WHEY PRODUCTS, MILK MINERALS AND DAIRY CALCIUM *New findings, Benefits and Applications*

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Calcium can be obtained in the diet by various sources, but the most highly recommended source is dairy products. Dairy products are a source of calcium with high bioavailability. The ingredient milk calcium is derived from milk by a unique separation technique. A variety of whey ingredients are also available for calcium fortification purposes.

WHEY PRODUCTS AS A SOURCE OF CALCIUM

Whey-based products are an excellent and cost efficient source of calcium (500-2,000 mg/100 g). In addition, natural milk calcium (and other calcium-rich whey ingredients) present advantages in terms of their neutral taste and bland odor. All natural and obtained from milk, these ingredients are preferred by consumers and help manufacturers design products with a "clean label" and natural image.

MORE CALCIUM IS NEEDED

The Food and Nutrition Board of the Institute of Medicine (IOM) of the National Academy of Sciences (NAS) released new recommendations for calcium and related nutrients. These new recommendations — now called Dietary Reference Intakes (DRIs) — update and expand the Recommended Dietary Allowances (RDAs) set in 1989 by the National Academy of Sciences.

The gap between calcium intakes and calcium recommendations is much wider than previously thought. Most people are not meeting the new recommendations for calcium. In addition, new scientific findings have added further support to the beneficial role of calcium in health. The World Health Organization sets recommendations for calcium intake, as well as individual countries health authorities, therefore recommended intakes might be different from those referred to in this monograph. Please consult local recommendations for intake, claims and product labeling.

Calcium Recommendations

Children 4–8	800 mg
Preteens and teens 9-18	1,300 mg
Adults 19–50	1,000 mg
Adults 51 and older	1,200 mg

Source: National Academy of Science. USA.

THE DAIRY ADVANTAGE

Foods naturally containing calcium, in particular dairy foods and ingredients, are the best sources of calcium. Milk and milk products such as whey and calcium products derived from whey or milk are the preferred source of calcium because of their high content of calcium. Also, the amount of calcium absorbed from foods varies. For example, little calcium is absorbed from spinach, and the calcium absorbed from navy, pinto or red beans is absorbed about half as well as that from milk. This means that one would need to consume more than a kilo of pinto beans to obtain the same amount of calcium absorbed from one glass of milk.

MAJOR FUNCTIONS OF CALCIUM IN THE BODY

CALCIUM'S ROLE IN BONE DEVELOPMENT

Bones serve as a basic support system protecting vital organs and as a reservoir for calcium — the most abundant mineral in the body. In fact, 99% of the body's calcium is found in bones and teeth (the other 1% is found in cells, blood, and other body fluids). Despite its static appearance, bone is constantly being formed and broken down. This process, called remodeling, is the resorption (breaking down) of existing bone and deposition of new bone to replace that which has been broken down. At any one time, about 10% to 15% of bone surfaces are undergoing remodeling. A number of interrelated hormonal, nutritional, mechanical, and genetic factors influence remodeling.

Resorption of old bone and formation of new bone are processes that continuously overlap. The importance of these processes varies at different times throughout the life cycle. In general, from birth until about age 20, the bones are in a phase of active growth. Beginning in the 40s or later, resorption of existing bone starts to exceed formation of new bone, resulting in a net loss. Age-related bone loss is influenced by both genetic and environmental factors.

The body's calcium status depends more on overall nutritional factors than just calcium intake. Some nutritive factors influence the body's absorption of calcium, while other factors affect calcium retention or urinary calcium excretion. Urinary losses of calcium are a big determinant of calcium loss.

Calcium nutriture depends not only on calcium intake, but also on numerous dietary and nondietary factors that influence calcium metabolism. Dietary factors aiding calcium absorption and retention include: vitamin D, lactose (which stimulates the intestinal absorption of calcium in laboratory animals and in human infants), fructo-oligosaccharides, phosphorus, protein, sodium and other elements.

BEYOND BONES

Calcium also is important for the development of teeth. Teeth, like bones, are calcified tissue. The teeth begin to form in the first few months of fetal life and the mineralization process continues into late adolescence. An adequate intake of calcium, in addition to phosphorus, protein, fluoride, and vitamins A, C, and D, is needed for proper development of tooth structures.

Although the mature tooth is metabolically active, the fully eruptive adult tooth is not significantly subject to resorption.

Outside of bones and teeth, the level of ionized calcium in the blood must be maintained within a narrow range to perform calcium's regulatory functions. When the diet is low in calcium, the bones release enough calcium into the bloodstream to meet the body's needs.

Although the amount of calcium outside bones and teeth is relatively small, it is required for a number of basic regulatory functions including:

- Contraction and relaxation of muscle (including normal heart beat)
- Coagulation of blood
- Transmission of nerve impulses
- Activation of enzyme reactions
- Stimulation of hormone secretions
- Integrity of intracellular cement substances

Calcium for Mature Adults 51 and Older

Everybody needs calcium. But with age, one needs more to offset calcium losses from bone and decreased calcium absorption. Individuals 51 or over need 1,200 mg of calcium a day. Though calcium can be found in a variety of foods, leading health experts recommend milk and milk products as the preferred sources of calcium.

FOUR GOOD REASONS TO COUNT ON CALCIUM

While there are no magic bullets or miracle cures, researchers are finding that some nutrients such as calcium can play a major role in disease prevention. Appropriate dairy consumption and calcium intake may help reduce the risk of:

- Osteoporosis
- High Blood Pressure
- Colon Cancer
- Cardiovascular Disease

CALCIUM AND CHRONIC DISEASE PREVENTION

Increasing scientific evidence indicates that an adequate calcium intake may help reduce the risk of several major chronic diseases including osteoporosis, hypertension, colon cancer, and possibly cardiovascular disease and kidney stones. These diseases are responsible for considerable morbidity and mortality in many patients, as well as rising national health expenditures.

OSTEOPOROSIS

One out of two women and one out of eight men will develop osteoporosis. A diet high in calcium can help slow bone loss.

Osteoporosis (porous bones) is a skeletal disease in which bones become so fragile they spontaneously break as a result of a minor fall or even from everyday activities. Decreased bone mass and microarchitectural damage to bone tissue cause the bones to become fragile.

The rate of osteoporosis has reached epidemic proportions in many countries of the world and is responsible for considerable morbidity, mortality, and economic costs.

Diet, specifically calcium intakes below the recommended levels throughout life, may increase the risk of osteoporosis. Also, an inadequate vitamin D status contributes to low bone mass. Ensuring an adequate calcium and vitamin D status throughout life is estimated to reduce osteoporotic fracture risk by 50% or more. Other dietary factors like sodium, protein, and fiber may influence the risk of osteoporosis by impacting calcium status. However, if calcium intake is adequate, these other dietary factors have relatively little effect on osteoporosis risk.

Osteoporosis experts agree that an optimal intake of calcium throughout life, from early childhood and adolescence through the postmenopausal and later adult years, reduces the risk of osteoporosis. Research indicates that it is never too early or too late to improve bone health and reduce the risk of osteoporosis. Intake of milk and milk products has been demonstrated to protect against osteoporosis by increasing bone retention and reducing fractures.

In a study involving over 5,500 women 50 years of age and older from six countries, an adequate calcium intake from milk decreased the number of hip fractures by 35%.

HYPERTENSION

As many as 50 million Americans and many millions in other countries have high blood pressure (hypertension), which increases the risk of heart disease, stroke, and kidney disease.

In the U.S. the Joint National Committee on Direction, Evaluation and Treatment of High Blood Pressure recommends consuming adequate amounts of calcium (as well as potassium and magnesium) to help reduce blood pressure. A review of 25 epidemiological studies investigating the relationship between the intake of calcium or calcium-rich foods and blood pressure found that the majority of these studies supported an inverse relationship. The beneficial effect of calcium on blood pressure provides yet another reason to ensure adequate intake of calcium-rich foods as part of a healthy diet. An advantage of milk minerals (as an ingredient for enrichment) over other calcium sources, is that this ingredient provides highly bioavailable calcium in balance with other minerals to optimize health benefits.

A diet containing an adequate amount of calcium is recommended as a nonpharmacological lifestyle modification for the prevention and treatment of high blood pressure. Many studies have demonstrated that calcium reduces the risk of hypertension or high blood pressure, especially in certain subgroups of the population.

Since the early 1980s, scientific research has shown that calcium plays an important role in regulating blood pressure. Findings from numerous population studies, experimental animal investigations, and clinical trials indicate that increasing calcium intake lowers blood pressure or reduces the risk of hypertension. In population studies, people with high blood pressure have lower intakes of calcium than people with normal blood pressure, and vice versa. In humans and experimental animals with hypertension, abnormalities in calcium metabolism have been detected. In clinical trials of calcium supplementation, blood pressure is reduced in many individuals, particularly those at high risk of hypertension and/or who have inadequate calcium intakes.

Although increased calcium intake generally lowers blood pressure more in adults than in children, a blood-pressure-lowering effect of calcium has been demonstrated in some young children, especially those whose calcium intakes are initially low. In teens, differences in calcium intake have been observed between those with high-normal and low-normal blood pressure (82). Because as many as one half of children with high blood pressure may have hypertension as adults' (83), children should consume an adequate intake of calcium.

Coronary heart disease (CHD) is the most common and serious form of cardiovascular disease in the United States. Cigarette smoking, high blood pressure (hypertension), and elevated blood cholesterol levels are the major risk factors for this disease. Calcium may protect against CHD by its effect on two of these risk factors: hypertension and blood lipid levels. In patients with mild to moderate hypercholesterolemia, an increased calcium intake lowers total and LDL (low-density lipoprotein) blood cholesterol levels. Calcium alone is not responsible for milk's protective effect against stroke. Total calcium intake or intake of calcium from nondairy sources did not have the same protective effect as milk.

Taking the Pressure Off: The Calcium Connection

Some studies suggest that cutting back on salt lowers the risk of high blood pressure. However, new research shows that increasing calcium consumption to at least recommended levels (1,000 mg/day for adults 19-50 and 1,200 mg/day for adults 51 and older) is also associated with a small, but important, reduction in blood pressure. This effect is expected to be even greater in people at high risk for both hypertension and low calcium intakes including African Americans and mature adults (ages 51+).

Calcium has two "partners" that help curb high blood pressure — potassium and magnesium. They pitch in to help keep blood pressure levels in check. Luckily, milk products and ingredients such as milk minerals contain ample amounts of all three.

COLON CANCER

Experimental animal and human evidence supports the hypothesis that calcium intake inversely correlates with colon cancer risk and cell proliferation in the colonic mucosa. Colon cancer is the third leading cause of cancer deaths in the United States and a leading cause in many countries. Both genetics and environmental factors contribute to this disease. While some dietary factors are suspected of contributing to colon cancer, others are thought to be protective. Several components in cow's milk fat such as conjugated linoleic acid, sphingolipids, and butyric acid have been found to protect against colon cancer in experimental animal and laboratory studies. Findings from a number of scientific studies indicate that calcium intakes in excess of current recommendations may reduce the risk of colon cancer.

Studies to date indicate that calcium intake of 1,500 to 2,000 mg/day — amounts greater than current calcium recommendations of 1,000 to 1,200 mg/day for most adults — are necessary to protect against colon cancer, especially in individuals at risk of this disease. However, further studies are needed to firmly establish calcium's protective effect against colon cancer and to determine the mechanism(s) involved. Advice to increase calcium intake above current recommendations to protect against cancer is considered premature at this time.

CALCIUM AND WEIGHT LOSS

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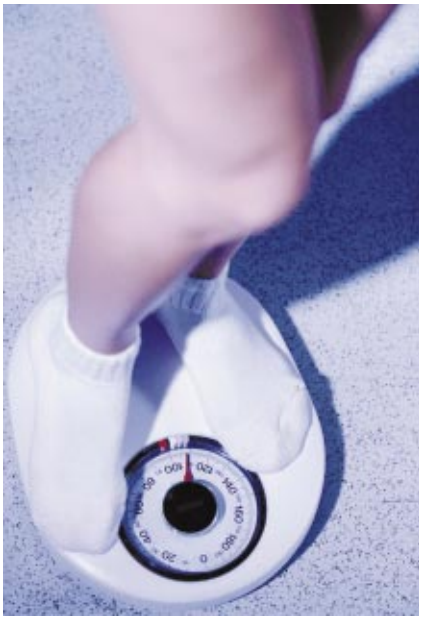
Dietary calcium plays a pivotal role in the regulation of energy metabolism as has been found through studies evaluating dairy calcium in weight loss diets. High dairy calcium diets have been shown to attenuate adipocyte lipid accretion and weight gain during periods of over-consumption of an energy-dense, and to increase lipolysis and preserve thermogenesis during caloric restriction, thereby accelerating weight loss.



Studies of the agouti gene conducted at the University of Tennessee Department of Nutrition in obesity and insulin resistance demonstrate a key role for intracellular Ca^{2+} in regulating adipocyte lipid metabolism and triglyceride storage with increased intracellular Ca, resulting in stimulation of lipogenic gene expression and lipogenesis and suppression of lypolysis. High calcium diets apparently inhibit lipogenesis, markedly accelerate fat loss and suppress fat accretion in animals maintained at identical caloric intakes. These findings are further supported by clinical data demonstrating that increased dietary calcium (as obtained in whey in milk products) results in significant reduction in fat tissue mass in obese humans.

Notably, dairy sources of calcium (such as calcium from dairy products) exert a significantly greater anti-obesity effect than supplemental sources in epidemiological studies, indicating an important role for dairy products in the control of obesity.

High Calcium Caramel Candy

Ingredients	Percent
Granulated Sugar (sucrose)	34.80
42 D.E. Corn Syrup	33.50
Partially Hydrogenated Coconut Oil (92°F)	11.80
Water	5.90
Skim Milk Powder (SMP)	4.20
WPC-34	4.20
Butter	3.00
Milk Minerals	2.30
Vanilla Extract	0.10
Soy Lecithin	0.10
Salt	0.10
Totals	**100.00**

Formula courtesy of Dairy Mangement Inc.

Procedure

1. Pre-hydrate WPC-34 and SMP separately with water to make a 30% solution and let sit overnight.
2. Mix sugar, corn syrup and water together and dissolve over heat.
3. Add remainder of ingredients.
4. Mix all ingredients under low heat (mix thoroughly).
5. Increase heat and boil to 242°F (116°C).
6. Transfer to cold table.
7. Cool and cut.

BUILDING AND MAINTAINING STRONG BONES:
A Case for Balance in Dietary Mineral Consumption

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Recently, the importance of dietary calcium has increased because research has established that calcium is not only essential for bone growth and development, it is important for regulation of cell function, nerve conduction, muscle contraction, and blood coagulation. In addition, calcium provides a protective role against osteoporosis, essential hypertension, gestational hypertension, hypercholesterolemia, certain cancers (colon and mammary) and possibly gallstones.

Several population segments in both developed and developing countries have low calcium intake. Calcium supplementation and fortification has become increasingly important and calcium is being incorporated into many food products around the world. Calcium supplements are usually calcium salts such as calcium citrate, calcium lactate, calcium carbonate, and calcium phosphate.

In the hype that has surrounded calcium supplementation and fortification, one of the basic principles of nutrition, balance, has been neglected and overlooked. Obviously, to maintain proper composition of mineral in the bone, there must be adequate absorption and delivery of all bone minerals to bone sites in the human body.

Phosphorus is required for bone growth and maintenance, and most recommendations for phosphorus are to maintain a dietary calcium : phosphorus ratio of 2:1. Magnesium is also an important mineral in bone development. Most of the calcium supplements deliver only calcium and none of the other bone building minerals such as magnesium, potassium, zinc and other minerals required for good bone health.

Just as Ca/Mg/K ratios have received little attention among researchers in the osteoporosis area, ratios of the required micronutrients also have received little attention. The effects of calcium supplementation with and without zinc, copper and manganese showed that bone loss in postmenopausal women could be only partly arrested by Ca supplementation, but to fully maintain bone mass, trace minerals were required. It can be concluded that many minerals are required for optimal bone growth and health, but that the extreme focus on only calcium has, in a sense, inhibited the promotion of a balanced approach for mineral supplementation, particularly for segments of the population that are at risk for osteoporosis.

One mineral supplement that has been widely accepted in Asia and is recognized there as the "premier" bone building supplement is "milk calcium" (more accurately called milk mineral). It has been recently shown by several studies that milk mineral contains the appropriate balance of minerals for optimal bone health. Milk mineral is an ingredient that retains the mineral balance of milk while allowing for mineral supplementation into products that traditionally do not contain good ratios of bone building minerals.

BIOAVAILABILITY OF CALCIUM FROM DAIRY SOURCES

There are many factors that influence calcium bioavailability. Both exogenous and endogenous factors influence calcium bioavailability. Level of calcium intake, vitamin D status, phytates, oxalates, lipids, phosphopeptides and other proteins, lactose, phosphorus and caffeine are among the exogenous factors influencing the intestinal calcium absorption.

Dairy foods and ingredients are not only rich in calcium, but the calcium from these sources is readily available. Normal healthy individuals absorb about 20 to 35% of the calcium in dairy foods and ingredients. Studies have shown that the calcium absorption efficiency from non-dairy calcium fortified sources (such as fortified soy milk) was 25% less than that from a dairy source*

For this reason, manufacturers can rely on dairy ingredients rich in calcium (from milk powders, whey minerals to various types of whey ingredients) to provide adequate fortification with a highly bioavailable calcium content. Furthermore, dairy calcium is 100% natural (all natural "clean" label appeal) and contains a range of other minerals such as phosphorus and magnesium.

*Source: American Journal of Clinical Nutrition. 2000. 71: 1166-1169.

Major U.S. dairy ingredients and their calcium content

Dairy ingredient	Typical calcium content, in mg/100 g
Demineralized whey	<100 mg/100g
Whey protein concentrate	500–700 mg/100 g
Whey protein isolate	600 mg/100 g
Reduced-protein (deproteinized) whey	600–700 mg/100 g
Sweet whey	700–800 mg/100 g
Whey permeate	800–900 mg/100 g
Reduced lactose whey	800–900 mg/100 g
Mineral concentrated whey	>5,000 mg/100 g
Whole milk powder	950–1,000 mg/100 g
Skim milk powder	1,300 mg/100g
Acid whey	2,000 mg/100 g
Milk minerals	23,000–28,000 mg/100 g

Typical composition and specifications of calcium-rich U.S. whey products

	Milk minerals Whey calcium	Reduced-lactose whey	Deproteinized whey	WPC34	WPC80
Protein	<5%	18–24%	3.5–6%	34%	80%
Lactose	<9%	50–60%	73–83%	48–52%	4–8%
Fat	1% max	2–2.5%	<1.5%	3–4.5%	4–8%
Ash	>70%	14–22%	8.4–12%	6.5–8%	3–4%
Moisture	8% max	3–5%	4.5–5%	3–4.5%	3.5–4.5%
Calcium	23,000–28,000 mg	800–900 mg	600–700 mg	550 mg	600 mg
Standard plate count	<10,000/g	<10,000/g	<10,000 mg	<10,000/g	<10,000/g
Coliform	<10/g	10/g	<10/g	<10/g	<10/g
E. Coli	Negative	Negative	Negative	Negative	Negative
Listeria	Negative	Negative	Negative	Negative	Negative
Salmonella	Negative	Negative	Negative	Negative/100 g	Negative/100 g
Staphylococci	Negative	Negative	Negative	Negative	Negative
Scorched particles content	7.5 mg/25 g	15 mg/25 g (max)	7.5–15 mg/25 g	15 mg/25 g (max)	7.5–15 mg/25 g
Appearance	Free-flowing powder	Free-flowing powder	Free-flowing powder	Free-flowing powder	Free-flowing powder
Flavor	Clean, bland flavor	Clean, slightly salty, whey flavor	Clean, bland flavor	Clean, bland whey flavor	Clean, bland flavor
Color	White to light cream	Light cream	Light cream	Light cream	Light cream
pH	6–6.5	Consult supplier	5.5–6.5	6–6.7	6–6.7

USING DAIRY INGREDIENTS FOR FORTIFICATION PURPOSES

A number of different ingredients are available from U.S. suppliers to be used by international manufacturers for fortification purposes. Studies show that consumers prefer dairy calcium-enriched products to non-dairy calcium-enriched products because of dairy's positive image and its health value. Market research studies also indicate that consumers are willing to pay more for products enriched with a natural, dairy source of calcium. The high awareness of, and preference for, dairy calcium-enriched products in many countries of the world offer unique marketing opportunities and selling points to help manufacturers around the world launch successful new products.

MILK MINERALS

Milk minerals are a natural source of calcium derived from milk. This ingredient has the advantage of also supplying phosphorus, magnesium, other minerals, lactose and proteins, all of which are important for absorption of calcium and utilization by the body. Typical applications include nutritional supplements, diet, sport and isotonic beverages, nutritional bars, and nutraceutical products.

Typical Composition of Milk Minerals

Component	Percentage
Total Mineral Content	79.00%
• Ash	70.00%
Calcium	25.00%
Phosphorus	14.00%
Ca/P	1.79%
Ca/PO4	0.58%
Magnesium	1.50%
Sodium	0.65%
Potassium	0.83%
Zn (mg/100 g)	27.40%
Cu (mg/100 g)	0.37%
Fe (mg/100 g)	1.88%
• Organic Mineral (citrate)	9.00%

Information courtesy of: Glanbia Foods, USA.

Mineral-concentrated Whey

All-natural source of calcium for fortification and functional purposes

Mineral-concentrated whey also functions to improve texture, flavor, solubility, and nutritional profile in food formulations. Foods containing mineral-concentrated whey will have a higher nutritional density than comparable other products. The functions and benefits of the ingredient are:

- Good solubility, heat stability and cost-efficiency
- Lower lactose content that help minimize texture problems caused by lactose crystallization
- High protein and minerals help provide the flavor and smooth texture desired in food products
- Conveys a milky flavor, help emulsify added fats, provides good stability and heat stability in sauces and gravies
- A rich source of calcium, magnesium and phosphorus, which enhances nutritional value and flavor profile in comminuted meat products and sauces

TYPICAL APPLICATIONS

For dairy, meat, confectionery, bakery, snack, seasonings, soups, sauces, follow-up formula, frozen desserts and nutritional drinks as:

- A cost efficient source of dairy solids with a high mineral content
- An alternative to other calcium sources when lower lactose concentrations are desired and higher mineral concentration is required
- A nutraceutical ingredient in powdered beverages, nutritional drinks, dairy products, powdered soups and desserts and baked goods.

REFERENCES

A compete listing of reference is available from the U.S. Dairy Export Council (www.usdec.org), USA.

MAKING NUTRITIONAL CLAIMS

A nutritional claim is any statement that indicates, suggests or implies that a food has special nutritional properties. Generally, three types of claims can be made: (1) a claim about the content of calcium simply describing the level of a nutrient in the food (see Table on Codex Recommendations), (2) a comparative claim comparing the levels of a calcium in two or more foods and (3) a functional claim that describes the physiological role of calcium during growth, development and normal bodily functions. The specific types of functional claims allowed vary from country to country. Please check local legislation for more information.

Claims for Calcium, Codex Recommendations

To be entitled to claim:	The food must contain at least	So, in the case of calcium, the following threshold values:
"source of"	15% of NRV/100 g (solids) or 7.5% of NRV/100 ml (liquids) or 5% of NRV/100 kcal or 15% of NRV/portion	120 mg of Ca/100 g or 60 mg of Ca/100 ml or 40 mg of Ca/100 kcal or 120 mg of Ca/portion
"high content of"	Twice the "source" value	240 mg of Ca/100 g or 120 mg of Ca/100 ml or 80 mg of Ca/100 kcal or 240 mg of Ca/portion

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