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Comparative Analysis of Nutritional Composition between plant-based and animal-based Milk

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Abstract : *This research examines the nutrient composition of both plant-based milk substitutes and traditional animal-based milk, focusing on fat, protein, calcium, and lactose content. The study included various milk samples such as Cow, Buffalo, and Goat milk, alongside homemade plant-based alternatives like Soy milk, Almond milk, and Oat milk. Tests were conducted to assess the levels of fat, protein, calcium, and lactose in each sample.*

The results reveal that Buffalo milk had the highest fat content, whereas oat milk had the lowest. Buffalo milks also exhibited the highest protein concentration, while Soy milk, among plant-based alternatives, closely resembled animal-based milk. Oat and Soy milk demonstrated notable calcium levels, surpassing those found in animal-based milk. In contrast, almond milk had the lowest calcium concentration. Lactose content was highest in Goat milk and lowest in Almond milk.

Plant-based milk substitutes can provide nutritional benefits comparable to animal-based milk. Such alternatives may appeal to individuals with dietary restrictions, environmental concerns, or health-conscious consumers. The study contributes valuable insights for consumers making informed choices between plant-based and animal-based milk.

Keywords: *Plant-based milk, Dairy consumption, Environmental impact, Nutrient analysis, Animal welfare, Sustainable food choices, Omega-3 fatty acids, Titration, Health-conscious consumers, Cruelty-free.*

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Introduction:

Dairy milk consumption traces back to 7000 BC, providing evolutionary advantages through lactose persistence (Porzi M et al., 2021). Today, all around the globe, encouragement for dairy milk and dairy product consumption is seen in public health policies and considered to play an important role in the diet of humans. (Comerford KB et al., 2021). However, their production poses significant environmental impacts, with emerging concerns about animal welfare in the industry.

Increasing worries, including lactose intolerance and environmental consequences, fuel the demand for plant-based milk substitutes. Options such as Almond milk, Oat milk, and Soy milk offer cruelty-free

alternatives, addressing both health and ethical considerations (Pistrich k *et al*., 2014). Plant-based diets contribute to the reduction of heart ailments, cancer, coronary artery disease, and hyperglycemia (Zujko.E., et al.,2014) and neurodegenerative disorders (Pistollato.et al.,2018).

The surge in plant-based milk sales reflects heightened consumer awareness and preferences (Wood Z., 2019). The appeal of plant-based options lies in their health benefits, environmental sustainability, and the alleviation of the burden on the dairy industry. Comparative nutrient analysis aids consumers in choosing appropriate plant-based substitutes, promoting a shift toward sustainable and ethical dietary choices.

Materials and Methods:

Animal milk (Cow, Buffalo, Goat) and homemade plant-based milk (Soy, Almond, Oat) avoiding commercial products. Prepared plant-based milk as follows:

Soy milk: Soy seeds were soaked in clean water overnight. Peels were removed and the seeds were ground in food processor along with two cups of water and then strained using a cheese cloth. The filtrate thus obtained was soy milk.

Almond milk: Almonds were soaked overnight in clean water. Peels were removed and almonds were ground in a food processor along with two cups of water. It was then filtered using a cheese cloth and the filtrate thus obtained was Almond milk.

Oat milk: Rolled oats were washed in clean water and was ground in a food processor. Then filtered using a cheese cloth. The filtrate thus obtained was Oat milk.

Procedure for determining Fat Content: Adjusted milk temperature to 29℃. Added milk to butyrometers with 90% H_2SO_4, Iso-Amyl alcohol, and centrifuged at 650℃, 1100rpm. Calculated fat content from graduations on the Butyrometer.

Procedure for determining Protein Content: Prepared K_2SO_4 + $CuSO_4$ mixture. Pipetted 20g of each milk sample into test tubes, added 10mL 98% H_2SO_4, digested at 350℃, 420℃ for 2 hours, cooled for 2 hours, distilled with Boric acid and alkali buffer. Titration against 0.1N HCl with methyl red as indicator.

Procedure for determining Calcium Content: Pipetted 25mL milk, added Eriochrome Black T indicator, pH 10 Ammonia buffer, titrated against 1/50N EDTA until pink turned blue.

Procedure for determining Lactose Content: Added 10mL milk to a measuring cylinder, diluted to 100mL. Added Fehling's solutions A and B, boiled, added methylene blue, titrated against lactose solution until methylene blue indicator disappeared. Recorded lactose volume used.

Summary: Collected animal and plant-based milk samples. Tested fat, protein, calcium, and lactose content using specific procedures, ensuring accurate measurements and controlled conditions.

Results:

A. Amount of fat in Milk Samples: The highest concentration of fat was observed in Buffalo milk and the lowest concentration was observed in oat milk. Almond milk, to a large extent, matches the fat percentage found in animal-based milk samples taken into consideration, as shown in Table 1. A well-illustrated comparative account for the percentage of fat in different milk samples can be observed in Fig.1.

Table 1. Concentration of fat in milk in different milk samples

Sl. No.	SAMPLE	FAT (%)
1.	Goat milk	4.6
2.	Buffalo milk	5.6
3.	Cow milk	5.2
4.	Oat milk	1
5.	Almond milk	4.79
6.	Soya milk	2.2

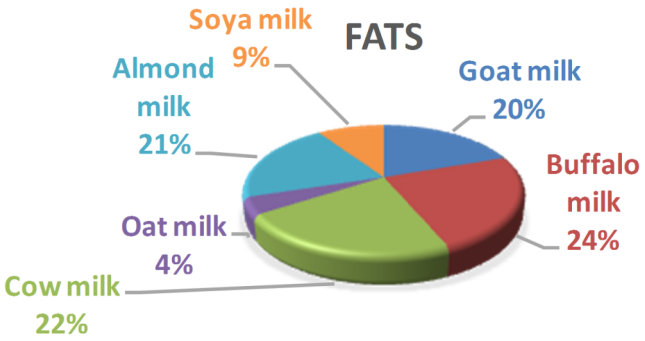

Fig. 1. Percentage of fats in different milk samples

B. Amount of protein in milk samples: The highest concentration of protein was found in Buffalo milk and the least concentration was found in Oat milk. Soy milk has almost similar potential to fulfill protein requirements as that of animal-based milk. In fact, it has a greater protein percentage than Cow milk and Goat milk, as shown in Table 2. It can serve as a great protein source for lactose intolerant individuals. A well-illustrated comparative account for the percentage of protein in different milk samples can be observed in Fig.2.

Table 2. Concentration of protein in different milk samples

S. No.	Sample	Initial Reading of HCL	Final Reading of HCL	Vol of HCL Used (Ml)	Protein (%)
1.	Blank	0	0.1	0.1	-
2.	Soya milk	0.1	1.7	1.6	4.5
3.	Almond milk	1.8	7.2	5.3	2.2
4.	Oat milk	7.4	10.1	2.6	1.0
5.	Goat milk	10.2	20.7	10.4	4.4
6.	Buffalo milk	20.7	32.6	11.8	5.1
7.	Cow milk	32.6	40.5	7.9	3.4

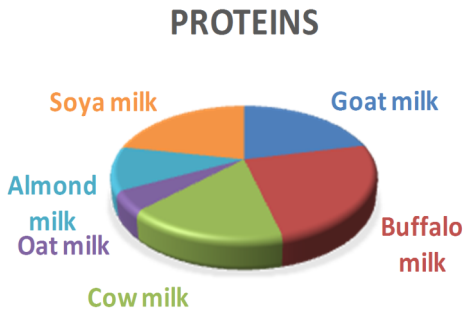

Fig. 2. Percentage of proteins in different milk samples

C. Amount of calcium in milk samples : The highest concentration of calcium was found in Oat milk and the lowest was found in Almond milk. Surprisingly, the calcium content of Oat milk turned out to be even greater than all the animal-based milk samples that were taken into consideration, as shown in Table 3. A well-illustrated comparative account for the percentage of calcium in different milk samples can be observed in Fig. 3.

Table 3. Concentration of calcium in different milk samples

Sl. No.	Name of sample (amount = 100ml)	Initial reading of EDTA	Final reading of EDTA	Volume of EDTA used(ml)	Millimoles of EDTA= Millimoles of calcium
1.	Soya milk	0	20	20	0.2
2.	Almond milk	0	0.6	0.6	0.006
3.	Oat milk	0	29	29	0.29
4.	Goat milk	0	3.75	3.75	0.0375
5.	Buffalo milk	0	3	3	0.03
6.	Cow milk	0	7	7	0.07

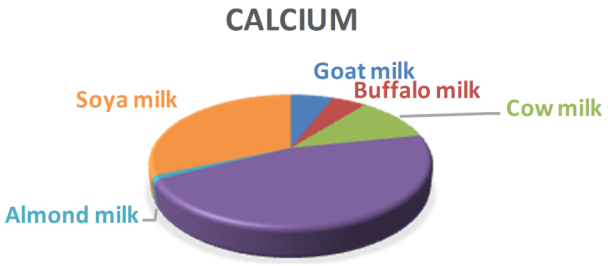

Fig. 3. Percentage of calcium in different milk samples

D. Amount of lactose in milk samples: Highest concentration of lactose was found in Goat milk and the least was found in Almond milk. It was found that plant-based milk contains significantly less lactose than animal-based milk, this result can be observed in Table 4. A well-illustrated comparative account for the percentage of lactose in different milk samples can be observed in Fig. 4.

Table 4. Concentration of lactose in different milk samples

Sl. No.	Name of the sample	Initial reading of standard lactose solution	Final reading of standard lactose solution	Amount of standard lactose solution used (ml)	Lactose present in milk (%)
1.	Control	0	60	60	1
2.	Almond milk	0	47	47	0.26
3.	Oat milk	0	30.6	30.6	0.588
4.	Soya milk	0	38.20	38.20	0.436
5.	Buffalo milk	0	123	123	1.26
6.	Cow milk	0	176	176	2.32
7.	Goat milk	0	100	100	0.8

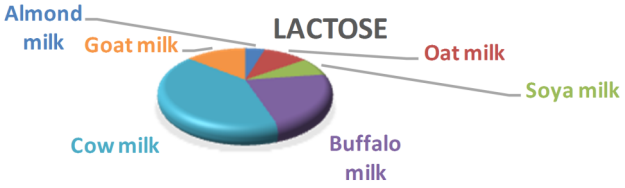

Fig. 4. Percentage if lactose in different milk samples

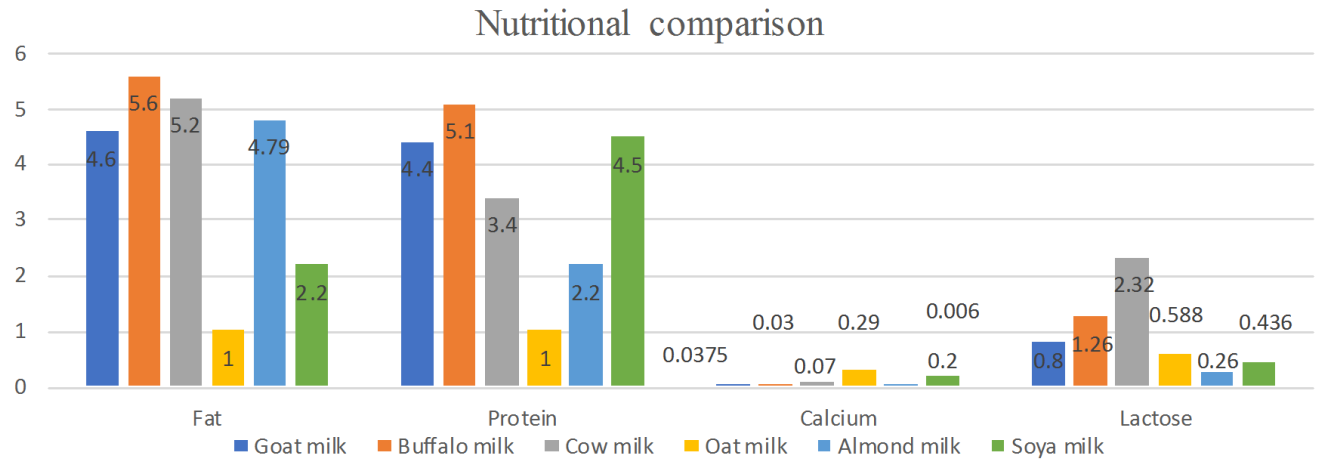

Fig. 5. Comparison between nutrients in different milk samples

This comparative account would provide a vivid information about the percentage of nutrients (Fat, Protein, Calcium and Lactose) present in different types of plant-based and animal-based milk samples. Here it can be easily made out that various kind of plant-based milk samples fulfil different nutrient requirements and also all of them have a very low lactose content. Hence, absolutely safe for lactose intolerants.

Discussion:

Presently, a significant number of consumers are opting for plant-based milk alternatives over traditional animal-based milk and its derivatives. This shift can be attributed to the rising prevalence of medical conditions like allergies from milk proteins and intolerance to lactose. In the modern way of life, a growing inclination towards veganism also contributes to this trend. The objective of this study was to contrast various animal-based milk options with three widely used plant-based substitutes, i.e., Soya milk, Almond milk, and Oat milk. Additionally, the study aimed to explore and assess the benefits of plant-based milk alternatives.

While the nutrient composition of different plant-based milk could be enhanced through fortification or adjustments in production processes, such measures would have implications for cost and environmental impact. Despite these differences, plant-based milks may offer unique values, such as the cholesterol-regulating β-glucan in oat milk (Ajithkumar et al., 2005).

Milk is the most complex of all natural fats as around four hundred distinct fatty acids constitute milk fat (Helena Lindmark Månsson, 2008). In the current study, it was found that animal-based milk has greater fat content and highest concentration was found in Buffalo milk, but surprisingly Almond milk, which is a plant-based milk, was capable to fulfill the similar level of fat requirements as it contained 4.79% of fat which is greater than that of Goat milk and quite less than Buffalo and Cow milk. In a previous study done by (Jensen RG *et al.* 1915), it was found that the milk fat majorly contains 98% of triglycerides, approximately 2% diacylglycerol, less than 0.5 % cholesterol, about 1% fatty acid and about 0.1% free fatty acids (FFA).

A study by Hoffman JR et al., 2004 and Parodi P., 2007, says that the major components of protein in milk are Whey protein and Casein. In cattle milk, 80% of total protein is Casein and 20% of total is Whey protein. However, through the tests it was found that, soy milk contains highest amount of protein, which is almost equivalent to animal-based milk samples, as shown in Fig. 2, hence, individuals who are lactose intolerant and cannot consume animal-based milk due to its high lactose content but require a good source of protein in their diet, can conveniently go for this plant-based alternative.

Animal-derived food, particularly dairy products, are globally recognized as the primary sources of calcium, contributing about 72% in High-Income Countries (HICs) like the US and over 50% in Sub-Saharan Africa (Joy et al., 2014; Miller *et al.*, 2001). However, because of environmental responsibilities and health consciousness, there is a current recommendation to increase food consumption based on plants and decrease animal source product intake,

especially in areas like HICs where there is unviable livestock production (Willett *et al*., 2019). Nevertheless, reducing dairy product consumption may raise concerns about calcium deficiency, as in the absence of dairy foods it becomes hard to meet dietary recommendations (Palacios *et al*., 2021). This study shows a positive finding: oat milk contains more calcium than all the animal-based milk samples that were examined as shown in Table 3.

Lactose, a distinctive carbohydrate present in most mammal's milk, has been a very important part of the human diet since human's earliest origins. In contemporary times, lactose is a component in various milk-derived products and serves as a significant raw material in pharmaceutical applications (Meurant G., 1995; Paques M. *et al.,* 2019). Results obtained in the present study indicate that plant-based milk exhibits notably lower lactose content compared to its animal-based counterpart as shown in Fig. 4.

In summary, this study conveys that the utilization of plant-based milk offers a means to lighten the burden on the dairy industry, thereby contributing to a significant reduction in the mistreatment of innocent animals. Similar conclusions were deducted in the studies conducted by Elif Feyza Aydar *et al*., 2020.

Conclusion:

The comparative analysis of plant-based and animal-based milks highlighted significant differences in nutrient profiles, as shown in Fig. 5. Notably, buffalo milk had the highest fat content, while oat milk had the least. Almond and soy milk provided non-animal fat sources with substantial levels. Soya milk is rich in Omega-3 fatty acids which reduces the risk of dementia (Pistollato, 2018). In terms of protein, buffalo milk led among animal-based options, closely matched by soya milk. Soya milk emerged as a strong contender, offering protein comparable to animal-based milk. Oat and soya milk exhibited higher calcium levels than animal-based options, particularly almond milk. Plant-based alternatives, low in lactose, are suitable for those with lactose intolerance.

These findings emphasize nutritional diversity, catering to various preferences and health considerations. Plant-based options, cruelty-free and environmentally friendly, offer a sustainable and personalized approach to milk consumption, allowing consumers to make informed choices based on nutrition, ethics, and environmental impact.

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