Calcium in Dairy Products

MICHAEL H. TUNICK
Eastern Regional Research Center
Agricultural Research Service
United States Department of Agriculture
Philadelphia, PA 19118

FUNCTION OF CALCIUM

Between 1.5 and 2% of the weight of the human body is calcium, over 99% of which is located in the skeleton and teeth (15, 25, 36). It is held in bone as a multiple apatite salt consisting of calcium phosphate and calcium carbonate in a crystal lattice (15). There is also a large amount of noncrystalline calcium phosphate, which may be predominant early in life (104). Bone is constantly being formed and resorbed, serving as the body's calcium reservoir. In a man weighing 70 kg, an estimated 700 mg of calcium enter and leave the bones every day (130).

Calcium not present in bone, about 10 to 12 g in an adult, plays a role in muscle contraction, normal function of nervous tissue, myocardial function, and coagulation of blood and is necessary for many enzyme functions in all biological systems (15, 25, 36). It accomplishes its effects by specific interactions with target proteins, such as the milk proteins casein and α-lactalbumin (118). The concentration of calcium in normal blood is 9 to 11 mg/dl, almost all of which is in serum. About 60% of serum calcium is in a soluble ionized form, and the rest is bound with protein and not readily diffusible (15, 25). Concentrations are precisely regulated by parathyroid hormone (PTH) and 1,25-dihydroxyvitamin D₃ [1,25-(OH₂)D₃], the metabolically active form of vitamin D. Reduced calcium causes an increase in PTH secretion, which stimulates the liver and kidneys to convert vitamin D to 1,25-(OH)₂D₃ (89). 1,25-Dihydroxyvitamin D₃ in the presence of PTH increases resorption of calcium from bone (26).

In recent years, calcium deficiency and low ratios of calcium to phosphorus have been implicated in a number of diseases, including osteoporosis (12, 30, 45, 46, 75, 88, 89, 94, 117), hypertension (59, 80, 102, 107), colorectal cancer (59, 80, 102, 107), colo-rectal cancer (66, 92, 97, 98), and amyotrophic lateral sclerosis (38). There has been a great deal of controversy surrounding these findings.

ABSTRACT

Increasing attention has been given to the nutritional role of calcium because many Americans do not consume their Recommended Dietary Allowance of this nutrient and because calcium deficiency may lead to the development of osteoporosis or other disorders. Calcium is absorbed in the intestines with the aid of a vitamin D metabolite and is used in the body for many essential functions. There are several ways to obtain calcium in the diet, but the best sources are milk and other dairy products because of their low cost and high bioavailability of this mineral. Some manufacturers have responded to the concern over lack of calcium in the diet by increasing its levels in milk. The amount of calcium in cheese and yogurt also can be elevated.

INTRODUCTION

Dietary calcium has received much publicity recently because of its possible role in minimizing or preventing certain diseases. Most of the research on calcium in nutrition has been performed on elemental calcium and relatively little on calcium as supplied by dairy foods (67). Dairy products are rich in calcium and are responsible for about 76% of the calcium available in the American diet (27, 72). Because it is preferable to obtain a nutrient through the diet rather than by supplements (91, 123), the role of milk and milk products is important when dealing with calcium deficiency, which is the most frequent mineral deficiency in nutrition (14, 47). This review will deal with the body's need for calcium, how the body obtains it, and the role of dairy products in supplying it.

Received March 23, 1987.
Accepted July 31, 1987.
(7, 41, 52, 60, 61, 78), causing the general public to become more aware of the role of calcium in diet and health.

**ABSORPTION OF CALCIUM**

1,25-Dihydroxyvitamin D$_3$ is responsible for most of the calcium absorption in the digestive tract; it induces synthesis of intestinal calcium-binding protein, which transports calcium to the plasma (95, 96, 128). The remainder of absorbed calcium is transferred by passive diffusion across intestinal mucosa (51). Absorption of calcium takes place in the duodenum and proximal jejunum within 4 h of ingestion (25). The amount of calcium in the diet does not indicate exactly the amount absorbed, since 70 to 80% is excreted in the feces (2, 131). Kidneys excrete serum calcium above 7 mg/dl (15), and an average of 15 mg/d is lost by sweating (36). The most significant influence on calcium absorption and bone mineralization is vitamin D (39). It is synthesized in the skin upon exposure to ultraviolet light and is also obtained from foods such as eggs, fatty fish, liver, and especially milk, which in the US is fortified with 10 btg vitamin D/95 L (1qt) (36). In addition, lactose, a major ingredient of milk, increases absorption of calcium in persons who are not lactose-intolerant (10, 20). Lactose, which is not readily digestible, reaches the ileum intact (85) and apparently increases the permeability of intestinal mucosa (10). The effect of lactose on calcium absorption in persons who are deficient in the enzyme lactase ($\beta$-galactosidase) is still uncertain (20, 21, 58, 93, 101, 121). A recent study has shown that levels of calcium absorbed from milk are similar to calcium levels absorbed from yogurt in both lactase-deficient and lactase-sufficient individuals (114).

However, there are many factors that decrease absorption. Oxalic acid, found in cocoa, kale, rhubarb, soybeans, and spinach, forms calcium oxalate, which is insoluble and passes unabsorbed through the intestines (15). Phytic acid (hexaphosphoinositol), which is found in the bran portion of cereals, forms insoluble salts with free calcium in the intestines (12, 53). Calcium retention decreases with large increases in dietary caffeine (44), protein (55, 110), and sodium (44). Absorption of ingested calcium is also affected by its ratio to ingested phosphorus. A ratio between 2:1 and 1:2 appears to be best for absorbing and retaining calcium (36). However, there is evidence that no recommended ratio is necessary (34). Furthermore, it appears that orthophosphates do not decrease calcium absorption, whereas polyphosphates, which have a greater affinity for calcium, do (135). More study is needed in light of the fact that people are ingesting increasing amounts of phosphates as food additives. Other factors affecting calcium absorption include alcoholism (2), lack of physical activity (45), certain medicines (43), stress, and illness.

**RECOMMENDED DIETARY ALLOWANCE**

The Recommended Dietary Allowance (RDA) for calcium in the United States is established by the Food and Nutrition Board (FNB) of the National Academy of Sciences. The RDA is based on studies of calcium balance, the difference between calcium consumed in the diet and that excreted in the diet and that excreted in sweat, urine, and feces. A positive balance implies that some calcium is being retained in the body. Calcium thought to be adequate for most healthy adults and children is 800 mg/d, and the RDA for pregnant women and 10 to 18-yr-olds has been established at 1200 mg/d (36).

Nutrient labeling on American food products is based on RDA derived by the FDA from the FNB data. The figure for calcium is 1000 mg/d (99). A product containing 200 mg calcium per serving will thus be labeled as having 20% of the Recommended Daily Allowance, although it has 25% of the Recommended Dietary Allowance for most people.

For over 30 yr, calcium has been one of the three nutrients most often ingested by Americans in amounts below the RDA (125). The average intake by women is particularly low—about 500 to 700 mg/d (18, 30). According to a study conducted from 1976 to 1980, two-thirds of women aged 18 to 30 and three-quarters of women over age 35 consumed less than their RDA (18, 45). One-half to three-quarters of men between ages 18 and 34 had a daily calcium intake at or above 800 mg/d, but 42% of the men above these ages consumed less than 70% of the RDA (126). A study of public school students showed that less than half received their RDA (105).
In other countries, the RDA is set lower. In the United Kingdom, for instance, 500 mg/d is considered adequate (45), and the Food and Agriculture Organization/World Health Organization suggests a daily intake of 400 to 500 mg (37). The FNB is of the opinion that such low intakes produce no advantages to the human and are therefore not recommended (36). Part of the discrepancy may be due to inaccuracies in calcium balance studies, which are quite difficult to perform (53, 61). Because of some of the findings concerning osteoporosis, a consensus panel of the National Institutes of Health has suggested raising the RDA to 1000 to 1500 mg/d (117).

Consumption of large amounts of calcium is not harmful in normal persons, since the excess is excreted and absorption can decrease at high intake levels. Ingestion of up to 2000 mg calcium/d does not result in a significant increase in urinary calcium (90). Calcium does not appear to be an important risk factor for kidney stone disease according to epidemiologic studies (90).

**DIETARY SOURCES OF CALCIUM**

Dairy foods are by far the leading sources of calcium in the diet (36). A quantity of .237 L (1 c) of milk or 227 g (1 c) yogurt supplies over 290 mg of calcium, and 28 g (1 oz) of many cheeses contain over 180 mg (Table 1). Consumption of .473 L (2 c) of milk along with 28 g (1 oz) of a high calcium cheese will fulfill the RDA of 800 mg calcium/d. Other foods, such as broccoli, kale, high calcium tofu, some seafood, and collard, mustard, and turnip greens, also contain significant amounts of calcium, although these foods are not eaten as frequently as dairy foods (122). Dietary supplements such as bone meal (which contains 31% calcium), calcium carbonate (40%), calcium gluconate (9%), calcium lactate (13%), and dolomite (22%) are also available (91, 122). However, bone meal contains lead, and dolomite, which is calcium carbonate and magnesium carbonate, may also contain lead (8). These two supplements are therefore not favored by physicians. Dicalcium and tricalcium phosphates, which are soluble in digestive juices, increase calcium balance in elderly patients (82). Antacids, which contain calcium carbonate as the active component, are being taken by some individuals as an inexpensive calcium source (91). Sales of calcium supplements increased by 50% in 1985 due to publicity about osteoporosis, but relying on them instead of a balanced diet could lead to improper absorption of minerals such as iron, magnesium, and zinc (123).

Therefore, the most desirable sources of calcium, both economically and nutritionally, are dairy products. The cost of obtaining the RDA of calcium by drinking milk is less than 40¢/d (73) and the cheeses listed in Table 1 can be purchased for less than 35¢/28 g (1 oz). Milk has a natural balance of nutrients and the highest biological availability of calcium of any food (57). Calcium in colloidal form is absorbed more efficiently than in ionic form (132), and about two-thirds of the calcium in milk is in colloidal suspension (50, 127) with casein, phosphorus, and citrate (54, 64). Commercially available milk has the additional advantage, not shared by other dairy products, of being fortified with vitamin D.

**Milk**

Calcium content of milk varies with the breed of cow. Milk from Jersey and Guernsey cows usually has over 130 mg calcium/100 g milk while Holsteins and Ayrshires generally have 120 mg/100 g or less (11). Seasonal variations in the calcium content of milk are rather small. Calcium concentrations in milk are at their lowest in July, August, and September, but the concentrations in those months are only about 10 mg/100 g lower than those in other months (54). Alteration of feed does change milk calcium (54, 64).

Ultra-high temperature processing of milk for greatly extending shelf life dates since the 1940's. Usually, the milk is heated to 130 to 150°C for 2 to 8 s and then aseptically packaged (81). Experiments with laboratory rats have shown that the absorption of calcium from UHT milk is the same as from raw or pasteurized milk (48, 129). Calcium retention in newborn infants may be higher with UHT milk (81).

In 1986, dairy processors began to market high calcium milk in response to the increased publicity over this mineral (5). When milk is fortified with tricalcium phosphate and stabilized with gum, most or all of the RDA of calcium can be obtained by drinking only one glass (.237 L; 8 oz). At present, calcium ob-
TABLE 1. Levels of calcium in dairy products (103).

<table>
<thead>
<tr>
<th>Product</th>
<th>Serving size</th>
<th>Calcium, mg/serving</th>
<th>% RDA of calcium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole milk</td>
<td>.237 L (1 c)</td>
<td>291</td>
<td>36</td>
</tr>
<tr>
<td>Skim milk</td>
<td>.237 L (1 c)</td>
<td>302</td>
<td>38</td>
</tr>
<tr>
<td>Buttermilk</td>
<td>.237 L (1 c)</td>
<td>285</td>
<td>36</td>
</tr>
<tr>
<td>Chocolate milk</td>
<td>.237 L (1 c)</td>
<td>280</td>
<td>35</td>
</tr>
<tr>
<td>Yogurt, lowfat</td>
<td>227 g (1 c)</td>
<td>314–415</td>
<td>39–52</td>
</tr>
<tr>
<td>Ice cream or ice milk, vanilla</td>
<td>112 g (4 oz)</td>
<td>88</td>
<td>11</td>
</tr>
<tr>
<td>Cheeses:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>American, pasteurized process</td>
<td>28 g (1 oz)</td>
<td>174</td>
<td>22</td>
</tr>
<tr>
<td>Brick</td>
<td>28 g (1 oz)</td>
<td>191</td>
<td>24</td>
</tr>
<tr>
<td>Camembert</td>
<td>28 g (1 oz)</td>
<td>110</td>
<td>14</td>
</tr>
<tr>
<td>Cheddar</td>
<td>28 g (1 oz)</td>
<td>204</td>
<td>26</td>
</tr>
<tr>
<td>Cottage, creamed</td>
<td>112 g (4 oz)</td>
<td>68</td>
<td>9</td>
</tr>
<tr>
<td>Cream</td>
<td>28 g (1 oz)</td>
<td>23</td>
<td>3</td>
</tr>
<tr>
<td>Edam</td>
<td>28 g (1 oz)</td>
<td>207</td>
<td>26</td>
</tr>
<tr>
<td>Gouda</td>
<td>28 g (1 oz)</td>
<td>198</td>
<td>25</td>
</tr>
<tr>
<td>Limburger</td>
<td>28 g (1 oz)</td>
<td>141</td>
<td>18</td>
</tr>
<tr>
<td>Mozzarella, part skim</td>
<td>28 g (1 oz)</td>
<td>183</td>
<td>23</td>
</tr>
<tr>
<td>Neufchatel</td>
<td>28 g (1 oz)</td>
<td>21</td>
<td>3</td>
</tr>
<tr>
<td>Parmesan</td>
<td>28 g (1 oz)</td>
<td>336</td>
<td>42</td>
</tr>
<tr>
<td>Port du Salut</td>
<td>28 g (1 oz)</td>
<td>184</td>
<td>23</td>
</tr>
<tr>
<td>Provolone</td>
<td>28 g (1 oz)</td>
<td>214</td>
<td>27</td>
</tr>
<tr>
<td>Ricotta, part skim</td>
<td>112 g (4 oz)</td>
<td>337</td>
<td>42</td>
</tr>
<tr>
<td>Romano</td>
<td>28 g (1 oz)</td>
<td>302</td>
<td>38</td>
</tr>
<tr>
<td>Roquefort</td>
<td>28 g (1 oz)</td>
<td>188</td>
<td>24</td>
</tr>
<tr>
<td>Swiss</td>
<td>28 g (1 oz)</td>
<td>272</td>
<td>34</td>
</tr>
</tbody>
</table>

Obtained in this manner does not appear to have a different bioavailability than calcium obtained from regular milk. Although high calcium milk can be 50% more expensive than regular milk, consumers will not have to drink as much to reach the desired calcium intake. Also, the UHT processing extends the shelf-life of the product to 7 wk (5), another desirable feature. It has been suggested that the availability of calcium in chocolate milk is decreased because of the oxalic acid in cocoa, but studies have shown that this is not the case when normal amounts are drunk (17, 124).

**Cheese**

Aged cheese, which contains little or no lactose, represents a good source of calcium, particularly for lactase-deficient individuals. Calcium levels are comparatively low in soft cheeses, because these products are prepared by acid coagulation, resulting in a change in the equilibrium between the colloidal and ionic states of calcium in the milk. The calcium converts from the colloidal state, in which it is held in the curd, to the ionic state, causing at least two-thirds of it to be lost in the whey (62, 133). In addition, lower coagulation temperatures result in a conversion of colloidal calcium to the ionic form and higher temperatures apparently cause calcium and phosphate ions to form colloidal calcium phosphate (56). Various calcium concentrations in cheeses are due in part to the various temperatures of coagulation (33, 79). Calcium concentrations can be slightly raised in hard cheeses by decreasing the acidity of the curd when the whey is drained (65). It has been thought that it is not feasible to make hard cheeses fortified with extra calcium since the presence of too much of this mineral in cheese making would result in a hard inflexible curd (111). However, recent advances may enable cheese makers to manufacture products with higher amounts of calcium, which would allow consumers to reach their RDA of calcium more easily.

A relatively new method of cheese making involves the use of membrane UF. In this approach, skim milk is ultrafiltered through a semipermeable membrane, allowing only the

Journal of Dairy Science Vol. 70, No. 11, 1987
soluble material in the milk to pass. The retentate, which is a protein-enriched milk, is collected when its protein and moisture contents are close to those of the cheese to be prepared. Starter culture and rennet are then added as in conventional cheese making (76, 119). The UF of milk on farms and subsequent cheese manufacture have been studied in France since 1979, and American plants for the production of various cheeses from retentates are in operation or under construction (6, 63). Over 85% of milk calcium is recovered in the retentate (35), compared with the 50 to 80% recovered in conventional hard cheese manufacture (33), making UF a possible route for production of cheese with increased calcium. In several studies, calcium was measured in cheeses made by UF and traditional procedures. Mozzarella cheese samples, which had 610 mg calcium/100 g when prepared conventionally, contained 1050 mg/100 g when manufactured by UF (24). A conventional cream cheese contained 60 mg/100 g, but the UF variety had a concentration of 140 mg/100 g (22). Cottage cheese prepared by UF showed a fourfold increase in calcium compared with conventionally made cheese (23). The formation of retentates with less than 40% moisture is not currently feasible, so commercial UF of cheese milk has been confined to soft, high moisture cheeses (32).

Another membrane process that may increase calcium in cheeses is RO, in which the membrane allows only water and other small molecules to pass (40, 70). All of the calcium is held in the retentate (71). The concentrated milk, about half the original volume, can then be transported at lower cost, as with the fractionated milk produced by UF (134). Several successful attempts at manufacturing Cheddar cheese have been made on both laboratory and industrial scales (1, 13, 16, 77, 109, 134). The first calcium-enriched cottage cheese product was introduced in mid-1986. Minerals are concentrated from the whey and are added back to the curds, resulting in a calcium concentration of 300 mg/112 g (4 oz) (31).

Calcium in cheese can be increased by the addition of calcium chloride, which is permitted in the US as long as it does not exceed .02% of the weight of the milk (100). During the cheese making process, rennet-treated milk will not clot in the absence of calcium ion; as increasing amounts of calcium chloride are added to milk, coagulation time decreases to a minimum and increases again (33). In one study, cottage cheese was fortified with calcium by substitution of calcium chloride for a portion of the sodium chloride in the creaming mixture (28). According to a taste panel, 100 mg calcium/112-g (4-oz) serving was still acceptable. In another cottage cheese study (133), addition of calcium chloride to the skim milk prior to pasteurization had no effect on calcium content of the curd. Cutting the curd at pH 4.9 or 5.0 instead of pH 4.8 also produced no difference. However, by draining the whey completely and washing the curd only once, calcium increased 46%. In addition, use of 1.28-cm cheese knives instead of knives half that size caused a 60% increase in calcium content, because the larger curd exposed less surface area from which the calcium was leached. No difference in calcium content has been found between cottage cheeses made from direct acidification and conventional short set processes (74, 113).

**Yogurt**

Yogurt is an excellent calcium source. Because calcium forms a complex with casein, the principal milk protein, an effective way to increase the amount of calcium in yogurt is to increase protein in the product (Table 2). This may result in higher costs but would furnish the consumer with additional protein as well. Membrane techniques can also be used for yogurt, allowing for control of amount of total solids without homogenization or addition of

<table>
<thead>
<tr>
<th>Variety</th>
<th>Milk used</th>
<th>Protein, g/227 g (1 c)</th>
<th>Calcium, mg/227 g (1 c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain</td>
<td>Whole</td>
<td>7.9</td>
<td>274</td>
</tr>
<tr>
<td>Fruit</td>
<td>Lowfat</td>
<td>9.0</td>
<td>314</td>
</tr>
<tr>
<td>Fruit</td>
<td>Lowfat</td>
<td>9.9</td>
<td>345</td>
</tr>
<tr>
<td>Fruit</td>
<td>Lowfat</td>
<td>11.0</td>
<td>383</td>
</tr>
<tr>
<td>Plain</td>
<td>Lowfat</td>
<td>11.9</td>
<td>415</td>
</tr>
<tr>
<td>Plain</td>
<td>Skim</td>
<td>13.0</td>
<td>452</td>
</tr>
</tbody>
</table>

1 Nonfat milk solids added to nonfat and skim milk yogurts.
milk solids (108, 120). Yogurt has been prepared from milk concentrated by RO, resulting in a decrease in whey drainage (29) and presumably an increase in calcium content. Good quality yogurts have been manufactured from UF milk as well (19, 106).

Milk Protein Products

The whey remaining from casein and cheese manufacture can serve as a calcium source for various products. Sweet whey is produced when cheese or casein are made through the action of rennet, and contains around 500 mg calcium/L (69). Acid whey results from acid coagulation of milk and contains three times as much calcium (69). Treatments such as UF and RO are often used to produce whey powders and protein concentrates, which are added to food for their functional and nutritional attributes (83). Cheeses such as ricotta are manufactured from whey and have very high amounts of calcium. Whey can also be used in many beverages, although the price might not be competitive with more popular drinks (49).

When added to food, calcium caseinate is used for such properties as emulsifying, whipping, foaming, viscosity, and texturization, and provides the added benefit of additional dietary calcium (84). It is produced by acid precipitation of casein curd from skim milk and neutralization of the curd with calcium hydroxide (83). Calcium content is typically 1.0 to 1.5% (86). Blends of whey protein and calcium caseinate are being developed for their nutritional benefits (3, 83).

When skim milk is heated until the whey proteins denature and complex with the caseins, a high calcium coprecipitate of the proteins can be formed by adding calcium chloride (86, 87). The amount of calcium can be controlled by varying amounts calcium chloride and length of heating (115). Calcium content can be up to 3%. Coprecipitates are used for many of the same properties as calcium caseinate and contribute nutritional value without affecting the flavor of the product (84, 116).

Other Products

Ice cream, one of the most popular desserts in the US and other countries, contains a significant amount of calcium. The oxide and hydroxide salts of calcium are often added to ice cream to give a creamy or rich appearance (9). Calcium sulfate is also added to improve the dryness and stiffness of the product during manufacture (9). The UF retentates can theoretically be used to produce high calcium ice cream as well as high calcium buttermilk (68). New high calcium milk drinks with varying concentrations of sodium, lactose, fat, cholesterol, and calories are also possible with membrane technology (68).

Imitation cheeses, which are cheaper and easier to handle than real cheeses, are gaining in popularity, especially in the frozen pizza industry (42). Casein and caseinate combinations are often used to impart textural properties similar to those of cheese (84). Vegetable oil and water are other ingredients (4, 112). Some imitation cheeses contain pasteurized process cheese, while others are made with no dairy products at all (4, 112).

CONCLUSIONS

Calcium, an essential nutrient, is often consumed below the recommended amounts, which could lead to various health problems. Dairy products provide the best dietary source of this mineral since normal servings of milk, cheese, and yogurt contain substantial percentages of the RDA of calcium. Alterations in the manufacture of dairy products, such as use of membrane procedures or addition of calcium salts, can raise their calcium levels even further. Additional research on dairy food calcium and its role in health is needed.

REFERENCES

damentals of food chemistry. Ellis Horwood Ltd., Chichester.


81 Mehta, R. S. 1980. Milk processed at ultra-high-temperatures—a review. J. Food Prot. 43:212.


83 Morr, C. V. 1979. Utilization of milk proteins as starting materials for other foodstuffs. J.

Journal of Dairy Science Vol. 70, No. 11, 1987
100 Office of the Federal Register. 1985. Code of
101 Pansu, D., and M. D. Chapuy. 1970. Calcium
104 Radzikowski, J. 1983. The national evaluation
of school nutrition programs: final report—execu-
tive summary. US Dept. of Agric., Washing-
ton, DC.
105 Renner, E. 1986. Nutritional aspects of fer-
106 Resnick, L. M. 1985. Calcium and hyperten-
sion: the emerging connection. Ann. Int. Med. 103:
944.
Recent developments in yoghurt manufacture.
Pages 1–34 in Modern dairy technology. Volume
2: advances in milk products. R. K. Robinson,
1986. Quality and yield of cheddar cheese manu-
factured from reconstituted reverse osmosis milk
21:125.
Effects on Ca and P metabolism in humans by
adding meat, meat plus milk, or purified
proteins plus Ca and P to a low protein diet.
110 Scott, R. 1981. Page 105 in Cheesemaking
111 Shaw, M. B. 1986. Modern cheesemaking: soft
cheeses. Pages 159–214 in Modern dairy tech-
112 Smith, T. M., J. C. Kolars, D. A. Savaiano,
and M. D. Levitt. 1985. Absorption of calcium
1197.
113 Sinha, D. K., K. M. Shahani, A. Kilara, and R.
M. Hill. 1979. Calcium, magnesium and phos-
phorus contents of cultured and acidified cottage
114 Smith, T. M., J. C. Kolars, D. A. Savijano,
and M. D. Levitt. 1985. Absorption of calcium
1197.
precipitates and their application in food prod-
ucts I. Observations on the manufacture of co-
13:77.
116 Southward, C. R., and A. Goldman. 1978. Co-
precipitates and their application in food prod-
ucts II. Some properties and applications. N.Z.
117 Spencer, H., and L. Kramer. 1986. Factors con-
118 Stuart, D. I., K. R. Acharya, N.P.C. Walker,
a-Lactalburnin possesses a novel calcium binding
Composition of hard cheese manufactured by
120 Tamime, A. Y., and H. C. Deeth. 1980. Yogurt:
technology and biochemistry. J. Food Prot.
43:939.
121 Tremaine, W. J., A. D. Newcomer, B. L. Riggs,


