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Physico-Chemical Properties and Cost Structure of Chakka Whey Beverage Fortified with Orange Juice

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Abstract
The present research was conducted at the Section of Animal Husbandry and Dairy Science, Nagpur, with the objective of developing a palatable, cost-effective, and nutritious beverage by utilizing chakka whey, a by-product of chakka (strained curd) production. The beverage was enriched with varying levels of orange juice to enhance its sensory and nutritional quality.

Four treatment formulations were prepared using 0% (T_1), 4% (T_2), 8% (T_3), and 12% (T_4) orange juice, each containing 10% sugar. These were evaluated organoleptically for color and appearance, flavor, body and texture, and overall acceptability.

The results showed that increasing levels of orange juice significantly improved the beverage's sensory attributes. Treatment T_3 (8% orange juice) scored the highest in overall acceptability with an average panel rating of 8.0 out of 9, followed by T_2 (6.5), indicating moderate acceptability.

Chemical analysis indicated a gradual increase in fat, protein, total solids, titratable acidity, and ash content with higher orange juice incorporation. While titratable acidity showed only a minor rise, the overall nutritional profile was positively impacted.

Economically, T_3 proved to be the most viable, with a production cost of Rs. 26.97 per litre, delivering a high-quality, consumer-acceptable beverage.

Keywords: Chhani, consumption, fuel-wood, households, Lanchaan

Introduction
Milk is regarded as nature's nearly perfect food, offering essential nutrients for human growth and development. It has been a vital part of the human diet since ancient times. India ranks first in global milk production, contributing 24.76% of the total. The country's milk output has grown at a CAGR of 5.62%, rising from 146.31 million tonnes in 2014-15 to 239.30 million tonnes in 2023-24 (Anonymous, 2024) [1]. The watery portion of milk that is left over after the curd or coagulated product that is produced when milk coagulates due to the action of an acid or a proteolytic enzyme is called whey. Whey is a valuable by product that is obtained during the production of chakka, chhana and cheese. With the exception of casein, fat, and fat soluble vitamins, whey includes nearly every component of milk. Whey typically comprises roughly half of the original milk's total solids. Along with water soluble vitamins, minerals and proteins, whey makes up 6.5 per cent to 7.0 per cent of the total solids.

Traditionally, whey from paneer or cheese production has been extensively studied and utilized in beverage formulation. However, chakka whey, due to its unique nutritional profile and acidic nature, is emerging as a favorable alternative for beverage innovation. Its high biological value proteins, natural acidity and lactose content contribute to both nutritional benefits and flavor development in beverages (Saraswathi, 2019) [6].

Fruits are a key component of a balanced human diet, offering not just energy rich nourishment but also essential protective nutrients. Sweet Orange (*Citrus sinensis L.*) is one of the most important subtropical fruits of India and belongs to the family rutaceae. It is widely consumed fruit RTS by normal as well as sick people and is well known for its instant energy, pectin, vit c and potassium content. Keeping these in mind, the present study entitled "Utilization of Orange juice for the preparation of chakka whey beverage'' was undertaken with the objectives to find out the suitable level of Orange juice along with the physico-chemical quality and its cost structure.

Materials and Methods

The research work entitled "Utilization of Orange juice for the preparation of chakka whey beverage" was carried out at the Section of Animal Husbandry and Dairy Science, College of Agriculture, Nagpur during the year 2024-2025. During the entire study fresh, clean, whole cow milk was obtained from Dairy farm of Animal Husbandry and Dairy Science section, College of Agriculture, Nagpur. The milk was strained through clean muslin cloth and transferred into well cleaned and sterilized flat bottom stainless steel vessel. Orange juice, Starter culture (1%), Sugar (10%), Stabilizer @ 0.3 % by weight are also used for preparation of chakka whey beverage.

Fresh milk is pasteurized at 80°C, cooled to 30°C, and inoculated with 1% *Streptococcus cremoris* culture. After incubation at 37°C for 14-16 hours, curd forms and whey is drained over 5-6 hours to obtain chakka whey. The whey is standardized to 0.6-0.7% acidity, heat-treated at 85°C, filtered, and cooled. Then, 10% sugar and orange juice are added, followed by heating at 80°C for 15 minutes and filtration. The beverage is bottled, pasteurized at 63°C, and stored at 5-10°C to maintain quality.

Treatment details

T_1 = 100 part of chakka whey + 0 parts of orange juice
T_2 = 96.0 parts of chakka whey + 4.0 parts of orange juice
T_3 = 92.0 parts of chakka whey + 8.0 parts of orange juice
T_4 = 88.0 parts of chakka whey + 12 parts of orange juice
Note: 10 per cent sugar was common in all treatments.

Chemical analysis of chakka whey beverage

Determination of fat

The fat was determined by Gerber method as per procedure in SP: 18 (Part XI), 1981.

Determination of protein

Protein percentage of chakka whey beverage was determined as per the semi- micro Kjeldahl method as recommended in IS: 1479 part II (1961).

Determination of total solids

The total solids percentage in chakka whey beverage was determined by using gravimetric method as per the procedure of IS: 1479 (Part II) (1961).

Determination of acidity

The acidity of milk expressed on per cent lactic acid will be determined by method described in IS : 1479 (Part II) 1961.

Determination of ash

Ash content of chakka whey beverage was determined as per the procedure described in IS: 1479 (Part II) 1961.

Cost structure of chakka whey beverage

The cost of materials required for manufacture of chakka whey beverage during experimental period were taken into account for cost calculations. The product was prepared on laboratory scale and expenditure made on the recurring items were only considered for cost estimation.

Statistical analysis

The experiment was laid out in Completely Randomized Design with four treatments in five replications. The data obtained were analyzed statistically according to method described by Snedecor and Cochran (1994).

Resuts and Discussion

Chemcal composition of chakka whey beverage

The finished product of chakka whey beverage was subjected for the proximate analysis *viz*., fat, protein, total solids, ash and acidity. The results obtained on account of these parameter are presented in Table 1.

Fat content

The mean fat content in the beverage was significantly affected due to addition of Orange juice. The fat content of beverage prepared in the proportion of 100:0 (T_1), 96:4 (T2), 92:8 (T3) and 88:12 (T4) chakka whey to Orange juice were 0.51,0.50, 0.48 and 0.47 per cent respectively. The fat content in treatment (T1) was highest (0.51%) among all the treatments. The lowest fat content (0.47%) was observed in beverage prepared with addition of 12 parts of Orange juice. The result indicated that fat content was highest in beverage prepared without addition of Orange juice (T1). Fat content in beverage 45 was decreased as the proportion of Orange juice in the beverage increased. This might be due to fat content in Orange juice.

Borkar *et al*. (2020) [3] reported that significantly highest fat content was noticed in T1 (0.48%) prepared without addition of watermelon juice and lowest fat content was noticed in T4 (0.38%) prepared with 15 parts of watermelon juice. It indicated that fat content in whey beverage decreased with the increased watermelon juice level.

Protein content

The average protein content in the beverage was significantly affected due to addition of Orange juice. The protein content of beverage prepared in the (T_1), (T2), (T3) and (T4), were 0.52, 0.53, 0.54 and 0.55 per cent respectively. The protein content in treatment (T4) beverage prepared with Orange juice was highest (0.55%) among all the treatments. From the present investigation it was observed that that as the addition of Orange juice increased there was increased in the protein content in the beverage.

Bhavsagar *et al.* (2010) [2] reported that the addition of pineapple pulp had significantly affected the protein content of whey beverage. Significantly highest total protein content was noticed in whey beverage T4 (0.76%) prepared with 15 parts of pineapple pulp and lowest protein content was noticed in whey beverage T1 (0.57%) prepared without of pineapple pulp. Borkar *et al.* (2020) [3] observed that maximum protein content in chakka whey beverage was recorded for the treatment T4 (0.52%) followed by T3 (0.49%), T2 (0.46%) and T1 (0.41%).

Total solids content

The average value of total solids content in beverage prepared in the proportion of 100:0 (T_1), 92:8 (T_2), 90:10 (T_3) and 88:12 (T_4) chakka whey to Orange juice were 6.7, 7.00, 7.23 and 7.41 per cent respectively. Highest total solids were noticed in T_4 (7.41%). It is indicated that as the Orange juice level increased, total solids content in beverage also increased. Gupta *et al*. (2014) [4] who prepared Orange juice whey beverage and found 8.7 per cent total solids at T_1 i.e. beverage prepared from whey and Orange juice in the proportion of 70:30. Prajapati *et al.* (2021) [3] recorded that the average total solids content for treatment 5 parts of plain rice (T_1), 2 parts of red rice (T_2), 4 parts of red rice (T_3) and 6 parts of red rice (T_4) were 40.45, 38.16, 39.35 and 41.47 per cent, respectively. The total solids in treatment T_4 was highest as 41.47 per cent and that of lowest observed in treatment T_2 i.e., 38.16 per cent.

Ash content

The average ash content in the beverage was significantly affected due to addition of Orange juice. The ash content of beverage prepared in the proportion of 100:0 (T_1), 96:4 (T_2), 92:8(T3) and 88:12 (T4) chakka whey to Orange juice were 0.45,0.47,0.48 and 0.49 per cent, respectively. The ash content in treatment (T1) plain beverage prepared without Orange juice was lowest (0.45%) among all the treatments. The highest ash content (0.49 %) was observed in beverage prepared with addition of 12 parts of Orange juice (T4). The increased in ash content might be due to the replacement of milk solids by Orange juice Prajapati *et al.* (2021) [3] prepared kheer with addition of red rice at different levels. The ash content in the kheer prepared with addition of plain rice 5 parts (T_1), red rice at 2 parts (T_2), 4 parts (T_3) and 6 parts (T_4) were recorded as 1.88, 1.73, 1.86 and 1.97 per cent, respectively.

Borkar *et al.* (2020) [3] investigated that significantly highest ash content was noticed in T4 (0.52%) whey beverage prepared with 15 parts of watermelon juice and lowest ash content was noticed in T1 (0.42%) prepared without addition of watermelon juice. It indicated that ash content in whey beverage increased with the increased watermelon juice level.

Cost of production

The cost of producing one litre of the beverage was calculated based on the current market rates of raw materials such as chakka whey, Orange juice, stabilizer and sugar. Additional operational expenses like fuel and labour were estimated based on the actual time spent on preparing one litre of the beverage. The cost of chakka whey beverage with different levels of Orange juice ranged between Rs. 21.13 to 29.89 per 1000 ml for treatment T1 to T4, respectively. The cost of treatment T2 and T3 were as 24.05 and 26.97 per 1000ml, respectively.

Khodake *et. al*, (2017) reported that the cost of whey based custard apple pulp beverage under various treatments T1, T2, T3 and T4 were as Rs. 21.36, Rs. 38.00, Rs. 54.63 and Rs. 39.05, respectively.

Borkar *et al.* (2020) [3] reported the cost of production of 1 litre chakka whey beverage prepared with addition of watermelon juice at 0 (T1), 5(T2), 10(T3) and 15(T4) parts were as Rs. 17.50, 19.90, 22.30 and 24.70 respectively.

Table 1: Physico- chemical attributes of chakka whey as affected by different levels of orange juice (per cent)

Treatments	Fat	Total solids	Protein	Ash
T_1 = 100 parts of chakka whey + 0.00 parts of orange juice	0.51[a]	6.7[d]	0.52[d]	0.45[d]
T_2 = 96.0 parts of chakka whey + 4.0 parts of orange juice	0.50[b]	7.00[c]	0.53[c]	0.47[c]
T_3 = 92.0 parts of chakka whey + 8.0 parts of orange juice	0.48[c]	7.23[b]	0.54[b]	0.48[b]
T_4 = 88.0 parts of chakka whey + 12 parts of orange juice	0.47[d]	7.41[a]	0.55[a]	0.49[a]
SE (m) ±	0.008	0.032	0.011	0.006
CD @ 5 %	0.023	0.096	0.032	0.017

Table 2: Cost of production of 1 Litres Chakka whey beveage prepared from different levels of Orange juice (Rs.)

Particulars	T1	T2	T3	T4
Chakka Whey (litres) @ 2.00 rs/lit	1000	960	920	880
Whey Cost	2.00	1.92	1.84	1.76
Orange @70 rs/ kg	-	40	80	120
Orange Juice Cost	-	3.00	6.00	9.00
Sugar (10%) @ 40 rs/kg	4.00	4.00	4.00	4.00
Stabilizer (0.3%) @ 240/kg	0.72	0.72	0.72	0.72
Fuel Charges rs 951.5/14.2 kg	3.51	3.51	3.51	3.51
Labour Charges @ 350/8 hrs	10.90	10.90	10.90	10.90
Total Cost (Rs.)	21.13	24.05	26.97	29.89

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