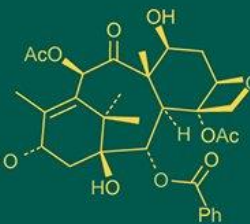
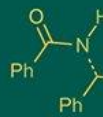


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## Economic evaluation of low-calorie functional ice cream incorporated with *Moringa oleifera* and polydextrose

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**Abstract**

The present study was conducted to evaluate the production economics of low-calorie functional ice cream incorporated with *Moringa oleifera* powder/extract and polydextrose under commercial-scale conditions. The cost of production was estimated by considering the prevailing market prices of ingredients along with labour, utilities, packaging, depreciation and other overhead costs. A production capacity of 100 kg ice cream premix per day was assumed for economic analysis. The capital investment required for the processing unit was estimated at ₹3,02,080. The production cost per 100 mL serving was ₹7.83, ₹7.72, ₹7.77, ₹8.65 and ₹8.73 for Control 1 (C1), Control (C), T<sub>9</sub>, T<sub>13</sub> and LC3, respectively. The results indicated that incorporation of *Moringa oleifera* powder/extract and polydextrose produced a nutritionally enriched functional ice cream with only a marginal increase in production cost, demonstrating its economic feasibility and commercial potential as a value-added dairy product.

**Keywords:** Cost economics, functional ice cream, *Moringa oleifera*, polydextrose, low-calorie ice cream, commercial feasibility

**Introduction**

The increasing awareness of the relationship between nutrition and health has significantly influenced consumer preferences towards functional foods that provide health benefits beyond basic nutrition. Consequently, the food industry is focusing on the development of value-added products enriched with dietary fibre, natural bioactive compounds and other functional ingredients while reducing calories, fat and sugar (Toliaty *et al.*, 2022) [10]. Besides nutritional enhancement, the commercial success of functional foods depends on their sensory quality, processing efficiency and economic feasibility, making cost-effective product development a major priority for both researchers and manufacturers. (Samakradhamrongthai *et al.*, 2021) [7]

Ice cream is one of the most widely consumed dairy products because of its desirable flavour, texture and consumer acceptability. However, its high fat and sugar content has prompted the development of healthier formulations enriched with proteins, dietary fibre and bioactive ingredients without compromising product quality (Kowalczyk *et al.*, 2021) [4]. The incorporation of functional ingredients into ice cream not only enhances its nutritional profile but also creates opportunities for the dairy industry to develop premium products with greater market value and consumer appeal (Vasundhara and Amrita, 2022) [11]. *Moringa oleifera* is recognized as a promising functional ingredient owing to its abundance of high-quality protein, dietary fibre, essential minerals, vitamins and phytochemicals, including polyphenols, flavonoids, carotenoids and glucosinolates (Ahmadiyan *et al.*, 2023) [1]. These bioactive compounds exhibit antioxidant, antimicrobial, anti-inflammatory, hepatoprotective and antidiabetic activities, making moringa suitable for the formulation of functional dairy products with enhanced health benefits (Farid and Hegazy, 2020; Padayachee and Baijnath, 2020) [2, 6].

Polydextrose is a low-calorie soluble dietary fibre (1 kcal g<sup>-1</sup>) that functions as a fat replacer, bulking agent, stabilizer and prebiotic. It improves creaminess, mouthfeel, freeze-thaw stability and texture while contributing to calorie reduction, glycaemic control and gut health (Shenana, 2022) [8].

Similarly, guar gum is an economical hydrocolloid widely used in frozen desserts because of its excellent water-binding capacity, viscosity and stabilizing properties. It improves body, texture and melting resistance while also acting as a soluble dietary fibre with prebiotic potential (Gupta and Variyar, 2018) [3].

In addition to nutritional and technological advantages, the incorporation of functional ingredients must be economically sustainable for successful commercialization. The cost of raw materials, ingredient functionality, processing efficiency, product yield, storage stability, packaging, transportation and consumer acceptance collectively determine the profitability of a functional food product. Ingredients capable of simultaneously improving product quality and processing performance can reduce production losses and enhance economic returns by increasing yield, extending shelf life and reducing wastage. Previous studies have highlighted that economic evaluation, along with physicochemical, microbiological and sensory assessment, is essential for determining the commercial viability of newly developed functional foods.

## Materials and Methods

### Source of materials

Fresh whole milk, cream, skim milk powder, sugar, glycerol monostearate (GMS), guar gum and other dairy ingredients required for the preparation of ice cream were procured from the local market of Hisar (Haryana, India). Food-grade polydextrose was obtained from a commercial supplier. Fresh *Moringa oleifera* leaves were collected from healthy plants growing in and around the Lala Lajpat Rai University

of Veterinary and Animal Sciences (LUVAS), Hisar. The leaves were thoroughly washed, shade-dried and ground into fine powder, while *Moringa oleifera* extract was prepared under laboratory conditions using the standardized extraction procedure. All analytical-grade chemicals and microbiological media used for physicochemical, antioxidant and microbiological analyses were procured from reputed commercial suppliers. The experimental work was carried out in the Department of Livestock Products Technology, College of Veterinary Sciences, LUVAS, Hisar.

## Result and Discussions

The cost of production of the control ice cream and the functional ice cream incorporated with *Moringa oleifera* powder/extract and polydextrose was estimated based on the prevailing market prices of all ingredients available in Hisar, Haryana, during the experimental period. The economic analysis was performed under commercial production conditions by considering both recurring and non-recurring expenditures. The production cost included the cost of raw materials, labour, water, electricity, packaging, and depreciation of equipment and machinery. For economic calculations, a production capacity of 100 kg of ice cream per day was assumed. The prices of all ingredients were calculated according to their local market rates at the time of the study. It was further assumed that the entire quantity of the finished product was successfully marketed without any processing, handling or storage losses. The final production cost was calculated by considering the total expenditure incurred per unit quantity of the finished product.

**Table 1:** Major capital investment with cost and annual depreciation for processing of 100 kg ice cream premix

| Sr. No. | Items                   | Particulars | Qty. | Estimated cost (Rs) | Rate of (%) depreciation | Annual depreciation (Rs) |
|---------|-------------------------|-------------|------|---------------------|--------------------------|--------------------------|
| 1       | Weighing balance        | 10 kg       | 1    | 5000                | 10                       | 500                      |
| 2       | Measuring bucket        | 20 lit      | 4    | 400                 | 20                       | 80                       |
| 3       | Stainless steel patila  | 40 lit      | 2    | 2200                | 10                       | 220                      |
| 4       | Stainless steel spoons  | Big         | 6    | 480                 | 10                       | 48                       |
| 5       | Stainless steel buckets | 20 lit.     | 2    | 1500                | 10                       | 150                      |
| 6       | Ice cream pasteurizer   | 150 lit     | 1    | 110000              | 10                       | 11000                    |
| 7       | Ageing vat              | 200 lit     | 1    | 35000               | 10                       | 3500                     |
| 8       | Tub plastic             | --          | 2    | 400                 | 20                       | 80                       |
| 9       | Refrigerator            | 300 lit     | 1    | 35000               | 10                       | 3500                     |
| 10      | Deep freezer            | 25 lit.     | 1    | 22000               | 10                       | 2200                     |
| 11      | Measuring vessels       | 1 lit       | 2    | 100                 | 10                       | 10                       |
| 12      | Ice cream blast freezer | 30 lit      | 1    | 90000               | 10                       | 9000                     |
|         | Total                   |             |      | 3,02,080/-          |                          | 30,288/-                 |

The calculations and results for the estimation of cost of production of control and developed products are presented in table 2-3. Capital investment was calculated to be Rs. 3,02,080/- for all developed products with annual

depreciation as Rs. 30,288/- (Table 1). Detailed break up of processing cost, fixed charges and general expenses are presented in table 2.

**Table 2:** Detailed break up of product cost for the manufacture of control ice cream and ice cream incorporated with *Moringa oleifera* powder/extract and polydextrose

| Component                                     | Added for 100 kg (For Control 1) | Added for 100 kg (For Control) | Added for 100 kg (For T <sub>9</sub> & T <sub>13</sub> ) | Added for 100 kg (For LC3) | Rate per kg (Rs) | Requirement (per month For Control 1) | Requirement (per month For Control) | Requirement (per month For T <sub>9</sub> & T <sub>13</sub> ) | Requirement (per month For LC3) |                        | Expenditure (per month) |                                                            |                                                              |                          |
|-----------------------------------------------|----------------------------------|--------------------------------|----------------------------------------------------------|----------------------------|------------------|---------------------------------------|-------------------------------------|---------------------------------------------------------------|---------------------------------|------------------------|-------------------------|------------------------------------------------------------|--------------------------------------------------------------|--------------------------|
|                                               |                                  |                                |                                                          |                            |                  |                                       |                                     |                                                               |                                 | Control ice cream (C1) | Control ice cream (C)   | <i>Moringa oleifera</i> powder ice cream (T <sub>9</sub> ) | <i>Moringa oleifera</i> extract ice cream (T <sub>13</sub> ) | LC3 (without emulsifier) |
| Standardized milk                             | 66                               | 72.5                           | 71.98                                                    | 72.25                      | 58               | 1980                                  | 2175                                | 2159.4                                                        | 2167.5                          | 1,14,840               | 1,26,150                | 1,25,245                                                   | 1,25,245                                                     | 1,25,715                 |
| Cream                                         | 14                               | 3.39                           | 3.43                                                     | 3.41                       | 320              | 420                                   | 101.7                               | 102.9                                                         | 102.3                           | 1,34,400               | 32,544                  | 32,928                                                     | 32,928                                                       | 32,736                   |
| Skim milk powder                              | 4.5                              | 4.36                           | 4.34                                                     | 4.33                       | 380              | 135                                   | 130.8                               | 130.2                                                         | 129.9                           | 51,30                  | 49,704                  | 49,476                                                     | 49,476                                                       | 49,362                   |
| <i>Moringa oleifera</i> powder                | -                                | -                              | 0.5                                                      |                            | 100              | -                                     | -                                   | 15                                                            |                                 | -                      | -                       | 1500                                                       | -                                                            | -                        |
| <i>Moringa oleifera</i> extract               | -                                | -                              | 0.5                                                      | 0.5                        | 545              | -                                     | -                                   | 15                                                            | 15                              | -                      |                         |                                                            | 54545                                                        | 54545                    |
| Polydextrose powder                           | -                                | 8                              | 8                                                        | 8                          | 250              | -                                     | 240                                 | 240                                                           | 240                             | -                      | 60000                   | 60000                                                      | 60000                                                        | 60000                    |
| Sugar                                         | 15                               | 11.25                          | 11.25                                                    | 11.25                      | 40               | 450                                   | 337.5                               | 337.5                                                         | 337.5                           | 18000                  | 13,500                  | 13,500                                                     | 13,500                                                       | 13,500                   |
| Guar gum                                      | 0.25                             | 0.25                           | 0.25                                                     | -                          | 135              | 7.5                                   | 7.5                                 | 7.5                                                           | 7.5                             | 1013                   | 1013                    | 1013                                                       | 1013                                                         | 1013                     |
| Glycerol monostearate                         | 0.25                             | 0.25                           | 0.25                                                     | -                          | 115              | 7.5                                   | 7.5                                 | 7.5                                                           | -                               | 863                    | 863                     | 863                                                        | 863                                                          | -                        |
| Polystyrene cup with spoon (Capacity -200 ml) | 1.5/pack                         | 1.5/pack                       | 1.5/pack                                                 | 1.5/pack                   | 1.5/pack         | 60,000 packs                          | 60,000 packs                        | 60,000 packs                                                  | 60,000 packs                    | 90,000                 | 90,000                  | 90,000                                                     | 90,000                                                       | 90,000                   |
| Sub Total (I)                                 |                                  |                                |                                                          |                            |                  |                                       |                                     |                                                               |                                 | 3,64,246               | 3,73,774/-              | 3,74,525/-                                                 | 4,27,570                                                     | 4,26,871                 |

| II. Operating labour and supervision  |             |            |               |
|---------------------------------------|-------------|------------|---------------|
|                                       | Rs.         | Req./month | Rs. per month |
| Skilled Labour                        | 15000/month | 2          | 30,000        |
| Sub-total (II)                        |             |            | 30,000        |
| III. Power and utility                |             |            |               |
| Power                                 | 6/KWH       | 450 KWH    | 2700          |
| Water                                 | 2/100 lit   | 12500      | 250           |
| Sub-total (III)                       |             |            | 2950          |
| IV. Maintenance/Miscellaneous charges | 1000/month  |            | 1,000/-       |
| V. Cleaning material (detergent)      | 80/kg.      | 10         | 800/-         |

|                                                                |          |
|----------------------------------------------------------------|----------|
| Sub-total (a) = I+II+III+IV+V                                  |          |
| For control (C1)                                               | 3,97,996 |
| For developed control ice cream (C)                            | 4,08,524 |
| For <i>Moringa oleifera</i> powder ice cream (T <sub>9</sub> ) | 4,09,275 |

|                                                                |          |
|----------------------------------------------------------------|----------|
| For <i>Moringa olifera</i> extract ice cream(T <sub>13</sub> ) | 4,62,320 |
| For LC3(without emulsifier)                                    | 4,61,621 |

| (b) Fixed charges                                               |            |            |
|-----------------------------------------------------------------|------------|------------|
| Rent for building                                               | 8000/month | 8,000/-    |
| Depreciation on capital investment (10%)                        |            | 2,524/-    |
| Insurance and taxes @ 4% of capital investment                  |            | 1,007/-    |
| Sub-total (b)                                                   |            | 11,531/-   |
| Sub-total A = a+ b                                              |            |            |
| For control (C1)                                                |            | 4,09,527/- |
| For developed control ice cream (C)                             |            | 4,20,055/- |
| For <i>Moringa oleifera</i> powder ice cream (T <sub>9</sub> )  |            | 4,20,806   |
| For <i>Moringa oleifera</i> extract ice cream(T <sub>13</sub> ) |            | 4,73,851   |
| For LC3(without emulsifier)                                     |            | 4,73,152   |
| B. General expenses Interest on investment @ 15% per month      |            | 3,776/-    |

| Product cost per month                                          | A          | B     | A+B        |
|-----------------------------------------------------------------|------------|-------|------------|
| For control (C1)                                                | 4,09,527/- | 3,776 | 4,13,303/- |
| For developed control ice cream (C)                             | 4,20,055/- | 3,776 | 4,23,831/- |
| For <i>Moringa oleifera</i> powder ice cream (T <sub>9</sub> )  | 4,20,806   | 3,776 | 4,24,582   |
| For <i>Moringa oleifera</i> extract ice cream(T <sub>13</sub> ) | 4,73,851   | 3,776 | 4,77,627   |
| For LC3(without emulsifier)                                     | 4,73,152   | 3,776 | 4,76,928   |

**Table 3:** Cost of ice cream per liter

| Product cost per Litre                                          | Total raw material (kg) | Overrun (%) | Final product (L) | Cost/L in Rs. |
|-----------------------------------------------------------------|-------------------------|-------------|-------------------|---------------|
| For control (C1)                                                | 100 kg                  | 88          | 176               | 78.3/-        |
| For developed control ice cream (C)                             | 100 kg                  | 96          | 183               | 77.2/-        |
| For <i>Moringa oleifera</i> powder ice cream (T <sub>9</sub> )  | 100 kg                  | 95          | 182               | 77.7/-        |
| For <i>Moringa oleifera</i> extract ice cream(T <sub>13</sub> ) | 100 kg                  | 97          | 184               | 86.5/-        |
| For LC3 (without emulsifier)                                    | 100 kg                  | 95          | 182               | 87.3/-        |

The estimated cost for the production of a 100 ml of ice cream cup of C1, C, T<sub>9</sub>, T<sub>13</sub> and LC3 is 7.83, 7.72, 7.77, 8.65 and 8.73 respectively. Developed ice cream incorporated with *Moringa oleifera* powder/extract and polydextrose can therefore, be exploited for marketing the product in domestic and foreign market to fetch better revenues.

### Conclusion

The developed formulations exhibited competitive production costs while providing added nutritional and functional benefits. The production cost of the developed functional ice creams ranged from ₹77.2 to ₹87.3 per litre (₹7.72-8.73 per 100 mL serving), indicating that the incorporation of functional ingredients resulted in only a marginal increase in manufacturing cost compared with the conventional product. The enhanced nutritional value, together with acceptable production economics, suggests that these formulations possess good commercial potential. Therefore, *Moringa oleifera*- and polydextrose-enriched functional ice cream may serve as a promising value-added dairy product with scope for commercial production and marketing to meet the growing consumer demand for healthier frozen desserts while ensuring sustainable economic returns to manufacturers.

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