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Comparison of dairy milk with vegan milk of different types available in India

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Abstract
There are different types of vegan milk available in India. Due to rising issues associated with cow milk such as cow milk allergy, lactose intolerance, calorie concerns, the incidence of hypercholesterolemia, nowadays the preference has been drawn towards vegan milk. Vegan milk is basically plant-based juice that resembles the taste, texture and qualities of conventional animal milk. Generally, plant milk aims to contain the same amount of nutrients as that of animal milk, but as these are manufactured using processed extracts of the starting plant, vegan milks are lower in nutrient density than dairy milk. So, are fortified during manufacturing to add precise level of micronutrients, commonly calcium, vitamin A and D. Presence of different bioactive phytochemicals, absence of cholesterol, high energy input given for the production, limited availability of milk in some region, emergence of vegan diet and limited resources like landmass, feed, *etc*. are acting as the driving force to search the alternative source of milk. Plant-based milk alternatives have an enormous expansion prospective for health food market, and needs to be widely investigated through the development of advanced processing, technological interventions, fortification techniques to develop a nutritionally complete beverage with high overall acceptability to the consumer.

Keywords: fortification, hypercholesterolemia, phytochemicals, vegan milk

1. Introduction
Plant-based or non-dairy milk is the fast growing segment in newer food product category of functional and specialty beverage all over the world. Consumers are increasingly choosing cow milk alternatives because of hypersensitivity reactions to cow milk, lactose intolerance, calorie concerns, the incidence of hypercholesterolemia, and a preference for vegan diets. Plant-based milk alternatives are a rising trend, which can function as an inexpensive alternate to poor economic group of developing countries and in places, where cow's milk supply is insufficient. Though numerous kinds of innovative food beverages from plant sources are being exploited for cow milk alternative, majority of these faces some/any type of technological issues; either related to processing or preservation. Majority of these milk alternatives lack nutritional balance as compared to bovine milk, however they contain functionally active components with health promoting properties which attracts health conscious consumers. Sensory acceptability, like with legume-based milk replacements, may be a major limiting factor in their widespread appeal. New and advanced non-thermal processing technologies such as ultra-high temperature treatment, ultra-high pressure homogenization, pulsed electric field processing are being applied to tackle the issues related to increase of shelf life, emulsion stability, nutritional completeness and sensory acceptability of the final product. More efforts are required in functional beverages segment to develop tailor-made newer products which are palatable as well as nutritionally adequate [1].
Vegan milk, also known as plant milk, nut milk, and non-dairy milk, is a beverage that has been enjoyed by people all over the world for a long time. Some choose to drink it because of health reasons like associated hypersensitivity reaction to milk sugar or dairy milk while others drink it for the nutritional benefits it offers. Lately, people have begun to comprehend the darker aspects of dairy *viz*. the cruelty towards cows, the damage it causes to the environment as well as to an individual's health. All these factor results that plant-based milk has increased in popularity with a wide assortment of types and flavours [2].
Loaded with protein, calcium, nutrients vitamin D and B12, milk is a nutritious food that is useful for bone wellbeing. Milk is additionally viewed as a complete protein since it contains all the nine essential amino acids for the body's requirement. Apart from the cow milk, the rising fame of plant-based milk presently opens up a couple of alternatives including almond

milk and oat milk for veggie lovers and lactose intolerant individuals [3]. The array of plant-based milks offers something for all taste buds and health needs of its consumers [1].

2. Plant Milk Vs Milk

According to traditional nutrition research, an adult should consume roughly 300g of dairy products per day. The foremost popular option is milk, while condensed milk is occasionally substituted for evaporated milk in milk teas. Generally, after lowering some amount of water, both condensed and evaporated milk are milk products. While both condensed and evaporated milk are sweetened along with lots of additives that's reason it is recommended to drink both in limited amount [3].

Plant milk is a plant juice that looks like cow/animal milk and refers to manufactured, non-dairy beverages made up of a water-based plant extract for flavouring and aroma. Plant milks are vegan beverages with a creamy mouthfeel that can be substituted for dairy milk. For commerce, plant-based liquids are typically packaged in containers similar and competitive to those used for dairy milk, however it cannot be labelled as "milk". Plant milk has long been a popular beverage as well as a flavorful element in sweet and savoury foods, such as curries made with coconut milk. Plant milks are also used to make ice- creams, plant cream, vegan cheese, yogurt, and much more items [4].

People due to various reason such allergy, lactose intolerance or vegetarianism, are not capable of absorbing milk. Apart from this, the production and storage of animal products generate abundant greenhouse gases, nowadays few consumers tend to avoid milk due to environmental issues. Plant milk made from soybeans, oats, and almonds, could be a good substitute for animal origin milk. Because plant milk has a gritty texture, some companies add sugar and thickeners to make their products smoother and more palatable. Consumers should thus check the nutrition label in detail before purchasing to avoid the added sugars[3]. Few of common plant milks are almond milk, coconut milk, rice milk, and soy milk, while other less used plant milks include hemp milk, oat milk, pea milk, and peanut milk [1, 5].

Plant milks are often made from processed extracts of the beginning plant. Plant milks have a lower nutrient density than dairy milk, which is which is the reason for their fortification with precise levels of micronutrients, commonly calcium and vitamins A and D while manufacturing [5, 6]. The following table compares the nutritional content of different products:

Table 1: Nutritional content of fortified cow, soy, almond and oat milks [15]

Nutrient value per 250 mL cup	Cow milk (whole)	Soy milk (unsweetened)[	Almond milk (unsweetened)	Oat milk (unsweetened)
Energy, kJ (kcal)	620 (149)	330 (80)	160 (39)	500 (120)
Protein (g)	7.69	6.95	1.55	3
Fat (g)	7.93	3.91	2.88	5
Saturated fat (g)	4.55	0.5	0	0.5
Carbohydrate (g)	11.71	4.23	1.52	16
Fiber (g)	0	1.2	0	2
Sugars (g)	12.32	1	0	7
Calcium (mg)[a]	276	301	516	350
Potassium (mg)	322	292	176	390
Sodium (mg)	105	90	186	140
Vitamin B_{12} (µg)	1.10	2.70	0	1.2
Vitamin A (IU)[a][b]	395	503	372	267
Vitamin D (IU)[a][c]	124	119	110	144
Cholesterol (mg)	24	0	0	0

Table 2: Calories, Protein and Fat content of different milk [3]

Nutrient Content (8oz)	Soy milk	Quinoa Milk	Oat milk	Almond milk	Whole milk	Skim milk	Low-fat milk
Calories	105 kcal	111 kcal	40 kcal	130 kcal	150 kcal	100 kcal	80 kcal
Proteins	6g	3.8g	1.51 g	7-8g	8-9g	8g	8g
Fat	4g	1.6g	3.58g	16g	8g	2.5g	1g

Table 3: Observations based on physiochemical studies of plant-based developed milk and curd Samples [7]

	Protein (g/100g)	Carbohydrate (g/100gm)	Calcium (mg/100g)	pH	Titrable Acidity (%)
Oats milk	1.033	33.51	8.2	7.5	0.009
Curd made from Oats milk	5.6	0.18	116	4.5	0.009
Rice milk	0.786	57.3	6.5	7.5	0.036
Curd made from Rice milk	2.9	0.37	78	5	0.027
Almond milk	1.70	4.5	13.15	6.5	0.009
Curd made from Almond milk	5.2	0.18	96	4.5	

Table 4: Mean greenhouse gas emissions for one glass (200 g) of different milks [8]

Milk Types	Greenhouse Gas Emissions (kg CO_2-Ceq per 200 g)
Cow's Milk	0.62
Rice Milk	0.23
Soy Milk	0.21
Oat Milk	0.19
Almond Milk	0.16

Table 5: Mean water footprint for one glass (200 g) of different milks [8]

Milk Types	Water Use (L per 200 g)
Cow's Milk	131
Almond Milk	74
Rice Milk	56
Oat Milk	9
Soy Milk	2

The actual content of the highlighted plant in commercial plant milks is around 2% only. Remaining ingredients commonly included are guar gum, xanthan gum, or sunflower lecithin for texture and mouth feel, select micronutrients (such as calcium, B vitamins, and vitamin D), salt, and natural/artificial ingredients. The production of almond-based dairy substitutes has been criticized on environmental grounds as large amounts of water and pesticides are used for their production and processing. The emissions, land, and water footprints of plant milks vary, due to differences in crop water needs, farming practices, region of production, production processes, and transportation [1, 8, 9, 10]. Milk is a healthful complete diet that contains a well-balanced mix of macronutrients (fats, proteins, and carbohydrates) and micronutrients (calcium, selenium, riboflavin, Vitamin B^{12}, and Vitamin B5). However, limited availability to milk in some parts of the world, low availability of certain minerals (iron), vitamins (folate), and other biomolecules (amino acids) compounded with issues like milk allergies, lactose intolerance, and hypercholesterolemia have compelled some people to seek out better milk replacements that are more or at least nutritionally equivalent to animal milk. Plant-based wholesome or blended milk analogues are better inexpensive alternates to conventional milk for people. Soya bean milk, oat milk, coconut milk, hemp milk, cocoa milk, multigrain milk, and other plant-based alternative milks are currently the market leaders. Plant milk is valued for its functionally active components, which are frequently linked to health-promoting and disease-prevention characteristics. Plant based milk require less energy input per unit of milk produced compared to animal milk. However, the important limiting factor for the acceptance of plant based milk is their challenging production technology and poor sensory profile which is very important for beverages derived from legumes [11].

In western countries, the utilization of plant-based milk alternatives is well established beverage and has been extensively used in recipes as an ingredient. Hence, there is a great scope to explore plant based milk for the preparation of milk beverages. Recently, it is proved that plant sources (cereals and legumes) are accepted as functional food and nutraceuticals due to presence of health promoting components such as dietary fibres, minerals, vitamins and antioxidants [12]. Improvements in the quality and acceptance of plant-based milk through technological interventions is being done nowadays. However, few bottlenecks such as improving product stability, removal of off-flavor, inactivation/removal of inhibitors and shelf life improvement are limiting factor to be solved for wide consumer acceptability [1].

Table 6: Nutritional Comparison of commercially available, selected plant-based milk alternatives [1]

Type of milk (per serving of 240 ml)	Calories (g)	Protein (g)	Fat (g)	Carbohydrates (g)	Dietary fibres (g)	Calcium (% daily value)	Iron (% daily value)	Vitamin A (% daily value)
Soy milk (Silk)	80	7	4	4	1	30	–	10
Quinoa milk (Ecomil)	104	4.5	6	9	–	–	–	–
Rice milk (Pacific)	130	1	2	27	0	30	6	10
Oat milk (Oatly)	80	2.5	4	16	2	15	0	10
Sesame milk (Ecomil, with agave syrup)	140	1.5	6	16.5	0.5	–	–	–
Almond milk (Silk)	40	1	3	2	1	20	2	10
Coconut milk (Silk)	80	1	5	7	0	45	4	10
Hemp milk (Living harvest)	70	2	6	1	0	30	6	10
Hazelnut milk (Ecomil)	124	1.4	6	14	–	–	–	–
Multigrain milk (Pacific Organic 7 grain milk)	140	3	2	27	1	35	8	15
Cow's milk (Amul Gold standardized UHT milk)	168	8	10	11	–	338 mg	1.25 lg	168 lg

3. Types of Vegan Milk

3.1 Soy Milk: Soy milk is the classic vegan milk that's been around for a really while. Of all the plant milks, soy milk may very closely resemble cow's milk in terms of nutritional content. It is low in calories and it's an excellent source of both protein and calcium.

It is used in cooking and baking. It can be used to replace cow's milk in most recipes and is comparatively stable at high temperatures, thus making soya milk an ideal cooking ingredient while making sauces or savory dishes. It is also used in teas and coffees and can also be foamed [2]. Soybeans are an excellent source of complete protein and thus a great alternative to avoid dairy beverage. Approximately an 8-ounce serving of unsweetened soy milk can provides 105 calories, 6 grams of protein and 4 grams of fat. It is an incredible food that naturally contains numerous nutrients, also good source of vitamins specially vitamin B_{12}, D and minerals such as calcium and phosphorus [3]. Most widely available easily and a budget-friendly milk alternative [1].

***Pros*:** Soy is a plant-based complete protein i.e. it contains all 10 essential amino acids as well as it is inexpensive as compared to other plant-based milks.

***Cons*:** The flavor of soy milk is an initial hurdle, however choosing a flavored variety may help overcome this issue. Soy milk does not naturally contain as much calcium as dairy milk that's the reason for calcium-fortification.

3.2 Almond Milk: Almond milk is the most popular plant-

based milk. However, this vegan milk is comparatively low in protein, contains lots of vitamins and other nutrients such as Vitamin E. Almond milk is rich in various antioxidants which could supposed to protect us against the numerous ailments *viz*. cancer and heart disease. Home-made almond milk is a good source of calcium [2].

Almond milk is a good beverage that you can drink as such or it can be drink as smoothies, shakes, teas, and coffees. It can be added into the cereal and oatmeal, cooking sweet and savory dishes. However, almond milk is a little too sweet for savory dishes and generally used for making desserts and smoothies by the people [2]. Almond milk has a nutty taste and contains magnesium, selenium and vitamin E. An 8-ounce glass of almond milk generally contains 40 calories, 3.58 grams of fat and 1.51 grams of protein [3]. Almond milk is easily available everywhere comparable to other vegan milk, which makes almond milk one of the best plant-based milk [1].

***Pros*:** Almond milk contains omega-3 fatty acids that are important for heart health and the antioxidant vitamin E. It's naturally low in sugar and available in a variety of flavours.

***Cons*:** Almonds milk is a nutritious whole food with protein and fat, however it is not a good source of protein and also low in calcium.

3.3 Cashew Milk: Cashew milk is a new recent addition to plant milks. It is filled with heart-healthy unsaturated fats, which may be beneficial for those who are diabetic and health conscious consumers. This vegan milk has creamy consistency that can be used for making teas, coffees, cooking and baking. Now, it is available in most grocery stores. Cashew milk has a nuttier sweet taste [2].

***Pros*:** Cashew milk completes 20% of our daily requirements of magnesium, it is rich source of mono- and polyunsaturated fatty acids, and it also contains potassium. This line-up of nutrients is important for heart health.

***Cons*:** Homemade cashew milk are usually higher in fiber, protein and fat compared to the store-bought cashew milk. Cashew milk might be not a good dairy replacement due to low protein content.

3.4 Oat Milk: Oat milk has a mild, slightly sweet flavour and high fiber compared to other milks. Fiber is essential in a balanced diet for healthy digestion and to decrease cholesterol levels. It is good for savoury and sweet recipes prepared from the cereals, smoothies, cream soups, and curries [2]. Oat milk is high in soluble fibre and beta-glucans, however, it is lower in protein, vitamins and minerals compared to cow's milk. Generally, an 8-ounce glass of oat milk contains 130 calories, 2 grams of fat and 4 grams of protein[3]. Its creamy consistency is helpful to substitute the dairy milk in baked goods, soups, lattes and more. This plant-based milk has more carbohydrates than other options, which makes for a good pre- or post-workout energy drink.

***Pros*:** Oat milk contains naturally occurring fiber and protein, and it's can be fortified with vitamins A, B_2, B_{12} and D, and minerals calcium and phosphorus. It doesn't contain lactose, nuts or soy therefore, it's an allergen-friendly option. It is a safe option for those with Celiac disease, if made with certified gluten-free oats.

***Cons*:** Some people love the thick texture and flavour of oat milk, while others find it a turn-off. Oats are a nutritious food, but drinking oat milk could not be equated with eating whole oats.

3.5 Hemp Milk: Hemp milk is milk made up using seeds of the hemp plant. This vegan milk is sort of high in protein with a thick and creamy consistency. Additionally, hemp milk also provides nearly 50 percent of the recommended daily intake of alpha-linolenic acid (α-LA), which is a type of omega-3 fatty acid, important for healthy heart and brain function. Due to its strong flavor, it is best used in savory dishes generally [2]. Soy was once the only known plant-based source of a complete protein, but now hemp seeds provide all 10 essential amino acids and has earthy and nutty flavour [1].

***Pros*:** Hemp seeds contain sufficient amount of magnesium, folate, phosphorus and potassium and can be fortified with additional calcium, phosphorus and vitamins A, B12 and D. It also contains higher amount of unsaturated healthy fats (omega-3 and omega-6) than other plant milks [2].

***Cons*:** Hemp has been reported to interact with certain pharmaceutical drugs. Too much consumption at once, may lead to digestive upset due to its high fat content [2].

3.6 Rice Milk: Rice milk is made by combining boiled rice with water and adding some sweeteners. Its sweet taste makes it perfect for deserts and its thinner consistency is suitable in soups and light weight sauces. Rice milk can also be used in baking however; due to its delicate texture it may require some thickening agents such as flour, corn-starch or xanthan gum [2]. Rice milk is an allergy-friendly choice for those who ought to avoid nuts, seeds, soy or lactose. It's easily available in various grocery stores. Rice milk has the largest carbohydrate level of any plant-based milk on this list (excluding sweetened and flavoured varieties), but this isn't always a bad thing unless you're watching your carb consumption for health reasons [13].

***Pros*:** Rice milk is inexpensive and can be fortified with vitamins and minerals such as vitamins B12 and D, and calcium. It has a mild flavor that's lightly sweet and adaptable [13].

***Cons*:** Rice milk is recognised for having a watery texture. It may contain added sugars, gums and additives for flavour, consistency and shelf-life. It is not a protein-rich food [13].

3.7 Coconut Milk: Coconut milk is available in two different forms, either in a can or as a beverage. Those utilized in cooking typically come in a can. It adds a delicious coconutty flavor to any dish in which it is used and works great when used in baking too. Coconut milk is ideal for different types of recipes such as curries, soups, stews, sauces, smoothies, puddings, and even ice creams. The coconut milk that is used for drinking has a thinner consistency and even can be used for teas, coffees, and cereals [2]. Coconut milk is less of a drinking beverage and more of an ingredient for cooking and is easily available [1].

***Pros*:** Coconut milk is rich in minerals, such as manganese, magnesium, potassium, copper and selenium and contains medium-chain triglycerides. It is high in fiber compared to

other plant-based milks. Wide varieties of coconut milk are available for different culinary needs, such as drinks, sauces, baking, cooking.

***Cons*:** It is high in calories and fat, low in protein. Again, this is not inherently unhealthy, but it-could be a con for some, depending on personal health needs, goals and lifestyle choices.

3.8 Flax Milk: Flax milk is basically cold-pressed flax oil combined with filtered water and it has a thin and smooth consistency. It is additionally an excellent supply of polyunsaturated fatty acid mainly omega-3 fatty acids. Flax milk is used in cereals or in coffee, can also be used in sweet and savoury dishes [2].

3.9 Pea Milk: Pea milk, derived from yellow peas, is naturally devoid of soy, gluten, lactose, and nuts, making it an excellent allergy-friendly option. Ripple is the most well-known brand of pea milk, and when compared to other plant milks, Ripple milk has an exceptional nutritious profile [1].

***Pros*:** Pea milk is high in protein and can be substitute for dairy. Branched-chain amino acids are abundant in pea protein. It's high in calcium and omega-3s (from algal oil). It contains A and D vitamins, as well as potassium and iron.

***Cons*:** According to some people, it has a chalky sensation and aftertaste. Certain types and flavors of pea milk measure high in sugar.

3.10 Quinoa Milk: Quinoa is an excellent source of manganese which is a cofactor of several enzymes to facilitate ample of different metabolic processes. Each 8-ounce serving of Quinoa Milk contains 111 calories, 1.6 grams of fat and 3.8 grams of protein [3].

3.11 Macadamia Milk: Macadamia milk has a more balanced flavor compared to other nut milks and it can be used on more frequent basis in various foods and beverages compared to other plant milks like cashew milk with stronger flavors [1].

***Pros*:** Macadamia milk is high in omega-3 and omega-6 fatty acids, making it a good source of nutrition. It also has a high calcium, vitamin D, and vitamin B_{12} content. It has a thicker consistency, making it a stronger alternative for coffee drinks, and a macadamia milk latte might hit the spot [1].

***Cons*:** It's more expensive than popular plant-based milks like almond and soy. The higher fat content makes this a higher-calorie nut milk, which isn't inherently a bad thing, but something to be kept in mind if you're trying to lose weight [1].

3.12 Banana Milk: Banana milk is actually rather yummy (if you like bananas). It has a flavour similar to that of a "healthified" milkshake. It's sweet, slightly fruity and super-creamy. Banana milk is a good choice to add flavor to smoothies, baked goods, oatmeal, and maybe even to coffee [1].

***Pros*:** Banana milk packs 8% of our daily needs for potassium, 25% of daily calcium needs (fortified, not naturally occurring) and contains vitamins B_6 and C. Without any additional sugar, it has a sweet, creamy banana flavour (unless you opt for the chocolate flavor). Banana milk is easy to make at home.

***Cons*:** Currently, Mooala is the only one brand you can buy in stores. As banana milk grows in popularity, other alternative corporations can most likely mount up the bandwagon. However, until that happens, accessibility to factory-made banana milk could also be restricted for a few. Banana milk is deficient in vitamin D when compared to other plant milks, the majority of which are vitamin D fortified.

4. Best Vegan Milk

When it comes to finalize the best option for the combination of nutrition, sustainability and versatility, oat milk and hemp milk is the best one. Plant-based milks can be used in a variety of ways, including coffee, smoothies, baking, cooking, and preparing sauces. Protein-rich, plant-based milk to replace dairy milk includes soy milk or pea milk is best one. The nutritional quality of most plant-based milks may be fortified with calcium, other vitamins, and minerals to match or even exceed that of cow's milk, therefore protein becomes the most important aspect.

According to a recent study, almond milk and curd were very accepted among panel members and had suitable pH and nutritional characteristics Hence, it indicates that milk and curd made from plant sources may exemplify safe food for lactose intolerant people as a part of their diet [7]. The soymilk, almond milk and the blends of both were analysed for their proximate and sensory properties. It is found that among the plant based milks, soy milk displayed higher moisture, pH and protein content whereas, the values of total solids, titratable acidity, ash, fat, iron and calcium were higher for almond milk. Therefore, based on nutrient and sensory profile, it can be implied that soy almond milk blend suits well as a candidate for use as non-dairy milk alternative [14].

5. Conclusion

Milk is a complete food which is non-replaceable, though we have come across the benefits of plant based milk substitutes over the dairy industry. Presence of different bioactive phytochemicals, absence of cholesterol, high energy input given for the production, limited availability of milk in some region, emergence of vegan diet and limited resources like landmass, feed, *etc*. are acting as the driving force to search the alternative source of milk.

Plant-based milk alternatives have an enormous expansion prospective for health food market, and needs to be widely investigated through the development of advanced processing, technological interventions, fortification techniques to develop a nutritionally complete beverage with high overall acceptability to the consumer. To enable plant-based milk to be used as nutritionally equivalent alternatives for bovine milk, it can be fortified with a suitable form of fortificant using appropriate technology, and maintaining the bioavailability of nutrients throughout the storage is needed.

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