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Physico-chemical Quality Comparison of Fortified Yoghurt with Strawberry Fruit Juice

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ABSTRACT

Background: Today, India is the world's largest and fastest growing market for milk and milk products. Yoghurt (also spelled "yogurt" or "yoghourt") has been a part of the human diet for several millennia and goes by many names throughout the world. Yoghurt is a coagulated milk product obtained by specific lactic acid fermentation, through the action of *L. bulgaricus* and *S. thermophilus*. In recent years, yoghurt has become a popular carrier for incorporating the probiotic species, *L. acidophilus* and *B. bifidium*. The carbohydrate content of yoghurt is easily absorbed by even lactose maldigestors which makes it a valuable adjunct to any healthy diet. Presence of α-D-galactosidase activity in pro-biotic yoghurt indicates its suitability for lactose-intolerant infants. Yoghurt is considered by most regulatory agencies worldwide to be a fermented milk product that provides digested lactose and specifically defined, viable bacterial strains, typically *Streptococcus thermophilus* and *Lactobacillus bulgaricus*.

Methods: The experiment was conducted in the laboratory of the Department of Animal Husbandry and Dairying, at Udai Pratap (Autonomous) College, in Varanasi. The Plain and Strawberry flavoured Yoghurt samples were tested and statistically analyzed. The experimental techniques employed during the course of present investigation were done under various stages.

Result: Physical properties of yoghurt are mainly influenced by milk composition and the manufacturing conditions under which it is prepared. Further, variables affecting the physical properties are the heat treatment applied to milk, the protein content, acidity, culture, additives, homogenization, mechanical handling of coagulum and presence of the stabilizers.

Key words: Fermentation, Milk, Probiotics, Strawberry, Yoghurt.

INTRODUCTION

Dairy is the largest agriculture commodity in India, contributing 5% to the national economy and employing over 8 crore farmers directly. According to Food and Agriculture Organization Corporate Statistical Database's (FAOSTAT) production data, India ranks first in milk production, accounting 24% of global milk production in the year 2021-22. Milk production has increased by 51.05% in the past eight years reaching 221.06 million tons in 2021-22 (FAO, 2023). Milk production is growing at the annual growth rate of 6.1% over the past 8 years whereas world milk production is growing at 1.2% per annum. Per capita milk availability in India is 444 grams per day, surpassing the world average of 394 grams per day.

Yoghurt (also "yogurt" or "yoghourt") is an ancient food that has known by many names over the millennia: katyk (Armenia), dahi (India), zabadi (Egypt), mast (Iran), leben raib (Saudi Arabia), laban (Iraq and Lebanon), roba (Sudan), iogurte (Brazil), cuajada (Spain), coalhada (Portugal), dovga (Azerbaijan) and matsoni (Georgia, Russia and Japan) (Fisberg and Machado, 2015). The word "yoghurt" is believed to have come from the Turkish word "yoğurmak" which means to thicken. It is believed that milk products were incorporated into the human diet around 10000-5000 BC, with the domestication of milk producing animals (Shree *et al.,* 2017). However, milk spoiled easily, making it difficult to use. At that time, herdsmen in the Middle East carried milk in bags made of intestinal gut. It was discovered that contact with intestinal juices caused the milk to curdle and sour, preserving it and allowing for conservation of a dairy product for extended periods of time (Shree *et al.,* 2017). Indian Ayurvedic scripts, dating from about 6000 BC, refer to the health benefits of consuming fermented milk products (Fisberg and Machado, 2015). Today, there are more than 700 yogurt and cheese products found in Indian cuisine (Kaur *et al.* 2017). For millennia, making yogurt was the only known safe method for preserving milk, other than drying it. Yogurt was well known in the Greek and Roman empires and the Greeks were the first to mention it in written references in 100 BC, noting the use of yogurt by barbarous nations. In the Bible (Book of Job),

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Abraham owed his longevity and fecundity to yogurt consumption and there is reference to the "Land of Milk and Honey," which many historians have interpreted to be a reference to yogurt (Fisberg and Machado, 2015). Yoghurt is more nutritious than milk (Banerjee *et al.,* 2017; Govindammal *et al.,* 2017). Even lactose-intolerant individuals can also consume yoghurt because lactose is converted to glucose and galactose before being fermented to produce lactic acid (Felix *et al.,* 2022).

Strawberry, *Fragaria ananassa* Duch., a member of family Rosaceae (Dwivedi *et al.,* 2024), is a well-known non-climacteric fruit that has lot of nutritional and organoleptic characteristics that are commercially acceptable, therefore it grown to eat as fresh, processed, preserved (Muttulani and Turnos, 2025). Strawberry fruit contains high content of flavonoids, epicatechin, catechin, proanthocyanidin B1 and flavonols (Dwivedi *et al.,* 2024; Muttulani and Turnos, 2025).

From the ancient time, fermented milk products were considered as health benefiting food (Shiby and Mishra, 2013; Govindammal *et al.,* 2017). It was used for treating diarrhea and intestinal disorders. Yoghurt consumption leads to decrease in pH of stomach, which can result in reduction of pathogen transit and also it improves the gut microflora and metabolic activity. Yoghurt can also be used to supplement the diet with heart-healthy nutrients. The microbial balance in the gut is critical to prevent gastrointestinal disorders. It also aids in the control of diabetes by increasing insulin sensitivity. Novel flavonol in the strawberry fruit plays an important role in anticancer and antioxidant activity (Muttulani and Turnos, 2025).

Physical properties of yoghurt are mainly influenced by milk composition and the manufacturing conditions under which it is prepared. Further, variables affecting the physical properties are the heat treatment applied to milk, the protein content, acidity, culture, additives, homogenization, mechanical handling of coagulum and presence of the stabilizers (Rasic and Kurman, 1978; Parnell *et al.,* 1986).

The objectives of the present study are, 1. To assess the physical qualities of milk samples. 2. To study the chemical qualities of milk samples. 3. To analyze the physicochemical quality of strawberry yoghurt prepared from addition of different concentration levels of strawberry juice.

MATERIALS AND METHODS

The experiment was conducted during January, 2023 to December, 2024, in the departmental laboratory of the Department of Animal Husbandry and Dairying, at Udai Pratap (Autonomous) College, Varanasi, Uttar Pradesh, India. The Plain and Strawberry flavoured Yoghurt samples were tested and statistically analyzed. The experimental techniques employed during the course of present investigation were done under various stages such as, Material required for preparation of plain and strawberry flavoured yoghurt, procurement of ingredients, Procedure adopted for preparation of Plain and Strawberry flavoured Yoghurt, Testing of experimental product, Chemical analysis of Plain and Strawberry flavoured yoghurt, Organoleptic quality of Plain and Strawberry flavoured yoghurt, Statistical analysis of Plain and strawberry flavoured yoghurt.

Preparation of fruit juice

Fruits were washed with clean water and chopping strawberry with the help of a knife aseptically. The seeds were removed from the strawberry and also the black spots were removed. Strawberries were blended and the juice was filtered with a clean cloth/sieve. Fruits juice was obtained from the crushed fruit and addition of desirable sugar concentration according to experimental design. Then boiling the mixture for 2 min at 90°C and filled into sterile glass jars.

Treatment combinations

The different treatment combinations used in experiment are as follows:

T_0- Yoghurt mix with 12% sugar and inoculated with 2.0% yoghurt culture. It is Control setup, *i.e.* without addition of strawberry juice.

T_1- Yoghurt mix with 12% sugar and inoculated with 2.0% yoghurt culture. The strawberry fruit pulp/juice was added at 5 per cent.

T_2- Yoghurt mix with 12% sugar and inoculated with 2.0% yoghurt culture. The strawberry fruit pulp/juice was added at 10 per cent.

T_3- Yoghurt mix with 12% sugar and inoculated with 2.0% yoghurt culture. The strawberry fruit pulp/juice was added at 15 per cent.

T_4- Yoghurt mix with 12% sugar and inoculated with 2.0% yoghurt culture. The strawberry fruit pulp/juice was added at 20 per cent.

The mix was then sent for incubation at 42°C until the complete curd formation/coagulation of yoghurt (8-10hrs). After that yoghurt was filled in the cups and sent for storage at about 4°C under refrigeration. Thus, the yoghurt was ready (Fig 1 and Fig 2).

A group of trained tasters (the panel) evaluates samples for organoleptic properties-like visual colour, texture, flavour and tastes for collected milk samples and strawberry yoghurt samples through nine point's hedonic rating scale (Table 1 and Table 4).

Statistical analysis

All the data obtained were statistically analyzed for its validity by using Completely randomized design and critical difference (C.D) technique. The statistical analysis plan includes total number of treatments 05, total number of errors 25 and total number of trails 30.

RESULTS AND DISCUSSION

The quality of yoghurt is greatly dependent on the type and quality of raw material used for its manufacturing. The compositional parameters, like fat content mainly control

the body and texture characteristics and flavour of the product. The research investigation is described separately in physical and chemical parameters. Results obtained during the course of this study have been summarized in the following tables after subjecting to statistical analysis wherever necessary. The findings have been also illustrated diagrammatically. A brief description of finding is also discussed with each table.

Physical qualities of milk

The five cow milk samples (S_1, S_2, S_3, S_4 and S_5) were taken and the observations were taken just after the collection of the samples with regard to physical properties of milk on the basis of colour, flavour and taste by panel of testers using nine point's hedonic rating scale (Table 1).

Colour: The cow milk samples showed light yellowish colour which was same for remaining all samples of milk.

Flavour: It indicates that all milk samples were obtained from dairy farm and local market were normal flavour and they were free from any off flavour.

Taste: The cow milk taste was to be found slightly sweet.

Chemical qualities of milk

In Table 2, some important nutritional constituents were analyzed separately for five different milk samples (S_1, S_2, S_3, S_4 and S_5) of cow to identify their chemical qualities, acidity, fat, protein and lactose. The data indicate that the acidity percentage of cow milk samples varied between 0.15 to 0.17 with an average of 0.158. The fat and protein

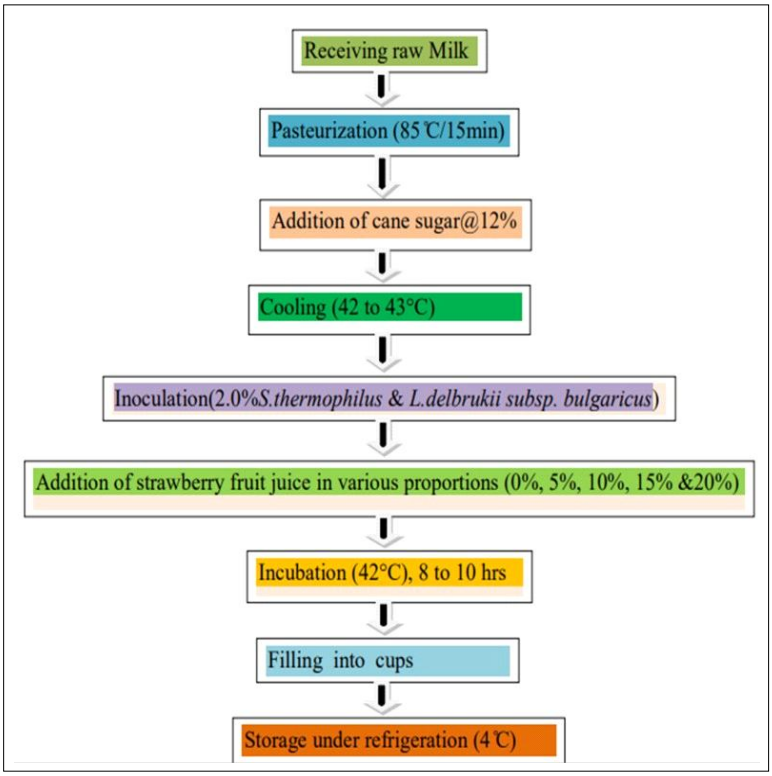

Fig 1: Flow diagram for making experimental strawberry flavoured yoghurt.

Fig 2: Strawberry flavoured yoghurt.

content of milk samples lies between 3.91 to 4.54 and 3.33 to 4.93 with an average of 4.306 and 3.866 whereas the lactose content of milk samples lies between 3.23 to 5.05 with an average of 4.302.

The null hypothesis (H_0) is rejected and the alternative hypothesis is taken because 78.881>3.239, (FC>FT).This means that the statistically analysis (Table 3) shows that there is a significant difference between the acidity, fat, protein and lactose content in milk samples.

Physical quality of yoghurt

The physical qualities, *viz.*, colour, flavour, body and texture of yoghurt samples were studied and the relevant data are presented in Table 4, the yoghurt obtained from the five different samples of cow milk with treatments (T_0, T_1, T_2, T_3 and T_4) they were different colours, flavour, body and texture due to addition of strawberry juice/pulp at different (0%, 5%, 10%, 15% and 20%) levels.

i) Colour

Colour is an important sensory parameter besides taste, aroma and texture. Colour is one of the factors that influence consumer acceptance of food products. Control yoghurt (T_0) is yoghurt without addition of any ingredients including sweeteners or other flavours. In this study, the control yoghurt produced was white whereas the yoghurt with addition of strawberry juice/pulp has a light pink colour that comes from the anthocyanin content in strawberries. The higher the concentration of strawberry juice/pulp added resulted in the lighter colour of the yoghurt (Jaster *et al.,* 2018).

ii) Body and texture

Yoghurt texture determines the quality of the resulting yoghurt. Generally, good yoghurt has a soft texture like porridge, not too runny and not too thick (Faisal *et al.,* 2019). The texture of the yoghurt produced in this study was soft and smooth at various levels. The addition of strawberry juice/pulp causes yoghurt texture becomes thicker.

iii) Flavour and taste

The taste of the strawberry yoghurt and the control yoghurt were sour in taste due to the fermentation takes place, by lactic acid bacteria that converts fructose, sucrose and galactose into lactic acid.

Chemical quality of yoghurt

The yoghurt samples were analyse on the basis of organoleptic and chemical tests. The physical qualities, *viz.*, colour, flavour, body and texture of yoghurt samples were studied. The result found that the yoghurt obtained from the five different samples of cow milk with treatments (T_0, T_1, T_2, T_3 and T_4) they were different colours, flavour, body and texture due to addition of strawberry juice/pulp at different (0%, 5%, 10%,15% and 20%) levels .In this study, the control yoghurt produced was white whereas the yoghurt with addition of strawberry juice /pulp has a light pink colour that comes from the anthocyanin content in strawberries. The higher the concentration of strawberry juice/pulp added resulted in the lighter colour of the yoghurt. The texture of the yoghurt produced was soft and smooth at various levels and the addition of strawberry juice/pulp causes yoghurt texture becomes thicker. The taste of the strawberry yoghurt and the control yoghurt were sour in taste.

In comparing chemical analysis, it was observed that moisture content and acidity were increased in prepared yoghurt with strawberry juice incorporation because strawberry juice contains higher moisture content (71.96%) and acidity (1.02) which decreases the shelf life of the yoghurt. It was observed that P(0% or plain yoghurt) contains lower moisture content (71.80%) and other samples of 5%, 10%, 15% and 20% contains 71.84%,

Table 1: Physical qualities of milk samples.

Type of milk	Colour	Flavour	Taste
Cow milk	Light yellowish	Pleasant	Slightly sweet

Table 2: Average mean values of chemical properties of five different milk samples of cow.

Samples*	Type of milk	Constituents	Mean (%)	Range (%)
05		Acidity	0.158	0.15 - 0.17
(S_1, S_2, S_3, S_4 and S_5)	Cow milk	Fat	4.306	3.91 - 4.54
		Protein	3.866	3.33 - 4.93
		Lactose	4.302	3.23 - 5.05

*****mean values, n=3.

Table 3: Analysis of Variance (ANOVA) for the acidity, fat, protein and lactose content in five different samples of cow milk (S_1, S_2, S_3, S_4 and S_5).

Sources of variation	Degrees of freedom	Sum of squares	M.S. (variance)	F Cal.	F. value at 5%
Between the groups	3	60.6395	20.2132	78.8807	3.239
Within the groups (error)	16	4.1	0.2563		
Total	19	64.7395			

71.86%, 71.94% and 71.96% respectively. It was also observed that P (0% or plain yoghurt) contains lower acidity content (0.8%) and the other samples of 5%, 10%, 15% and 20% contains 0.9%, 0.9% 1.00% and 1.02%. On the other hand , ash and fat content were decreased with the addition of strawberry juice because strawberry juice contains low ash (0.69%) and fat (4.01%) content. It was observed that P (0% or plain yoghurt) contains higher fat content (4.73%) and other samples of 5%, 10%, 15% and 20% contains 4.36%, 4.12%, 4.08% and 4.01% respectively. It was also observed by chemical composition analysis that P (0% or plain yoghurt) contains higher ash content (0.79%) and other samples of 5%, 10%, 15% and 20% contains 0.76%, 0.73%, 0.70% and 0.69% respectively. The protein content of P (0% or plain yoghurt) were decreased about (3.87%) and other samples of 5%, 10%, 15% and 20% contains higher protein content such as 4.15%, 4.24%, 4.34% and 4.41% respectively. Thus, total solids content increases as P (0% or plain yoghurt) contains (28.22%) and other samples of 5%, 10%, 15% and 20% contains 28.18%, 28.16%, 28.08% and 28.00% respectively.

Average of different physicochemical properties of the control and strawberry fruit juice/pulp yoghurt

The highest mean value for moisture percentage was found in T_4 (71.96) followed by T_3 (71.94), T_2 (71.86), T_1 (71.84) and T_0 (71.80). There were no significant differences found among the treatments. Thus, it showed that different levels of milk and strawberry juice have a great impact on the quality of fruit yoghurt. The highest mean value for total solids percentage was found in T_0 (28.22) followed by T_1 (28.18), T_2 (28.16), T_3 (28.08) and T_4 (28.00). There were no significant differences found among the treatments. F value was 0.0, indicating no significant effect of treatment on total solid. The highest mean value for fat percentage was found in T_0 (4.73) followed by T_1 (4.36), T_2 (4.12), T_3 (4.08) and T_4 (4.01). There were no significant differences found among the treatments. and the highest mean value for protein percentage was found in T_4 (4.41) followed by T_3 (4.34), T_2 (4.24), T_1 (4.15) and T_0 (3.87). There were no significant differences found among the treatments. The highest mean value for fat percentage was found in T_0 (0.79) followed by T_1 (0.76), T_2 (0.73), T_3 (0.70) and T_4 (0.69). There were no significant differences found among the

Table 4: Physical qualities of yoghurt evaluated by panel.

Sample no.	Treatments	Types of yoghurt	Colour	Body and texture	Flavour and taste
1.	T_0 (Control yoghurt)	Cow milk yoghurt	White	Smooth thin waxy	Pleasant sour
2.	T_1 (addition of 5% strawberry juice/pulp)	Cow milk yoghurt	Light pink	Smooth compact	Pleasant sour
3.	T_2 (addition of 10% strawberry juice/pulp)	Cow milk yoghurt	Light pink	Smooth compact	Pleasant sour
4.	T_3 (addition of 15% strawberry juice/pulp)	Cow milk yoghurt	Light pink	Smooth compact	Pleasant sour
5.	T_4 (addition of 20% strawberry juice/pulp)	Cow milk yoghurt	Light pink	Smooth compact	Pleasant sour

Table 5: Chemical quality of yoghurt.

Parameters*	Control and strawberry fruit juice yoghurt					Range (%)
	T_0 (0%)	T_1 (5%)	T_2 (10%)	T_3 (15%)	T_4 (20%)	
Moisture	71.80	71.84	71.86	71.94	71.96	71.80 - 71.96
Total solids	28.22	28.18	28.16	28.08	28.00	28.00 - 28.22
Fat	4.73	4.36	4.12	4.08	4.01	4.01 - 4.73
Protein	3.87	4.15	4.24	4.34	4.41	3.87 - 4.41
Ash	0.79	0.76	0.73	0.70	0.69	0.69 - 0.79
Acidity	0.8	0.9	0.9	1.00	1.02	0.8 - 1.02
Average	18.3683	18.365	18.335	18.3567	18.3483	18.335 - 18.3683

*mean values, n=3.

Table 6: Analysis of Variance (ANOVA) of five different samples of cow milk with treatments.

Sources of variation	Degrees of freedom	Sum of squares	M.S. (variance)	F Cal.	F.value at 5%
Between the groups	4	0.0043	0.0011	0.0	2.759
Within the groups (error)	25	19869.3704	794.7748		
Total	29	19869.3747			

treatments and the highest mean value for acidity percentage was found in T_4 (1.02) followed by T_3 (1.00), T_2 (0.9), T_1 (0.9) and T_0 (0.8). There were no significant differences found among the treatments.

Analysis of Variance (ANOVA) for the moisture, total solids, fat, protein, ash and acidity content in five different samples of cow milk (S1, S2, S3, S4 and S5) with treatments (T_0, T_1, T_2, T_3 and T_4) using different levels 0% (control yoghurt), 5%, 10%, 15% and 20% (with addition of strawberry juice) as shown in Table 5.

The null hypothesis (H_0) is accepted, since 2.759>0.0, (FT>FC). This means that, there is no significant difference between the mean of moisture, total solids, fat, protein, ash and acidity content in milk samples (Table 6).

CONCLUSION

This study was investigated on the basis of physico-chemical analysis of 0% (plain) and 5%, 10%, 15% and 20% level of strawberry juice yoghurt samples. With the increasing percentage of strawberry juice, there is also an increase in acidity percentage in yoghurt which shows that the physical quality of yoghurt samples is decreasing. Thus, the results obtained at 5% addition shows a better acceptance level and found to be best among all the treatments. In chemical analysis, nutritional quality decreases with the addition of strawberry juice. Future research may investigate by considering strawberry syrup and other varieties of strawberry fruits can be used.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal care and handling techniques were approved by the University of Animal Care Committee.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish or preparation of the manuscript.

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