml. hydrochloric acid of 1.19 specific gravity was made up to 1000 ml. with water.

2.5% oxalic acid: 25 gms. of crystaline oxalic acid were put into a bottle to which 1000 ml. water was added.

3% ammonium oxalate: 30 gms. crystaline ammonium oxalate were put into a bottle to which was added 1000 ml. water.

20% sodium acetate: 100 gms. crystaline sodium acetate were put into a bottle to which was added 500 ml. water. The sodium acetate solution was prepared frequently so that it was used within the week it was made. It was always filtered before being used.

0.6% ammonium oxalate: 6 gms. crystaline ammonium oxalate were placed in a bottle to which was added 1000 ml. water.

9 M sulfuric acid: 49.38 ml. sulfuric acid of 1.841 specific gravity was made up to 100 ml. with water.

Approximately .02 M potassium permanganate: 6 gms. potassium permanganate was dissolved in 2500 ml. water and simmered for three hours. It was allowed to stand overnight, and later poured off leaving about 500 ml. to be discarded. The potassium permanganate solution was filtered through a Gooch crucible with an asbestos mat into a dark reagent bottle. Sodium oxalate was used to standardize the solution according to Fales (11). Between 0.110 and 0.510 gm. desiccated sodium oxalate especially prepared for standardization was weighed out, 200 ml. boiling water was added, and 10 ml. 9 M sulfuric acid. It was titrated at once in triplicate with the potassium permanganate solution, (stirring vigorously and continuously). The end-point was matched with a blank using 10 ml. 9 M sulfuric acid in 200 ml. hot water.

The following equation was used to determine the

calcium equivalent of the potassium permanganate:

$$\frac{\text{Wt } Na_2C_2O_4 \times \frac{\text{Mol. Wt. } Ca\ C_2O_4}{\text{Mol. Wt. } Na_2C_2O_4} \times \frac{\text{Mol. Wt. Ca}}{\text{Mol. Wt. } CaC_2O_4}}{\text{ml. } KMnO_4 \text{ used}} =$$

Calcium equivalent of 1 ml. $KMnO_4$ solution

When prepared by the above method, the solution deteriorates very slowly, so that re-standardization was only necessary once in two months, when no change was found.

RESULTS AND DISCUSSION

The Pines

The results of the analysis of the food which was served to each girl during the week of February 2 to February 8, 1941 at The Pines cooperative house showed the amount of calcium present in each day's food. Starting with the first day, as shown in Table III, the amount supplied was 0.280, 0.443, 0.369, 0.629, 0.523, 0.333, and 0.335 gm. of calcium with an average value of 0.416 gm. of calcium per day supplied by food, exclusive of beverages.

To determine the additional calcium which each girl ingested in the form of milk and cream, calculations were made by using the girl's records of the amounts consumed at each meal and the results of the analysis of the milk and cream.

The analysis of the samples of milk from The Pines gave an average of 0.00126 gm. of calcium per gram of milk, while cream contained an average of 0.00107 gm. of calcium per gram.

The amounts of calcium each girl ingested in the form of milk and cream during each day of the week have been averaged in order to compare the amount of calcium supplied by beverages with the amount supplied by food. Since different quantities of milk were taken by individuals, the total calcium ingested varied according to the quantities of milk and cream consumed.

In Table IV, the amount of calcium ingested daily in the form of beverages by each girl who kept records is recorded and averaged, to show the average amount of calcium ingested daily by each subject.

TABLE III

CALCIUM INGESTED FROM FOOD BY EACH GIRL AT THE PINES

Date	Calcium
2/2	.280 gms.
2/3	.443
2/4	.369
2/5	.629
2/6	.523
2/7	.333
2/8	.336
Average amount Ca per day ingested in food	.416 gms.

The average amounts of calcium ingested in the form of milk and cream by different girls ranged from 0.044 to 0.646 gm. of calcium, the average value being 0.429 gm. as shown in Table V.

TABLE IV

CALCIUM INGESTED DAILY FROM MILK AND CREAM BY EACH GIRL AT THE PINES IN GRAMS

Subject Date	VA	JD	JG	EH	WK	JK
2/2	.291	.290	.600	.847	.320	.272
2/3	.178	.507	.632	.518	.342	-
2/4	.595	.537	.360	.590	.117	-
2/5	.522	.290	.650	.635	.310	-
2/6	.522	.290	.660	.681	.403	.038
2/7	.522	.290	.310	.543	.093	-
2/8	.527	-	.645	.605	.403	-
Average	.451	.315	.552	.624	.284	.044

	GL	DP	AS	ES	MLS	LW
2/2	.966	.290	.659	.290	.253	.396
2/3	.580	.580	.745	.290	.362	.290
2/4	.610	.660	.699	.330	.640	.301
2/5	.605	.325	.620	.335	.595	.484
2/6	.272	.660	.690	.305	.290	.522
2/7	.290	.600	.745	.290	.640	.467
2/8	.290	.401	.369	.338	.959	.124
Average	.516	.502	.646	.311	.534	.369

TABLE V

AVERAGE AMOUNT OF CALCIUM SUPPLIED BY MILK AND CREAM AND TOTAL AMOUNTS INGESTED BY SUBJECTS AT THE PINES

Subject	From Food	From Milk and Cream	Total
VA	.416	.451	.867
JD	.416	.315	.731
JG	.416	.552	.968
EK	.416	.624	1.040
WK	.416	.284	.700
JK	.416	.044	.460
GL	.416	.516	.932
DP	.416	.502	.918
AS	.416	.646	1.062
LS	.416	.311	.727
MLS	.416	.534	.950
MW	.416	.369	.785
Averages in grams	.416	.429	.845

Addition of 0.416 gm. of calcium from the food to the amounts of calcium ingested in beverages by individual girls in Table V shows a total intake of 0.460 and 1.082 gm. of calcium with an average of 0.845 gm. of calcium ingested daily by each girl.

The total amounts of calcium ingested daily by each girl can be compared with the recommended daily allowances for the various dietary essentials set up in May, 1941, by the Committee on Food and Nutrition of the National Research Council (7).

The average intake of 0.845 gm. of calcium meets the allowance of 0.8 gm. recommended for the 56 kg. woman of 20 years and over, yet only two out of the 12 girls attained the 1.0 gm. allowance recommended for girls 16 to 20 years of age. Seven of the girls reached or surpassed .8 gm. while the other five failed to attain it.

The influence of the quantities of milk and cream ingested upon the total intake of calcium can readily be seen. A low intake of milk in one subject has provided an intake of calcium (0.460 gm.) slightly more than half the recommended allowance (0.8 gm.).

In every way possible the girls should be made to realize the importance of milk in their diet. At The Pines 0.580 gm. of calcium, contained in two cups of

milk, when added to the average daily calcium content of the food, 0.416 gm., would provide .996 gm. of calcium, practically the 1.0 gm. recommended allowance for girls between 16 and 20 years of age.

Since four of the representative group of girls who kept records at The Pines were under 20 years of age, the maintenance of the 1.0 gm. recommended allowance is important for the health of the girls. Some may be completing their full growth, while others will be planning for marriage, for children. In either case, rich stores of calcium are essential to their future well-being, and, thus will enable them to contribute their best to their life in their community.

Margaret Snell Hall

The amount of calcium in each day's food served to one girl at Margaret Snell Hall during the week of February 16 to February 22, 1941, was, as shown in Table VI, starting with the first day, 0.425, 0.386, 0.243, 0.308, 0.402, 0.533, and 0.322 gm. with an average value of 0.374 gm. of calcium per day supplied by food.

Analysis of the samples of milk from Margaret Snell Hall showed an average of 0.00113 gm. of calcium per gram of milk, 0.000719 gm. of calcium per gram of

cream, and 0.00103 gm. of calcium per gram of cocoa. The additional amounts of calcium provided by milk, cream, and cocoa were calculated by the method mentioned above, and the amount of calcium ingested daily in the form of beverages by each girl who kept records is shown in Table VII. The average amount of calcium ingested in the form of milk, cream, and cocoa by different girls ranged from 0.067 to 0.414 gm. of calcium, with an average of 0.282 gm. as shown in Table VIII.

Addition of 0.374 gm. of calcium from the food to the amounts of calcium ingested in beverages by different girls shows a range between 0.441 and 0.788 gm. of total calcium with an average of 0.656 gm. of calcium ingested daily by each girl.

Compared with the recommended daily allowances, all of the average intakes of calcium of the girls who kept records fall below the .8 gm. allowance for the 56 kg. woman of 20 years and over, yet three of the girls were under 20 years of age, and should ingest the recommended allowance of 1.0 gm. of calcium.

At Margaret Snell Hall 0.521 gm. of calcium contained in two cups of milk, when added to the average daily calcium of the food, 0.374 gm., would provide 0.895 gm. of calcium, which fulfills the lower allowance.

TABLE VI

CALCIUM INGESTED FROM FOOD BY EACH GIRL AT MARGARET SNELL HALL

Date	Calcium - gms.
2/16	0.425
2/17	0.386
2/18	0.243
2/19	0.309
2/20	0.402
2/21	0.535
2/22	0.322
Average	0.374 gm.

TABLE VII

CALCIUM INGESTED DAILY FROM MILK, CREAM, AND COCOA BY EACH GIRL AT MARGARET SNELL HALL IN GMS.

Subject / Date	VE	MS	MN	AR	VSI
2/16	.260	.273	-	.019	.529
2/17	.260	.269	.260	.234	.269
2/18	.538	.518	.538	.019	.269
2/19	.260	.283	.260	.019	.529
2/20	.520	.009	.806	.009	.529
2/21	.520	.300	.260	.019	.269
2/22	.260	away	.676	.149	.013
Average	.374	.342	.400	.057	.344

	VSI	FT	MT	JT	RV
2/16	.269	.260	.260	.399	.065
2/17	.130	.260	.399	.399	.589
2/18	.143	.260	.529	-	.439
2/19	-	-	.399	.412	.297
2/20	-	.040	.535	.432	.600
2/21	.130	.260	.260	.139	.439
2/22	.130	away	.520	.148	.027
Average	.115	.180	.414	.276	.307

TABLE VIII

AVERAGE AMOUNT OF CALCIUM SUPPLIED BY MILK, CREAM AND COCOA AND TOTAL AMOUNTS INGESTED BY SUBJECTS AT MARGARET SMELL HALL

Subject	From Food	From Milk, Cream, and Cocoa	Total
VB	.374	.374	.748
KT	.383◇	.342	.725
MN	.374	.400	.774
AR	.374	.067	.441
VS1	.374	.344	.718
VS1	.374	.115	.489
FT	.383◇	.180	.563
HT	.374	.414	.788
JT	.374	.276	.650
RV	.374	.307	.681
Averages in grams	.376	.282	.658

◇ Average grams calcium in food for first six days

Three cups of milk supplying .800 gm., when added to the 0.374 gm. of calcium in the food would provide 1.174 gm. calcium, and would fulfill the 1.0 gm. allowance recommended for girls between 16 and 20 years of age.

Since food habits influence choices of foods and beverages to such a great extent, the problem of educating individuals to choose foods wisely for their own health is one which can be solved but slowly. The addition of milk to the diet can raise considerably the calcium ingested in the form of food. Roberts, Carlson, and MacNair (23) found that calcium in the form of dry skim milk added to the food value of a diet at a negligible cost. The use of dry skim milk is not widespread, perhaps partly because more recipes in which it is incorporated are needed, partly because people need more education to its value and uses. Although such an addition should not replace the education of girls to the fact that milk provides nutrients which are essential to their present and future well-being, further study on the means by which milk in any of its forms could be added to the diet would make a worthy contribution to our present knowledge.

SUMMARY AND CONCLUSIONS

In order to discover what amounts of calcium were contained in the diets of The Pines cooperative house and Margaret Snell Hall at Oregon State College, the food, excluding beverages, served to one girl during a period of one week was analyzed for calcium. Milk, cream, and cocoa were analyzed separately because of their high calcium content and the variation in quantities taken by different individuals.

During the week, food was collected at each place, while a representative group of the girls taking meals there kept records of the amounts of all foods and beverages consumed. The records were used to make certain that the subjects ate the food provided and to calculate the amount of calcium ingested by each girl in the form of beverages.

The average daily amount of calcium supplied by the food served February 2 to 8, 1941, at The Pines was 0.416 gm. With the addition of the average intake of 0.429 gm. of calcium per girl in the form of milk and cream to this amount, the total average intake of calcium was 0.845 gm. The average total amount fulfills the 0.8 gm. allowance recommended by the Committee of Food and Nutrition of the National Research Council (7), yet it does not reach the 1.0 gm. allowance recommended for girls 16 to 20 years old.

The average total amount of calcium ingested by the different girls ranged between 0.460 and 1.062 gm. of calcium. Since 0.416 gm. of calcium represents the part supplied to each girl by food, the variations in intake are due to the different quantities of milk and cream taken by the different girls.

The average daily amount of calcium supplied by the food served February 16 to 22, 1941, at Margaret Shell Hall was 0.376 gm. With the addition of the average intake of 0.282 gm. calcium per girl in the form of milk, cream, and cocoa to the 0.376 gm. supplied by food, the total average amount of calcium ingested by each girl was 0.658 gm. The average total amount falls below the 0.8 gm. allowance recommended by the Committee of Food and Nutrition of the National Research Council (7) yet three of the girls were under 20 years of age, and should ingest the recommended allowance of 1.0 gm. of calcium.

The average total amount of calcium ingested by the different girls ranged between 0.461 and 0.783 gm. of calcium. Since 0.376 gm. of calcium represents the part supplied by food, the variations in intake are due to the different quantities of milk, cream, and cocoa taken by the different girls.

Since choices of foods and beverages are affected by the food habits of the individual, there is always the need of educating the individual to choose his foods

wisely for health. The amount of calcium supplied by the diet is influenced to such a great extent by the quantities of milk and cream consumed by the individual, that, in order to meet the dietary standards, he must use care to insure a sufficient intake of these constituents. Bringing each person only to the realization that at least two cups of milk should be a part of his daily diet will not solve the problem entirely. With this realization must also come the conscious habit-formation of the individual in consuming consistently the amounts of milk and cream recommended for health.

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APPENDIX

Menus used during the food collection period at The Pines

	Breakfast	Lunch	Dinner
SUNDAY	Sliced Bananas Oatmeal cereal with cream Toast Prune jam Milk Coffee Cocoa	Roast pork Gravy Sweet potatoes Buttered turnips Hot rolls Butter Golden glow salad Ice cream Cookies Coffee	Tuna fish salad Ritz crackers Pineapple upside- down cake with whipped cream Milk Tea Cocoa
MONDAY	Oranges Oat cereal with raisins, cream. Toast Pear preserve Milk Cocoa Coffee	Cream of bean and celery soup Crackers Cottage cheese and pear salad Whole wheat muffins Butter Milk Tea	Hamburger balls in country gravy Mashed potatoes Scalloped tomatoes Bread and butter Radishes Apricot tapioca pudding Coffee
TUESDAY	Cherries Wheat cereal with cream Butterhorn Milk Cocoa Coffee	Creamed frankfurters on toast with peas Fruit jello salad with whipped cream dressing Cookies Milk Tea	Pigs in blankets Gravy Mashed potatoes String beans with peppers and tomatoes Bread and butter Pickled beets Apple crisp Coffee
WEDNESDAY	Apple sauce Cereal, cream Hot cakes Syrup Milk Cocoa Coffee	Scrambled eggs Buttered spinach Bread and butter Butterscotch pudding Milk Tea	Spanish rice Buttered carrots Bread and butter Sliced turnips Gingerbread with whipped cream Coffee

	Breakfast	Lunch	Dinner
T	Dried prunes	Baked beans with	Breaded pork
H	Cereal with	Boston brown bread	chops Gravy
U	dates, cream	Lettuce with	Chili Sauce
R	Quick apple	Thousand Island	Baked potatoes
S	coffee cake	Dressing	Peas
D	Milk Cocoa	Milk Tea	Bread and butter
A	Coffee		Banana cream pie
Y			Coffee

* *

F	Orange	Vegetable soup	Filet of Sole
R	Cinnamon toast	Crackers	Scalloped potatoes
I	Cereal with cream	Deviled eggs with	Harvard beets
D	Milk Cocoa	shredded lettuce	Tomatoes
A	Coffee	Bread and butter	Bread and butter
Y		Peaches Cookies	Prune whip
		Milk Tea	Coffee

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S	Loganberries	Macaroni & Cheese	Sausage cakes
A	Cereal with	Fresh fruit salad	Mashed potatoes
T	cream	with whipped	Buttered peas
U	Toast	cream dressing	Hot biscuits
R	Apricot jam	Rye bread	Carrot sticks
D	Milk Coffee	and butter	Apple brown betty
A	Cocoa	Milk Tea	Coffee
Y			

Menus used during the food collection period at Margaret Snell Hall

	Breakfast	Lunch	Dinner (tea)
S U N D A Y	Grapefruit Cereals Hot cakes Syrup Coffee, Milk Cocoa	Tomato juice Creamed chicken Biscuit Parsley buttered potatoes Spanish corn Pear cheese salad Chocolate ice cream Coffee	Toasted cheese sandwiches Toasted peanut butter sandwiches Fruit salad Spice cake Tea Milk Chocolate
	- -		
M O N D A Y	Canned prunes Cereals Scrambled eggs Toast - jam Coffee Milk Chocolate	Tuna fish souffle Sliced orange-grapefruit salad Fruit bars Tea Milk	Sausage cakes-gravy Mashed potatoes Stewed tomatoes Stuffed peach salad Chocolate cake whipped cream Coffee
	- -		
T U E S D A Y	Oranges Cereals Maple squares Coffee Milk Chocolate	Baked hash-catsup Apple-celery-nut salad Corn bread Raspberry jam Tea Milk	Meat stew-biscuits Baked potatoes Butter cabbage Asparagus salad Cherry cobbler-thin cream Coffee
	- -		
W E D N E S D A Y	Grapefruit Cereals Bacon Toast - jam Chocolate Coffee Milk	Macaroni & cheese Vegetable salad Apricots Tea Milk	Roast veal - gravy Mashed potatoes Buttered whole beets Sliced orange salad Steamed carrot pudding Coffee
	- -		
T H U R S D A Y	Grapefruit Cereals Fried eggs Toast - jam Coffee Milk Chocolate	Lima beans in tomato sauce Marshmallow fruit salad Sliced peaches Tea Milk	Artichoke cocktail Baked ham Horseradish sauce Scalloped potatoes Buttered peas Pineapple-cheese-salad Chocolate sundae Coffee

F R I D A Y	Applesauce Cereals Buttorhorns Chocolate Coffee Milk	Mongal soup Pear salad Plain muffins Strawberry jam Tea Milk	Salmon loaf Tartar sauce Baked potatoes Carrots and peas Apricot-grapefruit salad Chocolate nut pudding with whipped cream Coffee

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S A T U R D A Y	Oranges Cereals Graham rolls Jam Coffee Milk Chocolate	Spanish rice Apple-pineapple salad Oatmeal cookies Tea Milk	Swiss steak - gravy Mashed potatoes Scalloped corn with onion Jellied vegetable salad Mince pie Coffee