

Review Article

Prunus dulcis: Nutritional composition and implications for human healthChaitali S. Jadhav^{1*}, Ganesh Y. Dama¹¹Dept. of Pharmacognosy, Shri Gajanan Maharaj Shikshan Prasarak Mandal's Sharadchandra Pawar College of Pharmacy, Otur, Pune, India**Abstract**

Almonds (*Prunus dulcis* Mill.), a member of the Rosaceae family, are widely consumed for their nutrient density and health-promoting properties. Comprehensive compositional analyses show that almond kernels contain a balanced mix of macronutrients (healthy fatty acids, proteins, carbohydrates) and micronutrients (vitamins, minerals), together with diverse bioactive phytochemicals and amino acids. Kernel nutritional profile and quality are shaped by genetic and environmental factors, underscoring the need to understand how cultivar, climate, soil, and agronomic practices influence composition. Epidemiological and clinical evidence links regular almond consumption to multiple health benefits, including improved glycemic control, favorable lipid and uric acid profiles, body weight management, and reduced risk of metabolic disorders such as type 2 diabetes, obesity, metabolic syndrome, and cardiovascular disease. Emerging data also indicate prebiotic effects that support gut health. This review synthesizes current knowledge on almond composition, summarizes evidence for cardiometabolic and gut-health benefits, and discusses key genetic and environmental determinants of kernel quality.

Keywords: *Prunus dulcis*; Almonds; Nutritional composition; Bioactive phytochemicals; Cardiometabolic health; Gut microbiota.**Received:** 10-05-2026 **Accepted:** 15-06-2026 **Available Online:** 07-07-2026

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Almonds (*Prunus dulcis* Mill.), belonging to the Rosaceae family, are among the most widely consumed tree nuts worldwide and have been integral components of Mediterranean and Middle Eastern diets for centuries. In recent decades, almonds have gained increasing scientific and commercial interest due to their exceptional nutritional value and potential role in promoting human health. Growing evidence from epidemiological, clinical, and mechanistic studies suggests that regular almond consumption contributes to the prevention and management of several chronic diseases, particularly cardiometabolic disorders, obesity, and type 2 diabetes.^{1,2} These findings have positioned almonds as an important functional food with applications extending beyond basic nutrition.

The nutritional significance of almonds is attributed to their unique composition, which includes a favorable profile of unsaturated fatty acids, high-quality plant proteins, dietary fiber, essential vitamins and minerals, and a diverse range of bioactive phytochemicals. Together, these constituents contribute to antioxidant, anti-inflammatory, lipid-lowering, and metabolic regulatory activities. Emerging research has also highlighted the potential prebiotic properties of almonds, suggesting that their beneficial effects may be partially mediated through modulation of the gut microbiota and its metabolites.^{3,4}

Despite extensive research on the health benefits of almonds, considerable variability exists in their nutritional

composition. Factors such as cultivar, genetic background, rootstock selection, geographical location, climatic conditions, soil characteristics, irrigation practices, harvest maturity, and post-harvest processing can significantly influence kernel quality and bioactive constituent content. These variations not only affect nutritional value but may also alter the biological activities and health outcomes associated with almond consumption. Understanding the influence of these factors is therefore essential for optimizing almond production, ensuring product quality, and accurately interpreting findings from nutritional and clinical studies.⁵

Accumulating clinical evidence demonstrates that almond consumption is associated with improvements in glycemic control, lipid metabolism, body weight regulation, and cardiovascular health. Furthermore, recent studies indicate beneficial effects on gut microbial composition, inflammation, oxidative stress, and other physiological processes involved in chronic disease development. However, important knowledge gaps remain regarding the specific contributions of individual almond constituents, the mechanisms underlying their biological effects, and the extent to which genetic and environmental factors influence their health-promoting properties.^{6,7}

Although several reviews have examined either the nutritional composition or health benefits of almonds, a comprehensive synthesis integrating compositional characteristics, determinants of kernel quality, and evidence-based health outcomes remains limited. Addressing

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these aspects collectively is important for developing a holistic understanding of almonds as functional foods and for identifying strategies to maximize their nutritional and therapeutic potential.

Therefore, the present review provides a comprehensive overview of the nutritional composition of almonds, the genetic and environmental factors influencing kernel quality, and the current evidence supporting their health benefits. Particular emphasis is placed on cardiometabolic health, body weight management, gut microbiota modulation, and emerging therapeutic applications. In addition, current challenges, research gaps, and future directions are discussed to facilitate the development of evidence-based dietary recommendations and sustainable production practices that maximize the health benefits of almond consumption

2. Composition and Nutritional Profile of Almond Kernels

Almond kernels (*Prunus dulcis*) are nutritionally dense, comprising approximately 50–56% fat, 20–25% protein, 12–18% carbohydrates, and 10–12% dietary fiber per 100 g. The lipid fraction is predominantly unsaturated, with

oleic acid (C18:1) accounting for 60–70% of total fatty acids, followed by linoleic acid (C18:2, ~15–20%) and palmitic acid (C16:0, ~6–8%). This favorable fatty acid profile supports cardiovascular health by modulating serum lipids. Almond protein is rich in essential amino acids, particularly arginine, leucine, and phenylalanine, with a digestibility comparable to other plant proteins.^{8,9}

Carbohydrates in almonds are low relative to fat and protein, consisting mainly of simple sugars (glucose, fructose, sucrose) and complex polysaccharides. The fiber content includes both soluble (e.g., pectin-like fractions) and insoluble cellulose and hemicellulose, contributing to bowel health and prebiotic effects. Almonds are exceptionally rich in vitamin E, primarily as α -tocopherol (12–25 mg/100 g), a potent antioxidant protecting lipids from oxidation. Significant micronutrient content includes magnesium (250–280 mg/100 g), potassium (700–800 mg/100 g), calcium (240–270 mg/100 g), phosphorus (450–500 mg/100 g), and trace minerals such as iron, zinc, and copper.^{3,9}

Prunus dulcis (Almond): Nutritional Composition and Implications for Human Health

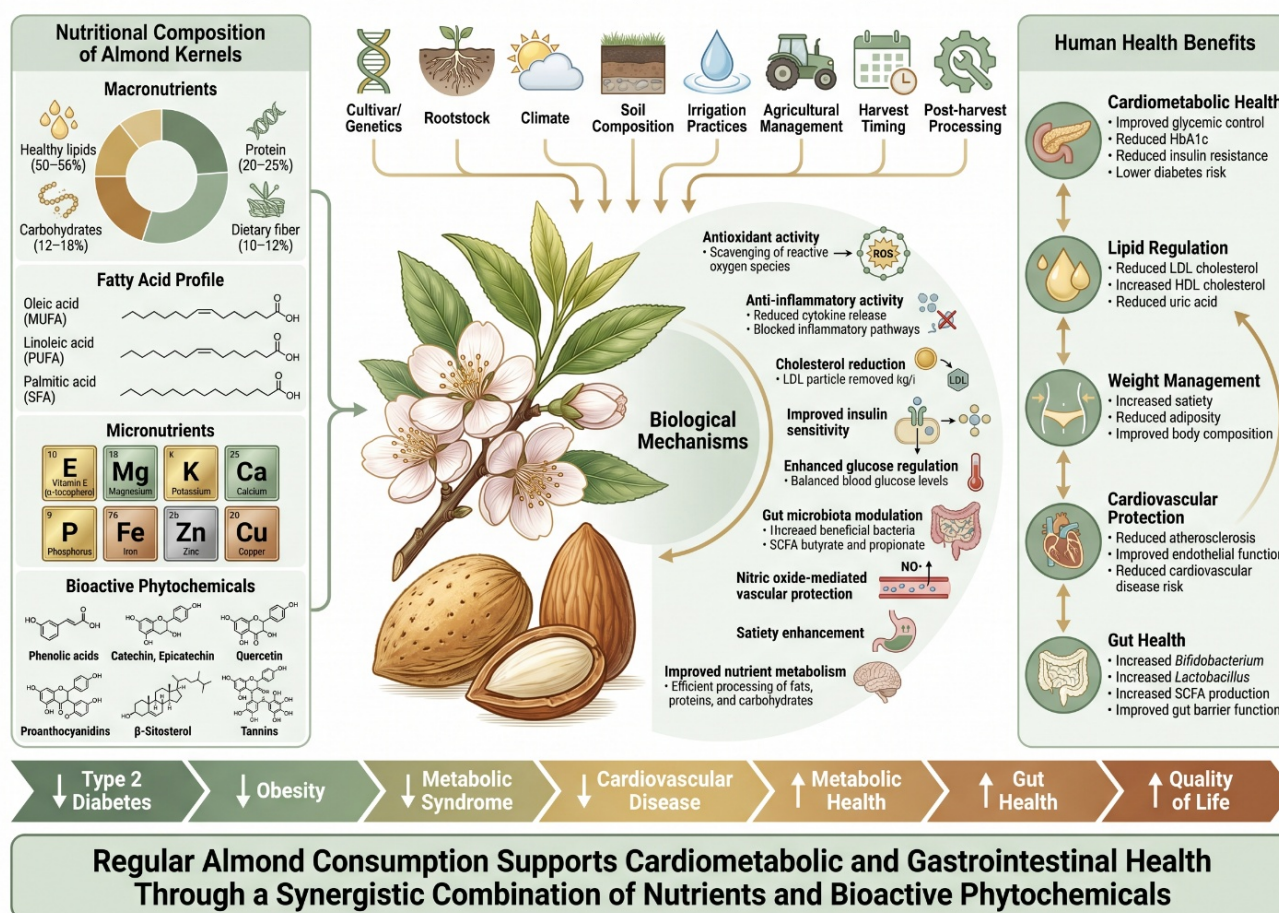


Figure 1: Nutritional Composition, Biological Mechanisms, and Health Benefits of *Prunus dulcis* (Almond): Graphical overview of the nutritional composition of *Prunus dulcis* (almond) and its implications for human health. Almond kernels provide healthy lipids, proteins, dietary fiber, vitamins, minerals, and bioactive phytochemicals. Their composition is influenced by genetic, environmental, and post-harvest factors. These components exert antioxidant, anti-inflammatory, lipid-lowering, glycemic-regulating, and gut microbiota-modulating effects, contributing to improved cardiometabolic health, weight management, cardiovascular protection, gut health, and reduced risk of type 2 diabetes, obesity, metabolic syndrome, and cardiovascular disease.

Beyond classic nutrients, almond kernels—and especially their brown skin—contain diverse bioactive phytochemicals. Phenolic compounds include phenolic acids (e.g., chlorogenic acid), flavonoids (catechin, epicatechin, quercetin), and proanthocyanidins. Phytosterols, notably β -sitosterol (60–120 mg/100 g), contribute to cholesterol-lowering effects. Tannins and melanin-like pigments in the skin add antioxidant capacity. However, the nutritional profile varies significantly by cultivar, rootstock, climate, soil composition, irrigation practices, and harvest timing. Post-harvest processing (roasting, blanching, oil extraction) further alters bioavailability and stability of nutrients. Understanding this compositional complexity is essential for interpreting health effects and optimizing almond production for maximal nutritional benefit.^{8,9}

3. Biological and Health Promoting Activities of *Prunus Dulcis*

3.1. Improved glycemic control and diabetes prevention

Regular almond consumption enhances glycemic control through multiple mechanisms. Almonds' low carbohydrate content, high fiber, and healthy fat profile reduce postprandial glucose excursions by slowing carbohydrate digestion and absorption. The high magnesium content (250–280 mg/100 g) supports insulin signaling and glucose uptake, while almond polyphenols improve insulin sensitivity by modulating oxidative stress and inflammatory pathways. Randomized controlled trials demonstrate that substituting almonds for high-carbohydrate snacks significantly lowers fasting glucose, HbA1c, and insulin levels in individuals with type 2 diabetes or metabolic syndrome. Acute feeding studies show reduced postprandial glycemia when almonds are consumed with carbohydrate-rich meals, attributed to fat-induced delays in gastric emptying and enhanced insulin-mediated glucose disposal. Long-term interventions (8–12 weeks) report sustained improvements in glycemic markers without adverse weight gain, supporting almonds as a dietary strategy for diabetes prevention and management.^{10–12}

3.2. Favorable lipid and uric acid modulation

Almonds exert potent lipid-modulating effects, primarily through their unsaturated fatty acid profile, plant sterols, and polyphenols. Regular intake reduces LDL-cholesterol by 10–15% and total cholesterol by 5–10%, while maintaining or modestly increasing HDL-cholesterol. Oleic acid displaces saturated fats in cell membranes, enhancing LDL receptor activity and cholesterol clearance. β -sitosterol competes with dietary cholesterol for intestinal absorption, while vitamin E and flavonoids inhibit LDL oxidation. Meta-analyses of RCTs confirm these benefits across diverse populations, with greater effects in individuals with elevated baseline cholesterol. Almonds also lower uric acid levels by 0.5–1.0 mg/dL, possibly through improved renal excretion and reduced oxidative stress in purine metabolism. This dual lipid-uric acid modulation reduces cardiovascular and metabolic syndrome risk.^{13–16}

3.3. Body weight management and obesity prevention

Despite high caloric density (570–600 kcal/100 g), almonds do not promote weight gain when consumed regularly.

Multiple RCTs show that 40–60 g/day almond intake over 3–12 weeks results in neutral or modestly reduced body weight, waist circumference, and fat mass. Mechanisms include enhanced satiety from protein/fiber-induced gastrin release, reduced subsequent energy intake, increased postprandial thermogenesis, and incomplete fat absorption (10–20% of almond fat remains unabsorbed due to cellular wall structure). Almond phenolics may also modulate adipogenesis and lipid metabolism genes. Long-term observational studies link regular nut consumption with lower obesity prevalence, supporting almonds as a weight-management tool.^{12,17,18}

3.4. Reduced cardiovascular disease risk

Almond consumption lowers cardiovascular disease (CVD) risk by 20–30% in epidemiological studies. Benefits stem from combined improvements in lipid profiles, glycemic control, inflammation (reduced CRP, IL-6), endothelial function (enhanced nitric oxide), and oxidative stress (increased plasma antioxidant capacity). Meta-analyses report 15% lower CVD mortality per 20 g/day nut intake. Almonds' vitamin E, magnesium, and polyphenols protect against atherosclerosis by inhibiting LDL oxidation, platelet aggregation, and vascular inflammation.^{19–22}

3.5. Prebiotic properties and gut health promotion

Almonds exhibit prebiotic effects by modulating gut microbiota composition. Feeding trials show increased bifidobacteria, lactobacilli, and butyrate-producing bacteria (e.g., *Faecalibacterium prausnitzii*) after 3–4 weeks of 40–60 g/day almond intake.³ Almond fiber and skin polyphenols reach the colon, undergoing microbial fermentation to produce short-chain fatty acids (acetate, propionate, butyrate) that enhance gut barrier integrity, reduce inflammation, and regulate immunity. Butyrate also improves glucose metabolism and reduces cancer risk. These gut-mediated effects contribute to almonds' systemic cardiometabolic benefits.^{3,23}

3.6. Anti-inflammatory and antioxidant effects

Almonds possess significant anti-inflammatory and antioxidant properties that contribute to systemic health. The high vitamin E content (α -tocopherol), along with flavonoids (catechin, quercetin) and phenolic acids in the skin, provides potent free-radical scavenging activity.²⁴ Clinical trials demonstrate that regular almond intake (40–60 g/day) reduces key inflammatory markers including C-reactive protein (CRP), interleukin-6 (IL-6), and tumor necrosis factor- α (TNF- α) by 10–20%. These effects stem from modulation of NF- κ B signaling and suppression of pro-inflammatory cytokine production.¹⁷ Almond polyphenols also enhance endogenous antioxidant enzymes (superoxide dismutase, glutathione peroxidase), reducing oxidative DNA damage and lipid peroxidation. This dual anti-inflammatory/antioxidant action protects against chronic diseases driven by oxidative stress, including cardiovascular disease, diabetes, and neurodegenerative conditions.^{14,25,26}

3.7. Bone health support

Almonds contribute to bone health through their rich mineral profile and bioactive compounds. Significant

amounts of magnesium (250–280 mg/100 g), calcium (240–270 mg/100 g), potassium, and phosphorus support bone mineralization and structural integrity.²⁷ Magnesium enhances calcium absorption and activates vitamin D, while potassium reduces urinary calcium excretion by neutralizing acid load.²⁸ Almond polyphenols may also inhibit osteoclast-mediated bone resorption and stimulate

osteoblast activity. Observational studies link regular nut consumption with higher bone mineral density and lower fracture risk, particularly in older adults. Although almond-specific bone trials are limited, their mineral composition and antioxidant properties suggest a protective role against osteoporosis.^{14,29,30}

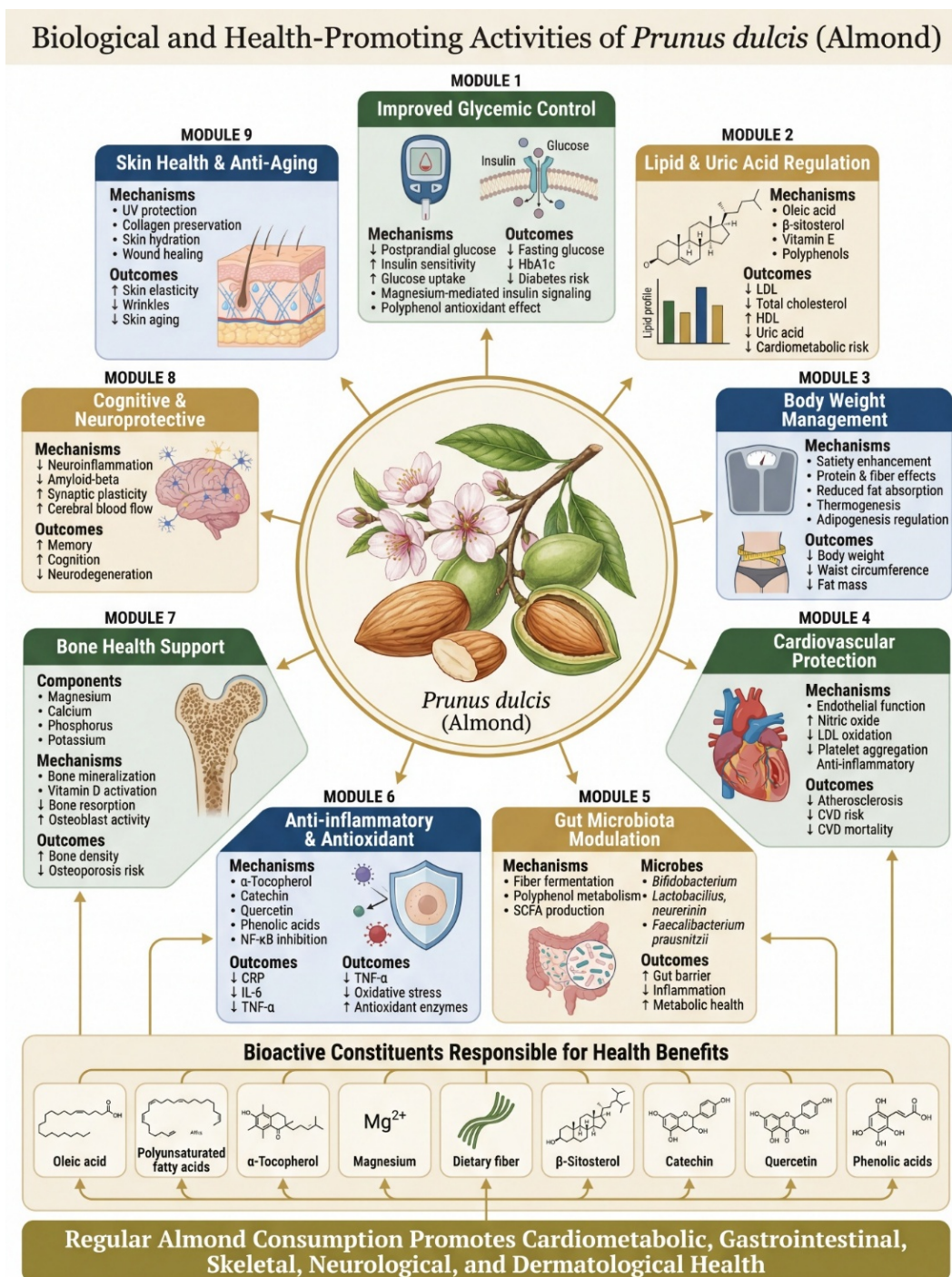


Figure 2: Biological and Health-Promoting Activities of *Prunus dulcis* (Almond): Bioactive Constituents, Mechanistic Pathways, and Health Outcomes: Schematic overview of the major biological and health-promoting activities of *Prunus dulcis* (almond). Almond bioactive constituents, including unsaturated fatty acids, α-tocopherol (vitamin E), magnesium, dietary fiber, β-sitosterol, catechin, quercetin, and phenolic acids, mediate multiple beneficial effects. These compounds contribute to improved glycemic control, lipid and uric acid regulation, body weight management, cardiovascular protection, gut microbiota modulation, anti-inflammatory and antioxidant activities, bone health support, cognitive and neuroprotective effects, and skin health maintenance. Collectively, regular almond consumption promotes cardiometabolic, gastrointestinal, skeletal, neurological, and dermatological health.

3.8. Cognitive and neuroprotective potential

Emerging evidence suggests almonds may support cognitive function and neuroprotection. The combination of vitamin E, flavonoids, and unsaturated fatty acids protects neuronal membranes from oxidative damage and maintains membrane fluidity essential for signal transduction.³¹ Magnesium supports synaptic plasticity and neurotransmitter regulation. Animal studies show almond polyphenols reduce neuroinflammation, inhibit amyloid-beta accumulation, and improve memory performance.^{32,33} Human data indicate that higher nut consumption correlates with better cognitive scores in older adults, possibly through improved vascular health, reduced inflammation, and enhanced cerebral blood flow.³⁴ While almond-specific neurocognitive trials are scarce, their nutrient profile aligns with known neuroprotective dietary patterns.³⁵

3.9. Skin health and anti-aging benefits

Almonds support skin health through multiple mechanisms. Vitamin E protects against UV-induced oxidative damage and maintains skin barrier integrity. Polyphenols reduce collagen degradation by inhibiting matrix metalloproteinases, while healthy fats maintain skin hydration and elasticity. Magnesium supports wound healing and reduces dermatological inflammation. Traditional use of almond oil for skin moisturization aligns with modern findings showing improved skin elasticity and reduced wrinkle depth after topical or dietary almond exposure. Antioxidant capacity also mitigates age-related skin changes, supporting almonds' role in cosmetic nutrition and dermatological health.^{35–37}

4. Conclusion

Almonds (*Prunus dulcis* Mill.) are nutrient-dense functional foods that provide a unique combination of unsaturated fatty acids, high-quality proteins, dietary fiber, essential micronutrients, and diverse bioactive phytochemicals. Current epidemiological, clinical, and mechanistic evidence supports their beneficial role in improving cardiometabolic health, regulating glycemic control and lipid metabolism, supporting weight management, and promoting gut health through microbiota modulation. Additional antioxidant, anti-inflammatory, neuroprotective, and bone-supporting properties further highlight their potential in disease prevention and health promotion.

The nutritional quality and bioactivity of almonds are influenced by genetic, environmental, and processing factors, emphasizing the importance of optimizing cultivation and post-harvest practices to maximize health benefits. Despite substantial progress, further research is needed to elucidate the specific mechanisms underlying almond-associated health effects, standardize clinical study designs, and explore the relationship between agronomic factors and nutritional outcomes. Overall, almonds represent a valuable component of healthy dietary patterns and offer significant potential as a sustainable food for supporting long-term human health.

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None.

7. Conflict of Interest

None.

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