Z Lebensm Unters Forsch A (1999) 208:178–182

ORIGINAL PAPER

S. Aktar Hossain · Pradip K. Pal · Prabir K. Sarkar
Giridhari R. Patil

Sensory characteristics of dudh churpi in relation to its chemical composition

Received: 6 July 1998

Abstract Dudh churpi, a traditional milk product, had more moisture, fat, water-dispersible protein (WDP), titratable acid, energy, lactic acid, free fatty acids (FFA), 2-thiobarbituric acid (TBA) and tyrosine contents and also reflectance, but less sensory attributes, when prepared in Darjeeling than the products prepared in Sikkim and Bhutan. Sensory attributes were positively correlated with total solids, protein, lactose, sugar, hydroxymethylfurfural (HMF) and *p*-dimethylaminobenzaldehyde reactivity, and negatively correlated with fat, FFA, TBA, WDP, tyrosine, lactic acid and titratable acidity. Whereas total solids, fat, protein, lactose, glucose-galactose and total sugar accounted for 71% of the flavour score, 64% of the body and texture score, 77% of the colour and appearance score and 77% of the total score, lactic acid, FFA, TBA, tyrosine and HMF jointly reflected variations of 61%, 50%, 81% and 67% in flavour, body and texture, colour and appearance, and total score, respectively.

Key words Traditional milk product · Prechurpi · Dudh churpi · Chemical composition · Sensory attributes

Introduction

Dudh churpi is a popular traditional milk product in several countries of the Indian subcontinent. It is prepared by acid-and-heat coagulation of partially defatted (made by using a bamboo churn) milk of yak, dzno (a crossbreed of male yak and cow) and cow in Bhutan, Sikkim and Darjeeling, respectively. The green curd is cooked in an open pan until the disappearance of free moisture. The hot cooked curd is wrapped in a hessian cloth, pressed heavily under stone overnight, cut into pieces, made into a ring with a cotton thread and dried over the warmth of a wood fire for 5–7 days. The partially dried product (prechurpi) is cooked in concentrated milk-sugar solution. However, in Darjeeling, the production process varies slightly: the green curd is not cooked and only pressed for 2–3 days, the cut pieces are dried for 1–2 days only, and the prechurpi is not cooked but only dipped in a hot milk-sugar solution. The cooked product is dried over a wood fire for 25–30 days [1]. Dudh churpi is sold as rectangular pieces having a creamy to chalky white surface (Fig. 1), moderately sweet and smoky with a hard and compact body. The product is consumed by biting or chewing, like betal nut or chewing gum.

Since the production of dudh churpi has remained a traditional family art practised in homes, there is a wide variation in chemical composition of the product, which in turn influences the sensory attributes. In view of the above, the present investigation was undertaken to evaluate the chemical attributes of market samples of dudh churpi, and to find out the impact of those chemical constituents on the sensory characteristics.

S.A. Hossain · P.K. Pal · P.K. Sarkar (✉)
Centre for Life Sciences, University of North Bengal, Siliguri-734430, India

G.R. Patil
Department of Animal Husbandry and Dairying, Marathwada Agricultural University, Parbhani-431402, India

Materials and methods

Collection of samples. Dudh churpi samples were collected from different shops in Phuntsholing (Bhutan), Gangtok (Sikkim) and Darjeeling (West Bengal). They were kept in stainless steel containers with tightly closed lids and transported immediately to the laboratory for analysis.

Physicochemical analyses. Samples of dudh churpi were cut into small pieces and powdered in an electric grinder. The ground mass was analysed for moisture [2], total fat [3], free fat [4], protein [5], lactose and glucose-galactose [6], sugar [5], titratable acidity [2], ash [7], lactic acid [8], free fatty acids (FFA) [9], 2-thiobarbituric acid (TBA) value [10], tyrosine [11], hydroxymethylfurfural (HMF) [12], *p*-dimethylaminobenzaldehyde (*p*-DMAB) reactivity [13] and reflectance using an Elico type CL-28

Fig. 1 Market sample of dudh churpi

reflectometer. Water-dispersible protein (WDP) was estimated by dispersing 5.0 g sample in 100 ml warm (40 °C) water. The well-mixed suspension was filtered through a Whatman no. 2 paper, and the nitrogen content in a known volume of the filtrate was estimated using the micro-Kjeldahl procedure [5]. The energy value of the sample was calculated by multiplying its percent protein, fat and carbohydrate contents by the factors 17.15, 38.91 and 17.15, respectively, to derive the kJ per 100 g value.

Sensory evalutation. The samples of dudh churpi (1 cm^3) were evaluated by a panel of seven trained judges for overall sensory quality consisting of flavour (10), body and texture (10) and colour and appearance (5), using a 25-point score card [1].

Statistical analysis. Analysis of variance was done according to Snedecor and Cochran [14]. The sensory values and compositional data were analysed in order to develop correlations and multivariate linear and log-linear (power function) relationships [15] as follows:

$$S = k_0 + k_1 I_1 + k_2 I_2 + \ldots + k_n I_n$$

$$S = k_0 I_1^{k_1} I_2^{k_2} \ldots I_n^{k_n}$$

where S is the sensory response, I is the value of compositional variable and k is the computed constant.

Results and discussion

Data on the physicochemical characteristics of dudh churpi from three different sources are presented in Table 1. The moisture, fat, total protein, lactose, total sugar, ash, titratable acidity, pH and energy value contents of the samples from Darjeeling differed significantly ($P < 0.05$) from those from Bhutan and Sikkim. However, in respect of these parameters, the samples from Bhutan and Sikkim did not differ significantly ($P < 0.05$). The glucose-galactose content of the samples from Bhutan was significantly ($P < 0.05$) lower than those of the samples fom Sikkim and Darjeeling. While the coefficients of variation for fat, protein and total sugar contents of individual samples were as high as 33%, 26% and 22%, respectively, the coefficients were 11% for moisture, 10% for lactose and 13% for ash content. Being higher in fat content, the samples from Darjeeling had significantly ($P < 0.05$) higher energy values than those from Bhutan and Sikkim. The variation of these compositional data from different sources was likely due to the differences in the type of curd and in the treatment of the prechurpi with concentrated milk with added sugar. The lactose and glucose-galactose content of the samples from Bhutan and

Table 1 Physicochemical characteristics of market samples of dudh churpi[a]

Parameters	Sources		
	Bhutan	Sikkim	Darjeeling
Moisture (%)	15.39 ± 0.46b	15.91 ± 0.47b	18.50 ± 0.77a
Total fat (%)	9.94 ± 0.32b	10.01 ± 0.40b	14.00 ± 0.54a
Free fat (%)	2.31 ± 0.07b	2.50 ± 0.08b	3.50 ± 0.08a
Total protein (%)	62.35 ± 0.52a	61.95 ± 0.62a	58.63 ± 0.87b
Water-dispersible protein (%)	4.13 ± 0.19c	4.90 ± 0.21b	7.90 ± 0.09a
Lactose (%)	3.59 ± 0.14a	3.51 ± 0.17a	1.25 ± 0.09b
Glucose-galactose (%)	0.93 ± 0.03b	1.01 ± 0.04ab	1.11 ± 0.05a
Total sugar (%)	5.23 ± 0.17a	5.17 ± 0.19a	2.82 ± 0.14b
Ash (%)	7.14 ± 0.77a	7.01 ± 0.26a	6.11 ± 0.25b
Titratable acidity (as % lactic acid)	0.31 ± 0.01b	0.36 ± 0.02b	1.75 ± 0.08a
pH	5.43 ± 0.09a	5.70 ± 0.12a	4.65 ± 0.16b
Energy (kJ/100 g)	1500 ± 0.01b	1540 ± 0.01b	1600 ± 0.02a
Lactic acid (%)	0.07 ± 0.00c	0.09 ± 0.00b	0.19 ± 0.01a
FFA (as % oleic acid)	0.93 ± 0.04c	1.22 ± 0.10b	1.86 ± 0.06a
TBA value (A_{530})	0.08 ± 0.00b	0.08 ± 0.00b	0.11 ± 0.00a
Tyrosine (mg/g)	0.15 ± 0.01b	0.16 ± 0.01b	0.26 ± 0.01a
Free HMF (μmol/g)	27.88 ± 0.92b	30.39 ± 1.02a	10.20 ± 0.53c
Total HMF (μmol/g)	59.26 ± 1.40b	62.04 ± 1.30a	40.15 ± 1.25c
*p*DMAB reactivity (A_{545})	0.20 ± 0.01b	0.23 ± 0.01a	0.11 ± 0.01c
Reflectance (%)	30.75 ± 0.73c	28.40 ± 0.55b	41.45 ± 0.88a

[a] Data represent the means, with standard error of measurements (SEM), of 20 samples. Means with different letters in each row differ significantly ($P < 0.05$)

Sikkkim indicated little or no evidence of lactose hydrolysis. Considerable hydrolysis of milk sugar in the samples from Darjeeling might apparently be due to the lack of heat treatment of milk and/or green curd and the higher moisture content at the onset of drying. The higher value of free fat in the samples of dudh churpi may be explained as the combined action of scraping and agitation during cooking of green curd and recooking of partially dried product (prechurpi) with concentrated milk-sugar solution. This probably causes rupture of fat glouble membranes resulting in the release of higher amounts of free fat. Coagulation of protein in the fat globule membrane also contributes to freeing fat [16]. The WDP of market samples of dudh churpi varied from 6.5% to 13.5% of the total protein content. Higher WDP in the samples from Darjeeling indicated that a smaller portion of protein was transferred to the solid network and resulted in a lower cohesive force and consequently less hard churpi.

The lactic acid, FFA, TBA and tyrosine contents and also the reflectance were significantly ($P < 0.05$) higher, but the HMF content and *p*-DMAB reactivity were lower ($P < 0.05$), in the samples from Darjeeling compared to those from Bhutan and Sikkim. Compared to other chhana-based milk products [17], the FFA of dudh churpi was fairly high and it might be due to the hydrolysis of fat by pseudomonad lipases which are not inactivated even at UHT processing. Prolonged drying at an elevated temperature (>30 °C) and in the open air could be responsible for a high TBA value of dudh churpi. Moreover, milk fat contains many minor polyunsaturated fatty acids and the auto-oxidation of dairy products can lead to a multitude of saturated and unsaturated aldehydes, resulting in higher TBA values [18]. Probably, owing to a lack of heat treatment of the milk/green curd, the tyrosine value in the sample from Darjeeling was fairly high.

By measuring the *p*-DMAB reactivity, the extent of the heat treatment of milk and milk products could be determined [19]. The samples of dudh churpi from Darjeeling had less *p*-DMAB reactivity and were much less heat treated than the samples from the two other sources. A higher HMF content is attained by high-temperature fragmentation from the Amadori product and polymerization of the products from the second phase yields brown melanoidin pigments in the third and final phase of the Maillard reaction [20]. Higher HMF values could be due to higher heat treatment, such as open pan heating with constant stirring, which reduced the inhibitory effect of thiol groups on browning, and also higher heat treatment in an open pan, which achieved greater activation energy for HMF accumulation [21]. Direct contact of a supersaturated solution of lactose with the hot surface of the pan could enhance lactose caramelization, resulting in the formation of HMF [22]. Finally, the higher HMF values can be attributed to the interaction between proteins and sugars in dudh churpi during its manufacturing process [23].

The sensory scores revealed that all attributes of the samples from Bhutan were significantly ($P < 0.05$) higher compared to those from other sources. Samples from Darjeeling were criticized by the judges as rancid and brittle, probably owing to less *p*-DMAB reactivity and higher tyrosine, FFA and TBA values, resulting from the type of milk and the mode of manufacture [1].

Correlation coefficients between sensory attributes and the composition of dudh churpi (Table 2) showed that while total solids, total protein, total sugar, HMF and *p*-DMAB reactivity were positively correlated ($P < 0.05$) with flavour, body and texture, colour and appearance and total score, fat, TBA, WDP, tyrosine, lactic acid and titratable acidity had negative correlations ($P < 0.001$) with all sensory attributes. The above

Table 2 Correlation coefficients* between sensory and chemical characteristics of market samples of dudh churpi

Chemical parameters	Sensory attributes[a]			
	Flavour	Body and texture	Colour and appearance	Total score
Total solids	0.438 (0.462)	0.413 (0.435)	0.376 (0.376)	0.437 (0.461)
Total fat	−0.618 (−0.585)	−0.601 (−0.584)	−0.676 (−0.653)	−0.660 (−0.638)
Free fat	−0.744 (−0.711)	−0.662 (−0.635)	−0.745 (−0.714)	−0.754 (−0.725)
FFA	−0.618 (−0.602)	−0.559 (−0.547)	−0.740 (−0.731)	−0.660 (−0.651)
TBA	−0.494 (−0.475)	−0.433 (−0.425)	−0.589 (−0.568)	−0.521 (−0.509)
Total protein	0.490 (0.526)	0.455 (0.482)	0.436 (0.444)	0.490 (0.524)
WDP	−0.781 (−0.715)	−0.718 (−0.664)	−0.844 (−0.795)	−0.815 (−0.759)
Tyrosine	−0.536 (−0.507)	−0.469 (−0.447)	−0.618 (−0.578)	−0.560 (−0.515)
Lactose	0.752 (0.764)	0.733 (0.733)	0.796 (0.813)	0.797 (0.809)
Total sugar	0.720 (0.712)	0.692 (0.688)	0.745 (0.759)	0.755 (0.756)
Lactic acid	−0.731 (−0.713)	−0.663 (−0.648)	−0.837 (−0.832)	−0.772 (−0.759)
Titratable acidity	−0.852 (−0.844)	−0.789 (−0.799)	−0.887 (−0.923)	−0.883 (−0.897)
Total HMF	0.678 (0.655)	0.607 (0.595)	0.725 (0.741)	0.700 (0.692)
p-DMAB reactivity	0.583 (0.651)	0.493 (0.561)	0.638 (0.733)	0.594 (0.675)

* Significant at $P < 0.001$

[a] Figures in parentheses are correlation coefficients for log-log relationships (58 *df*)

Table 3 Regression equations for sensory scores as related to chemical composition of dudh churpi. (*Fl* flavour score, *BT* body and texture score, *CA* colour and appearance score, *TSc* total score, *TS* total solids, *F* total fat, *P* total protein, *L* lactose, *GG* glucose-galactose, *Tsu* total sugar, *A* ash, *FF* free fat, *WDP* water-dispersible protein, *TA* titratable acidity, *LA* lactic acid, *FFA* free fatty acid, *TBA* 2-thiobarbituric acid, *Ty* tyrosine, *FHMF* free hydroxymethylfurfural, *THMF* total hydroxymethylfurfural, *p-DMAB* *p*-dimethylaminobenzaldehyde reactivity)

Equations		Correlation coefficient (*R*)
1	$\mathrm{Fl} = 4.28\mathrm{TS}^{1.58}\mathrm{F}^{-3.59}\mathrm{P}^{0.17}\mathrm{L}^{2.24}\mathrm{GG}^{0.79}\mathrm{Tsu}^{-0.66}$	0.84
2	$\mathrm{Fl} = 8.74 + 0.02\mathrm{TS} + 0.13\mathrm{Tsu} - 0.17\mathrm{A} – 0.25\mathrm{FF} – 0.18\mathrm{WDP} - 1.30\mathrm{TA}$	0.87
3	$\mathrm{Fl} = 7.75 – 13.06\mathrm{LA} + 0.04\mathrm{THMF} - 6.35\mathrm{Ty}$	0.77
4	$\mathrm{Fl} = 7.80 - 10.88\mathrm{LA} - 0.64\mathrm{FFA} + 3.17\mathrm{TBA} - 4.90\mathrm{Ty} + 0.04\mathrm{THMF}$	0.78
5	$\mathrm{BT} = 4.18 - 0.08\mathrm{TS} - 0.03\mathrm{F} + 0.12\mathrm{P} + 1.08\mathrm{L} - 0.67\mathrm{GG} - 0.21\mathrm{Tsu}$	0.80
6	$\mathrm{BT} = 0.20\mathrm{TS}^{0.76}\mathrm{Tsu}^{0.05}\mathrm{A}^{0.05}\mathrm{FF}^{-0.15}\mathrm{WDP}^{-0.04}\mathrm{TA}^{-0.23}$	0.81
7	$\mathrm{BT} = 6.98 - 11.45\mathrm{LA} + 0.03\mathrm{THMF} - 4.59\mathrm{Ty}$	0.69
8	$\mathrm{BT} = 1.41\mathrm{THMF}^{0.45}p\text{-}\mathrm{DMBA}^{0.19}\mathrm{TBA}^{-0.01}$	0.63
9	$\mathrm{BT} = 6.84 - 9.87\mathrm{LA} - 0.55\mathrm{FFA} + 4.22\mathrm{TBA} - 3.30\mathrm{Ty} + 0.30\mathrm{THMF}$	0.71
10	$\mathrm{CA} = 183.09\mathrm{TS}^{0.40}\mathrm{F}^{-1.14}\mathrm{P}^{-0.36}\mathrm{L}^{0.14}\mathrm{GG}^{1.06}\mathrm{Tsu}^{-1.02}$	0.88
11	$\mathrm{CA} = 20.04\mathrm{TS}^{-0.44}\mathrm{Tsu}^{-0.01}\mathrm{A}^{0.004}\mathrm{FF}^{-0.01}\mathrm{WDP}^{-0.06}\mathrm{TA}^{-0.39}$	0.92
12	$\mathrm{CA} = 0.04\mathrm{TBA}^{-0.21}\mathrm{THMF}^{0.96}$	0.75
13	$\mathrm{CA} = 4.61 - 1055\mathrm{LA} + 0.01\mathrm{THMF} - 4.71\mathrm{Ty}$	0.87
14	$\mathrm{CA} = 5.17 - 8.07\mathrm{LA} - 0.55\mathrm{FFA} - 1.41\mathrm{TBA} - 3.55\mathrm{Ty} + 0.01\mathrm{THMF}$	0.90
15	$\mathrm{CA} = 1.48\mathrm{LA}^{-0.32}\mathrm{FFA}^{-0.22}\mathrm{TBA}^{-0.02}\mathrm{Ty}^{-0.19}p\text{-}\mathrm{DMAB}^{0.19}$	0.90
16	$\mathrm{CA} = 0.85\mathrm{LA}^{-0.29}\mathrm{FFA}^{-0.21}\mathrm{TBA}^{0.01}\mathrm{Ty}^{-0.18}\mathrm{THMF}^{0.18}p\text{-}\mathrm{DMAB}^{0.17}$	0.90
17	$\mathrm{TSc} = 15.96\mathrm{TS}^{1.28}\mathrm{F}^{-2.35}\mathrm{P}^{-0.05}\mathrm{L}^{1.26}\mathrm{GG}^{0.78}\mathrm{Tsu}^{-0.69}$	0.88
18	$\mathrm{TSc} = 0.95\mathrm{TS}^{0.65}\mathrm{Tsu}^{0.04}\mathrm{A}^{0.11}\mathrm{FF}^{-0.15}\mathrm{WDP}^{-0.09}\mathrm{TA}^{-0.27}$	0.91
19	$\mathrm{TSc} = 36.60p–\mathrm{DMAB}^{0.46}$	0.68
21	$\mathrm{TSc} = 4.76\mathrm{FHMF}^{0.41}$	0.83
22	$\mathrm{TSc} = 19.80 - 28.72\mathrm{LA} - 1.74\mathrm{FFA} + 5.98\mathrm{TBA} - 11.76\mathrm{Ty} + 0.08\mathrm{THMF}$	0.82

results indicate the profound role of the compositional variables in determining the product's sensory attributes.

Compositional characteristics of dudh churpi were regressed against sensory attributes (Table 3). It can be seen that total solids, fat, protein, lactose, glucose-galactose and total sugar contents reflected 71% of the flavour score of dudh churpi (Eq. 1) and the combined effect of total solids, total sugar, ash, free fat, WDP and titratable acidity accounted for 76% variation (Eq. 2). The flavour of dudh churpi was greatly dependent (explaining 59% variation) on the combined effect of lactic acid, total HMF and tyrosine content (Eq. 3) and on the combined effect of lactic acid, FFA, TBA, tyrosine and total HMF (explaining 61% variation; Eq. 4). Significantly adverse effects of FFA and TBA on the flavour of dudh churpi could be associated with the autooxidative products of unsaturated fatty acids, mainly oleic, linoleic and linolenic acids together with phospholipids [24]. The protein-carbohydrate complex or its decomposition products result in the production of reducing substances, fluorescent substances and disagreeable flavour materials which are not desirable in food products during the Maillard reaction [25]. However, these substances seem to influence the characteristic flavour profile of dudh churpi, and consequent to this postulation a high positive correlation ($P < 0.001$) of free and total HMF with flavour was observed.

The body and texture score of dudh churpi was greatly governed by all the compositional characteristics (Eqs. 5–9). Higher heat treatment provides greater activation energy to form higher amounts of free and potential HMF [26] and increases the protein-protein interactions [27–29], leading to higher compactness. This justifies the positive correlation ($P < 0.001$) of *p*-DMAB reactivity and free and total HMF values with body and texture scores of dudh churpi. A high tyrosine content indicates extensive protein hydrolysis, which made the body soft and mellow. This is detrimental to the characteristic body and texture profile of dudh churpi.

The colour and appearance score of dudh churpi was greatly dependent also upon all the compositional characteristics (Eqs. 10–16) and had a better predictability. Total HMF and *p*-DMAB reactivity bore a positve correlation ($P < 0.001$) with total sensory scores of market samples of dudh churpi. The proximate compositional characteristics showed a greater effect.

Thus, the significant impact of chemical compositional variables on sensory attributes provides ample information in determining the sensory characteristics of dudh churpi.

References

1. Hossain SA, Pal PK, Sarkar PK, Patil GR (1996) J Hill Res 9:121–127
2. AOAC (1990) Official methods of analysis of the AOAC, 15th edn. AOAC, Arlington, Va
3. ISI (1981) ISI handbook of analysis, SP:18 (part XI) dairy products. Bureau of Indian Standards, New Delhi
4. Hall CW, Hedrick TI (1971) Drying of milk products. Avi, Westport, Conn
5. ISI (1967) Indian standard specification for canned rasogolla, IS:4079. Bureau of Indian Standards, New Delhi
6. Nickerson TA, Vujicic IF, Lin AY (1976) J Dairy Sci 59:386–390
7. ISI (1965) Indian standard specification for casein (edible quality), IS:4467. Bureau of Indian Standards, New Delhi
8. Harper WJ, Randolph HE (1960) Am Milk Rev 22:43–46
9. ISI (1966) Indian standard methods of sampling and test for ghee (butter fat), IS:3508. Bureau of Indian Standards, New Delhi

10. Sidwell CG, Salwin H, Benca M, Mitchwell JH (1954) J Am Oil Chem Soc 31:603–606
11. Hull ME (1947) J Dairy Sci 29:881–884
12. Keeney M, Bassette R (1959) J Dairy Sci 42:945–960
13. Kumar S, Hansen PMT (1972) J Agric Food Chem 20:1141–1146
14. Snedecor GW, Cochran WG (1989) Statistical methods, 8th edn. Iowa State University Press, Ames, Iowa
15. Croxton FE, Crowden DJ, Klein S (1975) Applied general statistics, 3rd edn. Prentice-Hall of India, New Delhi
16. Ranganadham M, Rajorhia GS (1989) J Dairy Sci 42:558–560
17. Sen DC, Rajorhia GS (1989) Indian J Dairy Sci 42:241–245
18. Kurtz FE (1974)The lipids of milk: composition and properties. In: Webb BH, Johnson AH, Alford JA (eds) Fundamentals of dairy chemistry, 2nd edn. Avi, Westport, Conn, pp 273–324
19. Hansen PMT (1967) J Dairy Sci 50:952
20. Labuza TP, Saltmarch M (1981) J Food Sci 47:92–96
21. Golubovic Z, Nenic M, Karabasenics (1983) Mljekarstvo 33:231–236
22. De S (1980) Outlines of dairy technology. Oxford University Press, New Delhi
23. Turner LB, Swaisgood HE, Hansen AP (1978) J Dairy Sci 61:384–392
24. Kinsella JE, Patton S, Dimick PS (1967) J Am Oil Chem Soc 44:449–454
25. Nickerson TA (1974) Lactose. In: Webb BH, Johnson AH, Alford JA (eds) Fundamentals of dairy chemistry, 2nd edn. Avi, Westport, Conn, pp 273–324
26. Berk Z (1976) Braverman's introduction to the biochemistry of foods, 11th edn. Elsevier, Amsterdam
27. Saio K, Koyama E, Watabe I (1968) Agric Biol Chem 32:448–452
28. Catsimpoolas N, Campbell TG, Meyer EW (1969) Arch Biochem Biophys 131:577–586
29. Catsimpoolas N, Funk SK, Meyer EW (1970) Cereal Chem 47:331–344