

Plant based milk analogs with special emphasis on coconut milk

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The search for dietary substitutes that accommodate diverse lifestyles and dietary limitations has gathered enormous pace in today's health-conscious society. An important change that has occurred recently is the growing use of dairy analogues to replace conventional dairy products. Dairy alternatives are becoming more and more appealing as consumer concerns about environmental sustainability, animal welfare, and personal health continue to grow. Plant-based dairy substitutes, sometimes referred to as dairy analogues, come from a variety of plant sources, including grains, legumes, nuts, and seeds. In comparison to traditional dairy production methods, these substitutes have a smaller environmental impact and provide a compelling range of advantages, such as cholesterol-free options for heart health, lactose-free options for those who are lactose intolerant, and more. These plant based milk alternatives (PBMA) are called as beverages, drinks or dairy alternatives to distinguish it from the widely consumed cow's milk. Among these, the most common milk alternatives include coconut, soybean and almond. The ingredients of these milk alternatives include water extractants of nuts, cereals, endosperm, and oilseeds of diverse plant sources, emulsifier, and additives. Despite the large share of soybean milk in this segment, the emerging milk alternatives derived from other plants such as coconut, oats, almond, and peanut have also witnessed a huge growth. The large-scale production and marketing of plant-based milk analogs have led

Classification of plant-based milk alternatives based on its origin

Origin	Plant based milk alternatives
Cereal based	Oats, Rice, Corn, Spelt, Rye, Kamut milk alternative
Legume based	Soybean, Peanut, Bambara groundnut, Kidney bean, Lupin, Pea, Cowpea, Chickpea milk alternative
Nut based	Almond, Cashew, Coconut, Hazelnut, Pistachio, Walnut, Tiger nut milk alternative
Oilseed based	Sesame, Flaxseed, Hemp, Sunflower milk alternative
Pseudo-cereal based	Quinoa, Teff, Amaranth milk alternative
Other based	Potato, moringa, colocynth (<i>Citrullus colocynthis</i>) seeds, cantaloupe-seeds milk alternative

(Source: F. Reyes-Jurado et al. (2021))



to its exponential growth worldwide.

Types of Plant Based Milk Analogs

Coconut milk

Coconut milk is used all around the world in confections, bakeries, biscuits, ice cream, and other baked goods. Coconut milk is a readily digested non-dairy replacement due to the presence of medium-chain triglycerides. Coconut has medium-chain fatty acids (MCFAs), which are easier for the liver to metabolize and transform into ketone molecules. These chemicals are useful for brain function and can provide relief from memory impairments like Alzheimer's disease. In contrast, other milk analogues include long-chain fatty acids. In addition to MCFAs, the nutritional value of coconut is enhanced by its soluble and insoluble fibre content, which has several anti-oxidant qualities (Fernando et al. 2015). Additionally, the milk has a respectable number of vitamins and minerals.

Other common PBMA are soy milk, oats milk, Rice milk, Cocoa milk, kidney bean milk, Peanut milk and hemp milk

Nutritional Properties

Dairy milk has been marketed for a very long time as a nutrient-dense food. The nutritional balance of cow milk makes it a high nutritional value product, which is a good source of protein, calcium, phosphorus, potassium, and vitamin D. Cow milk protein content has higher quality than PBMA because of its complete essential amino acid profile. The main nutritional differences between PBMA are in the proportions of protein, fat, and sugar and it vary depending on the raw materials used.

Nutritional Properties of Coconut Milk

Coconut milk contains roughly 54-57% moisture, 30-35% fat, and 11% solid non-fat. The amount of extractions and the condition of the milk extraction affect the composition. A lower percentage of fat and other solids are extracted from the coconut gratings when using the old manual method of extracting milk. Screw presses and hydraulic milk expellers are used in industrial manufacturing to improve the recovery of fat and other particulates. It is customary to add lukewarm water to the extraction process. Aqueous coconut products are divided into four categories based on total solids and total fat content: light coconut milk, coconut milk, coconut cream, and coconut cream concentrate, according to the Codex standard for aqueous coconut milk and coconut cream products (CODEX STAN 240-2003). To modify the necessary fat content in the finished product, many companies add water. As a result of dilution, the nutritional makeup would be changing accordingly.

Difference Between Bovine and Coconut Milk

Bovine milk is a chemically complicated bio-fluid that contains hundreds of distinct components and is rich in nutrients. The type of dairy cow, its breed, age, and nutrition, as well as the stage of lactation, the farming technique, and the physical environment, all affect the colour, flavour, and composition of bovine milk. Milk is the typical mammary secretion obtained from the whole milking of healthy milch cattle, according to the FSSAI (2015). It must be devoid of colostrum. If milk meets the minimum and maximum requirements for fat and SNF, it can also be referred to as "milk" after being adjusted for milk fat, milk

Product	Total Soilds 9% m/m) Min - Max	Non-fat Soilds (% m/m) min.	Fat (% m/m) min.	Moisture (% m/m) max.	pH
a) Light Coconut Milk	6.6-12.6	1.6	5.0	93.4	5.9
b) Coconut Milk	12.7-25.3	2.7	10.0	87.3	5.9
c) Coconut Cream	25.4-37.3	5.4	20.0	74.6	5.9
d) Coconut Milk Concentrate	37.1 min	8.4	29.0	62.6	5.9

(Source: CODEX STAN 240-2003)

SNF level, or both. However, no legal definition is available of coconut milk. It is a milky fluid obtained by the manual or mechanical extraction of fresh coconut endosperm with or without addition of water (De Leon and Delores, 2005).

1. Chemical Compositional differences

In general, the gross composition of cow's milk is 87.0% water, 13.0% Total Solid, 4.9% lactose, 4% fat, 3.4% protein, and 0.7% minerals. And in case of coconut milk is 67.6% water, 23.8% fat, 2.90% protein, 0.7% ash, 2.2% dietary fibre.

At a micro nutrient level, bovine milk contains many bio active compounds including vitamins, minerals, organic acids, nucleotides, oligosaccharides, and immunoglobulins (Fox et al., 2015) Bovine milk contains several essential nutrients and is an important part of dietary recommendations in many countries (Rozenberg, et al., 2016), For more than 8000 years, cow milk has been an essential part of

Parameter	Coconut milk	Cow milk
pH	6.00	6.40
Specific gravity	1.050	1.030
Solid not fat	1.20%	8.2%
Titration acidity	0.09%	0.15%
Viscosity	2.40cp	1.50cp
TSS	14.06%	12.50%

human nutrition (FAO, 2017)

2. Physico-Chemical Properties

Coconut milk and bovine milk were examined for their physico-chemical characteristics by Gupta et al., 2019.

Due to the light scattering caused by fat globules and casein micelles, milk appears turbid and opaque; on the other hand, coconut milk has an opaque, milky white colour and can have a consistency ranging from watery to creamy. The natural nutty flavour of coconut milk contrasts with the naturally sweet flavour of bovine milk (Seow and Gwee, 1997; Tansakul and Chaisawang, 2006).

3. Functional differences.

(a) Establishing the gut microflora and impact on

Immune System:

In addition to providing vital nutrition, cow's milk is crucial for the establishment of beneficial gut microbiota and immune system priming in all newborn mammals (Murphy et al., 2017). And lauric acid, a lipid found in coconut milk, has been shown by several studies to strengthen the immune system.

(b) Nutritional and Emulsifying characteristics:

The fat found in cow's milk can be thought of as an oil-in-water emulsion, with the majority of the lipid portion contained within the globules of milk fat. The distinct fatty acid profile that arises from the usual fatty acid pattern in cow milk fats greatly influences the technical and physical properties. A few components, including glycerides, sterols, and polar lipids, are present in milk fat in lesser levels. From an analytical and dietary perspective, the polar lipids found in milk products present a unique component. Because they are amphiphilic, milk polar lipids can be employed as an emulsifying agent in a variety of food products.

(c) Stability differences:

There have been reports that the high oil, moisture, and organic component content in fresh coconut milk causes it to spoil quickly after extraction. Gonzalez (1990), Coconut milk may often be kept fresher longer by thermal processing, but cow's milk only goes bad when the lactose in it coagulates into lactic acid. At the same storage temperature, cow's milk is more stable than other varieties of bovine milk. Proteins undergo structural alterations when dairy milk products are heated, and the primary whey proteins are changed into lactulosyl residues (Meltretter et al., 2007).

Coconut protein stabilises the oil-in-water emulsion in coconut milk, but the amount and quality of the protein present are inadequate, making the oil-in-water emulsion unstable (Tangsuphoom and Coupland, 2005) According to Tangsuphoom and Coupland (2005), homogenization with several surface-active agents, such as sodium caseinate, whey protein isolate (WPI), sodium dodecyl sulphate (SDS), and polyoxyethylene sorbitan monolaurate, might increase the stability of coconut milk emulsions.

Coconut Based Dairy Analogues			
Products	Intervention	Uniqueness	Reference
Non-Cheese	It is made by using combination of Soya milk, coconut milk, rennet, enzyme, salt, Sodium phosphate (stabilizer) and Calcium propionate (Preservative)	Sample containing 50% each soya milk and Coconut milk, 0.1% Rennet enzyme, 1.5% Salt, 0.5% Stabilizer, 1% Preservative was found to be the best.	Kadbhane et al., 2019
Pro biotic drink	Made from blends of milk analogues from African yam bean, soybean and coconut. Milk analogues were blended at different ratios. And samples were fermented for 24 h at 43°C using <i>Lacto bacillus delbrueckii</i> .	Fermented milk analogue of ratio 1: 1: 1 was the most acceptable in terms of sensory parameters.	Abiodun Victor Ikujenlola et al., 2019
White Chocolate	White chocolate was prepared from cow, rice, oat and coconut milk.	Chemical composition of cow white milk chocolate showed no significant difference in the protein contents compared to plant based white chocolate. Coconut chocolate contains the highest percent of fat (58.30%) and fiber (5.40%).	Shawir et al., 2023
Spicy ice cream	Coconut milk-based spicy ice cream was developed. Cinnamon ginger, and white pepper are the spices used in the preparation of the ice cream.	Three different formulas (0.010%, 0.018%, and 0.025%) were developed by changing the percentage of spices added. The 0.018% spice-added sample was found to be the best.	Perera et al., 2021
Creamy vegan dessert (CVD)	The CVDs were made with coconut milk powder, thickeners, sucrose, cocoa, modified starch, and potassium sorbate.	Creamy vegan dessert prepared from coconut milk shows similar texture profile of commercial dessert due to cocoa addition making this one was well accepted by consumers.	Leticia Sanches et al., 2022
Coconut milk powder	The spray drying process was used with an air inlet and outlet temperatures of 190°C and 90°C respectively.	The spray dried powder is stable during storage in polyethylene package under room conditions even after three months, giving a satisfactory reconstituted product.	Hassan, 1985
Coconut Milk Kefir	Coconut milk kefir was prepared by the fermentation of fresh coconut milk with milk kefir grains. Kefir grains are a mixture of beneficial lactic acid bacteria and yeast with a polysaccharide matrix.	The processed coconut milk kefir (without preservative) under the refrigerated condition (0–4°C), 7 days stored, was found to be safe and nutritious.	Khin Si Win. 2022
Coconut ice cream	Soy milk and coconut milk (either alone or as blends with cow milk) were found to be a good vehicle for the delivery of probiotic strains such as <i>Lacto bacillus acidophilus</i> and <i>Bifido bacterium bifidum</i> in ice cream.	Ice creams made of both the soy and coconut milk provide a richer growth medium of amino acids and sugar content for both the microbial strains than cow's milk ice cream.	Beegum et al., 2021

Coconut Based Dairy Analogues			
Products	Intervention	Uniqueness	Reference
Soy-coconut yogurt	For production mixture of soy milk and coconut milk are used at different levels resulted in a product which was rated excellent in flavour, texture, colour and overall acceptability.	50% Soy milk and 50% Coconut milk had the best cost effective and increased profitability because Soy beans and Coconut were much cheaper than Cow milk as ingredients for yoghurt production.	Belewu et al., 2005
Coconut milk based palmyrah drink	Product was developed with four product formulations by changing the pulp percentage (T1=0 %, T2=20 %, T3=40 %, and T4=60 %). Pulp was treated with acid and heat treatment to reduce and mask its bitterness.	Bitterness of the product is masked and the product boast significant nutritional and functional properties..	Thuraisingam et.al., 2023
Tender coconut milk pudding	Buffalo milk concentrated in ratio 2.5:1, sugar (16%), gelatin (2%), along with that different proportions of coconut milk was used for recipe and 10% was finalized.	Coconut milk is a rich source of fat than buffalo milk. The fat, carbohydrate and protein contents increased as the level of coconut milk increased.	Dawane et.al., 2010
Coconut milk smoothie	It was prepared using coconut milk along with oats and dry fruits.	Enrichment omega-3 and other nutrition like vitamin E and vitamin B6 from walnut; copper, selenium, vitamin K from dates at acceptance level with high fiber.	Kripa and Rana et al., 2022
Skim coconut milk	UHT skim coconut milk prepared by separating fat, CMC and Monotanox 60 was added at 0.6 and 0.6% respectively.	Contains coconut flavor but excluding fat. Fat content appeared less than 1%.	Khuenpet et al., 2016
Coconut candy	Utilization of coconut flour and coconut milk for the preparation of candy	Less moisture, carbohydrate, and high percentage of protein and fat compared to candies prepared with rice flour and cow milk.	Rakshitha and Jain, 2021
Coconut ball	Healthy chocolate- coated coconut balls are prepared by using desiccated coconut powder and condensed milk.	Herbal powder used has a very high effectiveness and vital source for new drug development.	Suse et.al., 2019
Coconut-soy condensed milk	Involved with the development of functional condensed milk by mixing soy milk and coconut milk	It contains a significant difference not only I the chemical composition but also in health benefit phenomenon.	Ahmed et.al., 2019
Milk beverage from coconut milk and cashew milk	1:3 of coconut : water and 1:4 of cashew nut: water were blended along with inclusion of xanthum gum, sugar and flavour in different proportions.	Blend with 60:40 mixture of butterscotch-flavoured cashew milk and coconut milk were most accepted with different proximate and sensory parameters.	Sanjana et.al., 2022

Coconut Based Dairy Analogues			
Products	Intervention	Uniqueness	Reference
Chocolate	Chocolates produced from coconut variants viz, coconut oil, coconut cream and coconut milk as a substitute for cocoa butter.	Cocoa butter fat replaced with coconut fat contains about 90% saturated fatty acid.	Divya et.al.,2016
Whipping cream	Different proportions of coconut cream and dairy cream were used for production, then whipping properties, physico-chemical properties and sensory evaluation were conducted.	Due to high and exorbitant expense of milk cream, the replacement of coconut cream reduces the cost.	Kavindi et.al., 2022
Coconut protein powder	Coconut milk was subjected to centrifugation, three phases were obtained. The coconut skim milk and insoluble protein were homogenized before spray drying to obtain a dehydrated protein powder.	Coconut protein powder have a good emulsifying properties and has a potential to find applications in emulsified foods.	Naik et.al.,2012

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