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Effect of incorporation of concentrated paneer whey on the sensory and physico-chemical characteristics of multigrain biscuits

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Abstract

In this study, the primary attempt was designed to utilize the concentrated paneer whey (CPW) in the production of multigrain biscuits. The whey was concentrated to a level of 25% and was used as a diluent with water for dough preparation of multigrain biscuits. The studies indicated that paneer whey concentrated to 25% TS can be used to replace up to 50% water in the preparation of dough for the biscuits. Further, the baking conditions are also optimized with respect to this implied that whey concentrated to 12.5% TS could replace water completely in the preparation of multigrain biscuits. The replacement resulted in improvement in sensory parameters, increased TS in biscuits and hence improved nutritive value. A baking temperature of 170 °C / 25 min was observed to be optimal and incorporation of baking powder at 2000 ppm improved significantly the sensory parameters of whey incorporated multigrain biscuits.

Keywords: Concentrated paneer whey, multigrain biscuits, whey incorporation, sensory evaluation, physico-chemical properties, nutritional quality

Introduction

Whey is one of the major by-products of the dairy industry all over the world. Whey, the liquid fraction remaining after the coagulation and removal of casein during cheese or paneer production, contains over 55% of the original nutrients present in milk, including lactose, water-soluble proteins, essential minerals, and vitamins (Chandrapala *et al.*, 2016; Deshmukh *et al.*, 2024) [3, 4]. Despite its high nutritional and functional value, whey is often discarded as industrial effluent, contributing to severe environmental concerns due to its high biological oxygen demand (BOD > 30,000 ppm) and chemical oxygen demand (COD > 60,000 ppm) (Zhao *et al.*, 2023) [11]. Whey typically contains 6-7% total solids, with lactose accounting for the majority (70-72%), followed by minerals (12-15%) and proteins (8-10%). Whey is broadly classified into two main types: sweet whey and acid whey, which differ in their method of production and compositional attributes. Sweet whey is derived from rennet-induced enzymatic coagulation during cheese production, whereas acid whey is generated when milk is acidified to pH 4.6, the isoelectric point of casein (Mc Entee *et al.*, 2023) [8]. The bakery industry is a vital segment of India's food processing sector, offering strong potential for growth, innovation, and employment. It includes a wide range of products such as breads, biscuits, cookies, chocolates, gums, sugar confectionery, and breakfast cereals. Rising demand for biscuits and cookies is a major growth driver, while increasing health awareness is pushing the market toward healthier and fortified bakery products. To meet evolving consumer preferences, manufacturers are innovating and enhancing nutritional value. The use of whey solids, in particular, provides a cost-effective ingredient with superior nutritional benefits and also helps reduce effluent disposal burdens, supporting both economic and environmental sustainability.

Whey proteins have wide applications in the food industry due to their foaming, emulsifying, water-holding, and texturizing properties. The appropriate use of whey solids can provide bakery manufacturers with low-cost ingredients of superior nutritional quality while also reducing the burden of effluent disposal. Their incorporation into bakery products enhances nutritional value while also improving nutraceutical and techno-functional characteristics.

In this context, the present research was aimed to utilize paneer whey for the production of multigrain biscuits.

2. Materials and Methods

Paneer whey was collected from the Institute's Experimental Dairy, Bengaluru. Wheat flour (Aashirvaad Whole Wheat Atta), Corn flour, Ragi, Rice flour and Oats (Quaker) and Cane sugar were procured from the super market Star Bazaar, Koramangala (Bengaluru). Shortening agent (Marvo Pride) was purchased from local bakery shop, Adugodi (Bengaluru). In all the trials the same brand of material was procured from the same source.

2.1 Preparation of paneer whey

Cow milk (4.2% fat, 13-14% total solids) from the Experimental Dairy was used to obtain paneer whey. Thirty liters of milk were heated to boiling, cooled to 85 °C, and coagulated using 2% citric acid. The whey was separated by filtration, reheated at 85 °C for 2 minutes, and collected for further processing. Approximately 25 liters of whey were obtained per batch.

2.2 Concentration of paneer whey

Whey concentration was carried out using a pilot-scale batch APV vacuum evaporator (40 L capacity). The condenser was cleaned with 1% sodium hydroxide at 70 °C for 15-20 min, followed by 0.25% nitric acid at 55-60 °C for 15 min, and rinsed with potable water. Twenty liters of paneer whey, preheated to 55-60 °C, were fed into the evaporator and concentrated at 55 °C under 24 inches of

mercury vacuum for about 30-40 min, with care taken to prevent foaming. Steam at 10 lb pressure was used for heating. Whey concentrated to ~25% total solids (TS) was collected, adjusted to the desired TS with distilled water, and final TS was determined by the gravimetric method.

2.3 Compositional analysis of Paneer whey and concentrated paneer whey: The composition of paneer whey and concentrated paneer whey (CPW) of 25% TS was analyzed for various compositional parameter such as total solids, fat, protein, lactose, ash, pH and acidity (% LA).

2.4 Preparation of multi-grain biscuits

Varieties of biscuits can be made by different formulations of ingredients. The formulation was collected for the preparation of sweet biscuits. In the preparation of biscuits, creaming of 118 g shortening agent and 48 g sugar was done for 5 min. Then 156 g of wheat flour was sieved and supplemented with 9 g each of rice, Ragi, corn and oat. After creaming of shortening agent and sugar, the mixture of multigrain flour was added and simultaneously 40 g water was added at interval to make dough consistency then kneaded the dough for 5-7 min. Dough is sheeted to 4 mm thickness with roller followed by cutting into circular shapes with the mould of 50 mm diameter and transferred into tray for baking. Bake the product at 150 °C for 35 min. then biscuits were slowly cooled to room temperature followed by biscuits were packed in metalized polyester pouches and store until analyzed. The flowchart for preparation of multigrain biscuits is as shown in the figure 1.

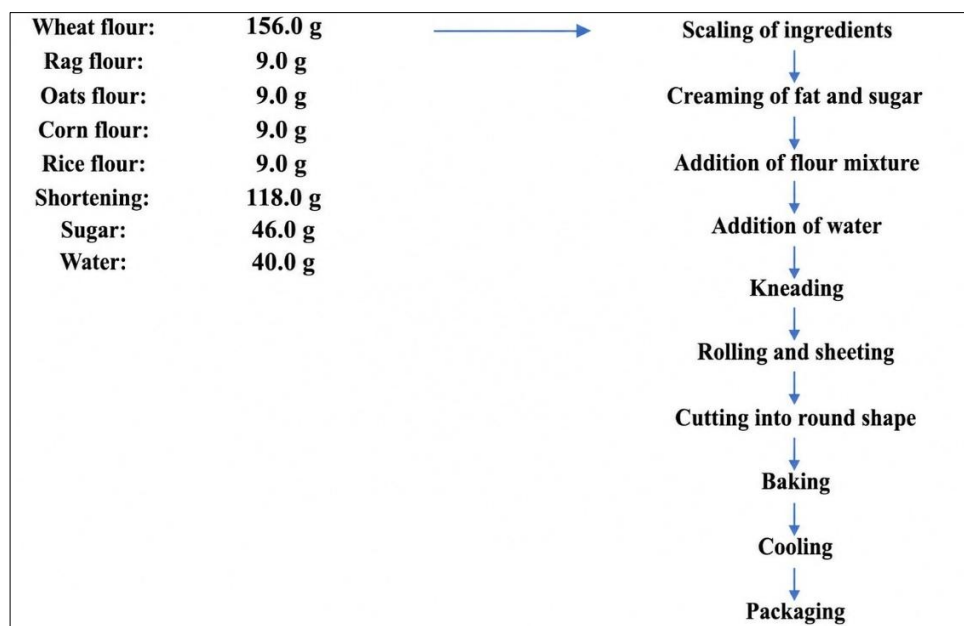


Fig 1: Flowchart for preparation of multigrain biscuits

2.5 Sensory evaluation

The organoleptic quality of multigrain biscuits was evaluated by an expert panel of judges on 9-point hedonic scale wherein a score of 1 represented 'dislike extremely' and score 9 represented 'like extremely'. The samples for evaluation were coded appropriately before serving the samples to the judges for sensory evaluation. Sensory evaluation of the samples was carried out in the sensory room. The panelists were asked to score for the following parameters: colour and appearance, body and texture, flavour and overall acceptability.

2.6 Proximate analysis of multigrain biscuits

Various compositional parameters of multigrain biscuits such as total solids, fat, protein, lactose, ash, pH and acidity (% LA) were analyzed. The compositional parameters *i.e.* fat content was determined as per the procedures described in AOAC (2005) ^[1]. The total protein content was determined by semi-micro Kjeldahl method mentioned in (ISI, 1981) ^[2]. The Total solids were estimated by the protocol described in Laboratory Manual (1959) ^[12]. The ash content was determined as per the procedures described in AOAC (2005) ^[1]. Total carbohydrate was derived by

difference of sum total of the major constituents like moisture, protein, fat and ash from 100. The method used to determine the acidity of whey was as described by Parmar (2003) [10]. The pH of whey was measured using digital pH meter. The method described by (AOAC, 2005) [11].

3. Results and Discussion

In the present research, paneer whey was collected and concentrated to 25% total solids using a vacuum evaporator. The compositional characteristics of paneer whey and concentrated paneer whey were analyzed for physicochemical properties. Concentrated paneer whey was then utilized as a partial replacement of water (0-100%) in the preparation of multigrain biscuit dough. Biscuits were prepared under standardized processing conditions and evaluated for sensory attributes using a 9-point hedonic

scale. Based on sensory optimization, proximate composition of control and optimized biscuits was analyzed to assess nutritional improvement due to whey incorporation.

3.1 Proximate composition of paneer whey and concentrated paneer whey:

The compositional analysis of paneer whey and concentrated paneer whey reveals substantial changes in physicochemical properties as a result of the concentration process. Paneer whey exhibited a relatively low total solids content (6.30%), which is characteristic of whey obtained during paneer manufacture. Upon concentration, the total solids increased markedly to 25.38%, confirming effective moisture removal and enrichment of soluble milk constituents.

Table 1: Proximate composition of paneer whey and concentrated paneer whey

Composition (%)	Paneer whey	Concentrated paneer whey
Total Solids	6.30 ± 0.181	25.38 ± 0.961
Fat	0.53 ± 0.045	2.13 ± 0.061
Protein	0.35 ± 0.015	1.67 ± 0.020
Lactose	4.83 ± 0.070	18.6 ± 0.600
Ash	0.61 ± 0.035	2.05 ± 0.066
pH	5.87 ± 0.041	5.13 ± 0.045
Acidity (%LA)	0.26 ± 0.025	0.59 ± 0.030

A proportional increase was observed in all major nutrients. Fat content increased from 0.53% to 2.13%, likely due to retention of residual fat globules during concentration. Protein content showed a significant rise from 0.35% to 1.67%, reflecting the concentration of whey proteins and highlighting the improved nutritional value of the concentrated product. Lactose remained the dominant component, increasing from 4.83% in paneer whey to 18.60% in concentrated paneer whey, indicating its high solubility and stability during concentration.

The ash content increased from 0.61% to 2.05%, suggesting enhanced mineral concentration, which contributes to the nutritional and functional attributes of the concentrated whey. A noticeable decrease in pH from 5.87 to 5.13 was observed, accompanied by an increase in titratable acidity from 0.26% to 0.59% lactic acid. These changes can be attributed to the concentration of acidic components and buffering salts present in whey. Multigrain cookies can be successfully developed with acceptable sensory and

nutritional quality. Incorporation of multiple cereals improved protein, fiber, and mineral content while maintaining consumer acceptability, indicating the potential of multigrain formulations for development of nutritious and health-oriented bakery products. Pal *et al.*, 2018 [9].

3.2-Effect of addition of CPW on sensory evaluation scores of multigrain biscuits

The effect of replacing water with whey in dough at different levels significantly influenced the sensory attributes of the product, including colour and appearance, body and texture, flavour, and overall acceptability. The control sample prepared without whey (0% replacement) recorded comparatively lower scores for all sensory parameters, indicating limited sensory enhancement in the absence of whey solids. Partial replacement of water with whey at 25% and 50% levels resulted in a significant ($p < 0.05$) improvement in sensory quality.

Table 2: Effect of addition of CPW on sensory evaluation scores of multigrain biscuits

Replacement of water with whey in dough (%)	Colour & appearance	Body & texture	Flavour	Overall Acceptability
0	6.99a ± 0.787	7.12a ± 0.661	7.00a ± 0.805	6.98a ± 0.710
25	7.43bc ± 0.495	7.30ab ± 0.530	7.38ab ± 0.573	7.42b ± 0.554
50	7.64c ± 0.486	7.71c ± 0.502	7.63b ± 0.523	7.77c ± 0.503
75	7.26ab ± 0.757	7.42bc ± 0.587	7.23a ± 0.989	7.28ab ± 0.854
100	7.28ab ± 0.729	7.40ab ± 0.610	7.29ab ± 0.802	7.32ab ± 0.733
F-value *	3.895	4.074	2.681	5.276

Note: Mean values with different superscripts are significantly different from each other ($p < 0.05$)

Among the treatments, dough prepared with 50% whey substitution achieved the highest scores for colour and appearance (7.64), body and texture (7.71), flavour (7.63), and overall acceptability (7.77), indicating superior consumer preference. This improvement can be attributed to the presence of lactose and whey proteins, which enhance browning reactions, contribute to improved dough structure,

and impart a mild, pleasant dairy flavour. The enhanced body and texture observed at this level may also be due to better water-binding capacity of whey proteins, resulting in a softer and more uniform product. However, further increase in whey substitution to 75% and 100% led to a decline in sensory scores, particularly for flavour and overall acceptability, though the products remained within

acceptable limits. The reduction at higher levels of whey incorporation may be associated with excessive lactose and mineral content, which can impart a slightly acidic taste and negatively affect dough handling and textural characteristics, Kathalsar *et al.*, 2020 [6]. The significant F-values obtained for all sensory parameters confirm the statistical influence of whey substitution on product quality. Overall, the results clearly indicate that moderate replacement of water with whey enhances sensory attributes, while excessive substitution adversely affects product acceptability. Based on the sensory evaluation, 50% replacement of water with whey can be considered the optimum level for achieving maximum sensory acceptability

and improved product quality, supporting the potential utilization of whey as a functional ingredient in dough-based food products Maurya & Mogra, 2023 [7].

3.3-Proximate composition of multigrain biscuits

Optimized product and control sample proximate composition was studied to check the acceptability of the final product. In present study found that there was no significant difference in total carbohydrate, Ash and moisture content in the control and optimized product. In optimized product founds higher fat and protein content due to addition of whey and multigrain.

Table 3: Proximate composition of multigrain biscuits

Parameters	Controlsample	Optimized sample	P value ($p < 0.05$)
Fat (%)	24.59 ± 0.370	26.12 ± 0.050	S
Total protein (%)	3.21 ± 0.100	3.93 ± 0.057	S
Total carbohydrate (%)	66.81 ± 0.717	69.35 ± 0.520	NS
Ash (%)	1.89 ± 0.040	1.94 ± 0.036	NS
Moisture (%)	3.16 ± 0.057	2.13 ± 0.057	NS

S= Significant, NS= Non-Significant

The fat content of control biscuits increased marginally from 24.59 ± 0.370 to $26.12 \pm 0.050\%$ and the protein was observed to increase from 3.21 ± 0.100 to $3.93 \pm 0.057\%$. The total carbohydrate also increased from 66.81 ± 0.717 to $69.35 \pm 0.520\%$ and the ash content changed from 1.89 ± 0.040 to $1.94 \pm 0.036\%$. The moisture content of the biscuits was observed to be $2.13 \pm 0.057\%$ for the CPW incorporated biscuits compared to $3.16 \pm 0.057\%$ for the control sample. The change in values observed could be ascribed to the increase in solids during the course of production due to the addition of CPW.

Conclusion

The present study successfully demonstrated the effective utilization of concentrated paneer whey (CPW) as a functional ingredient in the development of multigrain biscuits, thereby offering a sustainable approach for value addition of a dairy by-product. Concentration of paneer whey to 25% total solids resulted in a significant enhancement of its nutritional components, including lactose, protein, fat, and minerals, confirming the efficiency of the concentration process and the nutritional potential of CPW.

Incorporation of CPW as a partial replacement for water in biscuit dough significantly influenced the sensory attributes of the final product. Sensory evaluation revealed that replacement of water with CPW up to 50% resulted in marked improvement in colour and appearance, body and texture, flavour, and overall acceptability, with the 50% replacement level emerging as the optimum. The improved sensory quality at this level may be attributed to the functional properties of whey constituents, particularly lactose and whey proteins, which enhance browning reactions, texture, and flavour development. Higher levels of whey incorporation (75% and 100%) led to a slight decline in sensory scores, though the products remained within acceptable limits.

Proximate analysis of the optimized multigrain biscuits indicated a significant increase in fat and protein content, along with reduced moisture content, suggesting improved nutritional density and potential shelf stability. The overall

findings confirm that CPW can be effectively incorporated into multigrain biscuits without compromising product quality.

Conclusion

The study highlights the potential of concentrated paneer whey as a value-added ingredient in bakery products, contributing to improved nutrition, better sensory acceptance, and sustainable management of whey, thereby benefiting both the dairy and bakery industries

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