

Original Research Article

A Study on the Acceptability of Plant-Based Milk and Curd among the Lactose Intolerant People Residing in Kolkata

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ABSTRACT

Lactose intolerance is a common, gastrointestinal disorder. Its prevalence is highly variable depending on ethnicity. Hypolactasia or lactase deficiency may result in lactose mal-absorption, which combined with clinical symptoms, consists in the image of lactose intolerance. Management of lactose intolerance requires a total or partial exclusion of dairy products from diet. Plant milks may serve as boon since it contain no lactose. They are considered as suitable economical substitute for cow's milk and ideal nutritional supplement for lactose intolerant patients. On the other hand, yogurt is a fermented product that is also well tolerated by them. The present study aimed at finding and developing a local substitute for milk based product determining the physicochemical analysis and sensory evaluation (n=20) of Milk and "Dahi" (from oats, rice and almond) with a view of knowing the consumer acceptability of the product. Milk samples were prepared from different plant sources (oats, rice and almond) and then "Dahi" samples from these milk(s) were prepared using *Lactobacillus sp.* as culture starter (Vizylac Capsules) Milk and "Dahi" samples were also subjected to chemical parameters (pH, acidity, Calcium, Protein, Carbohydrate). The results from analyses were encouraging since the developed product contains no lactose. Milk and Curd prepared from almonds was liked most by the sensory panelists and contains appropriate amount of nutritive values.

Keywords: Lactose intolerance, plant milk, probiotics, yogurt, milk

1. INTRODUCTION

Lactose intolerance is a condition associated with malabsorption of lactose after consuming dairy products. Lactose due to inadequate lactase activity is not hydrolyzed into glucose and galactose. Lactose enters directly colon where the bacteria ferments it into saturated fatty acids, H₂ and CO₂ gas. According to survey (2015), Three out of four Indians have "no-milk" tolerance where 66% are sufferers from Northern part and 82% from Southern parts. [12,14] Primary lactose intolerance is the most common type that affects all age groups whereas Secondary lactose intolerance is a transient condition which

develops secondary to bacterial or viral infection caused by gastroenteritis, and severe diarrhoea, AIDS or giardiasis, which typically damages the intestinal villi thus reducing intestinal activity. The undigested lactose molecules and products of bacterial digestion result in predominantly gastrointestinal symptoms including diarrhoea, bloating and distention, flatulence and abdominal pain. [17][18][21] Diagnosis of lactase deficiency is made on the basis of history of gastrointestinal symptoms, occurring after and aggravated by milk ingestion and tests like Hydrogen Breath test, Faecal pH test, Blood glucose test (to understand tolerability of lactose) [8]

Better tolerable dairy products like yogurt, cultured dairy products and cheese can be given. Yogurt and fermented milk products improve lactose digestion and lowers the symptoms of lactose intolerance. These beneficial effects are due to microbial β -galactosidases which delays gastrointestinal transit and reduce sensitivity to symptoms and enhancement of gastrointestinal innate and adaptive immune responses. Fermentation of dairy products also breaks down as much lactose into its monosaccharides. Frozen yogurt is not well accepted as freezing destroys the microbial enzyme. Dairy products with added probiotics (*Lactobacillus* and *Bifidobacterium* spp.) may modulate gut microbial composition, leading to improved gut health and lactose intolerance symptoms. [27]

Diet for lactose intolerance includes complete exclusion of dairy products (since they are only food group containing lactose). As a result, patients' diet lacks calcium and Vitamin D requirements (dairy products are best sources of Calcium). Hence strategies to increase calcium intake could be possible by inclusion of non-dairy sources which include nuts and seeds, legumes and beans, leafy vegetables and some calcium-fortified breakfast cereals and fruit juices. Plant milks may act as boon for these patients since it contains no lactose and cholesterol. They may act as alternative to dairy milk economically and nutritionally. [7][19][26]

Thus keeping all these benefits in mind, the aim of the study was to extract milk and curd from plant sources and to understand the level of nutrition and quality of the same.

2. MATERIALS AND METHODS

Oats, Almonds and Rice (Tulsi bhog) were obtained from the local stores of Kolkata. Vizylac capsules were used as yoghurt starter culture from the medicine shop. The study was conducted in the food and chemistry laboratories of J. D. Birla Institute, Kolkata.

2.1 Preparation of Milk and Curd

Oats milk was prepared by soaking oats (50grams) in water (150-200 ml) for 10 minutes. It was then cooked till porridge consistency is developed. The porridge mix was then blended properly in grinder in ratio of 1:3. The liquid solution obtained was filtered using cheesecloth or muslin cloth. The filtered solution obtained was oats milk. [25]

For Rice milk, 50 grams Rice was washed several times and soaked for around 15 minutes. Water was added and the whole content was placed on heating mantle. The temperature was kept low and boiled for around 2-3 hours until soupy rice pudding is obtained. It was blended properly in grinder with 200-250 ml water. The solution was filtered using sieve. The filtered solution obtained was rice milk. [16][22][24]

For almond milk, unblanched and unroasted almonds amounted 50 grams were soaked overnight. After soaking, the skin of the almonds was manually removed. The hydrated almonds were blended with water (150-200 ml) in a ratio of 1:3 respectively for 2 minutes. The resulting slurry was strained through a double-lined cheese cloth to render almond milk. [2]

Curd or Yogurt from the developed milk(s) was prepared by heating the milk till lukewarm and then starter was added (breaking 2-3 Vizylac Capsules).The starter was well mixed and was covered and set for 6-8 hours)

2.2 Physicochemical tests conducted on the products:

2.2.1 Determination of pH and titratable acidity:

The pH and acidity of the developed products was determined by the help of pH meter and phenolphthalein indicator respectively as per FSSAI 2012. [4,5,9-11,13,20,23]

2.2.2 Determination of Lactose:

The lactose estimation was determined with the help of Benedict's reagent. [15]

2.2.3 Determination of Protein:

The protein content of developed plant-based products was determined by Biuret method. [4]

2.2.4 Determination of Carbohydrate:

The carbohydrate content was measured with the help of Anthrone assay [6]

2.2.5 Determination of Calcium:

The calcium content was measured by complexometric titration using the well-known chelating agent ethylenediaminetetraacetic acid (EDTA). [3]

2.2.6 Sensory evaluation of the developed products:

Acceptability of the recipes was evaluated from the ratings obtained through the score card using 9-point hedonic scale and 5-point scale (for oats, rice and almond milk) during sensory evaluation. [1]

Table 1: 5-point & 9-point Hedonic scale [23][24]

| 5-POINT HEDONIC SCALE | |
|-----------------------|--------------------------|
| 1 | Dislike very much |
| 2 | Dislike |
| 3 | Neither like nor dislike |
| 4 | Like |
| 5 | Like very much |
| 9-POINT HEDONIC SCALE | |
| 1 | Dislike extremely |
| 2 | Dislike very much |
| 3 | Dislike Moderately |
| 4 | Dislike Slightly |
| 5 | Neither like nor dislike |
| 6 | Like slightly |
| 7 | Like moderately |
| 8 | Like very much |
| 9 | Like Extremely |

2.3 Statistical analysis:

Data on proximate and mineral analyses were presented as mean of triplicate analyses while mean of sensory scores for each attribute was based on twenty judgments. The results were evaluated by ANOVA. Statistical significance was established at $F \text{ value} > F_c$

value (Null Hypothesis) or $F_c \text{ value} > F \text{ value}$ (Alternate Hypothesis)

3. RESULTS AND DISCUSSIONS

3.1 Lactose determination:

Lactose is a disaccharide sugar that is found in milk and is formed from galactose and glucose. Lactose makes up around 4.5~5% of milk (by weight). The enzyme lactase is essential for digestive hydrolysis of lactose in milk. Deficiency of the enzyme causes lactose intolerance. Benedict reagent for the estimation of reducing sugars contains potassium thiocyanate as well as copper sulfate, and in the presence of the former a white precipitate of cuprous thiocyanate is formed in the reduction instead of the usual red precipitate of cuprous oxide. [15] However, no such changes or precipitate formation was seen which confirmed that lactose is absent.

3.2 Sensory evaluation:

Table I shows the sensory scores of plant based milk and curd developed given by 20 panel members according to 5-point hedonic scale. Almond milk was more acceptable by panelists as it was creamy in texture, characteristic whitish in color similar to normal dairy milk and has nutty and sweet taste. Oats milk and rice milk is grainy in appearance and doesn't taste sweet.

On the other hand, Almond curd was most acceptable one since it was creamy, whitish in appearance and nutty in taste. Lactic acid bacteria present in Vizylac capsules (used as starter) are fermenting bacteria which are responsible for acidification and produce yogurt flavor and aroma.

Table 2: Results of Sensory Evaluation of different plant-based milk via 5-point hedonic scale

| Samples | Appearance | Color | Texture | Taste | Aroma/Odor | Overall Acceptability |
|-------------|------------|-------|---------|-------|------------|-----------------------|
| Oats milk | 3 | 3 | 2.5 | 3 | 3 | 2.9 |
| Rice milk | 3 | 3.5 | 2.5 | 2.5 | 2.5 | 2.8 |
| Almond milk | 3 | 4 | 4 | 3.5 | 4 | 3.9 |

Table 3: Results of Sensory Evaluation of different plant-based curd via 9-point hedonic scale

| Samples | Appearance | Color | Texture | Taste | Aroma/Odor | Overall Acceptability |
|----------------------------|------------|-------|---------|-------|------------|-----------------------|
| Curd made from Oats milk | 6 | 6 | 6 | 7 | 6 | 6.2 |
| Curd made from Rice milk | 7 | 7 | 6 | 6 | 6 | 6.4 |
| Curd made from Almond milk | 8 | 8 | 7 | 7 | 7 | 7.4 |

3.3 Physicochemical Analysis:

3.3.1 Protein:

Table (4) shows the protein content of different curd samples. Higher amount of protein was seen in almond and oats curd samples. Pasteurization is believed to modify protein so as to enhance proper viscosity and gelatinisation of the product and this account for the uniformity and smoothness in body texture. [25] As a fermented product, the starter culture is the soul. The microorganisms present helps break down the complex protein, carbohydrates and fats into more easily assimilated molecules. The growth and metabolism of the microbial during fermentation are the dominating factors for the protein aggregation behavior and texture of the resulted curd. [24]

Carbohydrate:

The carbohydrate content was higher in Rice curd sample whereas less in Oats and Almond ones as shown in table below (4). Oats and almonds are good sources are good sources of complex carbohydrates whereas rice is a good source of simple carbohydrates. Unlike animal milk, plant milk does not contain lactose sugar (a disaccharide) which causes lactose intolerance in individuals lacking the enzyme lactase to break down sugar leading to flatulence, bloating of the stomach and diarrhoea when animal milk is consumed. [10]

Calcium:

Table (4) shows the calcium content of different curd samples. Oats and Almond

curd samples showed good amount of calcium compared to rice curd samples. Oats (54mg/100 gms) and Almond (655 mg/100gms) are good sources of calcium which is required for lactose intolerant populations. Rice has little contribution in the calcium content (10 mg/100 gms) [26]

pH:

Table 4 shows the pH of different samples. The pH of Almond milk was below 7.0 (6.5) which is advantage that it will discourage the growth of pathogens that may cause gastrointestinal problems. [16][18][19]

On the other hand, the pH of different curd samples ranged from 4.5-5. *Lactobacilli sp* will grow continuously in between ph 4.0 to 4.4 since they are capable of producing acid. Acid production in the medium depends on the growth of microorganisms and their ability to ferment the available carbohydrates. [4][5]

Titration acidity:

Table (4) shows the percentage of titration acidity in different samples. Percent of titration acidity was higher in rice milk compared to almond and oats milk samples which may be due to acidic nature of protein present in rice. On the other hand, samples of Almond Curd (plain 0.135%). As titration acidity increased, the pH decreased as a function of fermentation time. Acid production in the medium depends on the growth of microorganisms and their ability to ferment the available carbohydrates. [10][20]

Table 4: Observations based on physicochemical studies of plant-based developed milk and curd

| Samples | Protein (g/100g) | Carbohydrate (g/100gm) | Calcium (mg/100g) | pH | Titration 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 | 0.135 |

3.4 Statistical analysis:

From the table (5), it is seen that the computed statistic under null hypothesis has a compared value compared to tabulated statistic value, hence null hypothesis is

accepted at 5% level of significance which implies that there is no significant difference in the average score of the panel members regarding physical parameters (appearance, odour, colour, taste, texture and overall).

From Table 5, it is seen that null hypothesis is rejected and alternate hypothesis is accepted which says that there is significant differences in the nutrient

content of different curd samples. It also shows that there is also significant difference in the physicochemical properties of curd samples.

Table 5: Statistical studies via one-way factor ANOVA (Analysis of Variance)

| At 5% level of Significance | Sensory Evaluation | Protein | Carbohydrate | Calcium | Titribale Acidity |
|-----------------------------|--------------------|----------|--------------|----------|-------------------|
| F Value | 2.1695 | 1195.8 | 1063 | 3936.1 | 5.19 |
| F _c Value | 3.0955 | 5.14 | 5.14 | 5.14 | 5.14 |
| P Value | 0.136 | 1.57E-08 | 2.11E-08 | 4.42E-10 | 1.93E-94 |

4. CONCLUSION

The data from the analyses done confirms that the products are lactose-free in nature. Milk and curd from almonds were highly acceptable among panel members and have appropriate pH and nutritive values. Hence it indicates that milk and curd developed from plant sources may represent safe food for lactose intolerant people as part of their diet. Further studies are required to validate these observations

5. Limitations and Future Recommendations

Due to time constraint, the study restricted to only development, sensory evaluation, physicochemical analysis and consumer acceptability of the developed products. Hence, more products can be developed to provide a variety in the diet both for lactose intolerance and vegans. More plant sources which are budget-friendly can be looked for the development of lactose-free products. Accurate microbiological, rheological, clinical and chemical studies on the products can be done to understand its tolerability, texture properties and its effect on consuming during digestion. A better labeling with nutritional facts can be made available in the market.

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