Phosphorus

Function

Phosphorus is a major component of the body's structural calcium-phosphate complexes—hydroxyapatite in bone and fluoroapatite in dental enamel. Phosphate is involved in the structure of the genetic materials DNA and RNA, and other essential roles of this mineral include energy transfer and storage, structure of phospholipids in cell membranes, and maintenance of acid-base balance (Knochel 1999; Arnaud and Sanchez 1996). The dietary requirement for phosphorus is dependent on calcium intake. That phosphate, as well as calcium, is required for bone formation is obvious; but the role that phosphate supplementation plays in making calcium optimally effective in relation to osteoporosis is only now becoming clear (Shapiro and Heaney 2003; Heaney and Nordin 2002; Heaney 2002; Heaney 2004). Bioavailable forms of dietary phosphorus are efficiently absorbed. Most dietary phosphorus is in the form of phosphates. Phosphorus homeostasis is achieved substantially through the regulation of urinary excretion. The phosphorus in the phytic acid of whole-grain foods is not bioavailable unless it is released by the enzyme phytase in yeast or other microorganisms. Phosphorus deficiency can result from the excessive use of antacids that contain aluminum hydroxide, which precipitates dietary phosphorus as insoluble and unabsorbable aluminum phosphate in the intestine (Food and Nutrition Board 1997).

Safety Evidence

The phosphorus levels in normal diets are not likely to be harmful, especially given adequate intake of calcium and vitamin D (Food and Nutrition Board 1997). Dietary supplements rarely contain significant amounts of phosphorus, except as calcium compounds. A calcium-to-phosphorus ratio lower than 1:2 can cause small decreases in blood calcium levels; therefore, a ratio closer to 1:1 is considered ideal. And while one's needs for calcium and phosphate are influenced by their interaction, an increase in dietary phosphorus from 800 mg to 2,000 mg per day in adult males failed to affect calcium balance regardless of calcium intake (Arnaud and Sanchez 1996).

In the absence of clinical signs of excess phosphorus, plasma phosphorus level is the most reliable indicator of excess phosphate (Food and Nutrition Board 1997). There is no convincing scientific support for the widely accepted notion that consuming too much phosphorus (i.e., phosphate) from certain carbonated beverages contributes to calcium loss and increases the risk of osteoporosis (Heaney 2004). Indeed, the opposite effect may be true—calcium intake without

simultaneous phosphorus intake may decrease the utilization of the calcium, at least partly obviating the potential benefits of the calcium on bone renewal.

Published Official Reviews of Phosphorus Safety

The FNB reviewed dietary phosphorus for potential adverse effects, including adjustment in calcium-regulating hormones, metastatic calcification, skeletal porosity, and interference with calcium absorption, and found no evidence of any such activity (Food and Nutrition Board 1997). In the absence of overt adverse effects, FNB selected plasma phosphorus levels as the appropriate indicator of excess phosphorus intake. Based on estimates of intake necessary to derange plasma phosphorus homeostasis, FNB identified a NOAEL of 10.2 g per day, and applied a UF of 2.5 to derive a UL of 4 g per day for adults. The UF of 2.5 is a default value meant to account for the uncertainty related to the pharmacokinetic relationship between food intake and blood levels (Petley et al. 1995). The FNB indicated that phosphorus intakes may have increased dramatically over the last decade, thus creating concern about excessive phosphorus intake. This suggestion is counterbalanced by the evidence that calcium supplements can induce temporary low values in plasma phosphorus, and that co-supplementation with calcium and phosphate can avoid this effect (Heaney 2002; Heaney and Nordin 2002).

The UK EVM found the existing evidence to be insufficient to derive an SUL value and instead set a GL for total and supplemental phosphorus (Expert Group on Vitamins and Minerals 2003). The organization expressed concern about the few reports of osmotic diarrhea and gastrointestinal disturbance reported in relation to supplemental phosphorus in the range of 750 to 2,250 mg per day, and on this basis identified a NOAEL of 750 mg supplemental phosphorus per day. A GL of 250 mg supplemental phosphorus was identified by applying a default UF of 3 to this NOAEL. Assuming an intake of 2,100 mg from food and water, UK EVM concluded that a GL of 2,400 mg was appropriate for total phosphorus intake from all sources.

CRN ULS for Phosphorus

In adults with normal kidney function, phosphorus is readily excreted, and no imbalance in calcium metabolism occurs except at extreme intakes. The gastrointestinal effects of phosphorus are greatly influenced by the specific chemical form consumed as well as by other dietary ingredients, especially calcium. There are no data appropriate for identifying direct adverse effects of dietary phosphorus, and therefore no LOAEL can be identified. Similarly, no specific intake level qualifies as the NOAEL or OSL level. The very high NOAEL value identified by FNB is perhaps too hypothetical, just as the very low NOAEL identified by UK EVM was based on a speculative, worst-case

interpretation of a very few reports that could have had other causes. There is a need for an appropriate ratio of calcium-to-phosphorus intake within a broad range of acceptable ratios; therefore, in the absence of more specific evidence, a ULS value of 1,500 mg is set for supplemental phosphorus.

Comparison of Safety Values for Phosphorus

CRN ULS	1,500 mg
US FNB UL	4,000 mg
EC SCF UL	Not reviewed (as of May 2004)
EC supplement maximum	Not established (as of May 2004)
UK EVM GL	250 mg supplement; 2,400 mg total

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