



The White Gold of the Barnyard: Scientific Insights into Donkey Milk

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For most consumers, milk simply refers to cow or plant-based dairy. However, a growing number of specialized farms across Europe and Asia are turning attention toward a historical alternative: donkey milk. Famous in folklore as Cleopatra's cosmetic luxury, donkey milk is now receiving attention from scientific researchers studying its therapeutic, antimicrobial, and nutritional potential.

Comparative Nutritional Profiling: Donkey Milk vs. Human Milk

A primary focal point for researchers is the biochemical similarity between donkey milk and human breast milk.

- **Macronutrient Balance:** Donkey milk is characterized by low levels of total protein, fat, and cholesterol, combined with high concentrations of lactose, calcium, selenium, and vitamin D3.
- **Protein Ratios:** Unlike cow's milk, donkey milk contains a low casein fraction alongside a high concentration of whey proteins, essential amino acids, β -lactoglobulins, and lysozymes.
- **Micronutrients and Functional Classification:** Rich in vitamin C, folic acid, and heart-healthy fatty-acid profiles, researchers increasingly evaluate donkey milk as a functional food rather than a basic beverage.

Quantitative Analysis of Bioactive Proteins

The concentration of key bioactive and protective proteins in donkey milk closely mimics human milk levels:

Bioactive Protein Component	Concentration in Donkey Milk	Biological & Functional Properties
Lysozyme	1.0 g/L	Antimicrobial, similar to human milk levels.
α -Lactalbumin	1.8 g/L	Antiviral, antitumor, anti-stress properties; matches human milk closely.
β -Lactoglobulin	3.75 g/L	Major whey protein fraction.
Lactoferrin	0.08 g/L	Regulates iron homeostasis, provides anticancer and antiviral protection.
Lactoperoxidase	0.11 mg/L	Minor antibacterial enzyme component.

Furthermore, sequence homology studies show that donkey milk proteins align more closely with human milk than cow milk does. Specifically, homology for α_{s1} -casein between donkey and human stands at 42% (compared to 31% for cow), while β -casein homology reaches 57% (compared to 54% for cow).

Clinical Implications: Pediatric Allergies and Hypoallergenicity

Donkey milk is frequently explored as a clinical alternative for infants diagnosed with Cow's Milk Protein Allergy (CMPA), a condition affecting 2% to 5% of young children.

- **Tolerability Rates:** Clinical trials demonstrate that donkey milk is tolerated by 82.6% to 88% of infants with CMPA.
- **Regulatory Thresholds:** Because the tolerability level remains below the standard 90% threshold required to claim official "hypoallergenic" infant formula status, caution is advised.
- **Nutritional Considerations:** Due to its lower caloric and lipid density relative to human milk, unsupplemented donkey milk can lead to caloric deficiencies and pediatric growth complications if used as an unformulated sole source of nutrition. It serves best as a dietary supplement rather than an unadjusted formula substitute.

Antimicrobial Efficacy and Gastrointestinal Therapeutics

Laboratory models highlight notable antibacterial, antifungal, and anti-inflammatory mechanisms:

1. **Pathogen Inhibition:** In vitro digestion studies demonstrate significant dose-dependent inhibition of *Listeria monocytogenes* and growth suppression of *Escherichia coli*. Bioactive peptides formed during digestion act synergistically with intact proteins like lysozyme.
2. **Dermatological & Antifungal Activity:** Testing reveals high growth-inhibiting zones against dermatomycotic fungi like *Trichophyton mentagrophytes* and *Trichophyton rubrum*, alongside activity against Gram-positive bacteria such as *Staphylococcus aureus*.
3. **Colitis and Intestinal Barrier Function:** In murine models of colitis, purified donkey milk lysozyme (DML)—a c-type lysozyme of 129 amino acids—helped mitigate colon damage and mucosal inflammation. It upregulated tight-junction proteins (occludin and zonula occludens-1) while promoting beneficial gut microbiota.

Broader Medical, Cosmetic, and Industrial Applications

Beyond infant care, clinical interest extends into several specialized areas:

- **Cardiovascular and Metabolic Health:** Diets incorporating donkey milk have been studied for safety in complex allergy cases, rehabilitation of coronary heart disease, and support in hypocholesterolemic regimens.
- **Dermatology and Cosmetics:** Owing to its antioxidant properties and polyunsaturated fatty acids, donkey milk is used in topical cosmetics for hydration, skin cleansing, and anti-aging benefits.
- **Probiotic Delivery:** The milk provides a viable matrix for fermented probiotic beverages utilizing beneficial lactobacilli strains.

Production Bottlenecks and Market Constraints

Despite its promising health profile, commercial scale-up faces substantial operational hurdles:

- **Physiological Yield Limits:** Equid mammary glands possess a low capacity (≈ 2.5 L), yielding only 1.54 to 1.73 kg/day per animal. Increasing daily milking sessions beyond three times per day fails to yield more milk and risks causing mammary tissue harm.
- **Declining Populations:** Donkey numbers are dropping significantly in key areas (e.g., adult female populations in India fell by 37% in recent census cycles).
- **Processing & Regulatory Gaps:** Heat treatments tend to degrade delicate bioactive peptides. Furthermore, a lack of standardized food product legislation and high lactose levels (which limit suitability for lactose-intolerant individuals without fermentation) restrict mass commercial adoption.

While human clinical trials are still needed to firmly establish several therapeutic claims, donkey milk continues to hold strong potential at the intersection of clinical nutrition, dermatology, and functional foods.