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Valorisation of Paneer Whey in the Development of Drinking Yogurt

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ABSTRACT: The dairy industry generates a significant amount of waste, including paneer whey, which constitutes a substantial portion of liquid waste and byproduct. Paneer whey contains valuable nutrients and minerals but is often discarded, leading to environmental concerns. In this study, the feasibility and nutritional value of developing a yogurt drink enriched with fermented whey were assessed. The fermented whey was obtained as a byproduct of paneer production and incorporated into yogurt at different levels. Sensory evaluation, physicochemical analysis, microbial analysis, and shelf life study were conducted to evaluate the quality and acceptability of the yogurt drink. The results showed that the yogurt drink with 35% fermented whey had the highest sensory scores and was considered optimal. The inclusion of fermented whey increased titratable acidity, total solids, fat content, and protein content in the yogurt drink. Microbial analysis revealed higher counts of lactic acid bacteria in the yogurt drink with fermented whey. The absence of yeast, mold, and coliform bacteria indicated good product quality. However, the shelf life of all the samples were limited to 15 days. Overall, the findings suggest that paneer whey can be valorized by incorporating it into yogurt to develop a nutritious and flavorful drink. Additionally, this valorization approach has the potential to enhance the overall economic viability of the dairy industry by creating additional revenue streams from the byproduct. Further research is needed to enhance the shelf life of the product by novel packaging to address spoilage issues.

Keywords: Whey, Yogurt drink, Optimisation, Sensory, Shelflife.

INTRODUCTION

An important concern within the food industry revolves around the substantial amount of waste products and byproducts generated during production (Comunian *et al*., 2021). In the dairy industry, paneer production results in the production of paneer whey, which constitutes approximately 85-90% of the milk used and serves as the primary liquid waste and byproduct (Gupta and Prakash 2017). India produces over 3 million tonnes of whey each year, which, if wasted, might result in a significant loss of about 2 lakh tonnes of important milk nutrients (Naik *et al.*, 2009). Whey has the highest biochemical oxygen demand (BOD) of all dairy wastes, making it the most harmful pollutant. This causes severe environmental concern for its disposal throughout the entire world. Notably, Paneer whey is a pool of nutrients containing 45-50% of total milk solids, 70% of lactose, 20% of proteins, almost all water-soluble vitamins and 70-90% of essential minerals of milk (Kumari and Rani 2019). Whey has been demonstrated to have beneficial effects in the treatment of various chronic conditions, including diarrhea, gallbladder disorders, skin ailments, urinary tract issues, cancer, high blood pressure, and cardiovascular diseases (Ashoush *et al*, 2013; Kerasioti *et al*., 2014). While developed nations have found ways to valorize whey by transforming it into value-added products such as ricotta cheese, whey protein concentrates, whey protein isolates, and whey-based fermented beverages, the majority of whey in developing nations is still discharged untreated into water sources.

Fermented dairy products play a vital role in the global human diet, and one such product is yogurt. Yogurt is made by fermenting milk with *Lactobacillus bulgaricus* and *Streptococcus thermophilus*, which convert lactose into lactic acid (FAO/WHO, 1966). This process makes yogurt more easily digestible compared to milk (Joseph *et al*., 2011). It is a well-balanced food, containing carbohydrates, protein, fat, vitamins, calcium, and phosphorus (Farahat and El-Batawy 2013). Additionally, yogurt is enriched with bioactive peptides like casomorphins, casokinins, immunopeptides, lactoferricin, and phosphopeptides, along with essential vitamins and minerals including calcium, sodium, phosphorus, and potassium (Meisel, 1988).

The consumption of yogurt has been associated with various health benefits, such as inhibiting the growth of cancer cells, protecting against osteoporosis, preventing coronary heart disease, and alleviating digestive disorders like constipation, diarrhea, and dysentery (Kamruzzaman *et al*., 2002; Foissy, 1983). Yogurt drinks, on the other hand, are characterized by their low viscosity, achieved through vigorous agitation to break the coagulum of set yogurt. These drinks are then packaged and refrigerated (Tamime and Robinson 2007).To meet the standards set by the Food and Drug Administration, yogurt drinks must contain over 8.25% milk solids-not-fat and can have different fat levels, such as nonfat yogurt (<0.5%), low-fat yogurt (2%), or yogurt with higher fat content (>3.25%) (Chandan *et al*., 2008). Against this backdrop, the present study aims to assess the feasibility and nutritional value of a yogurt drink enriched with fermented whey.

MATERIALS AND METHODS

Fresh pasteurized, homogenized, and toned milk (Brand-Milma), was procured from the local market and used for yoghurt making. The whey obtained as a byproduct of paneer was used for yogurt drink making. The standard yoghurt cultures *Lactobacillus bulgaricus* and *Streptococcus thermophilus* (YC-380,ChrHansen) was used as starter cultures for fermentation.

A. Preparation of yoghurt and fermented whey

Yoghurt was prepared by fermenting milk using the standard cultures at the rate of 2 per cent and incubating at 42^{o}C for 5 h. Whey was pasteurised and inoculated with one percent yoghurt starters followed by incubation at 42^{o}C overnight.

B. Optimisation of the level of fermented whey in yoghurt drink

The level of fermented whey (FW) addition in yogurt drink was optimised based on sensory evaluation. For this yogurt was mixed with fermented whey at different levels (15%, 25%, 35%, 45%, and 55%). Powdered sugar (12%) was added as a sweetener. The control sample was made by adding 25% potable water instead of fermented whey. The sensory analysis was carried out by a trained panel of 6 members by using a 9-point hedonic scale.

C. Physio-chemical analysis

The optimised fermented whey incorporated yogurt drink was analysed for physicochemical parameters like Titratable acidity (Part I of IS: 1479 (ISI 1960), Total solids (SP: IS: 18, Part XI, 1981), Fat content (Pearson, 1976), Protein content (AOAC 2012), Total soluble solid content (Shao and He 2009).

D. Microbial analysis

The microbial load in the product was assessed based on Lactic acid bacterial count, coliform count, and yeast and mold count (IS: SP-18, 1981).

E. Shelf life study

The FW incorporated yogurt drink was packed in sterilised glass bottles and kept under refrigeration (7±1°C). The product was subjected to sensory, physicochemical and microbiological examination in 5 days intervals for 15 days

F. Statistical analysis

Mean values and standard deviations of triplicate determinations were reported and statistical significance was set at $P < 0.05$. Analysis of variance was carried out to determine the difference between the control and the sample. The statistical analysis was performed using IBM SPSS STATISTICS (version 26).

RESULTS AND DISCUSSION

A. Optimisation of fermented whey incorporated yogurt drink

Table 1: Sensory analysis of yogurt drink added with different levels of FW.

Attributes	Control	Sample 1 (T_1)	Sample 2 (T_2)	Sample 3 (T_3)	Sample 4 (T4)	Sample 5 (T_5)
Flower	7.0 ± 0.75^a	7.0 ± 0.15^a	$7.3 + 0.12^b$	8.3 ± 0.2^c	7.3 ± 0.12^b	5.6 ± 0.29^d
Consistency	7.2 ± 0.12^a	7.0 ± 0.31^b	$7.4 + 0.31^c$	7.8 ± 0.12^d	7.2 ± 0.12^a	7.2 ± 0.12^a
Color and appearance	7.2 ± 0.8^a	7.2 ± 0.33^a	$7.4 + 0.18^b$	7.5 ± 0.15^c	7.4 ± 0.10^b	$7.4 \pm 0.1\ 0^b$
Overall acceptability	7.05 ± 0.7^a	$7.4 + 0.1^b$	7.4 ± 0.1^b	8.6 ± 0.1^c	6.8 ± 0.25^d	5.8 ± 0.25^e

Mean ± SE, n=3

a, b : means within rows with different lowercase superscripts are significantly ($p<0.05$) from each other

The findings from comparing the sensory evaluation results of various attributes of the yogurt samples (T_1, T_2, T_3, T_4, and T_5), which had different levels of FW (15%, 25%, 35%, 45%, and 55%), shows that there were no significant differences ($p< 0.05$) in the flavor attribute between the control group and samples T_2 and T_4, with similar ratings observed. Samples T_3 shows higher scores, indicating a more pronounced flavour characteristic, while sample T_5 received the lowest score, suggesting a less desirable flavor attribute. In terms of consistency, the control group and samples T_4 and T_5 exhibited comparable ratings, while samples T_3 had higher ratings, indicating a slightly firmer or more desirable consistency. Similarly, there were no significant differences in color and appearance between the control group and sample T_1 while samples T_3 and T_4 received higher ratings, implying a more visually appealing aspect. The overall acceptability ratings varied significantly, with samples T_1 and T_2 receiving higher ratings than the control group, and sample T_3 achieving even higher ratings. In contrast, sample T_5 received the lowest rating, indicating a lower overall appearance. Based on the findings, it can be inferred that sample T_3 (Yogurt drink with 35% fermented whey) received the highest sensory scores. These results suggest that sample T_3 is considered optimal and should be selected for further analysis. According to Singh *et al*. (2014), the beverage that had the greatest ratings for color, taste, aroma, and overall appearance was achieved by combining guava juice and whey in a ratio of 67.5:20. This ratio outperformed the control juice in terms of sensory attributes. For the sensory character assessed sweet whey yoghurt drink treatments were the most preferred and UF-milk permeate yoghurt drink was slightly less acceptable (Aita *et al*., 2019).

B. Physio-chemical analysis

Table 2: Physio-chemical analysis of fermented whey incorporated yoghurt drink.

Perimeters	Control	Sample
Titratable acidity (% Lactic acid)	0.736±0.05^a	0.846±0.5^b
Total solids	19.8 ±0.01^a	23.63±0.01^b
Fat content	2.3±0.05^a	2.53±0.05^b
Protein content	8.733±0.12^a	9.4±0.05^b
Total soluble solid content	12.1^0 brix	12.5^0 brix

Mean ± SE, n=3
a, b: means within rows with different superscripts are significantly different ($p<0.05$) from each other

The Yogurt drink with FW showed a slightly elevated titratable acidity (0.846±0.5) in comparison to the control drink (0.736±0.05), indicating a marginally higher acid content that could potentially impact the taste and overall sensory characteristics of the sample. This increased acidity is attributed to the inclusion of fermented whey.

The sample drink demonstrated a higher concentration of non-water components, as indicated by an increased total solids content (23.63±0.01), in contrast to the control drink (19.8±0.01). This suggests a potential influence on the texture, thickness, and mouth feel of the product. The higher total solids content in yogurt samples with fermented whey compared to the control group can be attributed to the solid content present in the fermented whey.

Additionally, the sample yogurt drink with FW had a slightly higher fat content (2.53±0.05) relative to the control yogurt drink (2.3±0.05), which may account for differences in creaminess and richness between the two groups. The slight increase in fat content is due to the smaller amount of fat that may be recovered in whey at the time of preparation. Chatterjee *et al*. (2015) found that the fat content of whey based orange beverages shows a fat content of 0.73 ± 0.4 and for control is zero

Furthermore, the protein content was higher in the sample group (9.4±0.05) compared to the control group (8.733±0.12), implying potential nutritional advantages for individuals seeking yogurt drinks with elevated protein levels. The orange drink that contained 50% whey had 67% higher protein content compared to orange drinks without whey (Jelen *et al*., 1987). The average protein content in acid whey ranges from 0.6 to 0.8 grams per 100 millilitres. It's important to mention that adding whey, which is a high-quality protein, to beverages enhances their biological effects.

Both the control and sample groups exhibited similar total soluble solid content, with the control group at 12.10 brix and the sample group at 12.50 brix, indicating no significant difference in dissolved solids between the two groups.

C. Microbial analysis

According to Shiby *et al*. (2013), the concentration of lactic acid bacteria in a yogurt drink containing fermented whey remained at a level typically associated with functional health benefits, ranging from 10^6 - 10^7cfu/g. The study found that the yogurt drink with fermented whey had a higher count of lactic acid bacteria, specifically 19.5×10^7cfu/g, compared to the control sample, which had a count of 16.3×10^7cfu/g. This difference in bacterial count can be attributed to the presence of LAB in fermented whey and the higher lactose content which might have provided a favorable environment for the further growth of lactic acid bacteria.

Yeast and mold are types of fungi commonly found in various environments, including food. Their presence can indicate potential spoilage or contamination issues. In this case, the absence of any yeast and mold counts across all dilutions suggests that the both sample and control had no visible signs of fungal contamination. This is generally a positive indication, as the absence of yeast and mold suggests a lower risk of spoilage and better product quality (Matthews, *et al* 2017).

Coliform bacteria are a group of bacteria that are commonly used as indicators of fecal contamination in water and food. The absence of coliform counts in the both sample and control indicates that there were no visible signs of coliform bacteria colonies. This is typically considered a desirable result, as the presence of coliform bacteria may imply poor hygiene or sanitation practices during production or handling. According to the FSSAI (2011) the maximum allowable limit for coliform count is set at 100 cfu/g. In the case of both samples, the coliform count is within the limit, indicating that it is reaching the acceptable threshold.

D. Shelf life study

The data provided in Fig. 1 presents a comparison between yogurt drink with added FW and control samples over a 15-day period. Four criteria were evaluated: flavor, consistency, color and appearance, and overall acceptability. Measurements were taken on the 0th, 5th, 10th, and 15th day for the samples. However, all the samples spoiled by the end of the study, possibly due to the growth of yeast and molds leading to pronounced proteolysis.

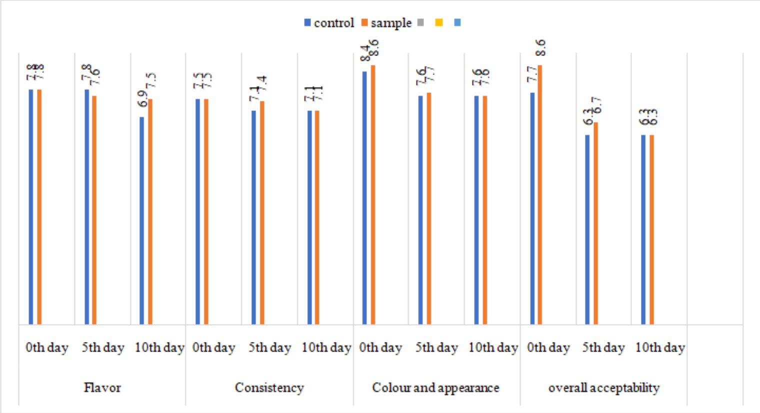

Fig. 1. Sensory score of yogurt drinks.

The Yogurt drink with FW consistently demonstrated better performance than the control group in various aspects. Regarding flavor, both the sample and control groups experienced a decline in scores over the 10-day period, with the control group exhibiting the highest decrease in ratings. The decrease in flavor scores for both samples can be attributed to the activity of yeast and molds, which contribute to the production of undesirable flavored peptides. The yogurt drink with FW, which had a higher acidity level, exhibited a higher flavor score compared to the control group, as the increased acidity promoted greater flavor production. Similarly, the sample group exhibited higher consistency ratings compared to the control group, and both groups had the same consistency rating by the 10th day. When it comes to color and appearance, the sample group initially had a slightly higher rating than the control group, and although both groups decreased by the 5th day, they stabilized at the same rating by the 10th day. The overall acceptability was also higher in the sample group, with higher initial ratings that remained consistent, while the control group's rating decreased by the 5th day and remained the same by the 10th day.

The Fig. 2 compares the titratable acidity measurements of a control group and a sample group over a storage period in days. Titratable acidity is used to assess the acid content and stability of food products. The results show that both groups experienced an increase in acidity over time. The sample group consistently had higher acidity levels compared to the control group at each time point, suggesting a potentially higher rate of acid production or accumulation in the sample group during storage. The increasing titratable acidity indicates a possible deterioration or spoilage of the product. However, determining the acceptability or decline in quality requires considering the specific product and its desired characteristics. Further analysis and comparison with quality standards or benchmarks would be necessary to evaluate the suitability of the observed acidity levels in both groups at different storage time points.

The yeast and mold counts and coliform counts for the control and sample groups were observed at various time intervals during storage (0, 5, 10, and 15 days). The data indicate that both groups experienced an increase in yeast and mold counts as time progressed. However, it is important to note that the counts for both samples remained within the safe limits according to FSSAI, 2011 until the 10th day. By the end of the study (day 15), both groups had slightly higher counts compared to day 10, with the control group at 320 cfu/ml and the sample group at 280cfu/ml, which exceeded the safety limits. It is worth mentioning that no coliforms were detected in either group throughout the entire study period. These findings indicate that both the control and sample groups experienced an increase in yeast and mold counts, while coliform contamination was absent in the samples.

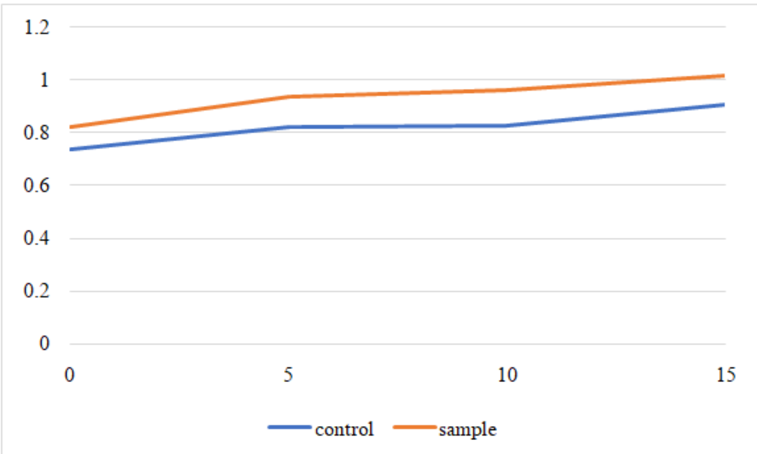

Fig. 2. Variation in the acidity (% of lactic acid) of yougurt drinks.

CONCLUSIONS

In conclusion, this study explored the feasibility and nutritional value of utilizing paneer whey, a by product of paneer production, to develop a yogurt drink enriched with fermented whey. The results indicated that incorporating fermented whey into yogurt at a level of 35% yielded the highest sensory scores and was considered optimal. The inclusion of fermented whey positively influenced the physicochemical characteristics of the yogurt drink, increasing titratable acidity, total solids, fat content, and protein content. Microbial analysis revealed higher counts of beneficial lactic acid bacteria in the yogurt drink with fermented whey, while the absence of yeast, mold, and coliform bacteria indicated good product quality. However, all samples experienced spoilage within the 15-day shelf life study, most likely due to the growth of yeast and molds. These findings suggest that incorporating paneer whey into yogurt can be a viable approach to produce a nutritious and flavorful drink. Future research should focus on extending the shelf life and addressing spoilage issues to ensure the product's commercial viability.

FUTURE SCOPE

Shelf Life Extension, Texture Optimization, Nutritional Enhancement, Consumer Acceptance and Market Potential, Waste Management and Sustainability, Process Optimization, and Scale-up and Commercialization are key areas for further research and development in the valorization of paneer whey for the production of drinking yogurt. Addressing the spoilage issue, improving texture and mouthfeel, optimizing the nutritional profile, understanding consumer preferences, and assessing market potential are essential. Evaluating waste management practices, exploring additional applications, optimizing fermentation parameters, and ensuring compliance with regulations are also important considerations. Overall, continued investigation in these areas will contribute to the successful implementation and realization of the benefits of this approach.

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Conflict of Interest. None.

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