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Moo-ove Over, Cow's Milk: The Rise of Plant-Based Dairy Alternatives



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Consumer demand for alternatives to dairy is on the rise, and with it, an ever-expanding array of plant-based products from which to choose. This is especially evident when considering milk substitutes. Each type of non-dairy milk offers a unique nutritional profile, with a wide range of values for protein, carbohydrates and fat, along with vitamins and minerals. Learn more about which non-dairy beverages are gaining in popularity and how these options compare nutritionally to cow's milk.

The Rise of Plant-Based Milks

When choosing milk, it is no longer simply a matter of whole, low-fat, or skim. Now more than ever, consumers can choose from a plethora of plant-based “milks” derived from a variety of sources, including nuts, seeds, legumes, and cereal grains.

Worldwide sales of non-dairy milk alternatives more than doubled between 2009 and 2015, reaching \$21 billion – a reflection of both consumer demand and the burgeoning array of products to meet that demand. Meanwhile, consumption of cow's milk has dropped 13 percent in the U.S. over the last five years.¹

Plant-based milk substitutes are essentially suspensions of dissolved and disintegrated plant material and extracts in water. Homogenization

and thermal treatments are used to improve the suspension and stability of the product. They are made to visually resemble cow's milk and often include the word “milk” in the beverage name. Specific nutritional properties depend on the plant source, processing, and fortification. The most widely available plant-based milks in the U.S. are identified in Table 1.

The increasing popularity of non-dairy milks can be attributed to many factors. More and more people are consuming non-dairy alternatives, whether due to an allergy, lactose intolerance or adherence to a vegan/plant-based diet. Still others are concerned over saturated fat levels, hormone content, and antibiotic use in dairy cattle. But with an ever expanding array of options, the dairy

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aisle can end up being a place of utter confusion, especially when weighing not only taste, texture, and other sensory attributes of non-dairy milks, but also the nutritional qualities of these beverages and how they compare to cow's milk.

How Do Plant-Based Milks Compare to Cow's Milk?

Dairy foods are often good sources of important nutrients, including protein, vitamin D, calcium, and phosphorus. As some plant-based milks are very low in these nutrients, consumer awareness is important when dairy-free alternatives are used as a direct replacement for cow's milk in the diet. For example, of all the non-dairy alternatives, only soy milk naturally contains protein in an amount comparable to cow's milk (8 g per 8 oz. cup). By contrast, almond milk – one of the most popular non-dairy options among consumers – only contains 1 g of protein per 8 oz. cup.

Moreover, every gram of protein is not created equally, and it is important to evaluate the quality of protein when comparing plant-based milks to cow's milk. Protein quality is based on amino acid composition, digestibility, bioavailability, and specific protein-derived components. Protein from animal sources is generally of higher quality than plant-based protein due to its more “complete” array of amino acids.² Cow's milk contains both whey and casein proteins, which have high biological value given their “usability” by the body. While soy protein is also recognized for its high biological value among plant sources, its usability when derived from soy milk has not been extensively studied.³ Most other proteins found in plant-based milks are not complete and do not offer the full array of essential amino acids.

While non-dairy alternatives do not offer exact nutritional equivalency to cow's milk, they can be fortified with certain nutrients – especially calcium, vitamin D, and vitamin B12 – to make them more comparable. In fact, many fortified plant-based milks are marketed as having equal or greater amounts of calcium and vitamin D than cow's milk. However, it is important to recognize that the bioavailability of such nutrients varies significantly among products and in many cases is not precisely known.³

Table 1. Plant-Based / Non-Dairy Milk Alternatives

Milk Alternative	Plant Type
Cereal-Based	<ul style="list-style-type: none"> • Oat milk • Rice milk
Legume-Based	<ul style="list-style-type: none"> • Soy milk • Pea milk
Vegetable-Based	<ul style="list-style-type: none"> • Potato milk
Seed-Based	<ul style="list-style-type: none"> • Flax milk • Hemp milk
Nut-Based	<ul style="list-style-type: none"> • Almond milk • Cashew milk • Coconut milk

By the same token, while the quantity of most micronutrients has been established for cow's milk, similar information is not available for most non-dairy beverages. In fact, only figures for calcium and vitamin D are consistently reported for non-dairy milks on the USDA's Food Composition Databases; figures on phosphorus, zinc, thiamin, niacin, vitamin B6, folate, vitamin E, vitamin K, and other micronutrients are often missing.⁴ Table 2, which compares the nutritional profile of popular plant-based milks to 2% cow's milk, omits these particular vitamins and minerals, as most of this information is not yet readily available.

In addition to protein and vitamin/mineral content, added sugar is another variable that can vary widely among plant-based milks and depart drastically from cow's milk. While unsweetened versions have as few as 25 calories per cup, most non-dairy milks are sweetened with added sugars (such as rice syrup, barley malt, or cane sugar) to make them more palatable. Many sweetened and/or flavored non-dairy milks contain up to 20 g of sugar, compared to 12.5 g of naturally occurring lactose in 2% cow's milk.

Finally, consumers should be aware of any additives used to emulsify and stabilize plant-based milks. Some leading nut milks, for example, contain carrageenan, a thickener and emulsifier derived from seaweed that has recently been implicated in some preliminary (though far from conclusive) studies on ulcers, inflammation, and

other GI complications. Other non-dairy milks can be thickened with sunflower lecithin or a variety of gums. Learn more about the specific properties of the most popular plant-based milks below.

Soy Milk

Likely the most recognizable among dairy-free alternatives, soy milk is the “original” replacement for cow’s milk, first appearing on shelves in the U.S. in the 1950s. Made by soaking, crushing, cooking, and straining soybeans, it is the only milk alternative that naturally contains the same amount of protein as a cup of cow’s milk - 8 grams - along with omega-3 fatty acids and fiber. Most manufacturers also fortify soy milk with vitamins A, D, B12, and calcium. In addition, soy milk can be a good source of manganese and magnesium.

Interestingly, when considering the manufacturing process, soy milk is likely the “least processed” out of all plant-based milks. At the same time, soy is one of the top three genetically modified organisms (GMOs) in the U.S., with 94% of all soybeans in the country being genetically engineered.⁵ Most mainstream brands, however, use certified non-GMO ingredients.

In recent decades, soy foods have garnered increasing attention for the amount of isoflavones they contain. These phytoestrogens are being extensively studied for their potential health effects ranging from heart disease and breast cancer prevention to bone mineral density reduction in post-menopausal women. Current evidence, however, is far from conclusive, and much remains to be learned about these compounds.⁶

Of additional note, soybeans do contain high levels of phytic acid, a compound sometimes referred to as an “anti-nutrient,” which is not destroyed or reduced during the conventional manufacturing process for soy milk.⁷ Phytic acid has a high affinity for binding minerals such as calcium, iron, magnesium, and zinc and can render these nutrients unavailable for absorption. This effect, however, only occurs when such minerals are ingested simultaneously with phytic acid.

Almond Milk

Almond milk is made from ground almonds and water. It is quickly gaining in popularity, especially among those avoiding soy due to allergies or other

health concerns. It is perhaps best known for being low in calories, typically between 30 and 50 per 8 oz. cup (unsweetened), or about one-third the calories of 2% cow’s milk. Sweetened varieties, however, can contain up to 90 calories per cup and 16 g of sugar.

Nut milks in general tend to be highly diluted with water. While this allows them to be relatively lower in calories, this also means that they supply minimal amounts of the nutrients typically found in nuts, including protein, manganese, magnesium, and copper. A major drawback of almond milk is that the protein content from the almonds is strained out of the milk along with the pulp; hence, it contains very little protein – usually only 1 g per 8 oz. cup, compared to 8 g in cow’s milk.

Through fortification, almond milk can offer a comparable amount of vitamins and minerals as cow’s milk – and in some cases, can offer more. However, it is still devoid of most B vitamins, essential fatty acids, and many trace elements such as zinc and copper. One unique aspect of almond milk is its high vitamin E (alpha tocopherol) content, with one cup offering up to 10 mg, or 50% of the daily value for adults.

Rice Milk

There are not many advantages to rice milk over other plant-based milks, but it is likely the most hypoallergenic of all non-dairy alternatives. Though usually derived from boiled brown rice and brown rice starch, it has no fiber and a thin consistency. It has considerably less protein than cow’s milk (only 1 g per 8 oz. cup) and a very small amount of natural calcium, though most brands are calcium-fortified and enriched with vitamins A, D, and B12. It is also low in fat; however, some manufacturers do add vegetable oil as an emulsifier and stabilizer.

Rice milk generally tastes sweeter than cow’s milk, owing to the addition of sweeteners (usually brown rice syrup) and vanilla. It is also significantly higher in carbohydrates.

Oat Milk

Oat milk is made from oat groats (oats that have been cleaned, toasted, and hulled), water, and potentially other grains and beans, such as triticale,

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barley, brown rice, and soybeans. It has a mild flavor and is slightly sweet. Its consistency is similar to that of 1% or skim milk.

Oat milk is low in overall calories, cholesterol, and saturated fat. It is higher in fiber than other milk alternatives, with 2 g per cup or sometimes more, depending on whether oat bran has been added. It also contains iron, vitamin E, and folic acid. In addition, it offers 4 g of protein per cup, which is relatively higher than most other non-dairy alternatives. At the same time, naturally occurring sugars give this beverage a higher carbohydrate content.

Depending on the manufacturer, oat milk could be another viable option for people with nut and seed allergies. It is important, however, to read the label for added ingredients that could be allergens.

Coconut Milk

Made from grated and squeezed coconut meat, this high-calorie, high-fat beverage is not for drinking straight-up but is usually reserved for cooking, especially in southeast Asian cuisine. It is often found canned and in the ethnic foods section of the grocery store. It has a natural, creamy thickness with a mild nutty flavor.

A 1-cup serving of canned raw coconut milk contains 445 calories and 48 g of fat, of which 43 g are saturated. Recently, however, manufacturers are now offering “coconut milk beverage,” which is essentially coconut milk that has been diluted with water, to appeal to consumers who seek to drink it more regularly. While this type of diluted coconut milk has far fewer calories and much less fat, it also has very little protein – less than 1 g per 8 oz. cup. This version of coconut milk is usually found in cartons (not cans) in the dairy aisle.

Whether concentrated or diluted, coconut milk offers medium-chain triglycerides and a relatively high amount of potassium. If fortified, it can serve as a good source of vitamin D and can also supply up to 50% more calcium than dairy milk.

In addition, coconut milk contains fiber and iron, two notable departures from cow's milk.

Hemp Milk

Though unlikely to ever gain the same kind of popularity as soy or almond milk, hemp milk is considered ideal for people who cannot consume gluten, nuts, and/or soy. It can also be a viable option for those who are on a starch-limited diet and/or must avoid oligosaccharides.

Hemp milk is made from the hulled seeds of the industrial hemp plant, which includes varieties of *Cannabis sativa* that are low in the psychotropic substance tetrahydrocannabinol (THC) and are grown for food and textile uses. It has an earthier flavor that may be off-putting to some consumers and/or lead them to buy the sweetened versions.

Hemp milk naturally contains more protein than other non-dairy alternatives, but at 2-3 g per 8 oz. cup, it is still not a particularly good source. It does offer a three-to-one ratio of omega-6 to omega-3 essential fatty acids, including around 1,000 mg of alpha-linolenic acid. Other nutrients include magnesium and phytosterols, as well as some calcium, fiber, iron, and potassium.

Pea Milk

Pea milk is one of the newer dairy-free milk alternatives, with only one major manufacturer currently in the U.S. but a second one gearing up to introduce its own line soon. Made from yellow field peas, this beverage is poised to gain more popularity, owing largely to its naturally high protein content (at least 7 g per 8 oz. cup). During manufacturing, yellow peas are milled into flour, which is then processed to separate the protein content from the fiber and starch, and the protein is then further purified and blended together with water and other ingredients. This is a departure from most nut-based milks, in which the protein content is removed and never reintroduced.

Like most other non-dairy alternatives, pea milk is fortified to contain 150% more calcium than cow's milk. Moreover, its taste and consistency is actually very close to cow's milk. An added benefit: yellow peas are easy and inexpensive to grow, so pea milk carries a much lower water footprint than almond milk and a much smaller carbon footprint than cow's milk.⁸

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Table 2. Nutritional Composition of Cow's Milk and Non-Dairy Beverages per 8 oz. Cup (240 mL)

Nutrition Content	Cow's Milk	Almond	Cashew	Coconut	Flax	Hemp	Oat	Pea	Potato	Rice	Soy		
Product	2% with Vitamin A & D	Blue Diamond Almond Breeze	Califia Farms Original	Silk Original	So Delicious Original (diluted beverage/ carton)	Thai Kitchen Coconut Milk (canned)	Good Karma Plain	Living Harvest Original	Pacific Original	Ripple Original	Dari-Free	Pacific Original	Silk Original
Energy (kcal)	122	41	59	60	70	424	24	101	130	101	70	130	100
Protein (g)	8.05	1.01	1.00	1.01	0	3.03	0	1.99	4.01	7.99	0	1.01	8.0
Fat (total g)	4.83	2.50	4.01	2.50	4.51	42.42	2.50	7.01	2.50	4.51	0	1.99	4.01
Saturated (g)	3.067	0	0	0	4.512	30.303	0	0.504	0	0.5	0	0	0.501
Carbohydrate (g)	11.71	4.01	6.00	9.00	7.99	9.09	1.01	7.99	24.00	6.00	20	27.00	7.99
Fiber (g)	0	1.0	0.9	0.0	1.0	0	0	0	1.9	0	0	0	1.0
Sugars (g)	12.35	3.00	5.00	7.01	7.01	3.03	0	6.00	19.01	6.00	2	13.99	6.00
Calcium (mg)	293	451	450	451	101	0	300	300	350	451	300	300	299
Iron (mg)	0.05	0.72	0.71	0.36	0	6.55	0.36	1.08	1.80	2.69	0.72	1.08	1.07
Magnesium (mg)	27	N/A	N/A	17	41	N/A	N/A	41	N/A	0	N/A	N/A	39
Potassium (mg)	342	180	N/A	29	41	491	0	N/A	120	451	50	N/A	299
Sodium (mg)	115	149	161	170	0	46	79	110	115	130	120	60	119
Riboflavin (mg)	0.451	0.034	0.424	0.509	N/A	N/A	N/A	0.425	0.509	N/A	0.13	N/A	0.510
Vitamin B12 (mcg)	1.29	N/A	3.01	3.00	3.00	N/A	1.49	1.49	N/A	N/A	0.96	N/A	2.99
Vitamin A (IU)	464	499	500	499	499	0	499	499	499	499	300	499	501
Vitamin D (IU)	120	89	100	101	101	N/A	101	101	101	120	90	101	119

Information obtained from the USDA Food Composition Databases.³ N/A = not available

Table 3. Pros and Cons of Cow's Milk and Non-Dairy Beverages

Beverage	Pros	Cons
Cow's Milk, 2%	High in protein, calcium and vitamin D	Not suitable for those with allergies or lactose intolerance; higher in saturated fat; may be derived from cattle treated with antibiotics and/or hormones
Soy Milk	Highest protein and least processed among plant-based milks	Higher fat than other plant-based milks; sweetened varieties can contain up to 19 g sugar
Almond Milk	Low-calorie; high in vitamin E	Very low-protein
Rice Milk	Best option for those with multiple allergies	Least amount of protein; often manufactured with added sugars
Oat Milk	Contains fiber, iron, and a moderate amount of protein	Ingredient list could contain potential allergens
Coconut Milk	Good source of potassium (490-600 mg per 8 oz. cup of canned milk); contains iron and fiber	Higher fat content than other plant-based milks; low in protein
Hemp Milk	High in essential fatty acids	Higher fat content than cow's milk; earthy flavor
Cashew Milk	Creamy taste and texture	Low-protein
Flax Milk	Low-calorie; high in essential fatty acids	Very low-protein
Pea Milk	High in protein; creamy taste and texture	Not widely available
Potato Milk	Fat-free; soy-, nut-, gluten- and casein-free	Very low-protein; not widely available; may contain allergenic additives

Other Milks

Cashew Milk

With only 60 calories per cup and no saturated fat or cholesterol, unsweetened cashew milk is often considered a good option for those looking for a creamier alternative to almond milk without the fat and calories of canned coconut milk. It is made by blending water-soaked cashews with water.

Like almond milk, after the pulp is strained away, most of the protein content and naturally occurring vitamins and minerals in cashews ends up being lost. Through fortification, however, cashew milk can offer close to 50% more calcium than cow's milk. Fortified cashew milk can also

be an excellent source of vitamin D. In addition, one 8 oz. cup contains 50% of the recommended daily value for vitamin E.

Flax Milk

With a similar nutrition profile to that of almonds, flax milk is low in calories (around 25 kcal in 1 cup of unsweetened) and very little protein. Flax milk is made commercially by combining cold-pressed flax oil with water, thickeners, and emulsifiers. Flax milk has the additional benefit of 1,200 mg of omega-3 fatty acids (alpha-linolenic acid) per 8 oz. cup. It is also fortified with calcium, vitamin D, and vitamin B12, though not to the same degree as some other non-dairy alternatives.

Flax does contain a very high amount of phytoestrogens - over three times that of soy - but it is unclear how much remains in the oil after the seeds are pressed. And again, the potential health effects (both positive and negative) of these compounds are still being extensively researched.

Potato Milk

Potato milk is another newcomer to the non-dairy milk scene. It is not widely available at grocery stores, but it can be ordered online. Commercially, it is usually found in powdered form. Like rice milk, potato milk is high in carbohydrates but low in protein, though it is usually fortified with calcium and vitamins. It is also a good option for those who may have a soy or nut allergy, as well as those following a gluten- and/or casein-free diet, although consumers should read the label to check for potentially allergenic additives.

In addition to providing as much calcium as cow's milk, potato milk provides more iron than many other non-dairy alternatives.

CONCLUSION

A growing number of consumers are opting for plant-based milk substitutes, either for medical reasons or as a lifestyle choice, and as a result, the current generation of plant-based milks continues to expand. Table 3 outlines the pros and cons of the various types of non-dairy milk alternatives. The nutritional profile of each type of "milk" depends not only on the plant source, but also the manufacturing process and the degree of

fortification. These factors are especially important when considering the protein, vitamins, minerals, and sugar in each serving. Most non-dairy milk alternatives are fortified to provide a reasonable amount of calcium and vitamin D, although amounts of other micronutrients are often unknown. Besides taste and texture, protein and added sugars are perhaps the most widely variable attributes among plant-based milks. Consumer awareness, therefore, is important when plant-based substitutes are used to fully replace cow's milk in the diet. ■

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