
WAYS OF ADDING CALCIUM TO THE DIET

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That calcium is needed for building bones and teeth, during growth, and also to maintain the calcium balance in adults, as replacements are needed for the losses that naturally occur, is known to all of us. Furthermore, calcium salts are necessary for maintaining the normal density in the fluids of the body, for aiding in the coagulation of blood, when that is a problem, and for helping to keep the heart beating in its accustomed rhythm. Also, we know that during pregnancy and lactation and bone healing, additional calcium is needed.

These needs are all important, and for that reason the National Research Council in 1948 recommended that the calcium standard be increased from 0.8 to 1.0 gram per day for the average adult. During pregnancy and lactation, of course, the standards are higher. However, when the amount was increased,

nutritionists and other people interested in the health of people were confronted with the problem of including enough of the high calcium foods in the diets of adults. Maynard (10) at the national meeting of the American Dietetic Association in 1948 stated that with this higher standard, we will have to check carefully to determine all of the possible sources of calcium in the diet.

There are not too many foods that are rich sources of this mineral element. We always think of milk and cheese, but milk is not liked by everyone, and cheese is even less of a favorite.

If we can add some form of calcium to foods that are liked by most people, it is possible to increase the amount of this mineral element in the diet. This was one factor that was responsible for the selection of this problem by one of the authors (M.M.L.). A somewhat similar study by Dawson, *et al* (2) furnished the starting point for the investigation. In the present study we decided to try the effect of adding not only the ground eggshell, but also powdered skim milk. The eggshell has definitely been a waste product so far as human dietaries are concerned. Likewise, the skim milk is not used as often by human beings as it could be. Because these products are high in calcium, their addition to foods can increase the amount of calcium in the diet. Furthermore, because they are waste products, especially the eggshell, they should be relatively inexpensive. If we can obtain satisfactory products by adding these substances to foods, we have made a definite improvement in the diets of people.

The first part of this study investigated the effects of adding these substances to certain foods that are ordinarily liked by people. We selected plain cake, muffins, a cream soup (asparagus in this case because the effects of these substances would be more noticeable) and meat loaf, because meat is low in calcium. Maxine Looper was responsible for this phase of the investigation. The purpose was to determine the largest amount of either the eggshell or the dried skim milk that could be added to each of these four foods and still obtain a satisfactory product.

Either the ground eggshell or the powdered milk changes the characteristics of a food product. The eggshell imparts a gritty consistency to the food, and the powdered skim milk changes the flavor and perhaps the consistency of the food. The problem is to evaluate these products in a satisfactory manner. Overman and Jerome (12) state that since there are few objective tests, we have to use subjective tests for determining the quality of foods. The tasting panel which is used in judging the products cannot be very large and the members should be as accurate as possible and consistent in their judging.

In the first study, that concerned with the effects of adding ground egg-shell and powdered skim milk to products, to determine the amount to add to cake, reference was made to the previous study of Dawson *et al* (2), except that slightly larger amounts were used. For the other products, an attempt was made to add enough to make the amount of calcium in one serving about the same as that in one serving of cake.

The powdered eggshell was furnished by Dr. Slosberg, Director of Research and Development at Henningson Lamesa, Inc., Lamesa, Texas. According to Dr. Slosberg (14) the eggshells, after drying, were ground fine enough to pass through a 100 mesh sieve in a hammer mill like the kind used in the preparation of dried egg albumin. The powdered skim milk was furnished by the Gilt Edge Dairy at Norman, Oklahoma (4). This milk was prepared for market by the spray dry method.

The recipe and method of mixing for the plain cake and muffins were taken from *How's and Why's of Cooking* (6). The recipes in *Young America's Cookbook* (7) were used for the cream of asparagus soup and for the meat loaf. In the case of the cake, muffins, and cream soup, the ground eggshell or dried skim milk was added to the flour, and was well mixed and sifted, before adding the flour to the other ingredients. Forty grams of water was added to

the muffins and to the cake in addition to the fluid milk. The eggshell or dried milk was thoroughly combined with the ground meat before the other ingredients were added. No additional seasonings were added to the experimental meat loaf in order that any effect the product might have would be more easily detected. All ingredients were weighed.

In each experiment one standard product and three experimental products, each one containing a different amount of either the ground eggshell or powdered skim milk, were prepared and scored at one time. Each experiment was repeated twice. The judges' scores were used to determine the next procedure. If even the smallest amount of added substance was scored low, the amounts were reduced and the whole experiment repeated. However, if all amounts received high scores, the substance was increased still more and the total experiment repeated. The amounts of the ground eggshell and of the powdered skim milk used are shown in Table I. For the cake and muffins, the amount prepared was one standard recipe, for the soup one cup, and for the meat loaf one and one-half pounds of ground beef.

TABLE I

*Amounts of Ground Eggshell and of Powdered Skim Milk
Used in the Experiments*

PRODUCT	NO. OF EXPERIMENTS	GROUND EGGSHELL		POWDERED MILK	
		GRAMS	TEASPOONS	GRAMS	TABLESPOONS
Muffins	6	4.0-10.0	1 -2½	72.0-104.0	9-13
Cake	3	6.0-10.0	1½-2½	56.0- 72.0	7- 9
Soup	6	5.0- 0.5	1¼- ¼	24.0- 2.0	3-¼
Meat Loaf	3	4.0- 8.0	1 -2	80 -112	10-14

The five people making up the tasting panel were selected because of their ability to judge. Following the plan of Overman and Jerome (12), no attempt was made to determine taste or smell thresholds. Furthermore, the judges received no training in the evaluation of flavor defects of the products. For each product the judges were asked to score certain characteristics as "Excellent", "Good", "Fair", "Poor", or "Inedible". The four products making up each experiment were placed on the table in appropriate serving dishes and were numbered. Where the experiment was repeated, the numbers for the different products were changed so that the judges could not associate any number with a certain product. Each judge was provided with a score card for each sample and did her scoring without discussing the product with any other judge. Each characteristic had a certain value, "Excellent", having the highest value. These values were used in the statistical analysis of the data.

In all there were six experiments or 24 trials on cake using eggshell, three experiments or 12 trials using powdered skim milk; the same number of experiments and trials on muffins for each of the substances; six experiments or 24 trials on the soup for the eggshell and the same for the powdered milk; and three experiments or 12 trials for eggshell on the meat loaf and the same number of the powdered milk. There were 36 experiments involving 144 trials altogether. In some cases the first experiment indicated that the largest amount of the substance had been used. In the soup, both with the ground eggshell and with the powdered skim milk, the amounts had to be reduced.

The qualities checked in muffins were flavor, texture, lightness, tenderness, smoothness (lack of grittiness), shape, pebbled top, and browning of the surface. The scores showed that the flavor and texture of the muffins to which the eggshell had been added were slightly superior to those of the standard muffins. The scores were then analyzed statistically, using a test of variance as described by Lindquist (9). This test showed that the differences in the scores had no significance. Although the muffins with the largest

amount of eggshell had a slightly lower total score, this difference was not significant. In fact, any of the amounts of eggshell can be used and produce a fairly acceptable product.

In the powdered milk muffins the lowest amount used, 72 grams or nine tablespoons per standard recipe, produced the most desirable product. Smoothness and texture were least affected and flavor, tenderness, and browning of the surface most affected. Statistical examination of the scores showed that the only significant differences were for tenderness and browning of the surface. However, there was no difference in tenderness or browning between the standard and the product containing the least amount of powdered skim milk.

In the experimental cakes containing eggshell the scores showed these products were lighter than the standard, and that smoothness and flavor were the qualities most affected. Statistical analysis indicated that smoothness was the only quality affected and that all of the amounts of eggshell used did affect the smoothness of the product. Although the eggshell made the cakes lighter, the dried milk had the opposite effect, even though water was added in addition to the fluid milk in the recipe. Analyzed statistically, the scores indicated that evenness of surface was the only quality not affected and that the other qualities were all less desirable in the dried milk cake than in the standard. This fact was especially true of texture.

The cream soup was more affected by the addition of either the eggshell or the dried milk than any of the other products. In the case of the other experiments more of either of these substances could be used, and if the amounts were changed, it was to a larger amount. However, in the cream soup both of the added substances had to be reduced to obtain a desirable product. The flavor, texture and smoothness of the "dried milk soups" were much inferior to the standard soup, with texture and flavor most affected. All of the larger amounts of ground eggshell tried affected the characteristics of the soup. When the smaller amounts were tried, smoothness was the only factor affected unfavorably.

Neither could as much eggshell be added to the meat loaf, for even when small amounts were added, smoothness was slightly affected. These differences were shown to be significant. The scores showed that the dried milk affected the flavor of the meat loaf. However, a statistical analysis showed that these differences were unimportant.

Comparing the ground eggshell and the dried milk, it was noted that the eggshell was preferred to the powdered dried milk in the plain cake and muffins. The powdered milk was preferred to the eggshell in meat loaf, while in the cream soup the two substances were about equally well liked. As much as 10.0 grams of eggshell or 72 grams of skim milk powder could be added to the muffins, 6.0 grams of eggshell or 72 grams of dried skim milk to the plain cake, 0.25 gram of eggshell or 6.0 grams of dried skim milk to the cream soup, 8.0 grams of ground eggshell or 112 grams of dried skim milk to the meat loaf and still obtain an acceptable product. Although differences could be noted between these products and their corresponding standards, for the most part these differences were not significant.

The second part of the experiment was concerned with the chemical determination of the actual amounts of calcium that were added to these products when the ground eggshell or powdered skim milk was incorporated in the product. Margaret Stephens made these determinations.

One may wonder whether it is worthwhile to add the powdered eggshell to these foods inasmuch as the calcium is not food calcium. However, inorganic forms of calcium have been used in experimental diets and according to Wohl (16), in diets for allergic patients. During World War II, because the diets in Great Britain were low in calcium, chalk was added to flour, and was found to be a satisfactory addition. Drake *et al* (3) compared the utilization by humans of the calcium of skim milk powder and of bone meal, and found

that the utilization of the calcium in bone meal was similar to that of milk. A report in the Canadian Medical Journal (11) states that in Newfoundland during the recent war, bone meal was added to meat products and now is added to all flour used in regions where the milk consumption is low. Furthermore, Kohman (8) and Wittwer, *et al* (15) have found that the calcium in some foods, especially in certain vegetables, is not well utilized by humans. It, therefore, is worth our while to investigate the possibilities of adding the ground eggshell to foods. The calcium in the milk is available to the body. The dried skim milk, however, since it is usually a waste product in human diets, can be an economical source of this important mineral.

The plan was to analyze the standard products and those which contained the most ground eggshell or powdered skim milk and still were considered acceptable as determined from the scores. Sufficient amounts of each product were prepared so that there would be enough for the judges to score and enough for the analyses. Since each experiment was repeated twice, there were three samples of each standard, three samples of each acceptable ground eggshell product and three samples of each acceptable powdered skim milk product. Three determinations were made on each sample, or enough to get checks on each sample. At least 27 determinations were made on each of the four products, producing 108 or more tests for the total.

In preparing the foods for analysis, current food composition tables by Sherman (13) and Bogert (1) were studied to determine approximately how much of each food product should be saved for analyses and how much should be used for each determination. An adequate amount of each sample was cut into small pieces with two knives and transferred without loss to evaporating dishes that had been thoroughly cleaned in cleaning solution and heated in the muffle furnace to constant weight. The samples were dried in a Freas oven at 80° C. to constant weight. Then, they were ground and stored in clean, dry, stoppered bottles.

For ashing, the samples were weighed into the cleaned, weighed evaporating dishes, burnt off over a low flame under the hood and then ashed in the muffle furnace. After approximately 12 hours ashing, the samples were checked to see if they were completely ashed. If no unashed material showed, the evaporating dishes were placed in the desiccator until the ash was to be dissolved and made up to volume. If any dark spots did appear, however, the dishes were returned to the muffle furnace for further heating.

To dissolve, the ash was dampened with a few drops of distilled water and then about five ml of concentrated hydrochloric acid was added. If all of the ash did not dissolve, a little more water and acid were added. The solution was transferred quantitatively to a 100 ml volumetric flask and made up to volume with distilled water.

The McCrudden volumetric method, as modified by Halliday and Noble (6), was used for the determinations. The size of samples was calculated to contain approximately 8.0 mg of calcium. A definite amount of solution was pipetted into a beaker, the solution diluted and dilute ammonium hydroxide added to bring the hydrogen ion concentration to pH 4.8 — 5.2, using brom cresol green as an indicator. While stirring, oxalic acid was added, and then ammonium oxalate. The beakers were covered and boiled slowly until the precipitate was crystalline. After cooling, more brom cresol green was added, with a few drops of sodium acetate until the color changed to blue-green. The mixture was allowed to stand 12 to 20 hours to settle the precipitate.

The mixture was filtered through a Gooch crucible, and the crucible and precipitate carefully and thoroughly rinsed with dilute ammonium hydroxide. The crucible was returned to the beaker and the precipitate dissolved in hot distilled water containing 1:1 sulfuric acid. The crucible was then rinsed with hot distilled water allowing the rinsings to run back into the beaker. Next, the solution was titrated against standardized 0.02 N potassium permanganate until the end-point was reached, the first faint pink tinge that persisted at

least 30 seconds. The temperature was not allowed to fall below 60° C. during the titration. Two blank determinations (boiling distilled water plus 1:1 sulfuric acid) were run each time a new quantity of potassium permanganate was prepared. The amount of calcium in the sample was then calculated from the amount of potassium permanganate used in the titration. At least three titrations, or enough to give a check, were run on each sample.

The results showed that significant amounts of calcium can be added to the diet by incorporating either the ground eggshell or powdered skim milk in plain cake, muffins, a cream soup or meat loaf. Also, the products are satisfactory so far as eating quality is concerned. An interesting fact was that the egg-shell increased the lightness and improved the texture of the cake and muffins.

The results of adding the eggshell or skim milk to these four products are shown in Table II. One serving of cake is a pie shaped piece, one-tenth of a two-layer cake (each layer eight inches in diameter and one and one-half inches high). The values are for the cake alone and do not include any filling or frosting that might be used. One serving of muffins is two muffins each one two and one-half inches in diameter and two and one-half inches high; one serving of cream soup is one cup (approximately one-half cup of thin white sauce and one-half cup of vegetable puree); and one serving of meat loaf is one-sixth of the meat loaf or one-fourth pound. The figures for calcium are in each instance averages for at least nine determinations.

TABLE II
*The Effect Upon the Calcium Content of Foods of Adding
Ground Eggshell or Powdered Skim Milk*

FOOD	TYPE	AMOUNT OF ENRICHMENT		CALCIUM PER
		Grams	Meas.	AVERAGE SERVING
				mg.
Plain Cake	Standard			89.40
	Dried Milk			
	Enriched	72.0	9T.	170.53
	Eggshell			
	Enriched	6.0	1½t.	248.40
Muffins	Standard			132.6
	Dried Milk			
	Enriched	72.0	9T.	269.53
	Eggshell			
	Enriched	10.0	2½t.	703.50
Cream of Asparagus Soup	Standard			139.86
	Dried Milk			
	Enriched	6.0	¾T.	221.33
	Eggshell			
	Enriched	0.25	1/16t.	375.33
Meat Loaf	Standard			49.06
	Dried Milk			
	Enriched	112.0	14T.	263.46
	Eggshell			
	Enriched	8.0	1T.	795.62

One can see that by adding either the powdered skim milk or the ground eggshell the amount of calcium in a serving of any one of the four food products can be increased. One serving of cake enriched with the dried milk would supply an average of 170.53 mg of calcium or 17 per cent of the daily standard for adults. We should recall that the new recommended daily allowance for adults is one gram or 1000 mg. When the cake has ground eggshell added, one serving furnishes 248.4 mg of calcium or approximately 25 percent of the day's standard. Two muffins, or one serving, enriched with the dried

milk, will furnish 269.53 mg or about 27 percent of the day's need. With the eggshell the increase is even greater, namely, 703.5 mg or 70 percent of the standard for the day. More of the eggshell can be added to muffins than to cake.

The effect of both the eggshell and the dried milk was more apparent in the soup than in the case of the cake and muffins, for grittiness due to eggshell and flavor due to the dried milk were easily noticed. However, considerable amounts of calcium can be included. We note from Table II that the soup with powdered skim milk supplied 221.33 mg or 22 per cent of the daily standard and with eggshell furnished 375.33 mg per serving or approximately 38 per cent of the day's need. The eggshell had a tendency to settle out while the dried milk seemed to thicken the soup.

Since meat is low in calcium one would expect the enriched meat loaf to have a greater amount of calcium than the standard. From Table II we note that one serving of the dried milk enriched meat loaf contained 263.64 mg or 26 per cent of the day's need, while the meat loaf with eggshell contained an average of 795.62 mg or approximately 80 percent of the daily standard. This amount is greater than in any of the products. The muffins enriched with eggshell were almost as high in calcium, 702.5 mg per serving. It was possible to add rather large amounts of both the dried milk and ground eggshell to the meat loaf.

We can see that either the powdered skim milk or ground eggshell when added to plain cake, muffins, cream soup or meat loaf can increase the calcium content considerably. Unless used in too large amounts these substances improved the lightness and texture of the cake and muffins. They did not have much effect upon the meat loaf, but were harder to incorporate in the cream soup than in any of the other products. The ground eggshell in each case caused a greater increase in the calcium content of the food products than the powdered whole milk did, due, of course, to the fact that the eggshell had a considerably greater calcium content than the dried milk has. As both of these products are ordinarily waste products, so far as human dietaries are concerned, they ought to be less expensive than other good calcium sources. There is the matter of the availability of the calcium in the eggshell. Considering this point, doubtless the two products would have somewhat similar values in calcium. It would be worth our while to investigate the possibility of producing these products so that human beings can make use of them in their diets.

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