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ORIGINAL ARTICLE

Quality of rusks prepared by incorporation of concentrated whey

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Abstract Concentrated paneer whey was utilized in place of water in the production of rusks. The studies indicated that paneer whey concentrated to 30% total solids can be used without adversely affecting the sensory attributes. The production time cycle can be reduced by incorporating ammonium phosphate at 2500 ppm which served as a nutritional supplement for the growth of yeasts and thus catalyzing fermentation process. The modified process required additional sugar incorporation to maintain the sweetness to that of market samples. The rusks prepared by the modified process had 2.5% moisture, 12.1% fat, 9.4% total protein, 1.9% ash and 74.1% total carbohydrate. Rusks with and without whey concentrate stored at 37°C for 9 days remained in good condition without significant variation in sensory attributes.

Keywords Rusks · Paneer whey · Quality

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Introduction

Whey is one of the major byproducts of cheese and casein industry. Whey contains lactose, whey proteins and minerals (Sienkiewicz and Riedel 1990). Qualitatively cheese whey is categorized as sweet whey while casein whey as acid whey. The composition of whey varies marginally depending on type of coagulation (Khamrui and Rajorhia 1998). In India large quantities of whey is produced during the production of *chhana* and paneer in the traditional dairy sector. It is estimated that about 2% of milk produced in India is converted to paneer and *chhana* (Aneja et al. 2002) and the production of whey due to this conversion is estimated at around 270 million kg/annum. In terms of solids, this amounts to 16.2 milllon kg of valuable milk solids. The whey produced in the country by the unorganized sector is used to certain extent as animal feed. Some attempts have also been made to utilize the whey solids by extracting whey proteins (Werner 1981), whey soups (Arora and Jha 2005) and whey beverages (Keerthana and Reddy 2006). In the organized dairy industry, the whey is disposed as effluent. This method of disposal results in loss of valuable milk solids which can be better utilized as source of nutrient. This apart the disposal also results in economic loss as it has been estimated that to treat each litre of whey it costs about 35 paise which can be avoided if whey is utilized gainfully by the dairy plants (Jarita and Kulkarni 2009). The production of bakery products is estimated at around 5 million tonnes in the year 2004–2005 and there is abundant scope to utilize whey in the production of bakery products. There are several reports for the use of whey protein concentrate in the production of bakery and other products (Patel et al. 1993, Jayaprakash and Brueckner 1999). However, use of whey protein concentrate will still result in whey containing larger proportion of lactose which otherwise could be utilized for human nutrition. Besides, discharging of whey containing lactose also increases the biological oxygen demand (BOD) of the effluent. The use of whole whey in con-

centrated form, on the other hand, will result in the better utilization of solids, reduction in BOD load of the effluent and also the conservation of water. It is in this context the present study was initiated to utilize the whey solids in the production of bakery products.

Materials and methods

Cheddar cheese and paneer whey were obtained from experimental dairy. The cheese whey was obtained after the coagulation of milk by microbial enzyme (Zytex, Japan) while the paneer whey was obtained by the coagulation of milk by citric acid. Refined wheat flour (Krishna, Bangalore), crystalline sugar (Shakthi, Coimbatore), hydrogenated fat (Ruchi, Mumbai) and refined sunflower oil (Sundrop, Mumbai) blend (1:1) were used as ingredients. In all the trials, the same brand of ingredients were used. Baker's yeast (Prestige, Bangalore) in stab form was used as leavener in the preparation of rusks. The yeast was activated 10 min before use by adding 20 ml luke warm water, 10 g refined wheat flour and 5 g sugar. This ferment was then added to the flour during dough formation.

Processing of whey: Whey obtained from cheese and paneer production was concentrated in a single effect evaporator (APV, Calcutta, India) at 26" Hg to a concentration of 30–33% before using in the preparation of dough for baking. The solids content of whey was adjusted to the required level by dilution with water before using in the preparation of rusks.

Dough preparation and baking: Dough was prepared by blending 500 g refined wheat flour with 80 g fat, 80 g sugar, 4 g salt and 16 g yeast. In control samples, additionally 12 g skim milk powder and 220 g water were used. In experimental samples, water was replaced by 240 g concentrated whey. The ingredients after mixing were kneaded to a smooth dough and allowed for 20 min. Again the dough was kneaded and allowed for further 20 min. The dough was then shaped and placed in greased baking tray and allowed for 15 min, for final processing followed by baking at 225°C for 15–20 min. The baked product was cooled, sliced uniformly and again baked at 150°C till the product attained brownish crisp end point, followed by cooling, slicing and rebaking at 150°C for 15 min. The baked products were packed in pre-sterilized polyethylene (LDPE) pouches (65 μ) and stored at 37°C and 30% relative humidity.

Analysis: The total solids (TS) of whey (IS:1981), fat content by Gerber method, total protein by Micro Kjeldhal, ash (AOAC 2005) and lactose by difference were determined. The rusk samples were analysed for TS (IS:1982), fat, protein, ash (AOAC 2005) and total carbohydrates (by difference). A digital water activity meter (Rotranic, BT – RSI, Switzerland) was used for measuring water activity (a_w) and pH by using a digital pH meter (Digisun, DI 707, India) after necessary calibration. The sensory evaluation was done by a select panel of 5 judges on a 9-point scale (9 most and 1 least acceptable) for appearance, flavour, body and texture and overall acceptability. The hardness was assessed by using texture profile analyser (TA – XT plus, Stable micro system, UK) as per the procedure outlined by the manufacturer. The results of 3 to 5 replicates were subjected to statistical analysis using SPSS 11.01.

Table 1 Sensory quality scores of rusks prepared by replacing water with concentrated cheese and paneer whey (30% total solids), and flour conditioners

	Appearance	Flavour	Body and texture	Overall acceptability
a. Concentrated cheese and paneer whey				
Control	7.3 ± 0.26	7.1 ± 0.23	7.2 ± 0.37	7.1 ± 0.38
Cheese whey	7.3 ± 0.28	7.1 ± 0.26	7.2 ± 0.18	7.2 ± 0.24
Paneer whey	7.2 ± 0.57	7.2 ± 0.16	7.2 ± 0.25	7.1 ± 0.46
F-value	0.0552	0.2548	0.1082	0.0357
b. Concentrated paneer whey (PW) levels				
Control	7.6 ± 0.07	7.4 ± 0.06	7.6 ± 0.14	7.5 ± 0.11
PW (20%TS)	7.5 ± 0.18	7.2 ± 0.23	7.2 ± 0.04	7.3 ± 0.03
PW (30%TS)	7.4 ± 0.19	7.1 ± 0.28	7.4 ± 0.33	7.1 ± 0.28
F-value	1.3527	1.2670	2.3518	3.6896
c. Concentrated PW (30% TS) and flour conditioners				
Control	7.2 ± 0.18	7.2 ± 0.24	7.2 ± 0.24	7.2 ± 0.02
AP, 2500 ppm	7.1 ± 0.49	7.2 ± 0.27	6.9 ± 0.19	7.2 ± 0.13
APS, 2500 ppm	7.3 ± 0.18	6.8 ± 0.56	7.1 ± 0.22	6.9 ± 0.02
F-value	0.2743	0.6083	1.2432	4.9581

AP = Ammonium phosphate, APS = Ammonium persulphate, Scores on 9-point Hedonic scale (n = 5 panelists). The differences between treatments were not significant ($p \geq 0.05$)

Results and discussion

The solids content in whey was adjusted to 30% based on preliminary trials. Use of whey beyond 30% TS increased the browning in rusks due to the Maillard reaction. Also the increase in whey solids could be raised to 30% with simple vacuum pan operation while raising solids content beyond 30% required multiple effect evaporators involving considerable capital investment. Taking this into consideration the concentration was restricted to 30% TS level. Cheese and paneer whey contained 0.7 and 1.1% fat, 3.3 and 2.8% total protein, 2.5 and 2.8% ash, 23.8 and 23.4% lactose, respectively. The a_w values were 0.940 and 0.945 while pH were 5.6 and 4.9 for cheese and paneer whey, respectively.

The results of sensory quality revealed no significant difference between control and experimental samples in all the sensory characteristics (Table 1). This indicated that without affecting sensory parameters, it is possible to replace water with concentrated whey in the preparation of dough for the production of rusk. The sensory scores of rusks prepared by using 20 and 30% TS paneer whey were also similar indicating that the rusks can be prepared by replacing water in dough preparation by concentrated paneer whey with 20 and 30% solids (Table 1). Similar observations were made by Mann (1982) in the preparation of bread and by Gallagher et al. (2005) in biscuits. To maximize utilization of whey solids, based on the results paneer whey with 30% whey solids could optimally be used for the production of rusks which is beneficial for both the dairy and bakery industry. The incorporation of whey solids in the production of rusks contributes to salty taste and lack of sweetness as reported by judges and required incorporation of additional sugar. Hence sugar was incorporated at 9 and 10% and the samples were compared with market samples for sweetness. The sensory sweetness score of market sample (7.6) was marginally higher than experimental samples with 9% sugar (7.3) and 10% sugar (7.4).

The use of whey solids delayed the proofing time (time required to double the volume of dough by fermentation). The proofing time was 55–60 min compared to 35–40 min when water was used (control). This would affect the production cycle time and thus indirectly increase the overhead costs. In order to reduce the proofing time permitted dough conditioners like ammonium phosphate and ammonium persulphate each at 2500 ppm level (PFA 2006) were incorporated independently in the production of rusks. The addition of dough conditioners decreased the proofing time to about 30–35 min when ammonium phosphate was used and 45–50 min when ammonium persulphate was used. The sensory evaluation indicated no significant difference in any of the parameters between the two (Table 1). Ammonium phosphate, as a flour conditioner was more suitable in the production of rusks as it required lesser time for proofing. Attempts made to improve quality parameters of rusks by altering the proofing time did not significantly improve the quality characteristics and hence the minimum proofing time of 30 min is recommended in the production of rusks with whey concentrate incorporation.

Based on the above results, the appropriate ingredient composition and physico-chemical quality of rusks without and with whey concentrate are presented in Table 2. The optimised manufacture involved the preparation of dough by mixing of ingredients into a dough by using concentrated whey (30% TS) followed by rising for about 20 min. The dough was again kneaded and allowed to rise for about 20 min. Then dough was moulded to scale, proofed for 45 min and baked at 225°C for 15 min. The semi baked product was cooled and sliced uniformly followed by 15 min baking at 150°C. The storage studies of optimized rusks during storage for 9 days at 37°C and 30% RH indicated that the sensory scores of whey incorporated samples were similar to the control samples (Table 3).

Conclusion

Paneer whey concentrated to 30% TS can effectively be used by replacing water in the production of rusks. This replacement not only contributes for the nutritional attributes but also to the economy of operation of dairy plants by reducing the cost of effluent treatment. The addition of legally permitted ammonium phosphate as flour conditioner at 2500 ppm was observed to be essential to maintain the production time cycle. There was no significant difference in the sensory attributes of whey incorporated rusks in com-

Table 2 Ingredient composition and physico-chemical quality of rusks with water (control) and with concentrated paneer whey (experimental)

	Control	Experimental
Ingredients		
Refined wheat flour, %	53.56	51.45
Fat, %	8.57	8.25
Sugar, %	8.12	10.0
Salt, %	0.42	0.40
Yeast, %	1.73	1.65
Skim milk powder, %	1.29	-
Water/whey, %	26.31*	28.25**
Physico-chemical quality		
Total solids, %	96.8 ± 3.38	97.5 ± 3.16
Moisture, %	3.2 ± 3.38	2.5 ± 3.16
Fat, %	12.3 ± 1.00	12.1 ± 0.90
Total protein, %	9.2 ± 0.05	9.4 ± 0.10
Ash, %	1.2 ± 0.15	1.9 ± 0.23
Total carbohydrate, %	74.2 ± 1.15	74.1 ± 1.10
Water activity, a_w	0.362 ± 0.04	0.274 ± 0.06
pH	5.6 ± 0.007	5.4 ± 0.02
Hardness, N	52.0 ± 4.72	70.3 ± 7.22

* Water, ** Whey concentrate (30% total solids)

Table 3 Sensory characteristics of control and experimental rusks packed in LDPE pouches during storage at 37°C and 30% RH

Storage, days	Appearance		Flavour		Body and texture		Overall acceptability	
	Control	Expt	Control	Expt	Control	Expt	Control	Expt
0	7.4 ± 0.02	7.1 ± 0.05	7.4 ± 0.07	7.2 ± 0.06	7.7 ± 0.07	7.3 ± 0.04	7.6 ± 0.06	7.2 ± 0.04
3	7.6 ± 0.05	7.4 ± 0.04	7.4 ± 0.10	7.2 ± 0.10	7.6 ± 0.05	7.3 ± 0.03	7.6 ± 0.04	7.3 ± 0.02
6	7.6 ± 0.01	7.4 ± 0.03	7.6 ± 0.10	7.2 ± 0.06	7.6 ± 0.09	7.3 ± 0.04	7.6 ± 0.04	7.2 ± 0.01
9	7.7 ± 0.02	7.3 ± 0.05	7.6 ± 0.08	7.3 ± 0.05	7.5 ± 0.08	7.2 ± 0.02	7.5 ± 0.06	7.2 ± 0.01

Expt: Replacing water by concentrated paneer whey with 30% total solids
Scores on 9-point Hedonic scale (n= 5 panelists)

parison to control samples up to 9 days of storage at 37°C and 30% RH.

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