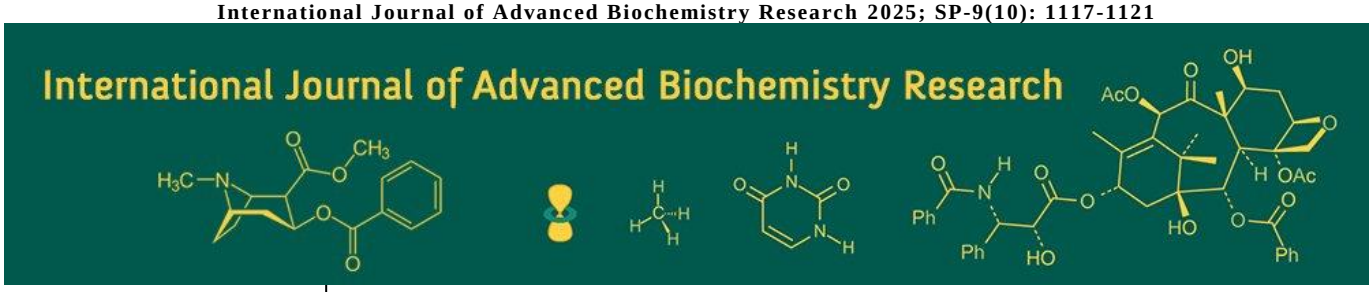


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# Process standardization for preparation of strawberry milkshake

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**Abstract**
The present study was conducted in the laboratory of the Department of Animal Husbandry and Dairy Science, Post Graduate Institute, M.P.K.V., Rahuri, with the objective of assessing the physico-chemical and microbiological qualities of strawberry milkshake. The milkshake was prepared using cow milk procured from the Research-cum-Development Project (RCDP) on Cattle, M.P.K.V., Rahuri, Ahilyanagar. Seven experimental treatments were evaluated under a Completely Randomized Design (CRD), keeping milk fat constant. The study evaluated the physico-chemical properties of milkshake prepared with strawberry (*Fragaria ananassa*) and sugar. The physico-chemical analysis recorded that $T_1$ had the highest content of fat (3.40%), ash (1.16%) and total sugar (10.4%), with total solids (18.06%) and acidity (0.14%)**.** The pH was recorded at 6.59, indicating good product stability. The study also indicated that the inclusion of strawberry pulp positively influenced mineral content, with $T_1$ showed highest calcium (120.29 mg/100 g), magnesium (11.31 mg/100 g) and zinc (0.38 mg/100 g) among the treatments, contributing to enhanced nutritional value. Microbial quality assessment showed that the standard plate count (SPC) was slightly lower in milkshakes with strawberry pulp, while yeast, mould and coliform counts were not detected, confirming the hygienic safety of the formulations.

**Keywords:** Milkshake, SPC, YCM, fat, ash, acidity, mineral

## Introduction
The concept of milkshakes dates back to the late 19th century, when the term was used to describe a tonic-like drink made with eggs, whiskey, and other ingredients. Over time, milkshakes evolved into a non-alcoholic beverage, with malted milk powder being introduced to add a malty flavour and improve the texture. Milkshakes were made easier to prepare with the introduction of electric blenders in the early 20th century. Ice cream helped to further popularize the drink and develop it into the dessert-like variant that is still loved today. A milkshake is a sweet, cold drink that is usually made with milk, ice-cream, or iced milk, along with flavorings or sweeteners like chocolate sauce or fruit syrup. A dairy processing factory processes milkshake mixes, which are then packed and distributed in bulk containers. India's dairy industry has expanded significantly over the years, and it continues to be the world's largest milk producer. It is projected that 239.3 million tons of milk would be produced in 2024, reflecting an annual growth of 5.47 percent. Approximately 46 percent of milk produced in India is sold to non-farmers in rural regions or is consumed directly by farmers, leaving 54 percent of the milk available for sale to both organized and unorganized players.

Strawberry (*Fragaria ananassa*) is one of the most popular berries globally, recognized for their bright red color, juicy texture, and sweet-tart flavour native to temperate and mountainous tropical region. Strawberries are not only delicious but also pack a variety of nutrients that make them a valuable addition to a balanced diet. The main characteristics associated with the quality of ripe strawberries are their texture, and presence volatile compounds (Jiawei *et al*., 2019) [11]. Strawberry is low in calories but rich in essential vitamins, minerals, and antioxidants. A typical serving of 100 grams of fresh strawberries provides approximately: 32 kcal of energy, 7.02 grams of carbohydrates, 2.3 grams of dietary fibre, 0.3 g of fat and 0.3 g protein. They are rich in polyphenols, particularly anthocyanins, ellagic acid, and flavonoids, which have been linked to various health benefits, including

anti-inflammatory and antioxidant effects. They are an excellent source of vitamin C, offering around 64.4 mg per 100 grams, 14.0 mg calcium, 166.0 g potassium which is best for balancing the sweet flavour (Ayub *et al*., 2010) [2]. These nutrients make strawberries an ideal choice for improving the health quotient of a milkshake. The high vitamin C content supports the immune system, while antioxidants help reduce oxidative stress in the body. Moreover, the dietary fibre in strawberries aids digestion, which can make strawberry milkshakes a slightly more health-conscious dessert option when made with fresh ingredients.

Optimizing the levels of strawberry and other ingredients viz., milk and sugar, assessing the physico-chemical and microbial qualities of strawberry milkshakes are crucial steps in developing a high-quality, safe, and consumer-friendly product. This study aims to develop a strawberry milkshake by addressing the following objective; to asses physico-chemical and microbial quality of Strawberry Milkshake.

## Methodology

The present study was undertaken in laboratory of Department of Animal Husbandry and Dairy Science, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri during the year 2023-2024. The experiment was laid down in the Completely Randomized Design with 4 replications and 7 treatments (Panse and Sukhatme 1967) [18]. The treatment details mentioned below-

The treatment details mentioned below-

| Treatment details: | | |
|---|---|---|
| $T_0$ | : | Controlled treatment of milk shake without addition of Strawberry Pulp |
| $T_1$ ($P_1S_1$) | : | Cow milk + 6 percent Strawberry Pulp + 8 percent selected type of sweetener |
| $T_2$ ($P_1S_2$) | : | Cow milk + 6 percent Strawberry Pulp + 10 percent selected type of sweetener |
| $T_3$ ($P_2S_1$) | : | Cow milk + 8 percent Strawberry Pulp + 8 percent selected type of sweetener |
| $T_4$ ($P_2S_2$) | : | Cow milk + 8 percent Strawberry Pulp + 10 percent selected type of sweetener |
| $T_5$ ($P_3S_1$) | : | Cow milk + 10 percent Strawberry Pulp + 8 percent selected type of sweetener |
| $T_6$ ($P_3S_2$) | : | Cow milk + 10 percent Strawberry Pulp + 10 percent selected type of sweetener |

## Results and Discussion

### Effect of strawberry pulp and sugar on physico-chemical composition of milkshake

The effect of different treatments on the physico-chemical constituents of milkshake, such as fat, protein, ash, sugars, total solids, acidity, and pH were analysed, and the results are presented in Table 1.

### Fat

The fat content varied from 3.4 percent to 3.12 percent across treatments. $T_1$ had the highest fat content (3.4 percent), while $T_6$ had the lowest (3.12 percent). The fat content in milkshakes is influenced by the composition of the added strawberry pulp and sugar. Treatment $T_2$, $T_3$ was at par with treatment $T_1$. The higher fat content in $T_1$ can be attributed to the use of optimal levels of strawberry pulp and sugar, which might have enhanced the fat concentration. This findings are in accordance with Kashid (2005) [12] who found that the golden milkshake had a little greater fat content (4.5 percent).

### Protein

The protein content ranged from 2.83 percent ($T_6$) to 3.32 percent ($T_0$). The highest protein content in $T_0$ (3.42 percent) indicates that this level of strawberry pulp and sugar maintained the milkshake's protein quality. This aligns with findings by Choudhury *et al*., (2021) [4], who reported that fruit additions can impact protein concentration in dairy products.

### Ash

The ash content, representing the mineral content, varied from 0.70 percent ($T_0$) to 1.16 percent ($T_1$). $T_1$ had the highest ash content (1.26 percent), indicating a higher mineral content, possibly contributed by the strawberry pulp. The observations in respect to ash content of present investigation are more or less similar to the values reported by Poul *et al*. (2009) [19] for custard apple milkshake and Ubale *et al*. (2014) [25] for sapota milkshake.

### Reducing Sugar

The reducing sugar content ranged from 4.1 percent ($T_0$) to 4.9 percent ($T_6$). Treatment $T_6$ had the highest reducing sugar content (4.9 percent), followed closely by $T_5$ (4.8 percent), reflecting the impact of higher sugar levels in the formulation. These findings align with somehow similar studies, such as those by Surve (2017) [24] for date milkshake.

### Non-Reducing Sugar

The non-reducing sugar content increased progressively from $T_0$ (5.7 percent) to $T_6$ (7.2 percent). $T_6$ had the highest non-reducing sugar content (7.2 percent), suggesting that higher levels of strawberry pulp and sugar contribute to an increase in non-reducing sugar. Treatment $T_3$ (6.1 percent) at par with treatment $T_6$. These findings align with similar studies, such as those by Kumar *et al*., (2016) [14] and Mishra *et al*., (2019) [16], who reported that the addition of fruit pulp to dairy beverages significantly alters the non-reducing sugar.

### Total Sugar

Total sugar content increased from 9.8 percent ($T_0$) to 12.1 percent ($T_6$). The highest total sugar content was observed in $T_6$ (12.6 percent). Treatment $T_5$, $T_4$, $T_3$ were at par with treatment $T_6$.The increase in total sugar content is expected due to the higher levels of both reducing and non-reducing sugars in the treatments with higher levels of strawberry pulp and sugar. These findings align with similar studies, such as those by Mishra *et al*., (2019) [16], who reported that the addition of fruit pulp to dairy beverages significantly alters the total sugar.

### Moisture

Moisture ranged from 80.93 percent ($T_6$) to 82.89 percent ($T_0$), with the highest moisture recorded in $T_0$ (82.89 percent). Higher moisture content in $T_0$ can be linked to the nature of strawberry pulp. These findings align with somehow similar studies, such as those by Surve (2017) [24] for date milkshake.

**Total Solids**

The total solids content increased from 17.11 percent ($T_0$) to 19.07 percent ($T_6$). $T_6$ had the highest total solids (19.07 percent), followed by $T_4$ (19.02 percent). Treatments $T_2$, $T_3$ and $T_4$ is at par with treatment $T_6$. Higher total solids are generally desirable as they contribute to creaminess and mouthfeel. This is consistent with the findings of Eshwarappa *et al*., (2018) [6], who reported that fruit pulp addition positively affects the total solids in milk-based products.

**Acidity**

Acidity ranged from 0.13 percent ($T_0$) to 0.17 percent ($T_4$), with the highest acidity recorded in $T_4$ (0.17 percent). Higher acidity in $T_4$ can be linked to the acidic nature of strawberry pulp. These findings align with similar studies, such as those by Kumar *et al*., (2016) [14] and Mishra *et al*., (2019) [16], who reported that the addition of fruit pulp to dairy beverages significantly alters the acidity content.

**pH**

pH of milkshake prepared with addition of strawberry milkshake are presented in Table 4.6 and illustrated in Fig 4.11. The pH values ranged from 6.36 ($T_6$) to 6.68 ($T_0$). The control treatment ($T_0$) had the highest pH, while $T_6$ had the lowest pH (6.36), likely due to the higher levels of strawberry pulp, which contributed to increased acidity, thereby lowering the pH. Treatments $T_1$, $T_2$, $T_3$ and $T_4$ is at par with treatment $T_0$. Kashid (2015) [13] evaluated that pH of milkshake increased along with addition of safflower in golden milkshake which resembles with above finding.

**Table 1:** Effect of levels of strawberry pulp and sugar on physico-chemical composition of milkshake

| Treatment | Physico-chemical Constituents | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Fat (%) | Protein (%) | Ash (%) | Reducing sugar (%) | Non reducing sugar (%) | Total Sugar (%) | Moisture (%) | Total Solid (%) | Acidity (% LA) | pH |
| $T_0$ | $3.29^{b}$ | $3.32^{a}$ | $0.70^{d}$ | $4.1^{g}$ | $5.7^{c}$ | $9.8^{c}$ | 82.89 | $17.11^{c}$ | 0.13 | $6.68^{a}$ |
| $T_1$ | $3.40^{a}$ | $3.10^{b}$ | $1.16^{a}$ | $4.2^{f}$ | $6.2^{b}$ | $10.4^{b}$ | 81.94 | $18.06^{b}$ | 0.14 | $6.59^{ab}$ |
| $T_2$ | $3.31^{ab}$ | $2.94^{bc}$ | $1.02^{b}$ | $4.4^{c}$ | $6.9^{ab}$ | $11.3^{ab}$ | 81.43 | $18.57^{ab}$ | 0.15 | $6.62^{ab}$ |
| $T_3$ | $3.30^{ab}$ | $2.95^{bc}$ | $1.11^{b}$ | $4.5^{d}$ | $6.1^{b}$ | $10.6^{b}$ | 82.04 | $17.96^{ab}$ | 0.15 | $6.51^{ab}$ |
| $T_4$ | $3.29^{b}$ | $2.88^{d}$ | $1.15^{ab}$ | $4.6^{e}$ | $7.1^{ab}$ | $11.7^{ab}$ | 80.97 | $19.03^{ab}$ | 0.17 | $6.49^{ab}$ |
| $T_5$ | $3.20^{c}$ | $2.90^{bc}$ | $1.08^{b}$ | $4.8^{b}$ | $6.4^{b}$ | $11.2^{ab}$ | 81.62 | $18.38^{b}$ | 0.16 | $6.42^{b}$ |
| $T_6$ | $3.12^{d}$ | $2.83^{e}$ | $1.02^{c}$ | $4.9^{a}$ | $7.2^{a}$ | $12.1^{a}$ | 80.93 | $19.07^{a}$ | 0.15 | $6.36^{b}$ |
| S.E.± | 0.03 | 0.07 | 0.04 | 0.06 | 0.11 | 0.31 | 3.3 | 0.34 | 0.008 | 0.08 |
| CD at 5% | 0.10 | 0.20 | 0.13 | 0.18 | 0.32 | 0.92 | NS | 9.87 | NS | 0.24 |

Mean of 4 replications NS=Not significant

**Minerals**

The mineral constituents of milkshakes formulated with varying levels of strawberry pulp and sugar were analysed to assess their impact on the nutritional profile. The results for calcium, magnesium, potassium, phosphorus, iron, and zinc are summarized in Table 2.

**Calcium**

Calcium content ranged from 111.02 mg/100 g ($T_0$) to 120.29 mg/100 g ($T_1$). Treatment $T_1$, which contained 6 percent strawberry pulp and 8 percent selected type of sweetener, exhibited the highest calcium content (120.29 mg/100 g). Treatments $T_3$, $T_2$, $T_4$, and $T_5$ is at par with treatment $T_1$.

The addition of strawberry pulp may also have contributed to calcium levels, as strawberries contain some calcium. Singh *et al*., (2020) [22], who found that fruit pulp can contribute to increasing calcium levels in dairy products but may experience dilution effects at higher concentrations, reported a similar trend.

**Magnesium**

Magnesium content ranged from 8.5 mg/100 g ($T_0$) to 11.31 mg/100 g ($T_1$). The addition of strawberry pulp and sugar increased the magnesium content, with $T_1$ showing the highest level (11.31 mg/100 g). Treatment $T_2$, is at par with treatment $T_1$. Choudhary *et al*., (2018) [3] also found that the mineral content of fruit-based dairy beverages increases with moderate additions of fruit but can decrease when the fruit concentration is too high, leading to dilution.

**Potassium**

Potassium content ranged from 154.21 mg/100 g ($T_1$) to 174.54 mg/100 g ($T_2$). The highest potassium level was observed in $T_2$, likely due to the high potassium content in both cow milk and strawberry pulp. Treatments $T_3$ is at par with treatment $T_2$. Increasing potassium levels are beneficial for cardiovascular health and regulating blood pressure. Jadhav *et al*., (2019) [10] noted a similar trend, where potassium levels peaked with moderate fruit pulp addition but declined at higher concentrations.

**Phosphorus**

Phosphorus content ranged from 86.00 mg/100 g ($T_6$) to 93.36 mg/100 g ($T_1$). Treatment $T_1$ again had the highest phosphorus level, which is expected given that cow milk is a rich source of phosphorus. Treatments $T_2$, $T_3$, $T_4$ is at par with treatment $T_1$. Rajput *et al*., (2017) [20] observed a similar pattern, where fruit additions to milk-based beverages led to reduced phosphorus levels at higher fruit concentrations due to complex interactions.

**Iron**

Iron content was relatively low across all treatments, ranging from 0.06 mg/100 g ($T_0$) to 0.14 mg/100 g ($T_6$). The increase in iron content in $T_6$ can be attributed to the presence of strawberry pulp, which contains small amounts of iron. Treatments $T_1$, $T_2$, $T_3$, $T_5$ is at par with treatment $T_6$. Goswami *et al*., (2020) [7] reported that the addition of fruit pulp to dairy products enhances the iron content, as fruits are natural sources of this mineral.

**Zinc**

Zinc content ranged from 0.29 mg/100 g ($T_0$) to 0.38 mg/100 g ($T_1$). Treatment $T_1$ had the highest zinc content

(0.38 mg/100 g), likely due to the mineral content of cow milk and the sugar used. Zinc is essential for immune function and cellular metabolism, and its increase in $T_1$ suggests a potential nutritional benefit. However, treatments $T_2$, $T_3$, $T_6$, is at par with treatment $T_1$. Kumar *et al*., (2019) [15] found that zinc levels in dairy products fluctuate similarly when fruit pulp is added, as the balance between milk and fruit ingredients influences mineral retention. Denka *et al*., (2022) [5] observed a corresponding rise in mineral content in bread that increased with the amount of pumpkin seed flour.

**Table 2:** Effect of levels strawberry pulp and sugar on mineral content of milkshake

| Treatment | Mineral Constituents | | | | | |
|---|---|---|---|---|---|---|
| | Calcium (mg/100 g) | Magnesium (mg/100 g) | Potassium (mg/100 g) | Phosphorus (mg/100 g) | Iron (mg/100 g) | Zinc (mg/100 g) |
| $T_0$ | 111.02$^{c}$ | 8.5$^{b}$ | 154.21$^{d}$ | 86.11$^{b}$ | 0.06$^{c}$ | 0.29$^{d}$ |
| $T_1$ | 120.29$^{a}$ | 11.31$^{a}$ | 150.26$^{c}$ | 93.11$^{a}$ | 0.13$^{ab}$ | 0.38$^{a}$ |
| $T_2$ | 116.34$^{ab}$ | 10.09$^{ab}$ | 174.54$^{a}$ | 92.17$^{ab}$ | 0.12$^{ab}$ | 0.36$^{ab}$ |
| $T_3$ | 112.61$^{ab}$ | 10.01$^{b}$ | 171.26$^{ab}$ | 90.12$^{ab}$ | 0.12$^{ab}$ | 0.35$^{ab}$ |
| $T_4$ | 118.22$^{ab}$ | 9.9$^{b}$ | 168.38$^{b}$ | 90.00$^{ab}$ | 0.1$^{b}$ | 0.31$^{bc}$ |
| $T_5$ | 110.16$^{ab}$ | 9.6$^{b}$ | 163.70$^{b}$ | 88.29$^{b}$ | 0.12$^{ab}$ | 0.32$^{b}$ |
| $T_6$ | 108.6$^{b}$ | 9.5$^{b}$ | 162.22$^{b}$ | 86.00$^{b}$ | 0.14$^{a}$ | 0.33$^{ab}$ |
| S.E.± | 4.8 | 0.41 | 3.2 | 1.8 | 0.006 | 0.019 |
| CD at 5% | 14.3 | 1.24 | 10.4 | 5.42 | 0.019 | 0.06 |

Mean of 4 replications

**Effect of levels of strawberry pulp and sugar on microbial quality of milkshake**

The microbial quality of milkshakes with varying levels of strawberry pulp and sugar was assessed, focusing on Standard Plate Count (SPC)**,** Yeast and Mould Count, and Coliform Count**.** The results are summarized in Table 3.

**Table 3:** Effect of levels of strawberry pulp and sugar on microbial quality of milkshake

| Treatment | Microbial Attributes | | |
|---|---|---|---|
| | Standard Plate Count ($10^4$ cfu/ml) | Yeast And Mould Count ($10^2$) | Coliform Count |
| $T_0$ | 1.20$^{c}$ | ND | ND |
| $T_1$ | 1.12$^{a}$ | ND | ND |
| $T_2$ | 1.14$^{ab}$ | ND | ND |
| $T_3$ | 1.16$^{b}$ | ND | ND |
| $T_4$ | 1.15$^{ab}$ | ND | ND |
| $T_5$ | 1.17$^{bc}$ | ND | ND |
| $T_6$ | 1.19$^{bc}$ | ND | ND |
| S.E. + | 0.01 | ND | ND |
| CD at 5% | 0.03 | ND | ND |

**Standard Plate Count (SPC)**

The SPC values ranged from 1.12 × $10^4$ cfu/ml ($T_1$) to 1.20 × $10^4$ cfu/ml ($T_0$). The control treatment ($T_0$) without any strawberry pulp or sugar had the highest SPC, indicating that the base milk itself supported moderate microbial growth. The addition of strawberry pulp and sugar in treatments $T_1$ to $T_6$ resulted in minor variations in SPC, with a general trend of slightly lower counts in treatments with 6 percent pulp ($T_1$ and $T_2$), and gradually increasing SPC as the strawberry pulp percentage rose to 10 percent ($T_6$: 1.19 × $10^4$ cfu/ml). This minimal fluctuation in SPC across treatments suggests that the addition of strawberry pulp and sugar did not significantly promote bacterial growth, likely due to the natural acidity of strawberries (which can have antimicrobial properties) and the sugar content's osmotic effects, which can inhibit microbial proliferation.

**Yeast and Mould Count ($10^2$)**

In all treatments ($T_0$ to $T_6$), the yeast and mould counts were not detected (ND)**.** This suggests that the milkshake formulations, including the strawberry pulp and sugar additions, did not favour yeast or mould growth under the study's conditions. The absence of yeast and mould can be attributed to proper pasteurization, hygienic handling, and the acidity contributed by the strawberry pulp, which may inhibit fungal growth. Rathod *et al*., (2020) [21] reported that fruit-based dairy products with low pH and adequate heat treatment typically show no yeast and mould growth, supporting the findings in this study.

**Coliform Count**

The coliform counts were also not detected (ND) in any of the treatments. The absence of coliforms indicates good hygienic practices and effective thermal treatment during milkshake preparation. Singh *et al*., (2017) [23] also found no coliform growth in fruit-flavoured milk beverages when proper processing conditions were maintained, which is consistent with the results observed in this study.

**Conclusion**

From the above observations, it was concluded that among all the compositional components evaluated with respect to physico-chemical and microbial properties, the most superior milkshake blended with strawberries was prepared using 6 percent strawberry pulp and 8 percent sugar.

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