MAKING SENSE of Milk

Looking for an alternative to cow's milk? Here's what you need to know.

By Frankie Wood-Black

Go to the dairy section of any grocery store, and you'll find a variety of milks made from soy, nuts, or rice in addition to good ol' cow's milk. Plant-based beverages aren't necessarily new (almond milk has been around for centuries), but their production has boomed in recent years. If you're looking to replace cow's milk, how do you know what to choose?

To understand the difference between plant milk and animal milk, let's first turn to biology. Animal milk is a complex fluid produced by the mammary glands of female mammals to feed their young. In some ways, the nutritional purpose of animal milk resembles that of nuts and seeds (technically, what we usually call nuts, such as almonds and walnuts, are seeds). Seeds contain nutrients that embryonic plants use to develop into seedlings.

Of course, a new plant's nutritional needs are distinct from what a nursing animal requires. And the process of getting milk from seeds is completely different from milking an animal. "Milking" seeds involves soaking them, blending them with water, and straining them.

Given the differences in how milks are produced, let's see how the nutritional profiles compare.

What's in dairy milk

You probably already know that cow's milk is a good source of calcium. But it's also a source of many vitamins, minerals, and lipids—or fats. Additionally, it contains sugars, hormones and proteins, such as casein, immunoglobins, cytokines, and enzymes. (The latter three types of proteins help nursing animals grow and develop their immune systems, but wouldn't necessarily have the same effect on you.)

This mixture is also complex from a physical standpoint. Milk is primarily water with sugars, minerals,

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FROM FARM TO STORE

Have you heard the expression: Cream rises to the top—as in the brightest people or ideas will naturally succeed? You can probably guess why we're bringing it up here: The saying comes from the chemistry of milk.

Milk is an emulsion, a suspension of droplets of one liquid in another liquid, not a solution in which a solute dissolves in a solvent to create a uniform mixture. If you let raw cow's milk sit for a bit, the fats in the milk will rise to the top because they are less dense than water, a major component of milk. The fat layer can be easily separated from the rest of the milk.

But you don't see separation in store-bought milk. The milk has been homogenized, which involves a mechanical process that breaks up the fats into smaller sizes to allow them to stay suspended in the watery mixture.

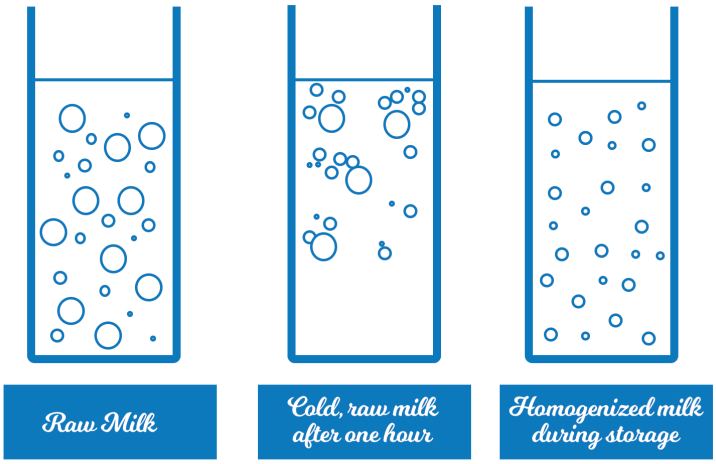

ILLUSTRATION: KELSEY CASSELBURY

lipids, and proteins blended together. The sugars and minerals remain dissolved in the watery solution, while lipids form small clumps of fat that stay suspended in store-bought milk.

Casein proteins, which comprise about 80% of cow-milk proteins, are also suspended in milk. They are too large to be soluble in water, and instead form droplets called micelles. The micelles are spherical particles with the hydrophilic, or "water-loving," side of casein facing outward. The protein's hydrophobic, or "water-hating," side gets tucked inside the droplets along with clusters of calcium phosphate. The suspension and dispersion of droplets of fat and protein make milk a colloid—more specifically, an emulsified colloid because the mixture components are all in liquid form.

Botanical beverages abound

Today, many people are choosing not to drink cow's milk for several reasons. Some people are allergic to milk proteins. Others are lactose intolerant. Cultural, personal, and environmental considerations provide additional reasons for some people to avoid cow's milk.

The most widely available plant-based milk alternatives in the United States are derived from soy, rice, almond, and coconut. Also available are milk beverages made from peas, oats, cashews, potatoes, flax, hemp, sesame, and peanuts.

Like store-bought cow's milk, plant-based milks are a suspension of ingredients. But from a nutritional standpoint, how do plant-based alternatives compare to cow's milk?

The short answer is: It depends. The nutritional value varies from product to product, and it might or might not provide the equivalent nutritional value of traditional cow's milk. To make sense of the varieties, first consider what your body needs.

The current U.S. dietary guidelines recommend that we consume dairy products, including milk, yogurt, and cheese, which are excellent sources of calcium, potassium, phosphorus, vitamin D, and protein.

Calcium, potassium, phosphorus, and vitamin D are essential for bone health. Calcium is also important for the development of strong teeth. And diets rich in potassium can help maintain healthy blood pressure, while proteins contribute to building muscle.

Additionally, proteins provide amino acids that our bodies need. So, when nutritionists look at protein quality, they are looking at the amino-acid composition, digestibility, and bioavailability—that is, how much of the protein your body can use.

Cow's milk typically has better protein quality than that of plant-based milks because the proteins are made with a wider array of amino acids and are easier for our bodies to use.

The one plant-based exception is soy. Soy contains the nine essential amino acids that the human body can't synthesize—so like cow's milk, soy is considered a "complete" protein source. As for nutrients, such as calcium, potassium, and vitamin D, they can be added to make soy-milk nutrition closer to cow's milk. Because of this and its complete protein content, fortified soy milk is the one plant-based milk the U.S. dietary guidelines list under the dairy recommendations.

But as with milk proteins, nut or soy proteins can cause allergic reactions in some people, so products with these ingredients aren't right for everyone. Additionally, if you're looking for a source of phosphorus, zinc, thiamin, vitamin B6, vitamin E, vitamin K, and folate, cow's milk has these nutrients, but they are not always found in plant-based alternatives. So, while nut and seed milks provide some benefits, they do not have the same nutritional value as cow's milk (see chart).

Types of Milk and Milk Alternatives

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COW'S MILK

Positives: High in protein, calcium, vitamin D, and phosphorus
Negatives: Contains lactose and saturated fat

PHOTO: PIXABAY

SOY MILK

Positives: High in protein, often fortified so its nutritional profile is close to cow's milk
Negatives: Can cause allergic reaction

PHOTO: PIXABAY

ALMOND MILK

Positives: Low calorie, high in vitamin E and can be fortified; no saturated fats
Negatives: Low in protein

PHOTO: THINKSTOCK

RICE MILK

Positives: Suggested for individuals with multiple allergies
Negatives: Low in protein; high in carbohydrates

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COCONUT MILK

Positives: Contains potassium, iron, and fiber
Negatives: Low in protein, more saturated fat than other plant milks

The bottom line

Curious to learn more about the potential health effects of increasingly popular milk alternatives, researchers have done some investigating and found that plant-based beverages could have benefits beyond providing proteins, vitamins, and minerals.

For example, soy milk contains isoflavones that some research suggests can protect against cardiovascular disease and osteoporosis. Peanut milk and almond milk contain antioxidants in addition to vitamin E that can guard against cellular damage. Coconut milk contains lauric acid, which some research suggests promotes brain development and helps boost the immune system.

The bottom line: Botanical milks differ considerably from cow's milk. And knowing the differences can help you make more informed decisions about your drink—or drinks—of choice.

Frankie Wood-Black is a science writer based in Tonkawa, Oklahoma.

Selected References

Haug, A. et al. Bovine Milk in Human Nutrition–a Review. *Lipids in Health and Disease*, Sept 25, 2007: https://lipidworld.biomedcentral.com/track/pdf/10.1186/1476-511X-6-25 [accessed Dec 2018].

Abou-Dorbara, M. I. et al. Chemical Composition, Sensory Evaluation and Stater Activity in Cow, Soy, Peanut, and Rice Milk. *Journal of Nutritional Health & Food Engineering*, Nov 28, 2016: https://medcraveonline.com/JNHFE/JNHFE-05-00175.pdf [accessed Dec 2018].

Bridges, M. Moo-ve Over, Cow's Milk: The Rise of Plant-Based Dairy Alternatives. *Practical Gastroenterology*, Jan 2018: https://med.virginia.edu/ginutrition/wp-content/uploads/sites/199/2014/06/January-18-Milk-Alternatives.pdf [accessed Dec 2018].

WHAT'S **SUNLESS** TANNER?

One simple molecule holds the key to keeping a tan year-round.

By Tien M. Nguyen/C&EN

When physician Eva Wittgenstein discovered a chemical that could bronze skin rapidly, cosmetics and sunless tanners were probably the last thing on her mind.

It was the mid-1950s, and Wittgenstein was conducting research at Children's Hospital at the University of Cincinnati. She was studying children who had a rare metabolic disease and examining the effects of treating them with dihydroxyacetone ($C_3H_6O_3$), which is a simple, plant-derived, sugar-like molecule.

Her small patients took big doses of the stuff—up to 1 gram (g) of $C_3H_6O_3$ per 1 kilogram (kg) of body weight—sometimes causing the kids to spit up on themselves, which, if not cleaned up right away, left strange brown spots on their skin. Their clothes, however, remained unstained.

Intrigued, Wittgenstein poured a solution of dihydroxyacetone onto her own skin and confirmed its color-changing effects. She found that unlike makeup, which lies inert on top of skin, dihydroxyacetone reacts with it.

The reaction, it turns out, is related to one of chemistry's

PHOTO: THINKSTOCK

tastiest transformations, called the **Maillard reaction**, responsible for the browned appearance of fried bacon and roasted coffee. In the Maillard reaction, sugars and amino acids react when heated to form a multitude of molecules, including some with a brownish hue. Similarly, the reaction that turns skin tan at room temperature occurs when dihydroxyacetone reacts with amino acids like arginine, lysine, and histidine found in the outer layer of skin to produce yellowish-brown pigments called melanoidins.

CREATING A FAUX GLOW

Word of dihydroxyacetone's browning abilities spread quickly to the cosmetic industry. By 1960, according to one newspaper report, at least a dozen sunless tanning products based on the molecule—with names like Man-Tan, Magic Tan, Tansation, and Tanorama—had been introduced to bronze the public.

The products' appeal grew as people recognized that sunbathing caused skin damage, though their understanding was flawed. At the time, many people thought that "good" ultraviolet-A (UV-A) radiation gave healthy-looking tans, while "bad" ultraviolet-B (UV-B) radiation caused burns and, in extreme cases, cancer, says

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