Calcium Bioavailability of Soyfoods, Dairy Examined

By Yongdong Zhao, Ph.D. and Connie Weaver, Ph.D.

A QUICK TASTE
Calcium bioavailability of most soyfoods is comparable to cow's milk. The average calcium intake of Americans and many other populations is lower than the daily requirement.1 Calcium rich soyfoods can be acceptable sources for meeting dietary calcium needs. This article discusses common methods to evaluate calcium bioavailability and studies on calcium bioavailability of soyfoods.

Osteoporosis prevention through dietary modification involves maintaining normal vitamin D status and ensuring adequate calcium intake to maximize calcium utilization from food sources. Calcium bioavailability, the percentage of calcium that can be absorbed from a calcium source, is an important measure by which to assess different foods as sources of calcium. Calcium absorption is dependent on the status of the person, which is determined by a number of factors including age,2 vitamin D status,3 and ethnicity.4 Thus, calcium bioavailability from various sources is best compared in the same individuals at similar calcium loads.5

Tracer Labeling
Calcium bioavailability can be measured through tracer labeling, which provides a more sensitive and accurate estimate than calcium mass balance (the difference between dietary and fecal calcium) because calcium tracers from labeled food products can be distinguished from endogenous calcium in body fluid samples, which introduces a source of error in balance studies. Calcium in food products is labeled as either radioisotope (45Ca) or stable (non-radioactive) isotopes. The assumption when using tracers is that the tracer is completely representative of the total calcium in the products. To assure that this is the case often requires the use of a special procedure called “intrinsic labeling.”6 For intrinsic labeling, calcium tracers are incorporated into foods through biosynthesis or through chemical synthesis of a salt rather than simply mixing the calcium label with the food. For example, intrinsic labeling can be accomplished by administering calcium tracers to hydroponically grown plants.7 For meat and dairy products, animals receive an intravenous dose of calcium tracer, which is subsequently utilized and incorporated into tissues of the animals.8 In contrast to intrinsic labeling, “extrinsic labeling” requires minimal effort. Typically, the calcium tracer is mixed with final food products overnight before testing.9 However, this method does not always yield reliable results due to the difference between the chemical forms of the calcium tracer and the calcium in food products, which can affect bioavailability. Thus, “extrinsic labeling” on a specific product needs to be validated against “intrinsic labeling,” and such a validation has been performed for cow’s milk.8

Testing Methods
In vitro assays,9 which are quick and relatively easy, and animal models10 are used for estimating calcium absorption in humans, but the gold standard is clearly human research using tracer-labeled food products. Such food products are ideally tested at a typical calci-
um load (100-300 mg) in humans because absorption efficiency is inversely related to dose, i.e., the higher the dose, the lower percent absorption efficiency. One approach for measuring calcium absorption is to calculate the difference between the tracer administered through food products and the tracer recovered from fecal collection. However, a more accurate approach, the double isotopic dilution method,11 12 requires a second calcium isotopic tracer be injected intravenously at similar time of ingestion of the labeled products. Because the absorbed calcium tracer from food products should go through the same metabolism as the injected (i.v.) calcium tracer, by comparing the ratio of these two isotopes (oral vs. i.v.) in a 24-hour urine sample, one can determine the calcium absorption fraction. A third method for assessing calcium absorption is to measure the change in serum calcium tracer. Heaney et al. has established a method using 5-hour serum calcium tracer specific activity (percent of tracer dose/g calcium) adjusted by body height and weight to calculate calcium absorption.13

**CALCIUM ABSORPTION FROM SOYFOODS**

**Recent Study**

Using a quick assay, calcium bioavailability of various beverages, including cow’s milk, calcium fortified orange juice and soymilk was recently reported in Nutrition Today.14 Beverages were mixed with 45 Ca in a highly soluble (CaCl2) form and stored overnight in a refrigerator. Samples were centrifuged the next day to separate the pellet, composed of insoluble particles in the beverage, from the supernatant, which contained soluble calcium. Total calcium and 45 Ca from each fraction were analyzed and used to calculate the “beverage score” as the sum of percent of calcium in the supernatant and the relative proportion of 45 Ca found in the pellet. This assay assumes that the soluble calcium in the supernatant can be absorbed efficiently, whereas the relative proportion of 45 Ca indicates the exchange-ability of the insoluble calcium. Using this assay, soy beverage yielded low beverage scores (57.5 to 70.6 percent) compared to cow’s milk (100 percent). In theory, calcium absorption from beverages with low scores would be poor. However, this assay mainly measures the solubility and exchangeability of calcium in the food products. Solubility at neutral pH is not a reliable indicator of calcium bioavailability.15 Certain calcium salts, i.e. calcium carbonate and tricalcium phosphate, can be dissolved in acid. Hence, calcium is released from the insoluble salts for absorption. Moreover, maximum settling would have occurred by refrigeration overnight without stirring of the calcium label because the fortificants are insoluble in fortified soy beverages. In contrast, much of the calcium in milk is stabilized in the micelles and complexes with phosphates and does not settle. As noted on most soymilk labels, it is important to shake calcium-fortified beverages just before serving to ensure the homogeneous dispersion of calcium fortificants.

**Human Studies**

Soybeans and calcium-set tofu contain similar amounts of calcium as cow’s milk,16 but the high phytate content of soyfoods has been shown to inhibit calcium absorption. To examine this issue, a study in our lab cultured soybeans with different amounts of phosphorus to produce soybeans with a range of phytate content. The beans were intrinsically labeled (45 Ca) and calcium absorption from low- and high-phytate soybeans was compared with cow’s milk in healthy premenopausal women using the 5-hour serum approach.17 Calcium absorption from the low-phytate (0.301 g/100 g) soybeans was similar to the calcium absorption from cow’s milk, whereas absorption from the high-phytate (0.978 g/100 g) soybeans was significantly lower. Apparently, there was a dose dependent inhibition of phytate on calcium absorption. In another study, calcium bioavailability of tofu and cow’s milk was compared.18 Calcium absorption was measured either through fecal recovery or 5-hour serum specific activity. Tofu was labeled with either 45 CaCl2 or 45 CaSO4, whereas milk was labeled with 45 CaCl. Regardless of the testing method, there was no difference in calcium absorption between tofu and cow’s milk. This study concluded that the calcium supplied by tofu is as bioavailable as the calcium supplied by cow’s milk.

Recent research suggests that calcium absorption from calcium-fortified soymilk is influenced by the type of calcium fortificant. The most common calcium salt used in fortified soymilk is tricalcium phosphate (TCP). Calcium bioavailability of TCP fortified soymilk was tested in men with a single 5-hour serum sample.19 In this study, TCP fortified soymilk was labeled with either 45 CaCl (an extrinsically labeled, highly soluble form) or 45 Ca-TCP (intrinsically labeled TCP in fortified soymilk). Cow’s milk was extrinsically labeled. Calcium absorption was significantly higher from extrinsically labeled soy milk than from intrinsically labeled soymilk, whereas calcium from the latter treatment was absorbed only 75 percent as well as that from cow’s milk. This study suggested that calcium fortified soymilk needs to be intrinsically labeled for an accurate evaluation of calcium bioavailability because extrinsic labeling underestimated calcium absorption. 

In addition to TCP, soymilk can also be fortified with calcium carbonate.
Food guidance systems have existed since nutritionists realized the need to communicate basic nutrient information to the public. USDA pronounced the first guide in 1894, and has revised the guide about every 10 years to reflect new knowledge about nutrient needs, the relationship of diet to health, and food composition. Dr. Atwater’s 1902 Principles of Nutrition and Nutritive Value of Food became the foundation for USDA’s dietary recommendations.

Over 100 years later, in April 2005, USDA unveiled the newest food guide, MyPyramid, which builds on the principles of the 1992 Food Guide Pyramid and adds physical activity. With attention to calorie, saturated fat and cholesterol control, soyfoods are mainstreamed into MyPyramid’s new American diet recommendations.

Go lean with protein. (MEAT & BEANS)

Vary your protein routine — choose more fish, beans, peas, nuts and seeds.

Tofu, tempeh, soynuts, soynut butter, soybeans, and soy meat alternatives (i.e., soy burgers or soy crumbles), are rich in high-quality protein, low in saturated fat, and cholesterol free.

Get your calcium-rich foods. (MILK)

If you don’t or can’t consume milk, choose lactose-free products or other calcium sources.

Fortified soymilk is rich in calcium, vitamins D and A, magnesium and potassium. Soy dairy alternatives, such as soy slices, cultured soy and frozen soy desserts, are also generally low in saturated fat, cholesterol and calories, and may be calcium-fortified. (Check the label.) For lactose intolerance problems, you might also try lactase enzymes with milk or take a calcium supplement with vitamin D.

Know your fats. (OILS)

Make most of your fat sources from fish, nuts and vegetable oils.

Soybean oil is low in saturated fat and high in heart-healthy omega-3 fatty acids. Soybean oil is flavor-free and works well in all kinds of cooking and baking. Soynuts and soynut butter provide protein, omega-3 fatty acids, fiber, potassium, folic acid and iron.

Soyfoods can reduce calorie intake. For example, blending soy crumbles with ground beef cuts calories. Drinking 8 oz. of regular, unsweetened soymilk rather than whole milk saves between 40 to 70 calories. Visit www.soyfoods.org for more ways to add soy to a daily diet.

ABOUT THE AUTHOR
Nancy Chapman, M.P.H., R.D. serves as Executive Director for the Soyfoods Association of North America (SANA).

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SOY SNACKING

By Dita Rago

Salty, crunchy, nutty, creamy or sweet. These sensations just might be what you’re looking for in a snack. Snacking with soy can provide all these flavors and textures to satisfy any craving. With so many companies experimenting with soy and soy products, the options continue to grow.

Many people are looking for ways to include soy’s health benefits in their diets. Soy has been shown to reduce cholesterol, which lowers the risk of heart disease. It also is a lean protein source, which is recommended in the 2005 USDA dietary guidelines. In addition, snacks that contain protein cause the body to digest food at a slower rate. This delay in digestion allows the body to stay satiated longer, and also helps to stabilize blood sugar.

Snacks, like the rest of a diet, should be low in saturated fat. Soy contains healthy fats that are unsaturated. Full-fat soyfoods are one of the few good plant sources of omega-3 fatty acids. Soy snacks made from the whole bean contain these fatty acids.

When snacking, it is important to determine the amount of calories for a portion size. Keeping the calorie content of a snack below 200 is a good general reference. Here are some ideas when searching for a soy snack:

- For a salty and crunchy snack, try soy crisps, which come in a variety of flavors including ranch, cheddar and barbecue. (Serving size: 18 crisps; average of 130 calories, 7g protein.)
- Craving a spicy kick? Pair tortilla chips made with soy with your favorite spicy salsa. (Serving size: 15 chips; average of 150 calories, 5g protein.)
- If you want something crunchy and sweet, add soy granola or cereal to yogurt or a trail mix. (Serving size: 3/4 cup cereal; average of 120 calories, 6g protein, or 1/4 cup granola; average of 95 calories, 5g protein.)
- When looking for something creamy and nutty, try soynuts or soynut butter. (Serving size: 1/3 cup nuts; average of 140 calories, 10g protein, or 2 Tb. butter; average of 180 calories, 10g protein.)
- Cookies made with soy flour also are available. Try them with a 1/2 cup of milk, or even soymilk. (Serving size: 2 cookies; average of 148 calories, 3g protein.)
- Cheese and crackers made with soy cheese is another tasty snack. (Serving size: 1 oz.; average of 70 calories, 5g protein.)
- Instead of popcorn with your next movie, heat up edamame, which can be found in the freezer section. Edamame, or green soybeans, is a fun finger food that can be served in or out of the pod. Sprinkle with salt or soy sauce to bring out its natural flavor. (Serving size: 3/4 cup; average of 180 calories, 20g protein.)

ABOUT THE AUTHOR
Dita Rago, a dietitian, graduated from Johnson & Wales University in Providence, Rhode Island, in 2004 with a bachelor’s in culinary nutrition. She served as culinary editor of The Campus Herald, the university’s biweekly newspaper, for two years.

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ate. A recent study in our lab examined calcium bioavailability of calcium carbonate fortified soymilk, TCP fortified soymilk, and cow’s milk in young women using the double isotopic dilution method. Fortificants were labeled intrinsically. TCP fortified soymilk, as reported before, had a lower calcium absorption than cow’s milk. However, calcium bioavailability of calcium carbonate fortified soymilk was equivalent to cow’s milk.

In summary, calcium-rich soyfoods, such as tofu and calcium carbonate fortified soymilk, provide comparable amounts of absorbable calcium as cow’s milk. This implies that daily calcium requirements can be met with daily consumption of three servings of calcium-rich soyfoods.

ABOUT THE AUTHORS
Yongdong Zhao, Ph.D.

obtained his doctorate from the Department of Foods and Nutrition at Purdue University. His research focuses on calcium bioavailability. Connie Weaver, Ph.D., is distinguished professor and head of the Department of Foods and Nutrition at Purdue University. Her research interests include mineral bioavailability, calcium metabolism and bone health. She received a doctorate in food science and human nutrition from Florida State University and holds minors in chemistry and plant physiology.

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Oils Take on New Role in MyPyramid

One of the changes in the new USDA Food Guide Pyramid reflects an update in the way health professionals have come to think about the role of oil in the diet.

In the old pyramid, oils were delegated to the very peak with fats and sweets, along with instructions to “use sparingly.” Now, in MyPyramid, oils are represented as a crucial part of the diet with a slender, golden stripe between fruits and milk.

The new pyramid creates a distinction between oils and discretionary calories, calories beyond those needed to meet nutritional needs. Oils, typically fats that are liquid at room temperature, are the major source of monounsaturated and polyunsaturated fats in the diet. Because polyunsaturated fats contain essential fatty acids necessary for good health, and because the monounsaturated and polyunsaturated fats found in foods like vegetable oils, fish and nuts do not raise LDL cholesterol levels, oils have achieved a new identity apart from discretionary calories.

For men and women who perform less than 30 minutes of physical activity each day beyond normal activities, the daily allowance of oil ranges from five to seven teaspoons. For children and adolescents, the allowance is three to six teaspoons, depending on age and gender. Consumption of liquid soybean oil through foods like mayonnaise, salad dressings, soybean oil with flavored vinegars, and soft margarine with no trans fats can provide a healthy way to meet the daily allowance of oil. Solid fats, like animal fats or hydrogenated oil, and certain oils, like palm and coconut oil, contain more saturated and/or trans fats than liquid oils, and are not as healthy a choice as liquid oils.

MyPyramid Offers Personal Guidance (Continued from Page 3)

A history function allows consumers to track their progress over time, up to one year.

For Professionals – provides nutrition educators with valuable information including the Getting Started guide, which can help them navigate through the MyPyramid system. This page is also the site of the educational framework that provides key concepts of the MyPyramid system from which professionals can develop consumer messages and materials. In addition, this page gives professionals easy access to downloadable print materials for consumers, the food intake patterns, and a sample 2,000 calorie menu.

A child-friendly version of MyPyramid for teachers and children will be released in the Fall. The child-friendly version is intended to reach children 6- to 11-years-old with targeted messages about the importance of making smart eating and physical activity choices.