4. RESULTS

4.1. Survey on traditional methods of preparation of dudh churpi

Following the survey in Bhutan, Sikkim and Darjeeling, a detailed information was obtained on different traditional methods of prepaaration of dudh churpi (Fig. 4). In the villages of the extreme north of Bhutan, dudh churpi is prepared from yak milk. Dzno, a cross breed of male yak (*Bos mutus*) and indigenous cow, is the common source of milk in the villages of North Sikkim. In Darjeeling, cow milk is used. Traditionally, a bamboo churn, partly similar to mathani, is used in defattening milk. Now a days, most of the producers are using small mechanical cream separators.

4.2. Analysis of market samples of dudh churpi

4.2.1. Chemical analysis

The proximate composition of dudh churpi is given in Table 6. The contents of mean moisture, fat, total protein, lactose, total sugar, ash, titratable acid, pH and energy value of the samples of Darjeeling differed significantly ($P<0.05$) from those of Bhutan and Sikkim. However, in respect of these parameters,the samples of Bhutan and Sikkim did not differ significantly ($P<0.05$). Water-dispersible protein of the samples of all the three sources varied significantly ($P<0.05$). Glucose-galactose content of the samples of Bhutan was significantly ($P<0.05$) lower than the samples of 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 of Darjeeling had

Bhutan and Sikkim

Yak (Bhutan)/dzno (Sikkim) milk

↓

Defatted with bamboo churn

↓

Warmed

↓

Coagulated with previous batch of whey

↓

Whey filtered off

↓

Coagulum cooked in open pan till disappearance of free moisture

↓

Hot cooked curd wrapped in hessian cloth and pressed heavily in a wooden box over night

↓

Cut into pieces, made a ring with a cotton thread and dried over wooden fire for 5-7 days

↓

Partially dried product cooked in concentrated milk with a little amount of sugar

↓

Dried over wooden fire for 25-30 days

↓

Dudh churpi

Darjeeling

Cow/dzno milk

↓

Defatted with bamboo churn

↓

Warmed

↓

Coagulated with previous batch of whey

↓

Whey filtered off

↓

Coagulum pressed heavily for 2-3 h, cut into pieces, wrapped in hessian cloth and stitched

↓

Cut into pieces, made a ring with a cotton thread and dried over wooden fire for 1-2 days

↓

Dipped in hot milk with a little amount of sugar

↓

Dried for 25-30 days

↓

Dudh churpi

Fig. 4. Traditional methods of preparation of dudh churpi

Table 6. Proximate composition of market samples of dudh churpi from three different sources

Constituents	Sources: Bhutan	Sikkim	Darjeeling
Moisture (%)	15.39^{b} (10.82 -18.33)	15.91^{b} (12.86 - 19.82)	18.50^{a} (12.61 - 26.21)
Total fat (%)	9.94^{b} (8.13 - 13.01)	10.01^{b} (6.13 - 12.63)	14.00^{a} (9.63 - 18.93)
Free fat (%)	2.31^{b} (1.71 - 2.69)	2.50^{b} (1.80 - 3.08)	3.50^{a} (2.15 - 3.98)
Total protein (%)	62.35^{a} (58.93 - 66.47)	61.95^{a} (58.50 - 67.06)	58.63^{b} (50.56 - 68.67)
Water- dispersible protein (%)	4.13^{c} (2.12 - 6.32)	4.90^{b} (3.17 - 6.17)	7.90^{a} (6.85 - 8.33)
Lactose (%)	3.59^{a} (2.13 - 4.65)	3.51^{a} (2.11 - 4.81)	1.25^{b} (0.61 - 4.81)
Glucose-galactose (%)	0.93^{b} (0.55 - 1.24)	1.01^{a} (0.74 - 1.39)	1.11^{a} (0.67 - 1.52)
Total sugar (%)	5.23^{a} (3.34 - 6.22)	5.17^{a} (3.44 - 6.45)	2.82^{b} (1.82 - 4.14)
Ash (%)	7.14^{a} (5.38 - 9.11)	7.01^{a} (5.13 - 9.15)	6.11^{b} (3.98 - 8.73)
Titratable acidity (as % lactic acid)	0.31^{b} (0.21 - 0.44)	0.36^{b} (0.24 - 0.52)	1.75^{a} (1.31 - 2.52)
pH	5.43^{a} (4.67 - 5.98)	5.70^{a} (4.52 - 6.22)	4.65^{b} (3.62 - 6.11)
Energy (MJ/100 g)	1.55^{b} (1.38 - 1.75)	1.54^{b} (1.30 - 1.75)	1.60^{a} (1.27 - 1.99)

Data represent the means of 20 samples. Ranges are given in parentheses. Means with different superscripts in each row differ significantly ($P < 0.05$).

significantly ($P<0.05$) higher energy value than those of Bhutan and Sikkim.

Table 7 shows the intrinsic properties of market dudh chupri. The contents of lactic acid, free fatty acid (FFA), 2-thiobarbituric acid (TBA), tyrosine and percent reflectance of the samples of Darjeeling were significantly ($P<0.05$) higher than the samples of two other sources. On the other hand, 5-hydroxymethylfurfural (HMF) and p-dimethylaminobenzaldehyde (p-DMAB) reactivity of the samples of Darjeeling were significantly ($P<0.05$) lower than those of Bhutan and Sikkim. Wheras the contents of lactic acid, FFA, HMF and p-DMAB reactivity of the samples of Sikkim were significantly ($P<0.05$) higher than the samples of Bhutan, percent reflectance of the sample of Sikkim was significantly ($P<0.05$) lower than those of Bhutan.

4.2.2. Sensory analysis

The sensory scores of market samples of dudh churpi are presented in Table 8. The scores of the samples from Bhutan were significatly ($P<0.05$) higher compared to those from other two sources with respect to every sensory attribute. Samples of Darjeeling were criticized by the judges as rancid and brittle. Dudh churpi with high elasticity, firmness, smoothness, gumminess and chewiness, but low crumbliness was rated most desirable, with respect to overall textural quality (Table 9). The samples of Darjeeling had significantly ($P<0.05$) lower scores, with respect to all the textural attributes except crumbliness, than the samples of other two sources. Samples of Bhutan and Sikkim also exhibited significant ($P<0.05$) difference with respect to all the sensory textural attributes.

Table 7. Intrinsic properties of market samples of dudh churpi from three different sources

Parameters	Sources		
	Bhutan	Sikkim	Darjeeling
Lactic acid (%)	0.07^{c} (0.05 - 0.09)	0.09^{b} (0.06 - 0.12)	0.19^{a} (0.12 - 0.25)
Free fatty acid (as % Oleic acid)	0.93^{c} (0.62 - 1.23)	1.22^{b} (0.67 - 2.09)	1.86^{a} (1.11 - 2.46)
2-Thiobarbituric acid value (A_{530})	0.08^{b} (0.06 - 0.13)	0.08^{b} (0.06 - 0.10)	0.11^{a} (0.08 - 0.14)
Tyrosine (mg/g)	0.15^{b} (0.09 - 0.24)	0.16^{b} (0.09 - 0.25)	0.26^{a} (0.15 - 0.28)
Free HMF (μmol/g)	27.88^{b} (20.17 - 34.21)	30.39^{a} (23.56 - 37.94)	10.20^{c} (7.17 - 14.13)
Total HMF (μmol/g)	59.26^{b} (48.19 - 71.17)	62.04^{a} (48.32 - 71.32)	40.15^{c} (30.29 - 50.28)
p-DMAB reactvity (A_{545})	0.20^{b} (0.13 - 0.28)	0.23^{a} (0.15 - 0.32)	0.11^{c} (0.08 - 0.16)
Reflectance (%)	30.75^{b} (26.00 - 35.00)	28.40^{c} (23.00 - 34.00)	41.45^{a} (35.00 -47.00)

Data represent the means of 20 samples. Ranges are given in parentheses. Means with different superscripts in each row differ significantly ($P < 0.05$).

Table 8. Sensory scores of market samples of dudh churpi from three different sources

Attributes	Sources		
	Bhutan	Sikkim	Darjeeling
Flavour	8.35^{a} (6.28 - 9.28)	7.77^{b} (5.86 - 8.86)	5.09^{c} (3.43 - 6.86)
Body and texture	7.62^{a} (6.00 - 8.71)	6.75^{b} (4.00 - 7.86)	4.73^{c} (3.28 - 5.71)
Colour and appearence	4.26^{a} (3.71 - 4.71)	3.61^{b} (2.57 - 4.00)	2.01^{c} (1.29 - 2.43)
Total score	20.23^{a} (17.14 - 22.00)	18.13^{b} (12.71 - 20.00)	11.83^{c} (8.99 - 14.41)

Data represent the means of 20 samples. Ranges are given in parentheses. Means with different superscripts in each row differ significantly ($P < 0.05$).

Table 9. Sensory textural characteristics of market samples of dudh churpi from three different sources

Attributes	Sources		
	Bhutan	Sikkim	Darjeeling
Elasticity	8.10^{a} (6.43 - 9.71)	7.33^{b} (6.28 - 9.00)	7.26^{b} (6.43 - 8.14)
Firmness	8.13^{a} (6.71 - 9.71)	7.60^{b} (6.86 - 9.00)	5.88^{c} (5.00 - 7.00)
Crumbliness	1.36^{c} (0.71 - 2.00)	2.03^{b} (1.28 - 2.43)	4.32^{a} (3.00 - 5.14)
Smoothness	8.11^{a} (6.57 - 9.57)	7.24^{b} (6.42 - 8.85)	5.13^{c} (4.57 - 6.43)
Gumminess	8.28^{a} (7.14 - 9.42)	7.50^{b} (6.57 - 9.00)	5.08^{c} (4.28 - 6.28)
Chewiness	7.62^{a} (6.57 - 8.71)	6.06^{b} (5.00 - 7.42)	5.09^{c} (4.28 - 6.14)
Overall textural quality	8.02^{a} (6.85 - 9.00)	7.46^{b} (6.43 - 9.00)	5.06^{c} (4.00 - 6.00)

Data represent the means of 20 samples. Ranges are given in parentheses. Means with different superscripts in each row differ significantly ($P < 0.05$).

4.2.3. Instrumental analysis

The instrumental textural properties of market samples of dudh churpi are shown in Table 10. Samples of Darjeeling had significantly ($P<0.05$) lower values for all the Instron parameters compared to the samples of two other sources. Significant ($P<0.05$) differences among the samples of Bhutan and Sikkim for all the Instron parameters indicated the extent of textural variability of the market product.

4.2.4. Relationship between sensory attributes and intrinsic parameters

The coefficients of correlations between various sensory attributes and intrinsic parameters of market samples of dudh churpi presented in Table 11 indicate that flavour was negatively correlated ($P<0.001$) with lactic acid, FFA, TBA and tyrosine content (log-log model). Whereas lactic acid alone accounted for 54% variation in flavour, FFA, TBA, and tyrosine content showed much lower effect (Table 12: equations 1,2,3,4). The combined effects of lactic acid and FFA and lactic acid and tyrosine were mostly the same (Table 12: equations 7,8).Flavour scores positively correlated ($P<0.001$) with free HMF, total HMF and p-DMAB reactivity (Table 11). While free HMF alone could explain 61% variation in flavour, total HMF explained much less (Table 12: equations 5,6). The five variables namely lactic acid, FFA, TBA, tyrosine and total HMF jointly explained 62% variability in flavour, indicating that these parameters have no joint effect on flavour.

Body and texture scores of dudh churpi tended to decline with increasing lactic acid, FFA, TBA and tyrosine content, but showed a significant ($P<0.001$) positive correlation with free HMF, total HMF and p-

Table 10. Instrumental textural properties of market samples of dudh churpi from three different sources

Attributes	Sources: Bhutan	Sikkim	Darjeeling
Hardness(N)	363.50[a] (238.00 - 507.00)	207.65[b] (142.00 - 296.00)	163.30[c] (118.00 - 214.00)
Cohesiveness	0.52[a] (0.35 - 0.78)	0.41[b] (0.38 - 0.58)	0.30[c] (0.23 - 0.46)
Springiness (mm)	1.05[a] (0.70 - 1.85)	0.93[b] (0.70 - 1.10)	0.73[c] (0.55 - 0.85)
Gumminess (N)	179.46[a] (78.20 - 365.40)	105.70[b] (60.68 - 168.72)	84.99[b] (42.35 - 145.52)
Chewiness (N.mm)	130.24[a] (62.56 - 310.59)	104.48[b] (69.52 - 145.90)	78.35[c] (33.88 - 138.24)

Data represent the means of 20 samples. Ranges are given in parentheses. Means with different superscripts in each row differ significantly ($P < 0.05$).

Table 11. Coefficients of correlations between sensory scores and intrinsic parameters of market samples of dudh churpi

	Sensory attributes			
Intrinsic parameters	Flavour	Body and texture	Colour and appearance	Total score
Lactic acid	-0.731 (-0.713)	-0.663 (-0.648)	-0.837 (-0.832)	-0.772 (-0.759)
Total HMF	0.678 (0.655)	0.607 (0.595)	0.725 (0.741)	0.700 (0.692)
Free HMF	0.766 (0.780)	0.711 (0.734)	0.815 (0.857)	0.799 (0.828)
Free fatty acid	-0.618 (-0.602)	-0.559 (-0.547)	-0.740 (-0.731)	-0.660 (-0.651)
2-Thiobarbituric acid value	-0.494 (-0.475)	-0.433 (-0.425)	-0.589 (-0.568)	-0.521 (-0.509)
Tyrosine	-0.536 (-0.507)	-0.469 (-0.447)	-0.618 (-0.578)	-0.560 (-0.535)
p-DMAB reactivity	0.583 (0.651)	0.493 (0.561)	0.638 (0.733)	0.594 (0.675)

Figures in parentheses are coefficients of correlations for log-linear relationships. Values are significant at $P<0.001$ (58 d.f.).

Table 12. Regression equations for sensory scores as related to intrinsic parameters of market samples of dudh churpi

Equations*	Coefficient of correlation (R)**
1. $FI = 9.59 - 21.73LA$	0.73
2. $FI = 9.79 - 2.04FFA$	0.62
3. $FI = 10.31 - 3.49TBA$	0.49
4. $FI = 10.17 - 17.54Ty$	0.54
5. $FI = 0.74FHMF^{0.39}$	0.78
6. $FI = 1.74 + 0.10THMF$	0.68
7. $FI = 10.15 - 16.90LA - 0.84FFA$	0.76
8. $FI = 10.47 - 18.40LA - 7.13Ty$	0.76
9. $FI = 7.75 - 13.06LA + 0.04THMF - 6.35Ty$	0.77
10. $FI = 7.80 - 10.88LA - 0.64FFA + 3.17TBA - 4.90Ty + 0.04THMF$	0.78
11. $BT = 8.46 - 18.01LA$	0.66
12. $BT = 8.61 - 1.68FFA$	0.56
13. $BT = 8.97 - 28.47TBA$	0.43***
14. $BT = 8.84 - 14.01Ty$	0.47
15. $BT = 2.00 + 0.08THMF$	0.61
16. $BT = 0.73FHMF^{0.36}$	0.73
17. $BT = 8.91 - 14.06LA - 0.68FFA$	0.69
18. $BT = 9.09 - 15.59LA - 5.19Ty$	0.68

Table 12. Continued

Equations*	Coefficient of correlation (R)**
19. $BT=6.17-13.04LA+0.03THMF$	0.68
20. $BT=0.35THMF^{0.46}.pDMAB^{0.19}$	0.63
21. $BT=6.98-11.45LA+0.03THMF-4.59Ty$	0.69
22. $BT=0.34THMF^{0.45}.pDMAB^{0.19}.TBA^{-0.01}$	0.63
23. $BT=6.84-9.78LA-0.55FFA+4.22TBA-3.30Ty+0.30THMF$	0.71
24. $CA=5.02-14.90LA$	0.84
25. $CA=5.24-1.46FFA$	0.74
26. $CA=-0.73TBA^{-0.77}$	0.57
27. $CA=-0.52FHMF^{0.55}$	0.86
28. $CA=-3.28THMF^{1.11}$	0.74
29. $CA=2.30pDMAB^{0.65}$	0.73
30. $CA=5.47-10.96LA-0.68FFA$	0.88
31. $CA=-1.47LA^{-0.48}.THMF^{0.38}$	0.85
32. $CA=-3.19TBA^{-0.21}.THMF^{0.96}$	0.75
33. $CA=4.61-10.55LA+0.01THMF-4.71Ty$	0.87
34. $CA=5.17-8.07LA-0.55FFA-1.41TBA-3.55Ty+0.01THMF$	0.90
35. $CA=0.39LA^{-0.32}.FFA^{-0.22}.TBA^{-0.02}.Ty^{-0.19}.pDMAB^{0.19}$	0.90
36. $CA=-0.16LA^{-0.29}.FFA^{-0.21}.TBA^{0.01}.Ty^{-0.18}.THMF^{0.18}.pDMAB^{0.17}$	0.90

Table 12. Continued

Equations*	Coefficient of correlation (R)**
37. $TSc = 1.79LA^{-0.44}$	0.76
38. $TSc = 1.56FHMF^{0.41}$	0.81
39. $TSc = 3.62+0.24THMF$	0.70
40. $TSc = 3.60pDMAB^{0.46}$	0.68
41. $TSc = 24.53-41.92LA-2.20FFA$	0.80
42. $TSc = 16.55-40.48LA+0.09THMF$	0.79
43. $TSc = 19.34-35.06LA+0.08THMF-15.64Ty$	0.81
44. $TSc = 19.80-28.72LA-1.74FFA+5.98TBA-11.76TY+.0.08THMF$	0.82

*Fl, flavour

LA, lactic acid

FFA, free fatty acid

TBA, 2-thiobarbituric acid

Ty, tyrosine

FHMF, free hydroxymethylfurfural

THMF, total hydroxymethylfurfural

BT, body and texture

pDMAB, p-dimethylaminobenzaldehyde reactivity

CA, colour and appearance

TSc, total score

** Significant at $P<0.001$

*** Significant at $P<0.01$

DMAB reactivity (Table 11). Whereas lactic acid explained 44% variation in body and texture, free HMF showed a much greater effect (Table 12: equations 11,16). The combined effect of lactic acid, FFA, TBA, tyrosine and total HMF did not predict better than that predicted by free HMF alone (Table 12: equation 23).

The colour and appearance scores of dudh churpi were greatly dependent upon all the intrinsic parameters (Table 11). Relevant regression equations showed that free HMF alone could account for 74% colour and appearance scores and lactic acid alone for 70% (Table 12: equations 27,24). Whereas lactic acid and FFA jointly explained 77% variation in colour and appearance, the combined effect of total HMF and tyrosine explained 76% variation (Table 12: equations 30,33). All the intrinsic parameters taken together explained 81% variability in colour and appearance scores of market samples of dudh churpi (Table 12: equation 36).

The total score of dudh churpi was negatively influenced by lactic acid, FFA, TBA and tyrosine content of dudh churpi (Table 11). Free HMF, total HMF and p-DMAB reactivity bore a positive correlation ($P<0.001$) with total scores of market samples of dudh churpi (Table 11). Whereas lactic acid alone accounted for 58% variation in total scores, free HMF showed a slightly greater effect (Table 12: equation 37,38). All the intrinsic parameters jointly explained 68% variation in total scores of market samples of dudh churpi.

4.2.5. Relationship between chemical composition and Instron parameters

Table 13 shows the coefficients of correlations between various texture profile parameters and compositional characteristics of dudh churpi. Instron hardness was positively correlated ($P<0.01$) with total solids. Water-dispersible

Table 13. Coefficients of correlations between proximate composition and Instron parameters of market samples of dudh churpi (58 d.f.)

Compositional variables	Hardness	Instron parameters			
		Cohesiveness	Springiness	Gumminess	Chewiness
Total solids	0.339** (0.383)**	0.010 (-0.035)	-0.194 (-0.234)	0.321* (0.331)**	0.264* (0.260)*
Total fat	-0.372** (-0.381)**	-0.056 (-0.072)	-0.015 (0.004)	-0.342** (-0.385)**	-0.356** (-0.427)**
Free fat	-0.539** (-0.578)**	-0.038 (-0.068)	0.189 (0.280)*	-0.498** (-0.562)**	-0.451** (-0.506)**
Total protein	0.319* (0.364)**	0.002 (0.018)	-0.034 (-0.086)	0.275* (0.323)*	0.265 (0.313)*
Water-dispersible protein	-0.589** (-0.635)**	-0.003 (-0.022)	-0.248 (0.355)**	-0.487** (-0.590)**	-0.397** (-0.491)**
Total sugar	0.479** (0.577)**	-0.098 (-0.097)	0.092 (0.015)	0.392** (0.475)**	0.364** (0.459)**
Titratable acidity	-0.544** (-0.637)**	0.146 (0.119)	0.110 (0.190)	-0.414** (-0.518)**	-0.393** (-0.492)**

Figures in parentheses are coefficients of correlations for log-linear relationships.

*Significant at P<0.05

**Significant at P<0.01

protein (WDP) showed a greater but equally significant negative correlation with hardness. The log linear relationship exhibited greater correlations as compared to linear ralationships for all chemical parameters affecting hardness. Whereas total solids alone accounted for 15% variation in hardness, WDP showed a much greater effect (40%) (Table 14: equations 1,3). The combined effect of total solids and WDP was near the combined effects of total sugar and WDP, and total sugar, WDP and free fat (Table 14: equations 7,9,11). These regressions provided slightly better prediction of hardness than that based on WDP alone.

Cohesiveness tended to decline with increasing total solids and so with increasing total fat, free fat, WDP and toal sugar contents (Table 13). The positive correlation of cohesiveness with total protein and titratable acidity were much smaller and non-significant. Regression analysis indicated that all the compositional parameters taken together explained only 23% variation in cohesiveness (Table 14: equation 16).

Springiness did not seem to be influenced by the compositional variables studied, although its correlation with WDP appeared to be appreciable (Table 13).

Gumminess was greatly dependent upon fat, WDP, total sugar and titratable acidity (Table 13). The coefficients of correlation are higher for the log-log model. Relevant regression equations showed that WDP alone could account for 35% gumminess, whereas titratable acidity accounted for 27% gumminess (Table 14: equations 24,25). The combined effect of total sugar, titratable acidity, free fat and WDP was higher (Table 14: equation 27).

Chewiness showed less dependence on the compositional parameters than gumminess. Combination of total solids, total fat, total protein, total sugar, free fat and WDP predicted better chewiness than any other single parameter (Table 14: equations 35, 30-32).

Table 14. Regression equations for Instron texture parameters as related to composition of market samples of dudh churp

Equations*	Coefficient of Correlation (R)**
1. $H = -12.90TS^{4.14}$	0.38
2. $H = -4.60P^{2.44}$	0.36
3. $H = 6.67WDP^{-0.74}$	0.64***
4. $H = 6.93F^{-0.63}$	0.38
5. $H = 6.38FF^{-0.97}$	0.58***
6. $H = 4.50TSu^{0.64}$	0.58***
7. $H = -1.12TS^{1.73}.WDP^{-0.67}$	0.65***
8. $H = -0.04TS^{1.15}.TSu^{0.59}$	0.58***
9. $H = 5.85TSu^{0.32}.WDP^{-0.53}$	0.67***
10. $H = 5.81TSu^{0.17}.WDP^{-0.41}.TA^{-0.11}$	0.68***
11. $H = 6.09TSu^{-0.19}.FF^{-0.27}.WDP^{-0.45}$	0.68***
12. $H = 1.66TS^{1.02}.TA^{-0.12}.FF^{-0.21}.WDP^{-0.36}$	0.69***
13. $H = 3.76TS^{-2.25}.F^{0.57}.P^{2.53}.TSu^{0.29}.TA^{-0.15}.WDP^{-0.38}$	0.70***
14. $C = 0.54+0.01P+0.12TA-0.06FF-0.02WDP$	0.36
15. $C = 0.78-0.01F+0.13TA-0.06FF-0.02WDP$	0.39
16. $C = 0.23+0.03TS-0.04F-0.03P-0.04TSu+0.12TA-0.02WDP$	0.48***
17. $Spr = 0.38FF^{0.26}$	0.28

Table 14. Continued

Equations*	Coefficient of correlation (R)**
18. $Spr = 0.51WDP^{0.23}$	0.36
19. $Spr = 5.03TS^{-2.97}.F^{0.07}.P^{1.63}.TSu^{0.03}.FF^{0.20}.WDP^{0.30}$	0.49***
20. $Spr = 5.47TS^{-2.94}.F^{0.07}.P^{1.53}.TSu^{0.26}.TA^{0.02}.WDP^{0.34}$	0.46
21. $G = -12.65TS^{3.93}$	0.33
22. $G = -5.02P^{2.37}$	0.32
23. $G = 3.89TSu^{0.\text{[illegible]}8}$	0.48***
24. $G = 5.99WDP^{-0.76}$	0.59***
25. $G = 4.56TA^{-0.27}$	0.52***
26. $G = 2.35TS^{0.83}.FF^{-0.50}.WDP^{-0.48}$	0.63***
27. $G = 5.98TSu^{0.10}.TA^{0.04}.FF^{-0.53}.WDP^{-0.51}$	0.63***
28. $G = 4.44P^{0.49}.TA^{0.02}.FF^{-0.54}.WDP^{-0.50}$	0.63
29. $G = 0.55TS^{2.59}.F^{-0.44}.P^{-1.19}.TSu^{0.08}.TA^{0.05}.WDP^{-0.61}$	0.61***
30. $Ch = -3.29P^{1.92}$	0.31
31. $Ch = 3.91TSu^{1.47}$	0.46***
32. $Ch = 5.46WDP^{-0.52}$	0.49***
33. $Ch = 5.17TSu^{0.14}.FF^{-0.39}.WDP^{-0.24}$	0.55***
34. $Ch = 5.31FF^{-0.40}.WDP^{-0.22}.TA^{-0.06}$	0.55***
35. $Ch = 5.16TS^{0.62}.F^{-0.35}.P^{-0.47}.TSu^{0.08}.FF^{-0.33}.WDP^{-0.18}$	0.57***

Table 14. Continued

Equations*	Coefficient of correlation (R)**
36. $Ch = 4.62 TS^{0.60} . F^{-0.42} . P^{-0.36} . TSu^{0.22} . TA^{0.04} . WDP^{-0.30}$	0.55***

*H, hardness

TS, total solids

P, total protein

WDP, water-dispersible protein

F, total fat

FF, free fat

TSu, total sugar

TA, titratable acidity

C, cohesiveness

Spr, springiness

G, gumminess

Ch, chewiness

** Significant at $P<0.01$

*** Significant at $P<0.001$

A negative correlation was observed between hardness and cohesiveness (Table 15). But gumminess and chewiness bore the opposite relationships with hardness (P<0.001). Cohesiveness exhibited negative correlation with springiness but significant (P<0.001) positive correlation with gumminess and chewiness. Chewiness showed a significant positive correlation (P<0.001) with gumminess but a less significant (P<0.01) negative correlation with springiness exhibiting a more chewy and less springy dudh churpi.

4.2.6. Relationship between sensory textural descriptors and Instron texture profile

Correlations between sensory texture descriptors and instrumental texture parameters of dudh churpi are given in Table 16. The sensory firmness was highly correlated (P<0.001) with Instron hardness. The log-linear relationship was appreciably higher than the linear one. Instron hardness reflected 42% sensory firmness (Table 17: equation 1). Instron hardness also showed significant (P<0.001) positive correlation with sensory elasticity, smoothness, gumminess, chewiness and overall textural quality, and negative correlation (P<0.001) with crumbliness (Table 16). The correlation being higher for log-log model in all the cases excepting sensory elasticity. Thus, hardness could account for 56% crumbliness, 26% elasticity, 48% smoothness, 49% sensory gumminess, 55% sensory chewiness and 43% overall textural quality (Table 17: equations 9,17,22,25,30,39).

Cohesiveness measured by Instron was not significantly correlated with any of the sensory textural descriptors (Table 16).

Instrumental springiness bore no significant correlation with firmness, smoothness, sensory gumminess and overall textural quality (Table 16). However, this was positively correlated (P<0.01) with crumbliness and

Table 15. Coefficients of correlations among different Instron texture parameters of market samples of dudh churpi (58 d.f.)

Parameters	Hardness	Cohesiveness	Springiness	Gumminess	Chewiness
Hardness	1.000 (1.000)				
Cohesiveness	-0.072 (-0.107)	1.000 (1.000)			
Springiness	-0.465* (-0.530)*	-0.102 (-0.077)	1.000 (1.000)		
Gumminess	0.960* (0.855)*	0.455* (0.424)*	-0.451* (-0.571)*	1.000 (1.000)	
Chewiness	0.849* (0.724)*	0.469* (0.466)*	-0.123 (-0.315)**	0.904* (0.906)*	1.000 (1.000)

Figures in parentheses are coefficients of correlations for log-linear relationships.

*Significant at $P<0.001$

**Significant at $P<0.01$

Table 16. Coefficients of correlations between sensory texture descriptors and Instron texture parameters of market samples of dudh churpi (58 d.f.)

Instron parameters	Sensory texture descriptors						
	Firmness	Crumbliness	Elasticity	Smoothness	Gumminess	Chewiness	Overall textural quality
Hardness	0.612* (0.652)*	-0.637* (-0.745)*	0.513* (0.495)*	0.666* (0.696)*	0.660* (0.703)*	0.715* (0.745)*	0.574* (0.656)*
Cohesiveness	-0.051 (-0.068)	0.001 (-0.007)	0.003 (-0.023)	-0.056 (-0.081)	-0.064 (-0.083)	-0.099 (-0.127)	-0.045 (-0.065)
Springiness	-0.164 (-0.170)	0.258** (0.403)*	-0.317** (-0.308)**	-0.219 (-0.237)	-0.192 (-0.223)	-0.305** (-0.361)*	-0.143 (-0.190)
Gumminess	0.511* (0.558)*	-0.553* (-0.682)*	0.449* (0.439)*	0.548* (0.592)*	0.536* (0.597)*	0.570* (0.613)*	0.471* (0.663)*
Chewiness	0.529* (0.565)*	-0.482* (-0.567)*	0.427* (0.372)*	0.522* (0.560)*	0.517* (0.566)*	0.449* (0.501)*	0.436* (0.541)*

Figures in parentheses are coefficients of correlations for log-linear relationships.

*Significant at $P<0.01$
**Significant at $P<0.05$

Table 17. Regression equations between sensory texure descriptors and Instron texture profile of market samples of dudh churpi

Equations*	Coefficient of correlation (R)**
1. $Fr = 0.42H^{0.28}$	0.65
2. $Fr = 0.91G^{0.27}$	0.56
3. $Fr = 0.42H^{0.28}.C^{0.01}$	0.65
4. $Fr = 0.15H^{0.34}.Spr^{0.18}$	0.68
5. $Fr = 0.06C^{-0.32}.Ch^{0.36}$	0.68
6. $Fr = 0.16H^{0.17}.C^{0.17}.Spr^{0.03}.G^{0.18}$	0.68
7. $Fr = 0.16H^{0.19}.C^{0.15}.Spr^{0.03}.Ch^{0.18}$	0.68
8. $Fr = 0.14H^{-12.05}.C^{1.18}.Spr^{-13.55}.G^{0.18}.Ch^{13.57}$	0.68
9. $Cr = 6.25H^{-1.0}$	0.75
10. $Cr = 0.93Spr^{0.9}$	0.40***
11. $Cr = 4.76G^{-0.84}$	0.68
12. $Cr = 6.17H^{-1.02}.C^{-0.21}$	0.75
13. $Cr = 0.98C^{0.06}.Spr^{0.99}$	0.40***
14. $Cr = 6.02H^{-1.18}.C^{-104.37}.G^{-104.34}.Ch^{104.52}$	0.77
15. $Cr = 6.28H^{-0.85}.Spr^{0.27}.G^{-0.10}.Ch^{-0.20}$	0.76
16. $Cr = 6.14^{-94.58}.C^{-10.31}.Spr^{-104.10}.G^{-0.09}.Ch^{103.88}$	0.77
17. $El = 6.60+0.01H$	0.51
18. $El = 8.57-1.22Spr$	0.32***

Table 17. Continued

Equations*	Coefficient of correlation (R)**
19. $El = 7.07 + 0.01H - 0.42Spr$	0.52
20. $El = 8.82 - 0.01H - 2.36C - 1.23Spr + 0.01Ch$	0.56
21. $El = 8.49 + 0.001H - 1.28C - 1.55Spr - 0.01G + 0.02Ch$	0.57
22. $Sm = -0.18H^{0.38}$	0.70
23. $Sm = -0.43H^{0.43}.Spr^{0.17}$	0.71
24. $Sm = -0.47H^{-34.54}.C^{-3.68}.Spr^{-38.60}.G^{0.18}.Ch^{38.66}$	0.72
25. $SG = -0.33H^{0.41}$	0.70
26. $SG = -0.62H^{0.47}.Spr^{0.21}$	0.72
27. $SG = 0.40G^{0.32}$	0.60
28. $SG = -0.37H^{0.33}.C^{-35.11}.G^{-35.22}.Ch^{35.21}$	0.71
29. $SG = -0.69H^{-32.86}.C^{-3.46}.Spr^{-36.80}.G^{0.23}.Ch^{36.81}$	0.73
30. $SCh = -0.19H^{0.37}$	0.74
31. $SCh = 0.51G^{0.28}$	0.61
32. $SCh = 0.57Ch^{0.27}$	0.50
33. $SCh = -0.20H^{0.37}.C^{-0.04}$	0.75
34. $SCh = -0.20H^{0.41}.G^{-0.04}$	0.75
35. $SCh = -0.15H^{0.39}.Ch^{-0.04}$	0.75
36. $SCh = 0.65G^{0.37}.Ch^{-0.13}$	0.62

Table 17. Continued

Equations*	Coefficient of correlation (R)**
37. $SCh = -0.23H^{0.34}.C^{-24.16}.G^{-24.23}.Ch^{24.18}$	0.75
38. $SCh = -0.27H^{-21.63}.C^{-2.40}.Spr^{-24.45}.G^{0.03}.Ch^{24.41}$	0.75
39. $OTQ = -0.11H^{0.37}$	0.66
40. $OTQ = 0.53G^{0.29}$	0.56
41. $OTQ = 0.36Ch^{0.33}$	0.54
42. $OTQ = -0.42H^{0.43}.Spr^{0.21}$	0.68
43. $OTQ = -0.11H^{0.37}.C^{0.01}$	0.66
44. $OTQ = 0.41G^{0.20}.Ch^{0.11}$	0.57
45. $OTQ = -0.43H^{0.24}.C^{0.20}.Spr^{0.03}.G^{0.23}$	0.68
46. $OTQ = -0.47H^{-33.08}.C^{-3.47}.Spr^{-36.98}.G^{0.23}.Ch^{37.00}$	0.69

*Fr, firmness

H, hardness

G, gumminess (Instron)

C, cohesiveness

Spr, springiness

Ch, chewiness (Instron)

Cr, crumbliness

El, elasticity

Sm, smoothness

SG, sensory gumminess

SCh, sensory chewiness

OTQ, overall textural quality

** Significant at P<0.001

*** Significant at P<0.01

negatively correlated ($P<0.05$) with elasticity. Springiness alone predicted 16% crumbliness and only 10% elasticity (Table 17: equations 10,18). Coupled with hardness, springness explained 46% firmness, and in combination with hardness, cohesiveness, gumminess and chewiness explained 59% crumbliness, 52% smoothness, 53% sensory gumminess, 56% sensory chewiness and 47% overall textural quality (Table 17: equations 4,14,24,29,38,46).

Instron gumminess and Instron chewiness showed a positive correlation ($P<0.01$) with all the sensory texture descriptors except crumbliness (Table 16). The correlations were higher for log-log model, excepting with elasticity. Thus, gumminess explained 31% firmness, 47% crumbliness, 36% sensory gumminess, 38% sensory chewiness and 32% overall textural quality (Table 17: equations 2,11,27,31,40). Instrumental chewiness, when correlated with sensory chewiness, explained only 25% variability (Table 17: equation 32). Sensory chewiness was better predicted jointly either by hardness and cohesiveness, hardness and gumminess, hardness and chewiness. Combination of all the instrumental parameters did not improve the predictability of the sensory chewiness (Table 17: equations 33,34,35,38). Whereas Instron hardness coupled with cohesiveness explained 43% and with springness explained 46% overall sensory texture score (Table 17: equation 43,42), 47% of the same could be explained by all the Instron texture parameters taken together (Table 17: equation 46).

4.3. Optimization of process parameters in the manufacture of dudh churpi

4.3.1. Milk used for cooking prechurpi

4.3.1.1. Fat level

The influence of different fat levels in cow milk, used for cooking, on the sensory attributes of dudh churpi is shown in Table 18. Prechurpi when cooked in milk of 1% fat scored significantly ($P<0.05$) higher with respect to each sensory attribute than the samples cooked in milk of 2.0 and 3.0% fat. It had the desired body, smooth texture and characteristic flavour. Dudh churpi prepared by cow skim milk of 0.1% fat was criticized as having flat flavour. However, these samples did not differ significantly ($P<0.05$) with respect to body, texture, colour and appearance with the samples, cooked in milk of 1.0% fat. The samples of dudh churpi, cooked in milk of 2.0 and 3.0% fat, were criticized as having slight to pronounced rancid flavour and soft body.

Instrumental analysis of dudh churpi, cooked in milk of different fat levels showed that the mean values of almost all the instrumental parameters of dudh churpi cooked in skim milk of 0.1% fat were significantly ($P<0.05$) higher than the samples cooked in milk of other fat levels (Table 19). While hardness, cohesiveness, gumminess and chewiness varied almost inversely with increase in fat level of milk used for cooking, except springiness which showed an opposite effect.

The chemical composition of dudh churpi as influenced by different fat levels in milk, used for cooking, is presented in Table 20. The moisture content of dudh churpi varied almost inversely with fat level in milk. However, total fat, free fat, total protein, lactose, total sugar and ash increased with the increase in fat level.

Fat levels in milk used for cooking had no significant ($P<0.05$) relation with lactic acid, tyrosine and p-DMAB reactivity of dudh churpi (Table 21). While FFA and TBA values increased with the increase in fat level, free and total HMF values decreased correspondingly.

Table 18. Sensory attributes of dudh churpi as influenced by fat level in milk used for cooking

Attributes	Fat content (%)			
	0.1	1.0	2.0	3.0
Flavour	7.00[b] (6.71 - 7.28)	8.35[a] (8.28 - 8.43)	7.65[b] (7.43 - 7.71)	6.00[c] (5.86 - 6.14)
Body and texture	8.00[a] (7.86 - 8.14)	8.00[a] (7.86 - 8.14)	7.46[b] (7.28 - 7.71)	6.00[c] (5.86 - 6.14)
Colour and appearance	4.75[a] (4.71 - 4.86)	4.82[a] (4.71 - 4.86)	3.68[b] (3.57 - 3.86)	3.07[c] (2.86 - 3.28)
Total score	19.75[b] (19.28 - 20.28)	21.17[a] (21.14 - 21.28)	18.79[b] (18.28 - 19.28)	15.07[c] (14.86-15.56)

Data represent the means of four replicates. Ranges are given in parentheses. Values bearing different superscripts in each row differ significantly ($P < 0.05$).

Table 19. Instrumental texture profile of dudh churpi as influenced by fat level in milk used for cooking

Attributes	Fat (%)			
	0.1	1.0	2.0	3.0
Hardness (N)	405.25[a] (396.00-417.00)	361.75[b] (354.00-372.00)	345.25[b] (341.00-349.00)	326.00[c] (305.00-340.00)
Cohesiveness	0.63[a] (0.58-0.67)	0.59[ab] (0.57-0.62)	0.56[b] (0.53-0.58)	0.46[c] (0.44-0.48)
Springiness (mm)	0.66[c] (0.60-0.70)	0.71[bc] (0.65-0.75)	0.75[ab] (0.70-0.80)	0.81[a] (0.75-0.85)
Gumminess (N)	255.30[a] (231.42-274.03)	213.52[b] (204.63-230.64)	193.34[c] (182.85-202.42)	149.80[d] (146.40-156.04)
Chewiness (N.mm)	169.08[a] (152.62-191.82)	152.14[ab] (133.01-161.45)	145.25[b] (128.00-161.94)	121.75[c] (112.20-132.63)

Data represent the means of four replicates. Ranges are given in parentheses. Values bearing different superscripts in each row differ significantly ($P<0.05$).

Table 20. Chemical parameters of dudh churpi as influenced by fat level in milk used for cooking

Parameters	Fat (%)			
	0.1	1.0	2.0	3.0
Moisture (%)	16.03^{a} (15.93 - 16.08)	15.41^{b} (15.36 - 15.46)	14.93^{c} (14.91 - 14.96)	13.88^{d} (13.86 - 13.90)
Total fat (%)	7.67^{d} (7.62 - 7.71)	7.80^{c} (7.78 - 7.82)	8.06^{b} (8.04 - 8.08)	8.39^{a} (8.37 - 8.41)
Free fat (%)	1.65^{d} (1.63 - 1.67)	2.12^{c} (2.08 - 2.16)	2.96^{b} (2.94 - 2.98)	3.05^{a} (3.02 - 3.08)
Total protein (%)	64.53^{c} (64.49 - 64.56)	64.96^{b} (64.90 - 65.02)	64.98^{b} (64.94 - 65.06)	65.56^{a} (65.47 - 65.61)
Water- dispersible protein (%)	4.15^{a} (4.12 - 4.18)	4.16^{a} (4.11 - 4.21)	4.17^{a} (4.15 - 4.19)	4.17^{a} (4.11 - 4.23)
Lactose (%)	3.14^{b} (3.10 - 3.18)	3.16^{b} (3.13 - 3.18)	3.17^{b} (3.13 - 3.21)	3.22^{a} (3.20 - 3.24)
Glucose-galactose (%)	0.76^{a} (0.72 - 0.79)	0.76^{a} (0.74 - 0.78)	0.77^{a} (0.75- 0.79)	0.78^{a} (0.76 - 0.80)
Total sugar (%)	4.92^{b} (4.88 - 4.98)	4.94^{b} (4.92 - 4.96)	5.10^{a} (5.08 - 5.12)	5.15^{a} (5.11 - 5.19)
Ash (%)	6.85^{c} (6.87 - 6.83)	6.90^{b} (6.88 - 6.92)	6.93^{b} (6.91 - 6.95)	7.02^{a} (7.01 - 7.03)
Titratatable acidity (as % lactic acid)	0.31^{a} (0.30 - 0.32)	0.31^{a} (0.29 - 0.33)	0.32^{a} (0.30 - 0.34)	0.33^{a} (0.31 - 0.35)
pH	5.45^{a} (5.41 - 5.47)	5.45^{a} (5.41 - 5.47)	5.42^{ab} (5.40 - 5.44)	5.39^{b} (5.36 - 5.42)

Data represent the means of four replicates. Ranges are given in parentheses. Values bearing different superscripts in each row differ significantly ($P < 0.05$).

Table 21. Intrinsic parameters of dudh churpi as influenced by fat level in milk used for cooking

Attributes	Fat (%)			
	0.1	1.0	2.0	3.0
Lactic acid (%)	0.04^{a} (0.03-0.05)	0.04^{a} (0.03-0.05)	0.05^{a} (0.04-0.06)	0.05^{a} (0.04-0.06)
Free fatty acid (as % oleic acid)	0.85^{d} (0.83-0.87)	0.95^{c} (0.93-0.97)	1.09^{b} (1.03-1.15)	1.22^{a} (1.20-1.24)
2-Thiobarbituric acid value (A_{530})	0.02^{d} (0.02-0.03)	0.06^{c} (0.05-0.07)	0.08^{b} (0.07-0.09)	0.09^{a} (0.09-0.10)
Tyrosine (mg/g)	0.16^{a} (0.15-0.17)	0.16^{a} (0.15-0.17)	0.15^{a} (0.13-0.17)	0.14^{a} (0.12-0.16)
Free HMF (μmol/g)	27.89^{a} (27.83-27.95)	27.69^{b} (27.65-27.73)	27.61^{c} (27.59-27.63)	27.64^{c} (27.61-27.66)
Total HMF (μmol/g)	59.26^{a} (59.24-59.28)	59.11^{b} (59.06-59.16)	59.03^{c} (59.01-59.05)	58.93^{d} (58.91-58.97)
p-DMAB reactivity (A_{545})	0.22^{a} (0.20-0.24)	0.21^{a} (0.19-0.23)	0.21^{a} (0.20-0.22)	0.20^{a} (0.18-0.22)

Data represent the means of four replicates. Ranges are given in parentheses. Values bearing different superscripts in each row differ significantly (P<0.05).

4.3.1.2. Sugar concentration

Prechurpi was cooked in milk of 1.0% fat, but varying concentrations of sugar. The sensory scores of each attribute increased with the increase in sugar concentration upto 2.0%, but declined significantly ($P<0.05$) when the concentration of sugar increased to 3.0% (Table 22).

The mean values for all the instrumental parameters of dudh churpi, cooked in milk of 2.0% sugar, were higher compared to the products cooked in milk of 0, 1.0 and 3.0% sugar (Table 23).

Variation in the concentration of sugar had no influence on the intrinsic parameters of dudh churpi, excepting FFA and HMF (Table 24) which increased in sugar concentration.

4.3.1.3. Total solids content

Milk of 1.0% fat and 2.0% sugar was concentrated to different total solids content ranging from 11.70 to 29.25% and used for cooking prechurpi. All the sensery attributes increased almost significantly ($P<0.05$) with the increase in total solids content (Table 25).

The mean values for Instron parameters increased with the increase in total solids content of milk (Table 26). But, no significant ($P<0.05$) difference was observed among the products when the total solids contents of milk were 23.4% and 29.25%.

4.3.2. Duration of prechurpi cooking time

Prechurpi was cooked in milk of 1.0% fat, 2.0% sugar and 29.25% total

Table 22. Sensory atributes of dudh churpi as influenced by sugar level in milk used for cooking

Attributes	Sugar (%)			
	0	1.0	2.0	3.0
Flavour	7.18^{d} (7.00-7.28)	7.90^{b} (7.86-8.00)	8.36^{a} (8.28-8.43)	7.61^{c} (7.57-7.71)
Body and texture	6.96^{d} (6.86-7.14)	7.74^{b} (7.71-7.86)	8.00^{a} (7.86-8.14)	7.50^{c} (7.73-7.57)
Colour and appearance	3.35^{d} (3.38-3.43)	4.50^{b} (4.43-4.57)	4.81^{a} (4.71-4.86)	3.78^{c} (3.71-3.86)
Total score	17.50^{d} (17.29-17.70)	20.14^{b} (20.00-20.28)	21.17^{a} (21.14-21.28)	18.89^{c} (18.71-19.00)

Data represent the means of four replicates. Ranges are given in parentheses. Values bearing different superscripts in each row differ significantly ($P<0.05$).

Table 23. Instrumental texture profie of dudh as influenced by sugar level in milk used for cooking

Attributes	Sugar (%) 0	1.0	2.0	3.0
Hardness (N)	293.25^{c} (283.00-312.00)	325.50^{b} (321.00-332.00)	361.75^{a} (354.00-372.00)	329.00^{b} (309.00-340.00)
Cohesiveness	0.53^{b} (0.52-0.54)	0.55^{b} (0.53-0.58)	0.59^{a} (0.57-0.62)	0.58^{a} (0.56-0.60)
Springiness (mm)	0.63^{b} (0.60-0.65)	0.69^{ab} (0.65-0.75)	0.71^{a} (0.65-0.75)	0.74^{a} (0.70-0.80)
Gumminess (N)	154.64^{c} (147.68-162.24)	179.82^{b} (173.88-189.66)	213.52^{a} (204.63-230.64)	109.92^{b} (173.04-198.60)
Chewiness (N.mm)	96.54^{c} (93.49-99.33)	123.87^{b} (113.02-142.25)	152.14^{a} (133.01-161.45)	141.03^{ab} (121.13-158.88)

Data represent the means of four replicates. Ranges are given in parentheses. Values bearing different superscripts in each row differ significantly (P<0.05).

Table 24. Intrinsic parameters of dudh churpi as influenced by sugar level in milk used for cooking

Parameters	Sugar (%) 0	1.0	2.0	3.0
Lactic acid (%)	0.04^{a} (0.03-0.05)	0.04^{a} (0.02-0.06)	0.04^{a} (0.03-0.05)	0.05^{a} (0.04-0.06)
Free fatty acid (as % oleic acid)	0.84^{b} (0.82-0.86)	0.84^{b} (0.82-0.88)	0.95^{a} (0.93-0.97)	0.96^{a} (0.93-0.99)
2-Thiobarbituric acid value (A_{530})	0.06^{a} (0.03-0.09)	0.06^{a} (0.05-0.07)	0.06^{a} (0.05-0.07)	0.06^{a} (0.05-0.07)
Tyrosine (mg/g)	0.15^{a} (0.12-0.18)	0.15^{a} (0.13-0.17)	0.16^{a} (0.15-0.17)	0.16^{a} (0.13-0.19)
Free HMF (μmol/g)	26.43^{d} (26.40-26.46)	27.19^{c} (27.15-27.23)	27.69^{b} (27.63-27.77)	28.33^{a} (28.28-28.35)
Total HMF (μmol/g)	49.19^{d} (49.18-49.20)	56.01^{c} (55.09-56.13)	59.11^{b} (59.06-59.16)	61.28^{a} (61.25-61.31)
p-DMAB reactivity (A_{545})	0.19^{a} (0.17-0.21)	0.21^{a} (0.19-0.23)	0.21^{a} (0.19-0.23)	0.22^{a} (0.21-0.23)

Data represent the means of four replicates. Ranges are given in parentheses. Values bearing different superscripts in each row differ significantly ($P<0.05$).

Table 25. Sensory atributes of dudh churpi as influenced by total solids content of milk used for cooking

Attributes	Total solids (%) 11.70	15.60	23.40	29.25
Flavour	6.57[d] (6.43-6.71)	7.35[c] (7.28-7.43)	7.96[b] (7.86-8.14)	8.35[a] (8.28-8.43)
Body and texture	6.14[c] (6.00-6.28)	7.57[b] (7.43-7.71)	7.93[a] (7.86-8.00)	8.00[a] (7.86-8.14)
Colour and appearance	2.57[d] (2.43-2.71)	3.14[c] (3.00-3.28)	4.07[b] (4.00-4.14)	4.81[a] (4.71-4.86)
Total score	15.28[d] (14.86-15.56)	18.07[c] (17.86-18.42)	19.97[b] (19.86-20.00)	21.17[a] (21.14-21.28)

Data represent the means of four replicates. Ranges are given in parentheses. Values bearing different superscripts in each row differ significantly (P<0.05).

Table 26. Instrumental texture profile of dudh churpi as influenced by total solids content of milk used for cooking

Attributes	Total solids (%) 11.70	15.60	23.40	29.25
Hardness (N)	301.25[c] (296.00-309.00)	312.75[b] (302.00-318.00)	355.50[a] (349.00-361.00)	361.75[a] (354.00-372.00)
Cohesiveness	0.47[b] (0.43-0.52)	0.54[a] (0.48-0.58)	0.57[a] (0.54-0.61)	0.59[a] (0.57-0.62)
Springiness (mm)	0.46[c] (0.45-0.50)	0.58[b] (0.55-0.60)	0.68[a] (0.65-0.70)	0.71[a] (0.65-0.75)
Gumminess (N)	141.52[c] (131.12-157.04)	168.77[b] (151.20-175.16)	202.75[a] (190.62-220.21)	213.52[a] (204.63-230.64)
Chewiness (N.mm)	65.34[c] (59.00-70.67)	97.20[b] (83.16-105.10)	137.14[a] (123.90-154.15)	152.14[a] (133.01-161.45)

Data represent the means of four replicates. Ranges are given in parentheses. Values bearing different superscripts in each row differ significantly (P<0.05).

solids content for different periods. Scores on each sensory attribute increased significantly (P<0.05) with the increase in time of cooking upto a period of 15 min. There was no significiant (P<0.05) difference in flavour, body and texture scores of the samples of dudh churpi, cooked for 15 and 20 min, but the colour and appearance and total scores significantly (P<0.05) decreased (Table 27).

The mean values for all the instrumental parameters, except hardness and springiness, were significantly (P<0.05) higher in the samples of dudh churpi cooked in milk for 15 min. Hardness increased with the increase in cooking time up to 15 min, beyond which the increase was not significant (P<0.05). On the other hand, the increase in cohesiveness, gumminess and chewiness continued upto 15 min beyond which the values declined significantly (P<0.05) (Table 28).

4.3.3. Moisture level of prechurpi

Pieces of cooked and pressed green curd (4 cm x 2 cm x 1 cm) were smoked over wooden fire for 30 min and dried at different temperatures. The traditional drying over wooden fire was continued at an average temperature of 34°C. Three different drying chambers maintained at 35, 40 and 45°C were also used. Prechurpi samples having 40, 35, 30 and 25% moisture were cooked for 15 min in milk of 1.0% fat, 2.0% sugar and 29.25% total solids content, and further drying was continued under the same previous conditions of drying till the product attained a moisture content of 15.4%.

None of the samples cooked at 40, 35 and 25% moisture levels and dried at different temperatures met the quality requirements with respect to any sensory attribute (Table 29). Samples of dudh churpi, cooked at 30%

Table 27. Sensory atributes of dudh churpi as influenced by time of cooking prechurpi

Attributes	Cooking time (min) 5	10	15	20
Flavour	6.21^{c} (6.00-6.43)	6.57^{b} (6.43-6.71)	8.35^{a} (8.28-8.43)	8.24^{a} (8.14-8.28)
Body and texture	5.86^{c} (5.71-6.00)	7.75^{b} (7.57-7.86)	8.00^{a} (7.86-8.14)	8.07^{a} (8.00-8.14)
Colour and appearance	2.50^{d} (2.43-2.57)	2.85^{c} (2.71-3.00)	4.81^{a} (4.71-4.85)	4.57^{b} (4.43-4.70)
Total score	14.57^{d} (14.43-14.71)	17.17^{c} (17.13-17.29)	21.17^{a} (21.13-21.28)	20.88^{b} (20.71-21.12)

Data represent the means of four replicates. Ranges are given in parentheses. Values bearing different superscripts in each row differ significantly (P<0.05).

Table 28. Instrumental texture profile of dudh churpi as influenced by time of cooking prechurpi

Attributes	Cooking time (min)			
	5	10	15	20
Hardness (N)	323.25^{c} (320.00-326.00)	333.00^{b} (330.00-336.00)	361.75^{a} (354.00-372.00)	368.00^{a} (366.00-369.00)
Cohesiveness	0.47^{c} (0.45-0.49)	0.48^{c} (0.47-0.49)	0.59^{a} (0.57-0.62)	0.55^{b} (0.51-0.58)
Springiness (mm)	0.45^{b} (0.40-0.50)	0.48^{b} (0.45-0.50)	0.71^{a} (0.65-0.75)	0.71^{a} (0.70-0.75)
Gumminess (N)	151.96^{c} (144.90-159.25)	159.83^{c} (157.45-161.70)	213.52^{a} (204.63-230.64)	200.57^{b} (188.19-214.02)
Chewiness (N.mm)	68.35^{c} (58.88-72.45)	75.91^{c} (71.49-80.64)	152.14^{a} (133.01-166.45)	142.82^{b} (131.73-149.81)

Data represent the means of four replicates. Ranges are given in parentheses. Values bearing different superscripts in each row differ significantly ($P<0.05$).

Table 29. Effect of different moisture levels of prechurpi for cooking and different drying temperatures on sensory quality of dudh churpi

Moisture (%)	Drying temperature (°C)	Sensory score: Flavour	Body and texture	Colour and appearance	Total score
40	T*	4.61 (4.43-4.71)	5.04 (4.86-5.14)	2.28 (2.14-2.43)	11.92 (11.71-12.14)
	35	4.79 (4.71-4.86)	5.11 (5.00-5.14)	2.32 (2.14-2.43)	12.21 (11.86-12.43)
	40	4.28 (4.14-4.43)	4.79 (4.71-4.86)	2.07 (2.00-2.14)	11.14 (11.00-11.43)
	45	4.36 (4.28-4.43)	4.50 (4.43-4.57)	1.90 (1.86-2.00)	10.75 (10.71-10.86)
35	T*	7.28 (7.14-7.43)	6.97 (6.86-7.14)	3.43 (3.28-3.57)	17.68 (17.43-17.86)
	35	7.32 (7.14-7.43)	7.04 (6.86-7.14)	3.46 (3.28-3.57)	17.82 (17.28-18.14)
	40	7.07 (7.00-7.14)	6.21 (6.14-6.28)	3.36 (3.28-3.57)	16.64 (16.57-16.71)
	45	6.79 (6.71-6.86)	5.97 (5.86-6.14)	2.21 (2.14-2.28)	14.96 (14.71-15.14)

Table 29. Continued

Moisture (%)	Drying temperature (°C)	Sensory score			
		Flavour	Body and texture	Colour and appearance	Total score
30	T*	8.36 (8.28-8.43)	8.00 (7.86-8.14)	4.82 (4.71-4.86)	21.18 (21.14-21.28)
	35	8.28 (8.14-8.43)	8.07 (7.86-8.28)	4.79 (4.71-4.86)	21.14 (21.00-21.28)
	40	7.90 (7.86-8.00)	7.69 (7.63-7.71)	3.79 (3.71-3.86)	19.37 (19.28-19.57)
	45	7.47 (7.43-7.57)	7.50 (7.43-7.57)	3.21 (3.14-3.28)	18.18 (18.00-18.28)
25	T*	7.50 (7.43-7.57)	7.25 (7.14-7.43)	3.47 (3.43-3.57)	18.21 (18.00-18.28)
	35	7.54 (7.43-7.71)	7.32 (7.14-7.43)	3.47 (3.43-3.57)	18.32 (18.00-18.43)
	40	6.97 (6.86-7.14)	6.68 (6.57-6.71)	2.61 (2.43-2.57)	16.25 (16.00-16.56)
	45	6.75 (6.71-6.86)	6.39 (6.28-6.43)	2.11 (2.00-2.14)	15.24 (15.00-15.43)
CD (P<0.05)		0.14	0.15	0.14	0.28

Data represent the means of four replicates. Ranges are given in parentheses.
*T, the traditional process of drying, temperature varied from maximum 44°C to minimum 26°C

moisture level and dried by traditional way and at 35 and 40°C, scored above the acceptable values. There was no significant ($P<0.05$) difference in quality of the product cooked at 30% moisture level and dried at traditional method and 35°C (Table 29 and Figs 5-8). Statistical analysis of the processing factors (Table 30) showed that the interactions among moisture levels, drying temperatures and in between moisture levels and drying temperatures were hightly significant ($P<0.01$) for all the sensory attributes studied.

4.3.4. Drying behaviour of cooked prechurpi

The plots of moisture ratio versus time of drying under four different temperatures and with three different sizes of dudh churpi are shown in Figs 9-12. The data on drying behaviour were recorded only after cooking prechurpi of 30% moisture level in milk of 1.0% fat, 2.0% sugar and 29.25% total solids content for 15 min. Maximum and minimum drying temperatures and relative humidities at different days of traditional drying are presented in Table 31. The rate of reduction in moisture ratio was less in the samples of larger sizes under all temperature conditions (Fig 9-12). The rate of drying was decreased with the time of drying. The miosture contentvariation during drying was monitored by the formula of material balance $Q_1(100 - M_1) = Q_2(100 - M_2)$, where, Q_1 and Q_2 are initial and final weights in g and M_1 and M_2 are moisture contents at Q_1 and Q_2. The rate of drying was expressed by the model (Page 1949):

$$MR = \frac{M_t - M_e}{M_o - M_e} = \exp(-k_1 t^{k_2})$$

Where, M_t is the moisture content at time t, M_e is the equilibrium moisture

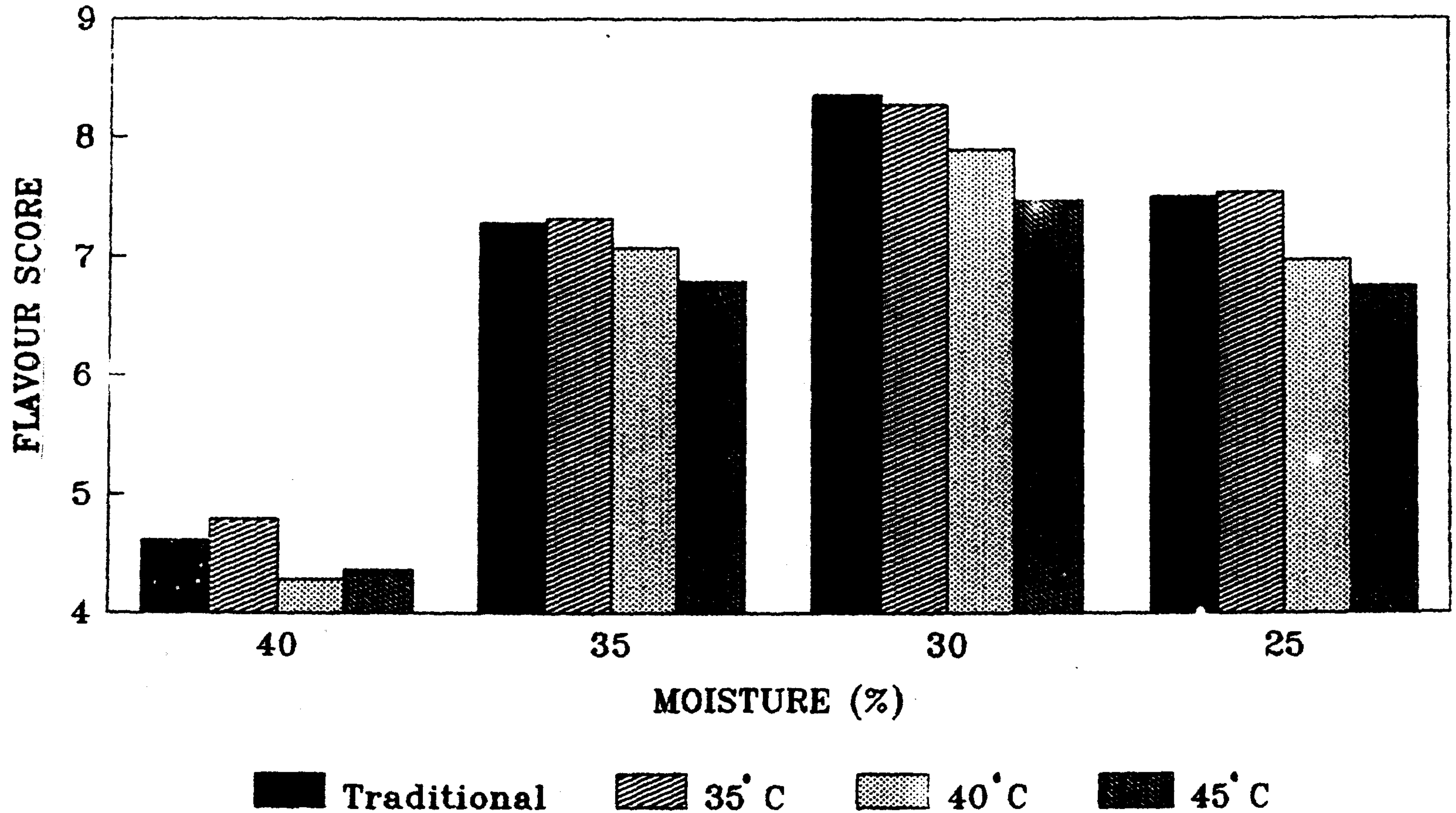

Fig. 5. Flavour scores of dudh churpi as influenced by diffrent moisture levels used for cooking prechurpi dried at diffrent temperatures

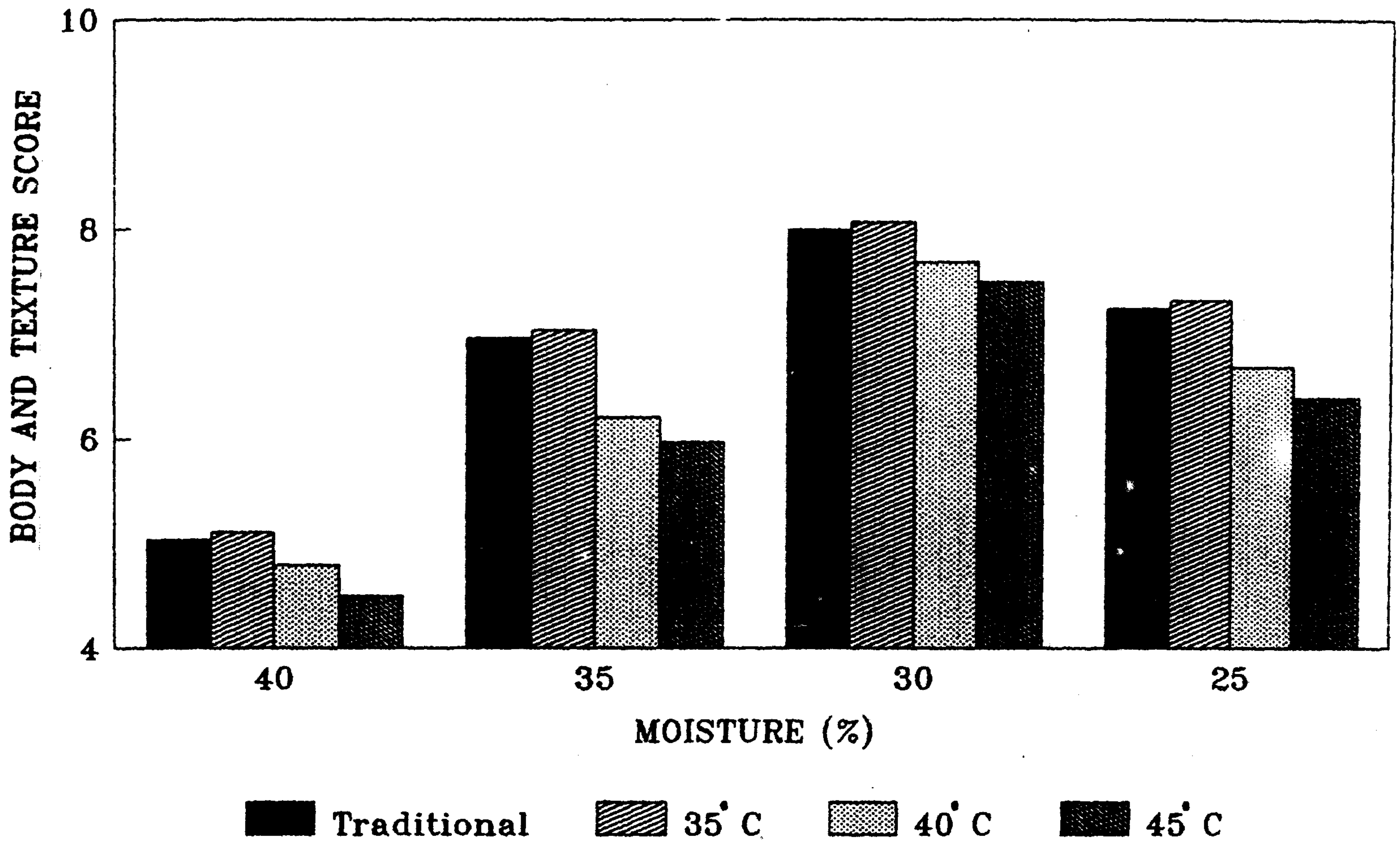

Fig. 6. Body and texture scores of dudh churpi as influenced by diffrent moisture levels used for cooking prechurpi and dried at diffrent temperatures

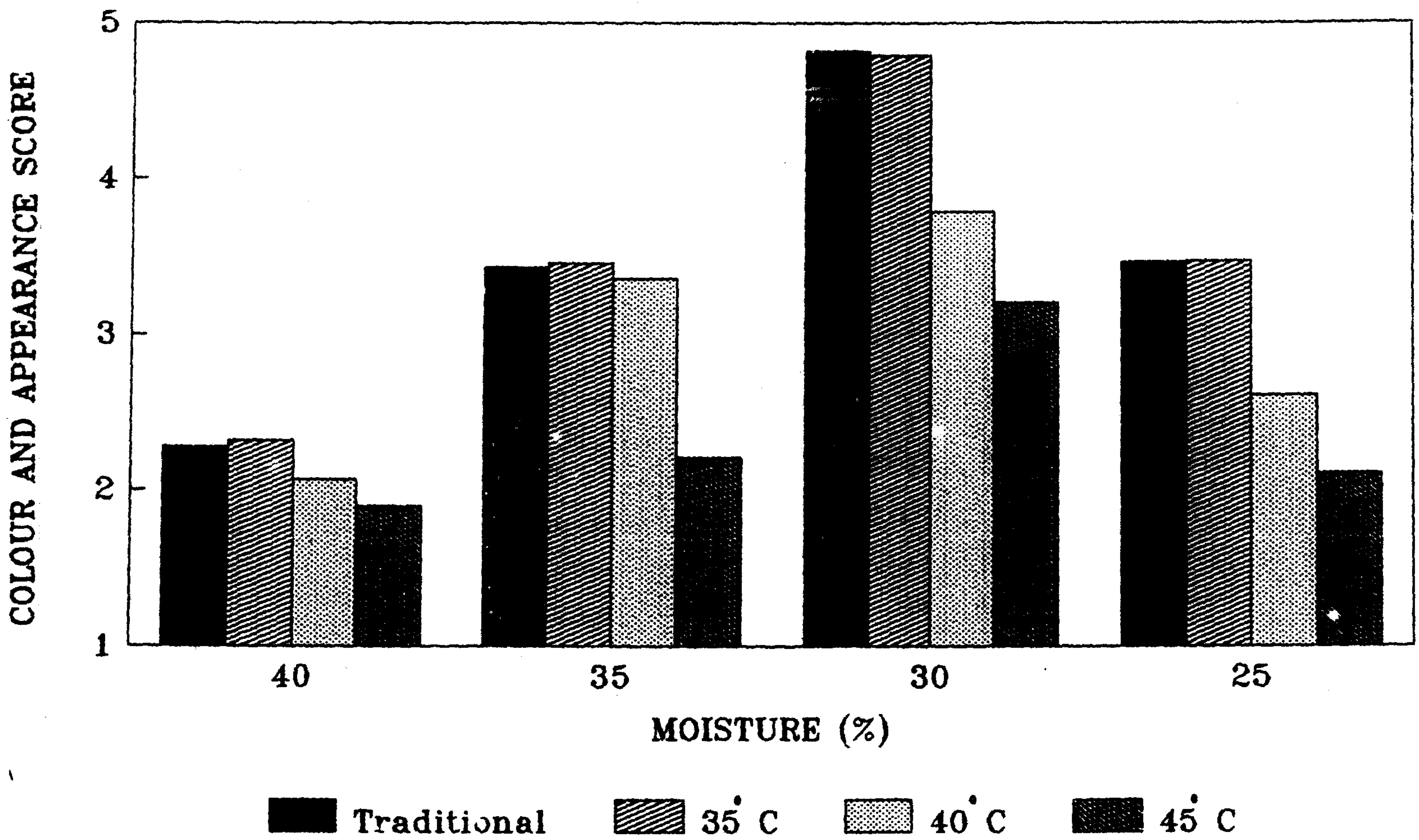

Fig.7. Colour and appearance scores of dudh churpi as influenced by diffrent moisture levels used for cooking prechurpi and dried at diffrent temperatures

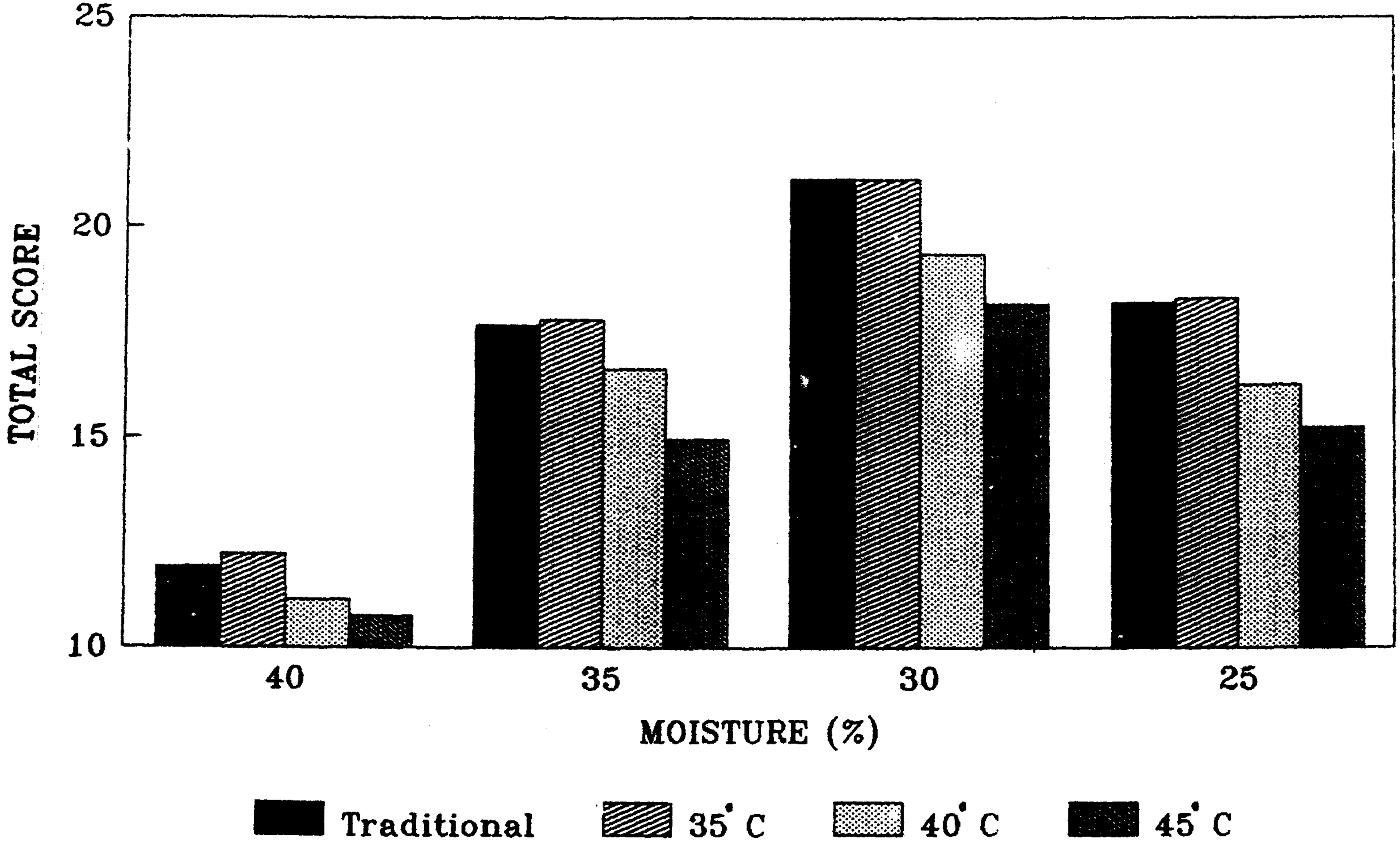

Fig.8. Total scores of dudh churpi as influenced by diffrent moisture levels used for cooking prechurpi and dried at diffrent temperatures

Table 30. Analysis of variance for sensory attributes of dudh churpi cooked at different moisture levels and dried at different temperatures

Source of variation	Degrees of freedom	Mean sum of squares*			
		Flavour	Body and texture	Colour and appearance	Total score
Among moisture levels (M)	3	36.837	24.513	10.967	198.103
Among drying temperatures (T)	3	1.529	2.313	4.803	24.276
Interaction (M x T)	9	0.071	0.078	0.373	0.731
Error	45	0.010	0.012	0.010	0.039

* Significant at $P<0.01$

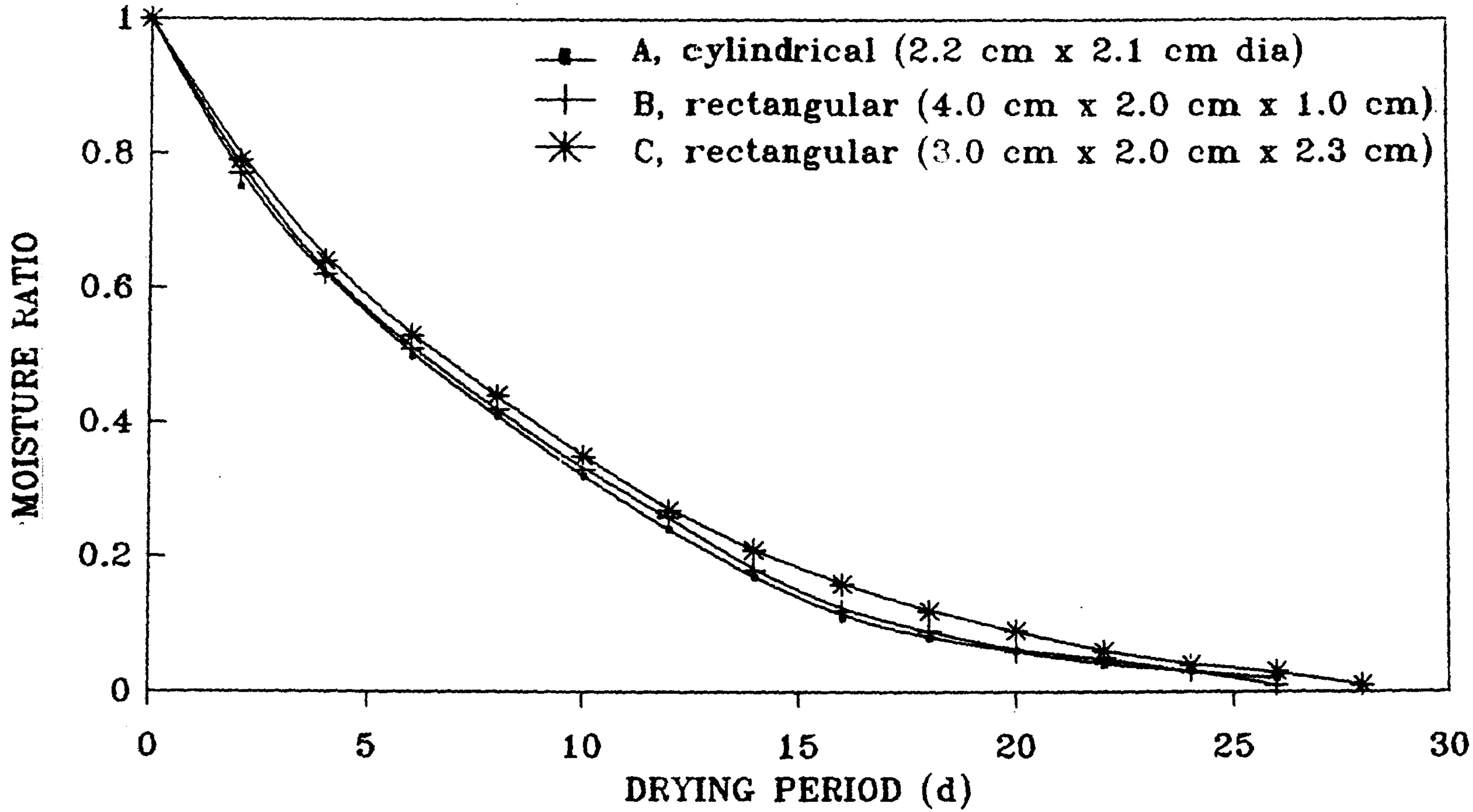

Fig. 9. Effect of size and period of drying at traditional drying on drying behaviour of dudh churpi

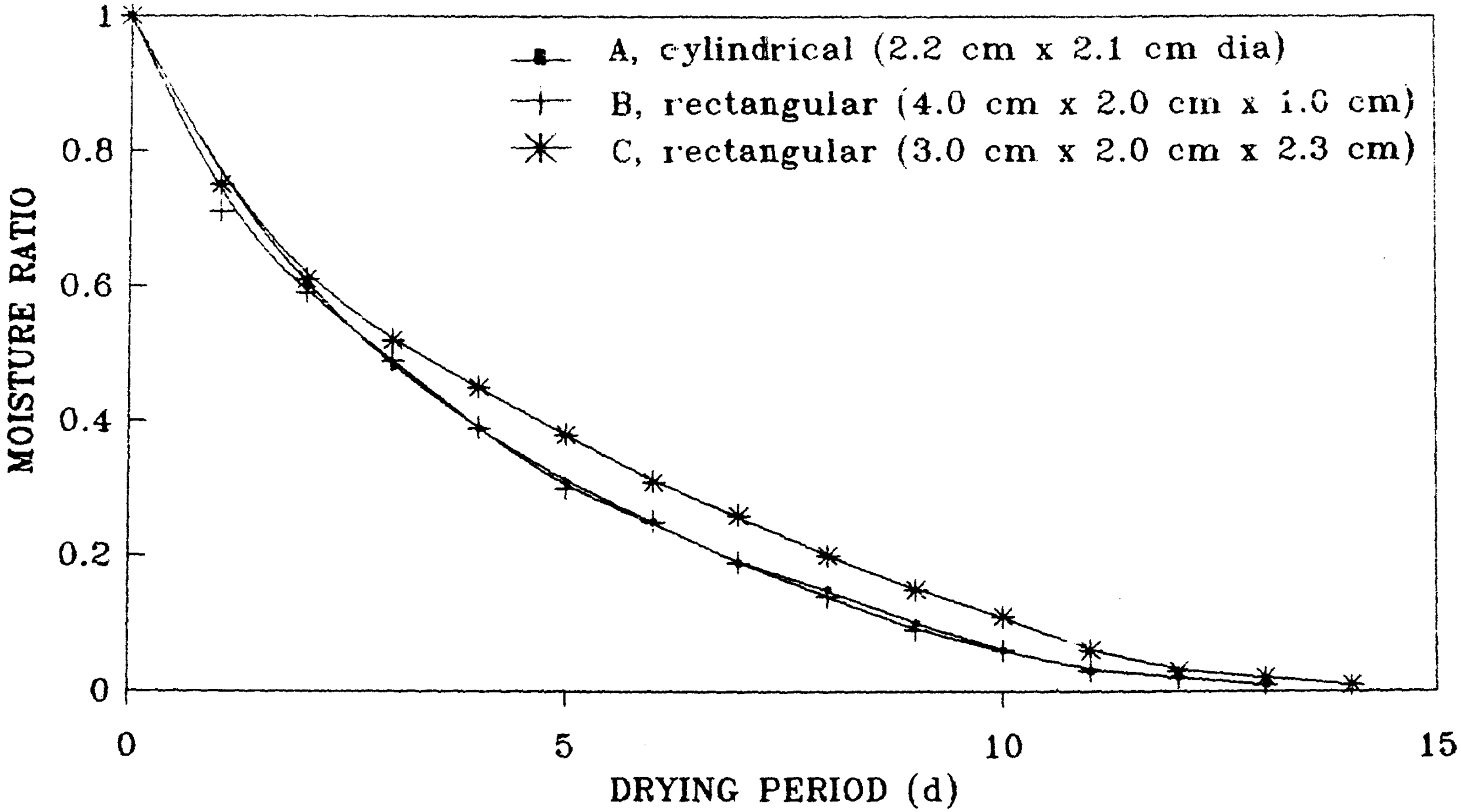

Fig. 10. Effect of size and period of drying at 35°C on drying behaviour of dudh churpi

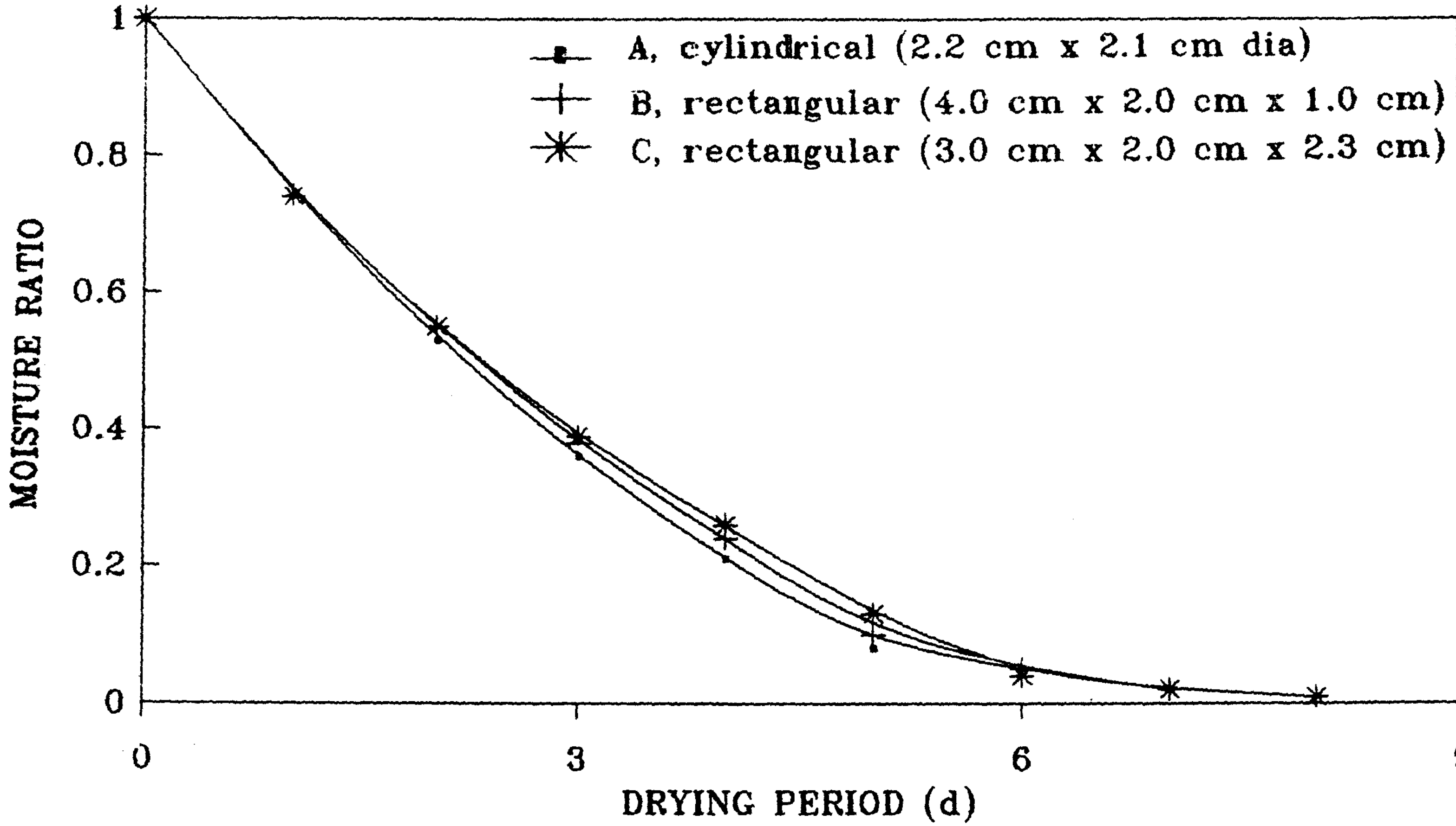

Fig. 12. Effect of size and period of drying at 45°C on drying behaviour of dudh churpi

Table 31. Maximum and minimum temperatures and relative humidities at different days of traditional drying

Day	Relative humidity (%)		Temperature (oC)	
	Maximum	Minimum	Maximum	Minimum
0	67.0	36.0	41.0	27.5
2	63.0	32.0	40.0	26.5
4	64.0	29.0	38.0	27.5
6	65.0	36.0	42.0	28.0
8	65.0	31.0	43.0	27.0
10	66.6	31.5	40.5	26.5
12	65.7	39.0	41.5	26.5
14	66.0	37.0	39.5	27.5
16	65.6	36.0	42.5	28.0
18	66.0	34.0	43.0	29.5
20	62.0	33.0	41.5	28.0
22	64.0	32.0	43.0	32.0
24	63.0	31.5	41.0	28.0
26	61.0	32.0	42.0	27.0
28	66.0	35.0	39.0	26.0
30	61.0	29.0	44.0	30.5
32	63.0	28.0	41.0	26.5
34	64.0	27.0	40.0	26.0
36	60.0	28.0	38.0	27.0

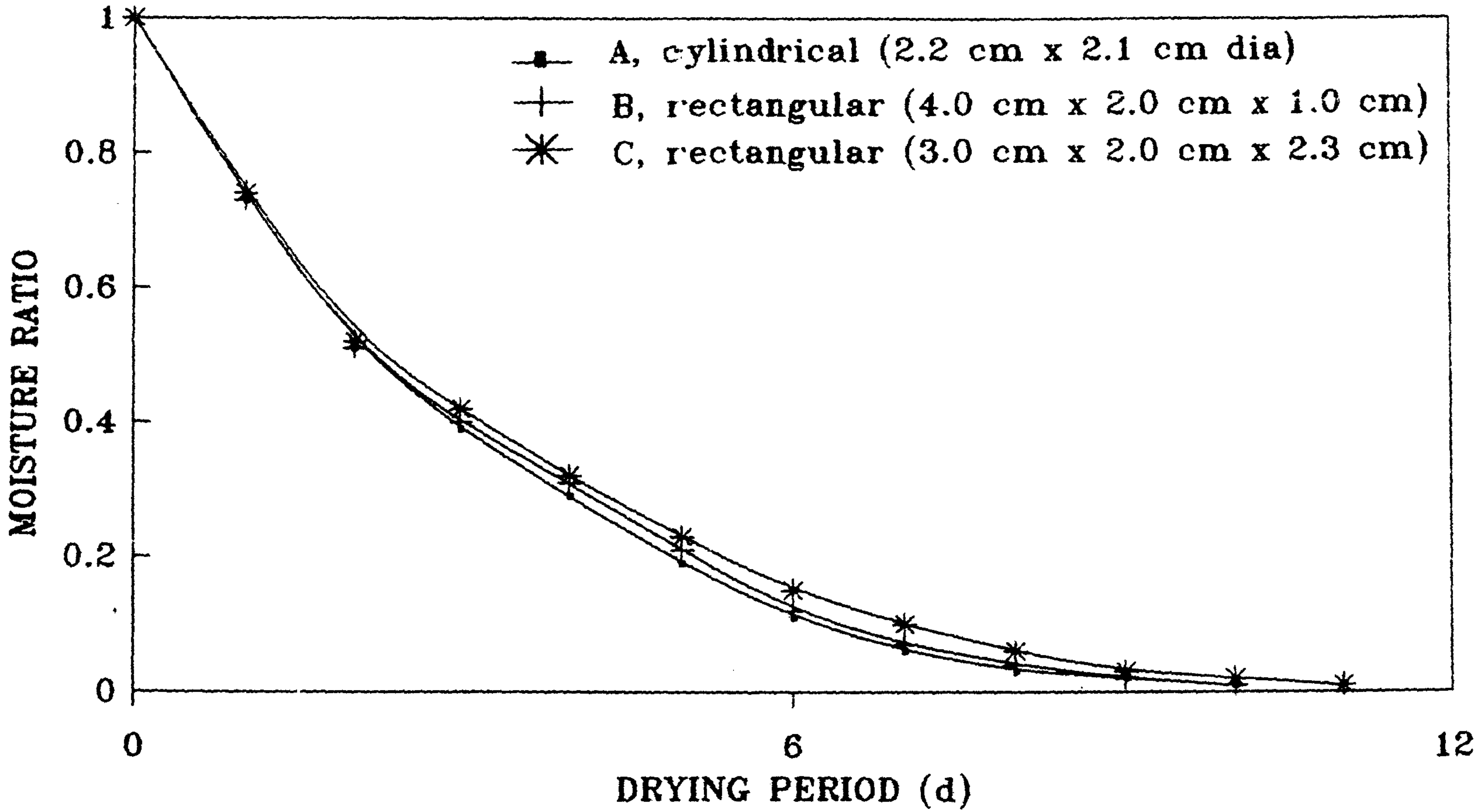

Fig. 11. Effect of size and period of drying at 40°C on drying behaviour of dudh churpi

content and M_0 is the initial mositure content. The constants k_1 and k_2 are found to depend upon temperature and relative humidity. These constants can be expressed in the form:

$$k_1 = 0.389 - 0.11T + 0.002RH$$
$$k_2 = 0.267 + 0.02T + 0.002RH$$

where, T denotes temperature in °C and RH denotes relative humidity. The effects of size on the rate of drying of dudh churpi at different temperatures can be evaluated by considering the time of half-response ($t_{1/2}$). The $t_{1/2}$ is defined as the time required to remove the first half of the free moisture. This corresponds to the time required to reach a miosture ratio of 0.5. Drying eqations, $t_{1/2}$ and predicted drying period (days) as evaluated by the Page's model with percent root mean square (% RMS), are presented in Table 32 This shows that rate of drying was higher for smaller sizes of dudh churpi and the drying rate increased with the increase in temperature. The fitness of Page equation to the data was tested by calculating the %RMS which lies between 1.26-1.62 in case of traditional drying and between 3.78-5.92, 0.99-1.86 and 0.76-1.65 during drying at 35, 40 and 45°C, respectively. These low % RMS suggest that the Page model fit well to the data.

The Instron texture profile of dudh churpi of three different sizes dried at four different temperatures is shown in Table 33.
Increase in temperature beyond 35° C adversely effected the Instron parameters, but no significant ($P<0.01$) difference with respect to size and temperature was observed when the samples of dudh churpi dried traditionally and in drying chamber at 35°C.

No significant ($P<0.01$) differences of Instron parameters were observed among sizes of dudh churpi and the interactions between size and temperature

Table 32. Drying behaviour of dudh churpi evaluated from Page's model

Drying temperature (oC)	Size*	Equations developed	Coefficient of correlation	Time of half response ($t_{1/2}$) (d)	Drying time (d)	RMS (%)
	A	$MR = e^{-0.113t^{1.059}}$	0.993	5.526	33.03	1.26
Traditional	B	$MR = e^{-0.103t^{1.087}}$	0.992	5.753	32.82	1.62
	C	$MR = e^{-0.093t^{1.095}}$	0.994	6.235	35.11	1.34
	A	$MR = e^{-0.237t^{1.072}}$	0.982	2.721	15.92	3.78
35	B	$MR = e^{-0.253t^{1.049}}$	0.977	2.607	15.85	4.90
	C	$MR = e^{-0.220t^{1.036}}$	0.974	3.021	18.78	5.92
	A	$MR = e^{-0.281t^{1.179}}$	0.992	2.148	10.71	1.21
40	B	$MR = e^{-0.284t^{1.139}}$	0.993	2.190	11.54	0.99
	C	$MR = e^{-0.270t^{1.140}}$	0.989	2.284	12.02	1.86
	A	$MR = e^{-0.269t^{1.338}}$	0.993	2.025	8.34	0.76
45	B	$MR = e^{-0.258t^{1.340}}$	0.990	2.087	8.27	1.10
	C	$MR = e^{-0.248t^{1.378}}$	0.987	2.109	8.33	1.65

*A, cylindrical (2.2 cm x 2.1 cm dia)
B. rectangular (4.0 cm x 2.0 cm x 1.0 cm)
C. rectangular (3.0 cm x 2.0 cm x 2.3 cm)

Table 33. Effect of size and drying temperature on Instron parameters of dudh churpi

Drying temperature (°C) (T)	Sizes (S)	Hardness (N)	Cohesiveness	Springiness (mm)	Gumminess (N)	Chewiness (N.mm)
Traditional	A	363.00 (354.00-372.00)	0.59 (0.57-0.62)	0.68 (0.60-0.75)	214.30 (201.78-230.64)	145.21 (123.89-172.98)
	B	362.00 (355.00-371.00)	0.60 (0.58-0.62)	0.71 (0.65-0.75)	216.33 (208.80-230.02)	153.79 (149.51-157.47)
	C	365.25 (358.00-370.00)	0.61 (0.59-0.63)	0.69 (0.65-0.75)	222.55 (211.22-232.47)	153.23 (137.29-174.35)
35	A	364.00 (356.00-368.00)	0.60 (0.58-0.63)	0.73 (0.70-0.75)	218.33 (211.70-224.28)	158.24 (151.57-165.60)
	B	364.75 (359.00-370.00)	0.62 (0.61-0.63)	0.68 (0.65-0.70)	224.29 (220.21-228.78)	151.39 (143.14-158.32)
	C	365.00 (355.00-371.00)	0.61 (0.58-0.63)	0.73 (0.70-0.75)	221.63 (204.60-225.68)	160.72 (150.22-167.74)
40	A	374.50 (371.00-376.00)	0.61 (0.59-0.63)	0.54 (0.50-0.60)	229.38 (221.84-236.88)	123.33 (110.92-139.50)
	B	373.50 (371.00-374.00)	0.60 (0.58-0.63)	0.58 (0.55-0.60)	224.41 (216.34-233.73)	129.11 (118.99-140.24)

Table 33. Continued

Drying temperature (°C) (T)	Sizes (S)	Instron parameters				
		Hardness (N)	Cohesiveness	Springiness (mm)	Gumminess (N)	Chewiness (N.mm)
40	C	375.00 (374.00-376.00)	0.62 (0.60-0.63)	0.56 (0.50-0.60)	230.62 (225.00-235.62)	129.58 (117.81-137.62)
	A	402.50 (398.00-406.00)	0.43 (0.40-0.46)	0.35 (0.30-0.40)	173.15 (159.20-186.76)	60.95 (47.76-74.70)
45	B	404.25 (399.00-408.00)	0.44 (0.42-0.45)	0.36 (0.30-0.40)	175.82 (171.36-181.35)	63.60 (54.41-70.00)
	C	403.75 (400.00-407.00)	0.43 (0.40-0.46)	0.38 (0.35-0.40)	173.67 (160.00-186.76)	65.12 (59.09-74.70)
CD ($P<0.05$)		7.62	0.01	0.06	6.76	14.87
CD ($P<0.01$)		10.24	0.01	0.08	9.08	19.98

Data represent the means of four replicates. Ranges are given in parentheses.

* Variable temperature, temperature varied from maximum 44°C to minimum 26°C

conditions. But, the products prepared under different temperatures differed significantly ($P<0.01$) (Table 34).

4.4. Packaging and storage studies of dudh churpi

Fresh samples of dudh churpi, prepared under optimized conditions were packed in different containers as described in section 3.2.8. and stored at ambient temperatures.

4.4.1. Changes in sensory attributes

4.4.1.1. Flavour

The flavour scores of control samples (P_1B: without packaging and preservative) decreased with the increase in storage period (Table 35 and Fig.13). Throughout the storage period, flavour score of the samples treated with 0.01% sorbate and stored in glass containers remained at the minimum level (8.46-8.04).

4.4.1.2. Body and texture

Least change in the body and texture score (8.36-7.93) was observed in the samples of dudh churpi treated with 0.1% sorbate and packed in glass container (Table 35 and Fig. 14).

Table 34. Analysis of variance for Instron parameters of dudh churpi of different sizes and dried at different temperatures

Source of variation	Degrees of freedom	Mean sum of squares				
		Hardness (N)	Cohesiveness	Springiness (mm)	Gumminess (N)	Chewiness (N.mm)
Among sizes (S)	3	8.7233	0.000130	0.00070	29.75	72.96
Among drying temperatures (T)	3	4159.25*	0.091000*	0.30670*	7197.15*	21975.85*
Interaction (S x T)	9	4.0000	0.000122	0.00130	25.81	31.63
Error	33	28.0478	0.000040	0.00182	22.09	106.83

*Significant at P<0.01

Table 35. Mean sensory scores of dudh churpi as influenced by type of packages, storage periods and preservatives

Stogare periods (months)	Packaging materials and forms**							
	P_1A	P_1B	P_2A	P_2B	P_3A	P_3B	P_4A	P_4B
				Flavour (10)				
0	8.46	8.46	8.46	8.46	8.46	8.46	8.46	8.46
1	8.07	8.43	8.36	8.43	8.04	8.25	8.00	8.21
2	7.11	8.14	8.21	8.25	7.86	8.07	8.00	8.21
3	6.14	8.04	8.07	8.21	7.86	8.07	7.82	8.04
4	5.07	7.64	7.79	8.11	7.68	7.86	7.61	8.00
5	4.60	7.28	7.82	8.11	7.21	7.78	7.54	7.86
6	3.50	5.61	7.79	8.04	7.07	7.75	6.79	7.68
				Body and texture(10)				
0	8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36
1	8.11	8.21	8.04	8.28	7.97	8.11	8.04	8.21
2	7.71	8.07	8.00	8.18	7.75	8.11	7.71	8.07
3	7.36	7.90	8.00	8.14	7.57	8.00	7.71	7.86
4	6.47	7.79	7.90	8.14	7.54	7.93	7.43	7.82
5	6.07	7.50	7.82	8.04	7.32	7.79	6.93	7.64
6	5.97	7.04	7.60	7.93	7.18	7.68	6.64	7.25
				Colour and appearance(05)				
0	4.79	4.79	4.79	4.79	4.79	4.79	4.79	4.79
1	4.64	4.75	4.64	4.75	4.64	4.75	4.68	4.64
2	3.64	4.64	4.54	4.64	4.39	4.64	4.36	4.39
3	2.79	4.50	4.36	4.64	4.21	4.47	4.11	4.39
4	2.32	4.07	4.32	4.54	4.18	4.47	3.79	4.10
5	1.93	3.75	4.25	4.36	3.90	4.18	3.61	3.93
6	1.47	3.50	4.11	4.25	3.79	4.11	3.36	3.86
				Total scores(25)				
0	21.61	21.61	21.61	21.61	21.61	21.61	21.61	21.61
1	20.82	21.39	21.03	21.46	20.64	21.10	20.71	21.06
2	18.46	20.85	20.75	21.06	20.00	20.82	20.07	20.67
3	16.28	20.43	20.43	20.99	19.64	20.54	19.64	20.29
4	13.86	19.50	20.00	20.78	19.39	20.25	18.82	20.00
5	12.61	18.53	19.89	20.50	18.43	19.74	18.07	19.43
6	10.93	16.14	19.57	20.21	18.03	19.53	16.78	18.79

* Mean of four replicates,

** P_1, without packaging; P_2, glass container; P_3, plastic container; P_4, plastic pouch; A, without sorbate and B, with 0.1% sorbate.

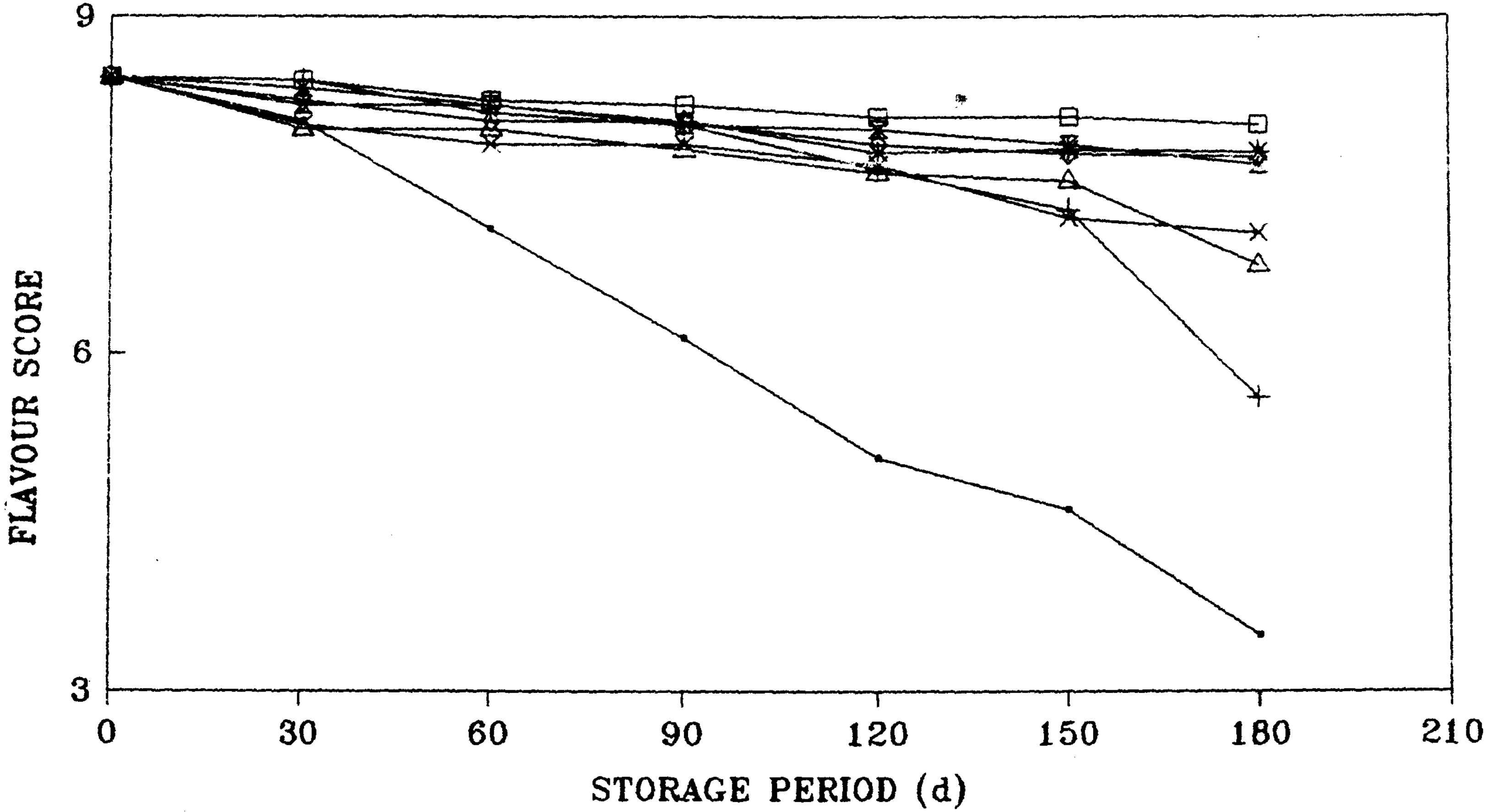

Fig. 13. Effect of packaging and storage on flavour scores of dudh churpi

P1A, without packaging and preservative; P1B, without packaging and with preservative;
P2A, glass container and without preservative; P2B, glass container and with preservative;
P3A, plastic container and without preservative; P3B, plastic container and with preservative;
P4A, plastic pouch and without preservative; P4B, plastic pouch and with preservative;

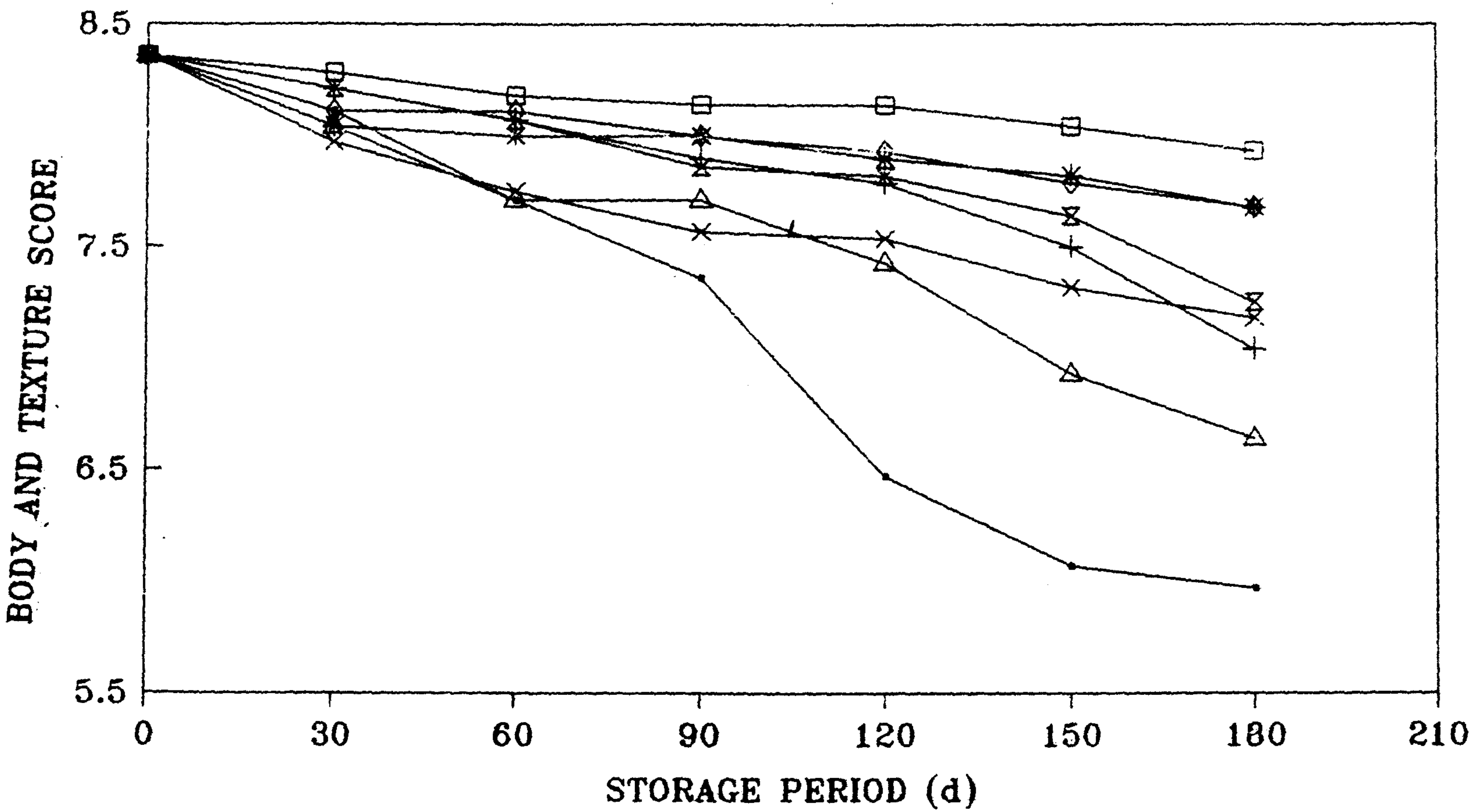

Fig. 14. Effect of packaging and storage on body and texure scores of dudh churpi

P1A, without packaging and preservative; P1B, without packaging and with preservative;
P2A, glass container and without preservative; P2B, glass container and with preservative;
P3A, plastic container and without preservative; P3B, plastic container and with preservative;
P4A, plastic pouch and without preservative; P4B, plastic pouch and with preservative;

4.4.1.3. Colour and appearance

Similar to the obsevations in flavour and body and texture scores, the changes in colour and appearance scores were also minimum (4.79-4.25) in the samples of dudh churpi treated with 0.1% sorbate and stored in glass containers (Table 35 and Fig. 15).

4.4.1.4. Total score

Since total score is the sum of all the individual sensory scores, the minimum change in total score (21.61-20.21) was observed in the samples of dudh churpi treated with 0.1% sorbate and stored in glass containers (Table 35 and Fig. 16).

4.4.1.5. Statistical significance of sensory data

Statistical analysis of the data (Table 35A) revealed that three types of packages and the control samples (without packages) two types of dudh churpi (with and without sorbate) and the duration of storage, all individually had a significant ($P<0.01$) influence on the sensory data of dudh churpi. Interactions between packages and intervals, intervals and types, packages and types. and packages, types and intervals were also significant ($P<0.01$).

4.4.2. Physico-chemical changes

4.4.2.1. Moisture

The adsorption of moisture in the samples of dudh churpi was maximum

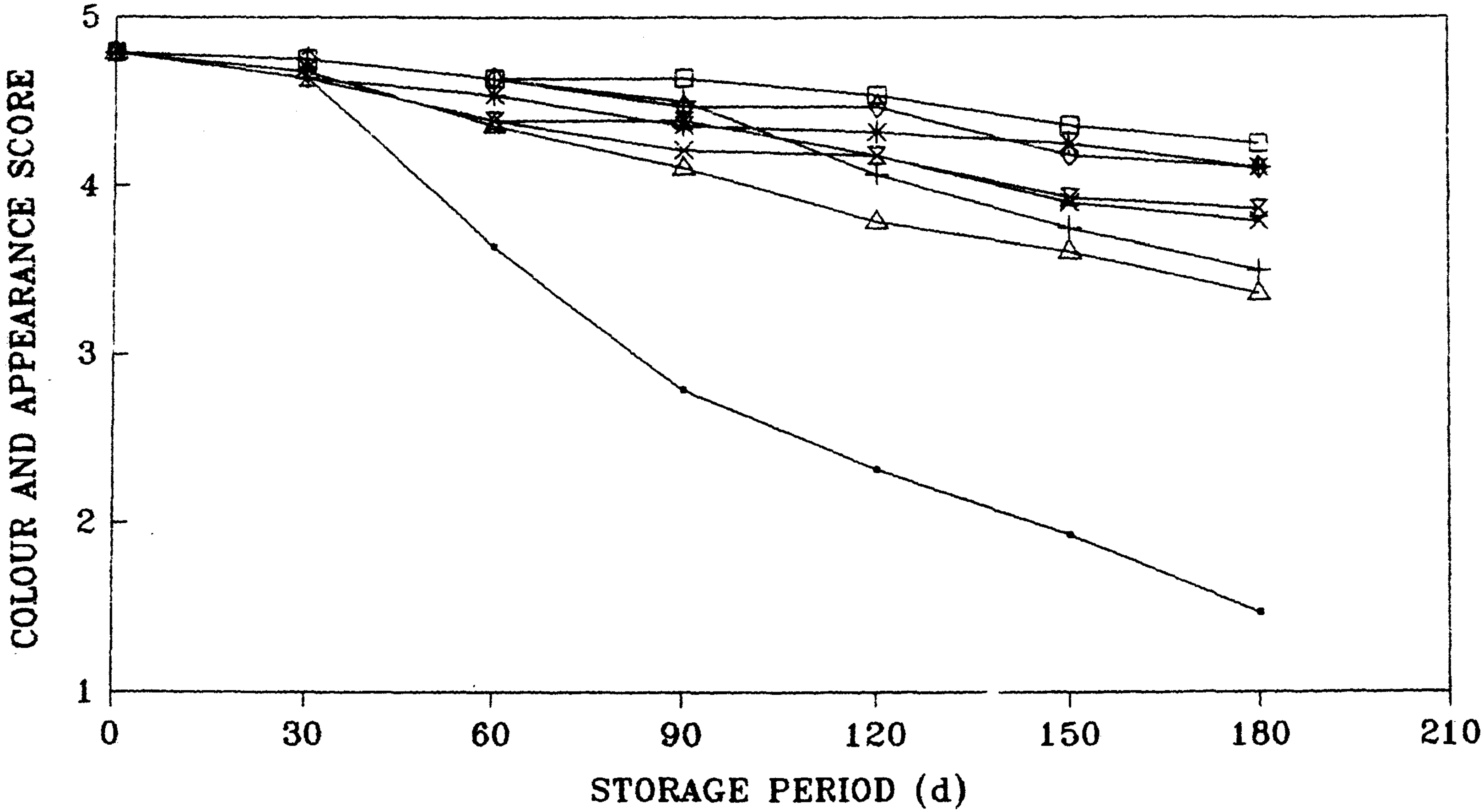

Fig. 15. Effect of packaging and storage on colour and appearance scores of dudh churpi

P1A, without packaging and preservative; P1B, without packaging and with preservative;
P2A, glass container and without preservative; P2B, glass container and with preservative;
P3A, plastic container and without preservative; P3B, plastic container and with preservative;
P4A, plastic pouch and without preservative; P4B, plastic pouch and with preservative;

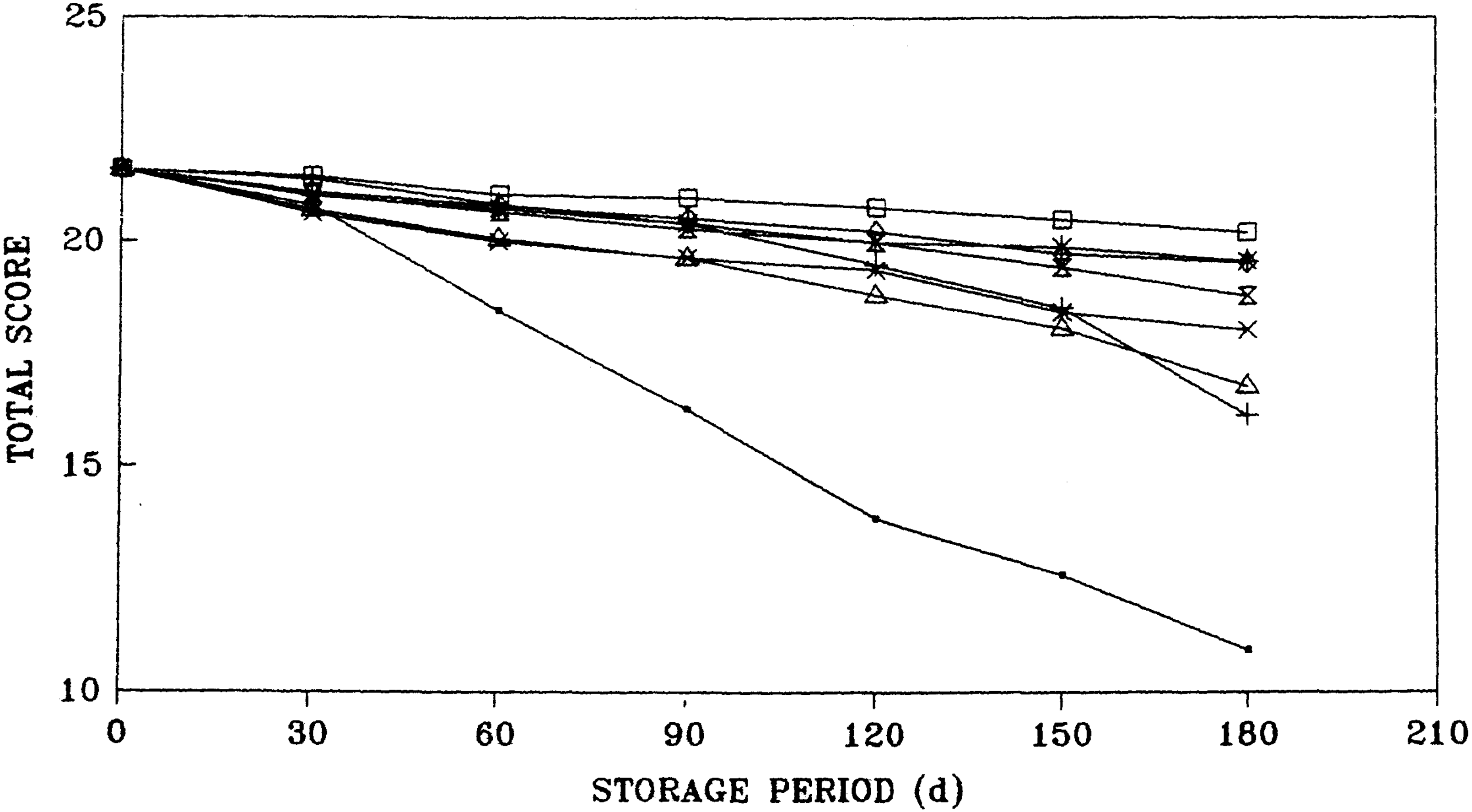

Fig. 16. Effect of packaging and storage on total scores of dudh churpi

P1A, without packaging and preservative;
P1B, without packaging and with preservative;
P2A, glass container and without preservative;
P2B, glass container and with preservative;
P3A, plastic container and without preservative;
P3B, plastic container and with preservative;
P4A, plastic pouch and without preservative;
P4B, plastic pouch and with preservative;

Table 35A. Analysis of variance for sensory attributes of dudh churpi during storage

Source of variation	Degrees of freedom	Flavour		Body and texture		Colour and appearance		Total score	
		MSS	CD	MSS	CD	MSS	CD	MSS	CD
Replicates	3	0.01		0.03		0.01		0.01	
Among packages (P)	3	17.24*	0.06	3.14*	0.06	7.19*	0.04	71.51*	0.10
Among storage periods (S)	6	10.81*	0.08	5.49*	0.08	6.94*	0.05	67.89*	0.13
Among preservatives (D)	1	18.42*	0.04	8.29*	0.04	10.97*	0.03	109.90*	0.07
Interactions:									
P x S	18	2.41*	0.16	0.46*	0.15	0.74*	0.11	8.98*	0.27
P x D	3	5.65*	0.08	0.65*	0.08	3.62*	0.06	25.63*	0.14
S x D	6	1.21*	0.11	0.53*	0.11	0.74*	0.08	6.97*	0.19
P x S x D	18	0.46*	0.22	0.12*	0.21	0.28*	0.15	2.17*	0.38
Error	165	0.015		0.014		0.007		0.043	

*Significant at P<0.01.
MSS; Mean sum of squares,
CD; Critical difference

(15.51-18.14) when stored traditionally and without any treatment with sorbate and was minimum (15.51-15.88) when treated with 0.1% potassium sorbate and stored in glass containers (Fig. 17).

4.4.2.2. Titratable acidity

An increase of 0.05% titratable acidity was observed when the samples were treated with 0.1% sorbate and kept in glass containers (Fig. 18). The rate of increase in acidity in all the cases was much higher when the samples were not treated with 0.1% sorbate.

4.4.2.3. Free fatty acid

Changes in free fatty acid profile were much more when the samples were not treated with 0.1% sorbate. Release of free fatty acid was controlled appreciably with the addition of sorbate (Fig. 19). Samples with sorbate and in glass containers showed the least (from initial 0.95 to 0.99 %) change in free fatty acid during the entire storage period.

4.4.2.4. Tyrosine value

Addition of sorbate inhibited the breakdown of proteins (Fig. 20). Samples with sorbate and in glass containers showed a negligible change during the storage period.

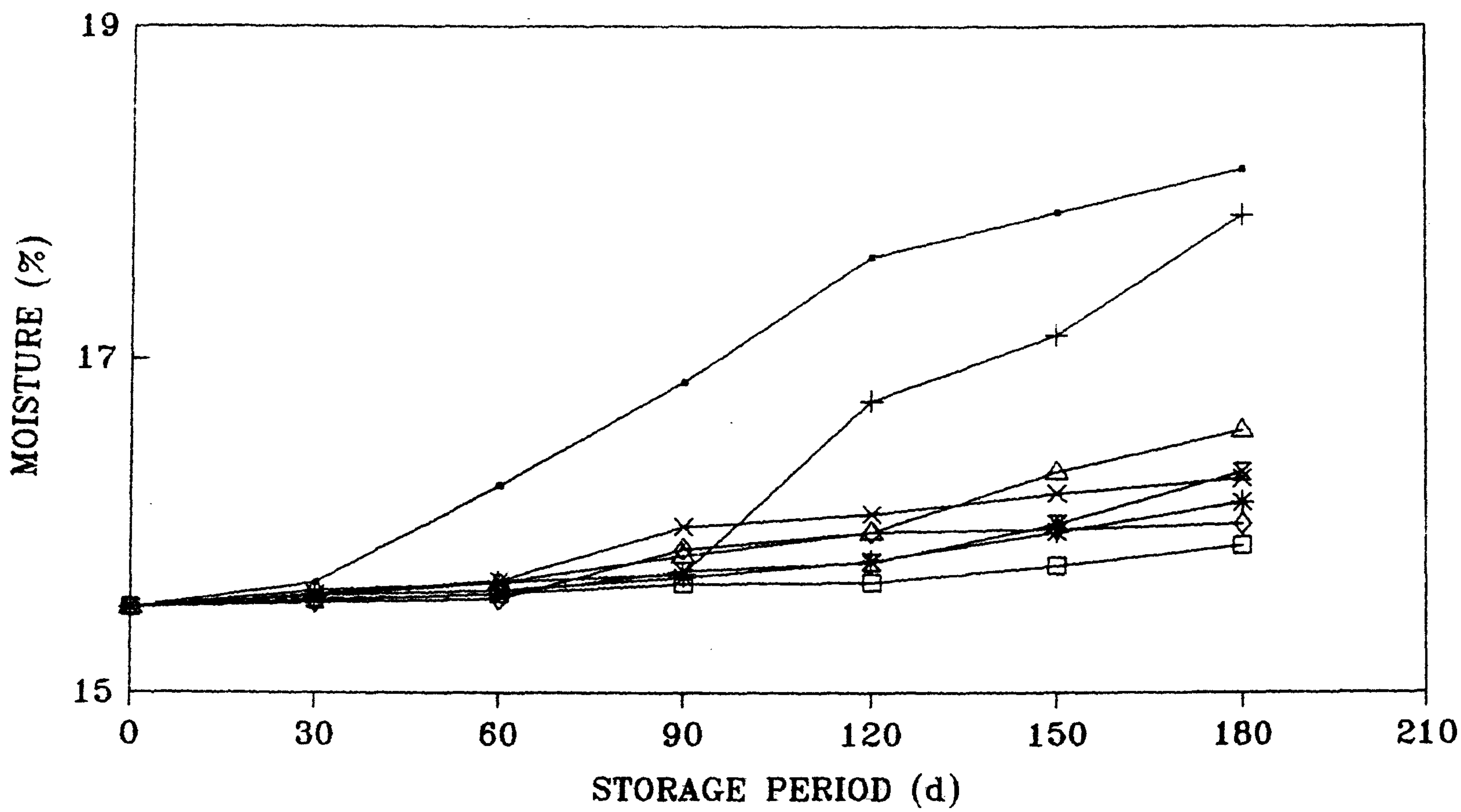

Fig. 17. Effect of packaging and storage on moisture of dudh churpi

P1A, without packaging and preservative; P1B, without packaging and with preservative;
P2A, glass container and without preservative; P2B, glass container and with preservative;
P3A, plastic container and without preservative; P3B, plastic container and with preservative;
P4A, plastic pouch and without preservative; P4B, plastic pouch and with preservative;

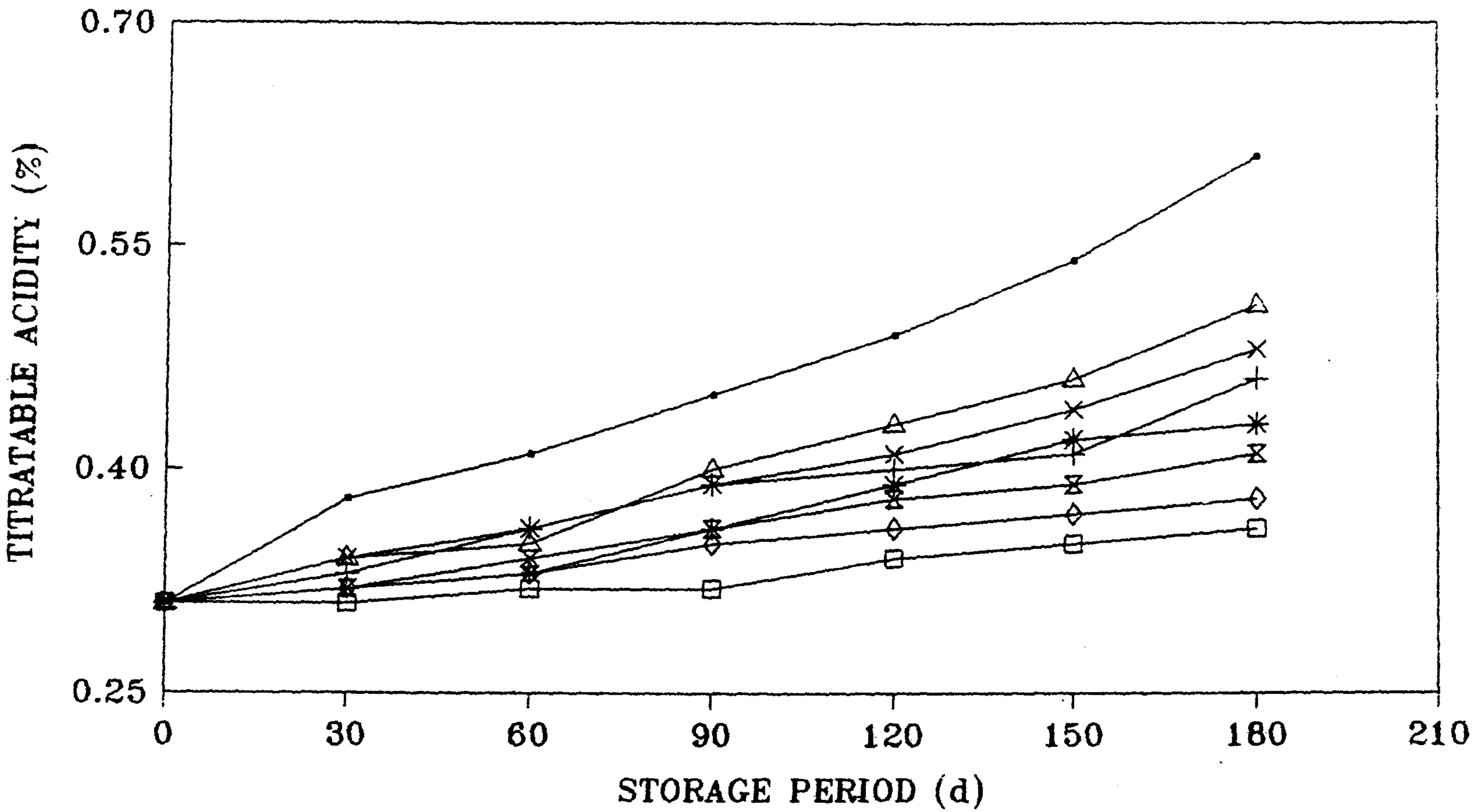

Fig. 18. Effect of packaging and storage on titratable acidity of dudh churpi

- P1A, without packaging and preservative;
- P1B, without packaging and with preservative;
- P2A, glass container and without preservative;
- P2B, glass container and with preservative;
- P3A, plastic container and without preservative;
- P3B, plastic container and with preservative;
- P4A, plastic pouch and without preservative;
- P4B, plastic pouch and with preservative;

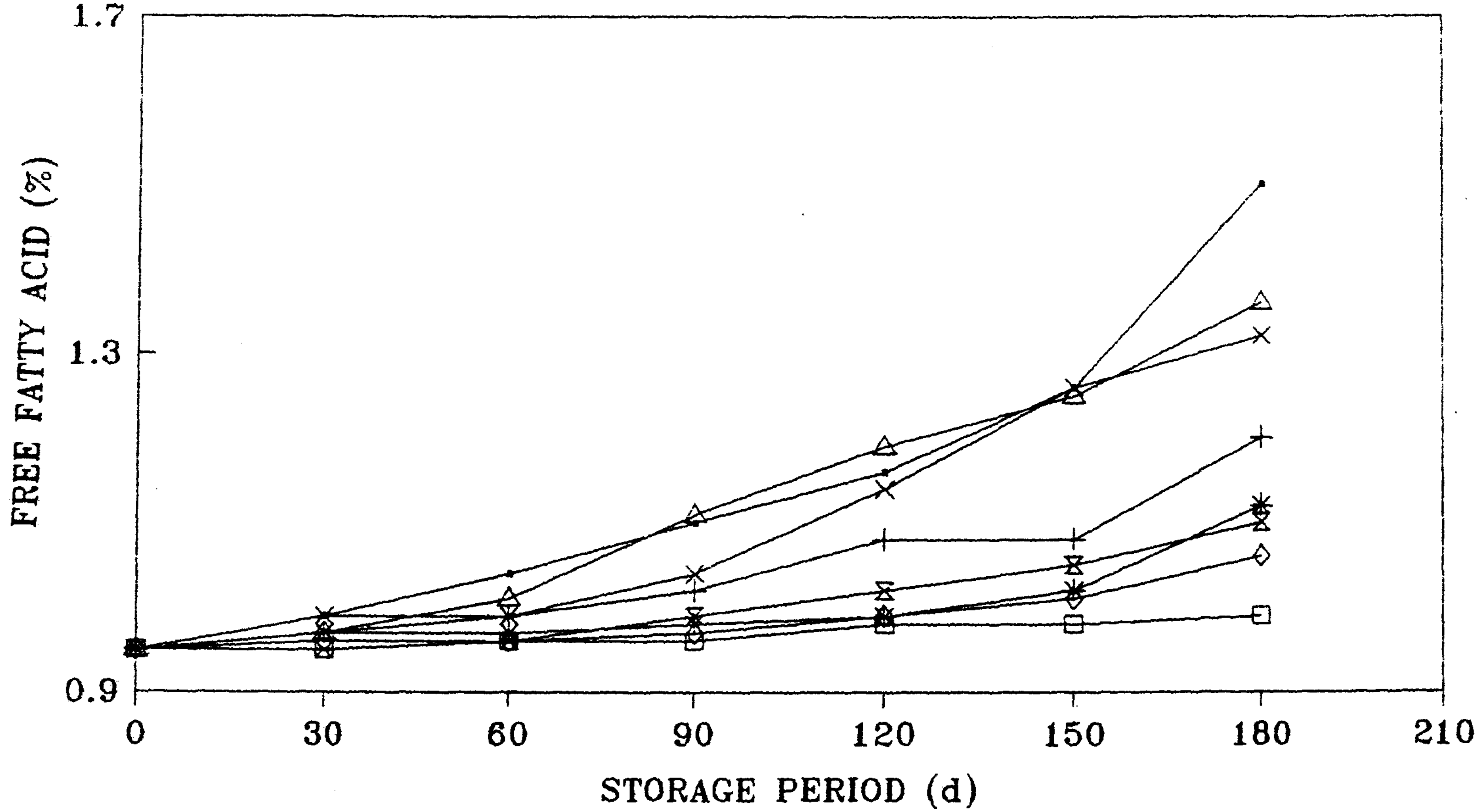

Fig. 19. Effect of packaging and storage on free fatty acid of dudh churpi

P1A, without packaging and preservative; P1B, without packaging and with preservative;
P2A, glass container and without preservative; P2B, glass container and with preservative;
P3A, plastic container and without preservative; P3B, plastic container and with preservative;
P4A, plastic pouch and without preservative; P4B, plastic pouch and with preservative;

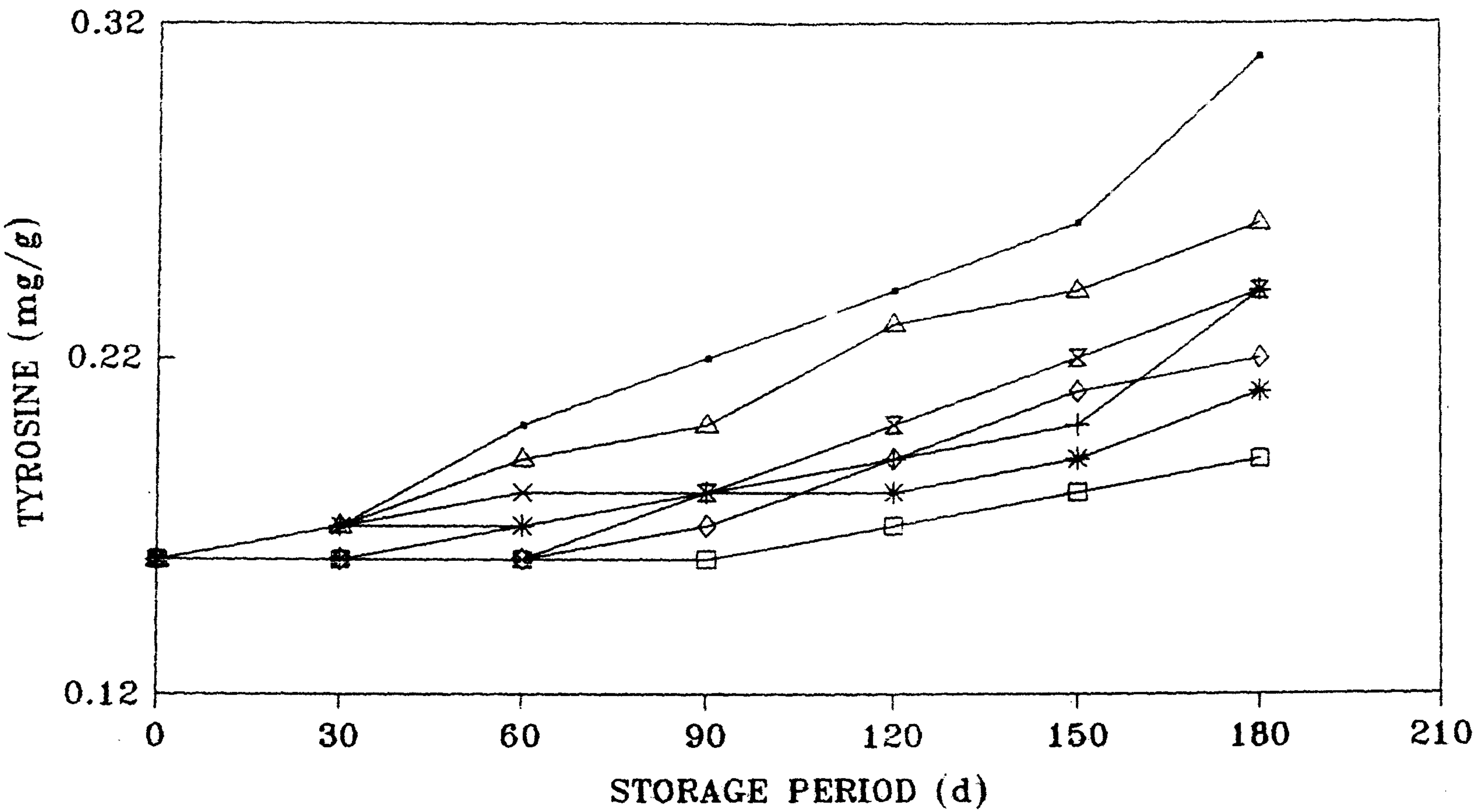

Fig. 20. Effect of packaging and storage on tyrosine of dudh churpi

P1A, without packaging and preservative; P1B, without packaging and with preservative;
P2A, glass container and without preservative; P2B, glass container and with preservative;
P3A, plastic container and without preservative; P3B, plastic container and with preservative;
P4A, plastic pouch and without preservative; P4B, plastic pouch and with preservative;

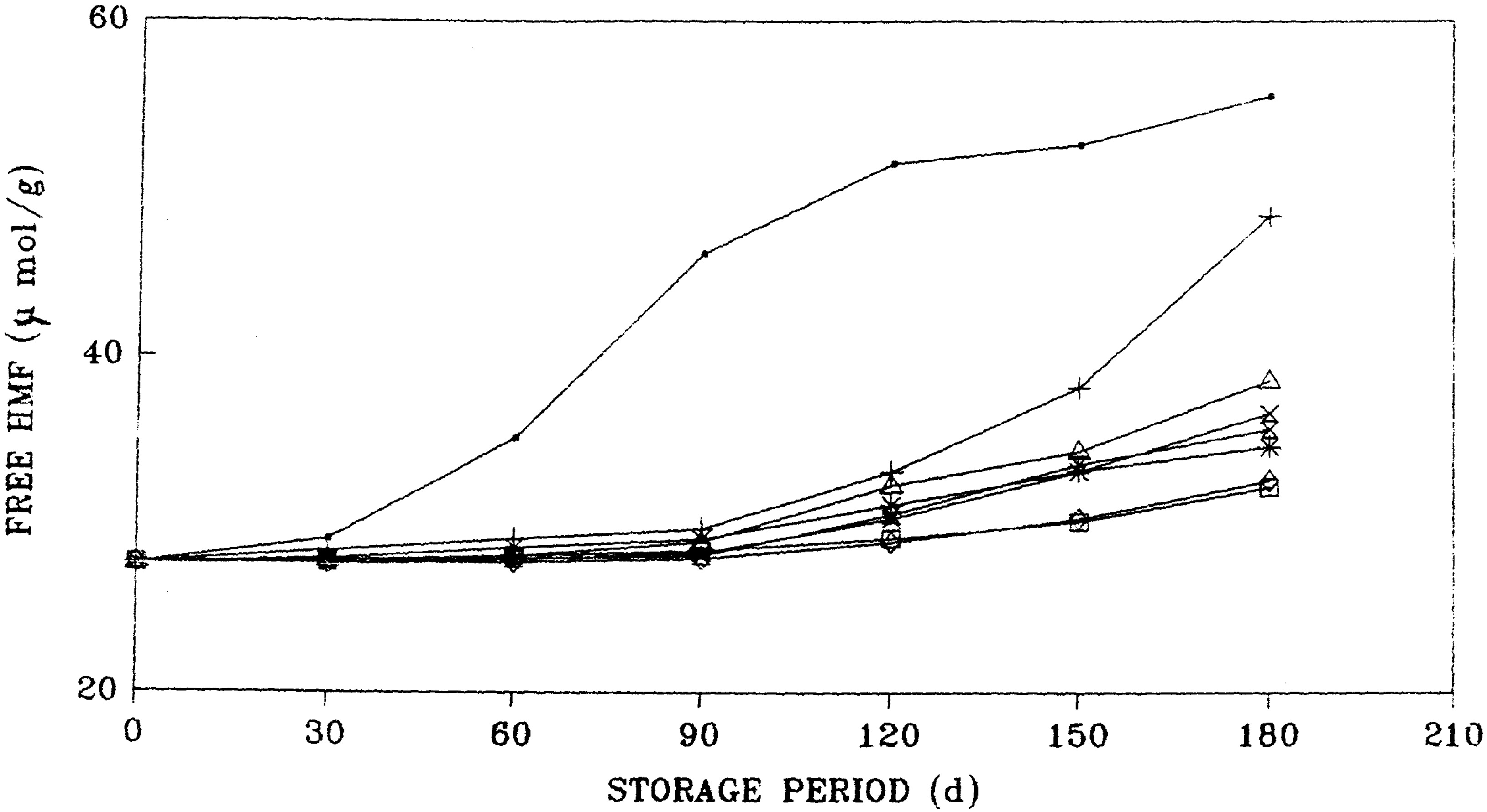

Fig. 21. Effect of packaging and storage on free hydroxymethylfurfural of dudh churpi

P1A, without packaging and preservative; P1B, without packaging and with preservative;
P2A, glass container and without preservative; P2B, glass container and with preservative;
P3A, plastic container and without preservative; P3B, plastic container and with preservative;
P4A, plastic pouch and without preservative; P4B, plastic pouch and with preservative;

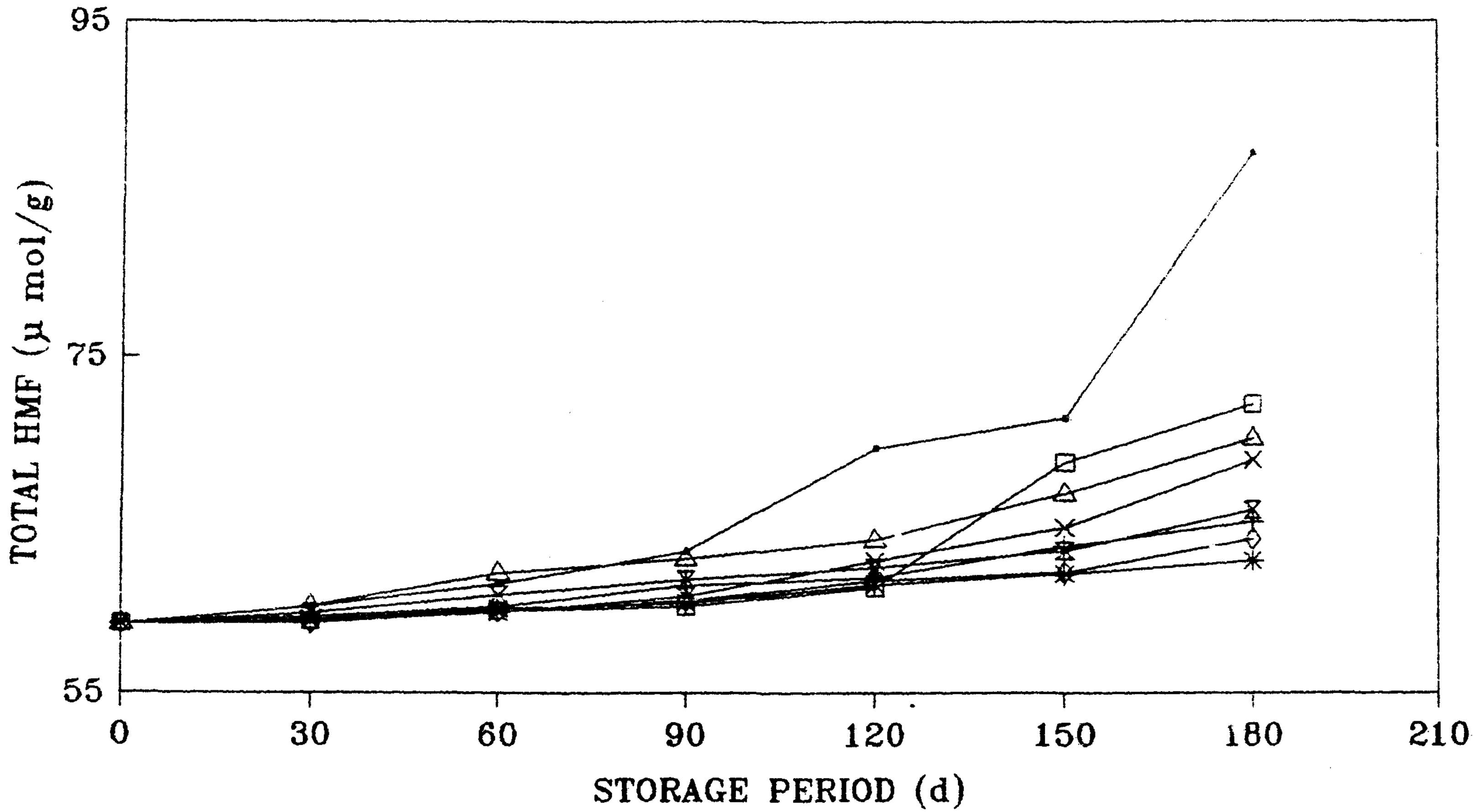

Fig. 22. Effect of packaging and storage on total hydroxymethylfurfural of dudh churpi

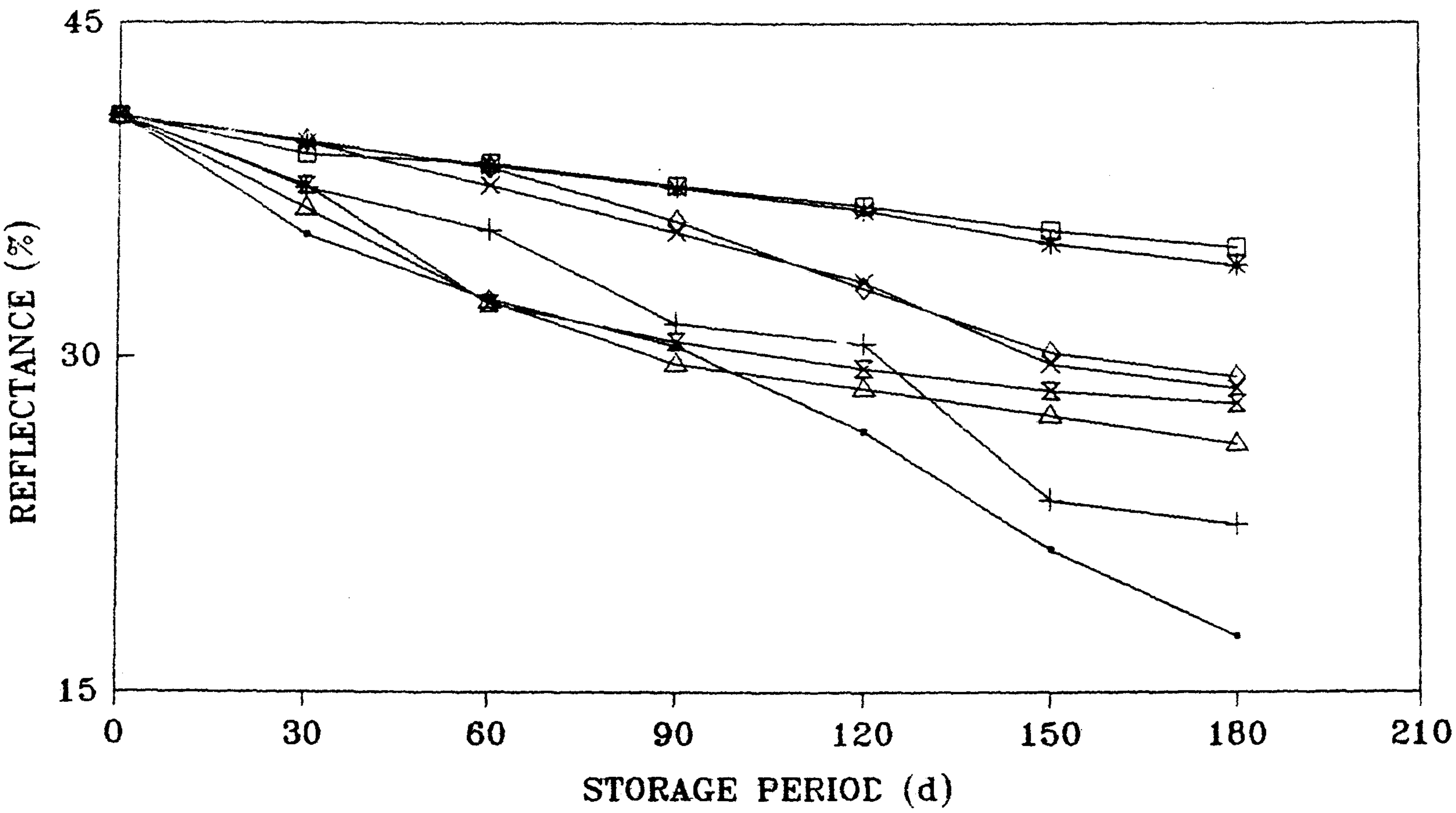

Fig. 23. Effect of packaging and storage on reflectance of dudh churpi

P1A, without packaging and preservative; P1B, without packaging and with preservative;
P2A, glass container and without preservative; P2B, glass container and with preservative;
P3A, plastic container and without preservative; P3B, plastic container and with preservative;
P4A, plastic pouch and without preservative; P4B, plastic pouch and with preservative;

Table 36. Regression equations for physico-chemical parameters during storage of dudh churpi

Parameter	Packaging material and form*	Regression equation**	Coefficient of correlation (R)
Moisture (M)	P_1A	$M = 15.33+1.81x10^{-2}t-3.00x10^{-6}t^2$	0.99
	P_1B	$M = 15.51-2.73x10^{-3}t+8.90x10^{-5}t^2$	0.98
	P_2A	$M = 15.53+2.97x10^{-4}t+1.70x10^{-5}t^2$	0.99
	P_2B	$M = 15.52+4.52x10^{-4}t+7.00x10^{-6}t^2$	0.98
	P_3A	$M = 15.47+5.20x10^{-3}t-1.00x10^{-6}t^2$	0.98
	P_3B	$M = 15.45+4.26x10^{-3}t-2.00x10^{-6}t^2$	0.94
	P_4A	$M = 15.50+2.53x10^{-3}t+1.30x10^{-5}t^2$	0.99
	P_4B	$M = 15.53-8.30x10^{-4}t+2.80x10^{-5}t^2$	0.99
Free HMF (FHMF)	P_1A	$FHMF = 25.27+0.21t-4.00x10^{-5}t^2$	0.98
	P_1B	$FHMF = 28.06-0.02t+4.53x10^{-4}t^2$	0.99
	P_2A	$FHMF = 27.65-2.94x10^{-3}t+2.07x10^{-4}t^2$	0.99
	P_2B	$FHMF = 27.86-9.90x10^{-3}t+1.82x10^{-4}t^2$	0.99
	P_3A	$FHMF = 27.95-3.15x10^{-2}t+4.40x10^{-4}t^2$	0.95
	P_3B	$FHMF = 27.88-2.11x10^{-2}t+2.58x10^{-4}t^2$	0.99
	P_4A	$FHMF = 27.83-2.17x10^{-2}t+4.50x10^{-4}t^2$	0.99
	P_4B	$FHMF = 27.78-2.23x10^{-2}t+3.77x10^{-4}t^2$	0.99
Total HMF (THMF)	P_1A	$THMF = 61.63-14.83x10^{-2}t+1.52x10^{-3}t^2$	0.95
	P_1B	$THMF = 59.12+9.95x10^{-3}t+1.31x10^{-4}t^2$	0.99
	P_2A	$THMF = 59.05+1.15x10^{-2}t+5.50x10^{-5}t^2$	0.99
	P_2B	$THMF = 59.00+1.32x10^{-2}t+2.90x10^{-5}t^2$	0.98
	P_3A	$THMF = 59.26-1.71x10^{-2}t+3.83x10^{-4}t^2$	0.99
	P_3B	$THMF = 59.05+4.18x10^{-3}t+1.28x10^{-4}t^2$	0.99
	P_4A	$THMF = 59.38+2.00x10^{-2}t+2.09x10^{-4}t^2$	0.99
	P_4B	$THMF = 60.12+9.95x10^{-3}t+1.05x10^{-4}t^2$	0.99

Table 36. Continued

Parameter	Packaging material and form*	Regression equation**	Coefficient of correlation (R)
Reflectance (Re)	P_1A	$Re = 39.45-5.62x10^{-2}t-3.70x10^{-4}t^2$	0.96
	P_1B	$Re = 40.69-8.48x10^{-2}t-1.10x10^{-4}t^2$	0.99
	P_2A	$Re = 40.73-3.34x10^{-2}t-1.00x10^{-5}t^2$	0.99
	P_2B	$Re = 40.57-3.43x10^{-2}t+1.50x10^{-5}t^2$	0.99
	P_3A	$Re = 41.04-5.15x10^{-2}t-1.10x10^{-4}t^2$	0.99
	P_3B	$Re = 41.15-4.77x10^{-2}t-1.20x10^{-2}t^2$	0.99
	P_4A	$Re = 40.62-1.56x10^{-1}t+4.28x10^{-4}t^2$	0.99
	P_4B	$Re = 41.01-1.55x10^{-1}t+4.62x10^{-4}t^2$	0.99

*P_1, without packaging; P_2, glass container; P_3, plastic container; P_4, plastic pouch; A, without preservative; and B, with 0.1% potassium sorbate

**Storage period (d)

4.4.2.5. Hydroxymethylfurfural value

Both free and total HMF content of dudh churpi were determined to evalute the progression of Maillard browning during storage of the product. In all the cases, the free and total HMF contents increased with the increase in storage period, but the rate of progression was considerably less when the samples were treated with 0.1% sorbate. The least increase in free (from initial value of 27.69 to 32.23 μmol/g) and total (from initial value of 59.11 to 62.86 μmol/g) HMF content was observed in the samples added with the sorbate and in glass containers (Figs 21 and 22).

4.4.2.6. Reflectance

With the progression of Maillard browning there was a gradual drop in percent reflectance at 450 nm. In concurrence with the observation of browning, the change in reflectance was also minimum (from initial value of 40.80 to 34.90%) in the samples added with 0.1% sorbate and stored in glass containers (Fig. 23).

4.4.2.7. Regression equations

Regression equations for the values of moisture, free and total hydroxymethylfurfural and reflectance are presented in Table 36. The changes in all the physico-chemical parameters fit best to the second degree equations. Howwever, the first degree fits also yielded comparable results. Moisture, free and total HMF and reflectance values can be explained by quadratic regression model of the type $y = A + Bt + Ct^2$ with a correlation coefficient

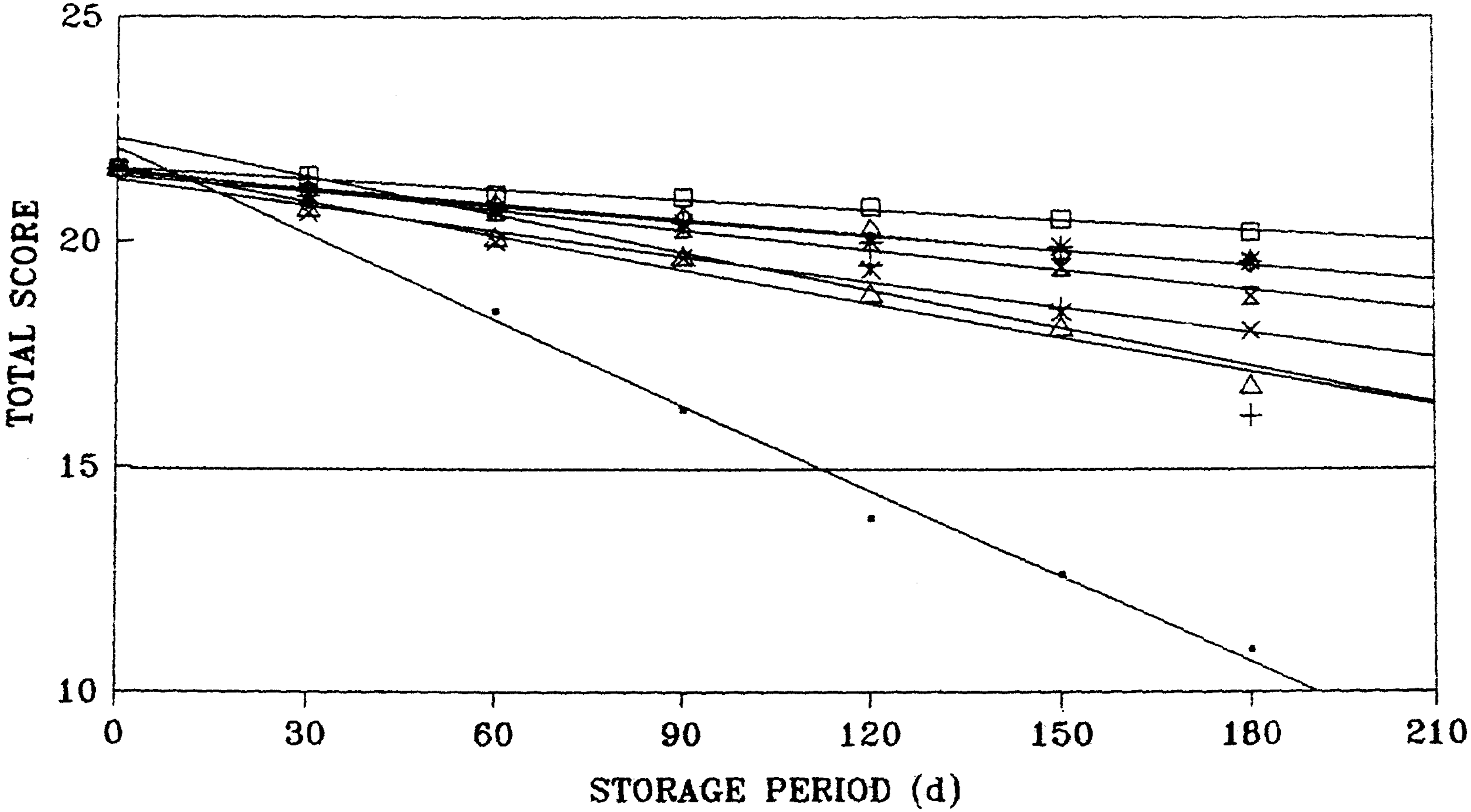

Fig. 24. Effect of packaging and storage on total scores of dudh churpi

P1A, without packaging and preservative; P1B, without packaging and with preservative;
P2A, glass container and without preservative; P2B, glass container and with preservative;
P3A, plastic container and without preservative; P3B, plastic container and with preservative;
P4A, plastic pouch and without preservative; P4B, plastic pouch and with preservative;

of more than 0.96, where y is a physico-chemical parameter, t is the storage period in days and A, B and C are the constants of regression model.

4.4.2.8. Predicted shelf-life of dudh churpi

The shelf-life of the product was assessed from the regression line of the mean overall acceptability scores or total scores on storage period, assuming the total score '15' to be the limit, below which the product was not acceptable. The sensory scores for overall acceptability and the shelf-life of the product are shown in Fig. 24 and Table 37. The figures of these regression equations to the data were tested by calculating % RMS which ranged between 0.286 to 3.357. The low % RMS value shows that the equations fit well to the data. Analysis of variance of mean overall acceptability scores indicated that there was a significant ($P<0.05$) difference due to the use of potassium sorbate in prolonging the shelf-life of dudh churpi. The predicted shelf-life of dudh churpi added with 0.1% sorbate and stored in glass container is 871 days which is significantly ($P<0.01$) higher than the other conditions.

4.5. Water sorption characteristics of dudh churpi

4.5.1. Sorption isotherms of dudh churpi

Moisture sorption isotherms of dudh churpi were determined at 15, 25, 35 and 45°C over an a_w range of 0.11 to 0.97. Adsorption isotherms of dudh churpi are shown in Fig 25. In general, the equilibrium moisture content

Table 37. Shelf-life prediction of dudh churpi packed with different packaging materials and stored at ambient condition

Packaging material and form*	Regression equation**	Coefficient of correlation (R)	%RMS	Predicted shelf-life (d)
P_1A	$y = 22.05\text{-}6.31\text{x}10^{-2}t$	-0.99	2.402	112
P_1B	$y = 22.29\text{-}2.79\text{x}10^{-2}t$	-0.93	3.357	261
P_2A	$y = 21.44\text{-}1.09\text{x}10^{-2}t$	-0.96	0.487	592
P_2B	$y = 21.63\text{-}0.76\text{x}10^{-2}t$	-0.93	0.286	871
P_3A	$y = 21.36\text{-}1.88\text{x}10^{-2}t$	-0.97	0.918	339
P_3B	$y = 21.53\text{-}1.13\text{x}10^{-2}t$	-0.97	0.302	577
P_4A	$y = 21.63\text{-}2.50\text{x}10^{-2}t$	-0.98	1.134	265
P_4B	$y = 21.59\text{-}1.48\text{x}10^{-2}t$	-0.96	0.493	444

*P_1, without packaging; P_2, glass container; P_3, plastic container; P_4, plastic pouch; A, without sorbate; and B, with 0.1% sorbate. **y, overall ecceptability (total score); t, period of storage; Predicted shelf-life was calculated on the basis of minimum acceptability score of 15.

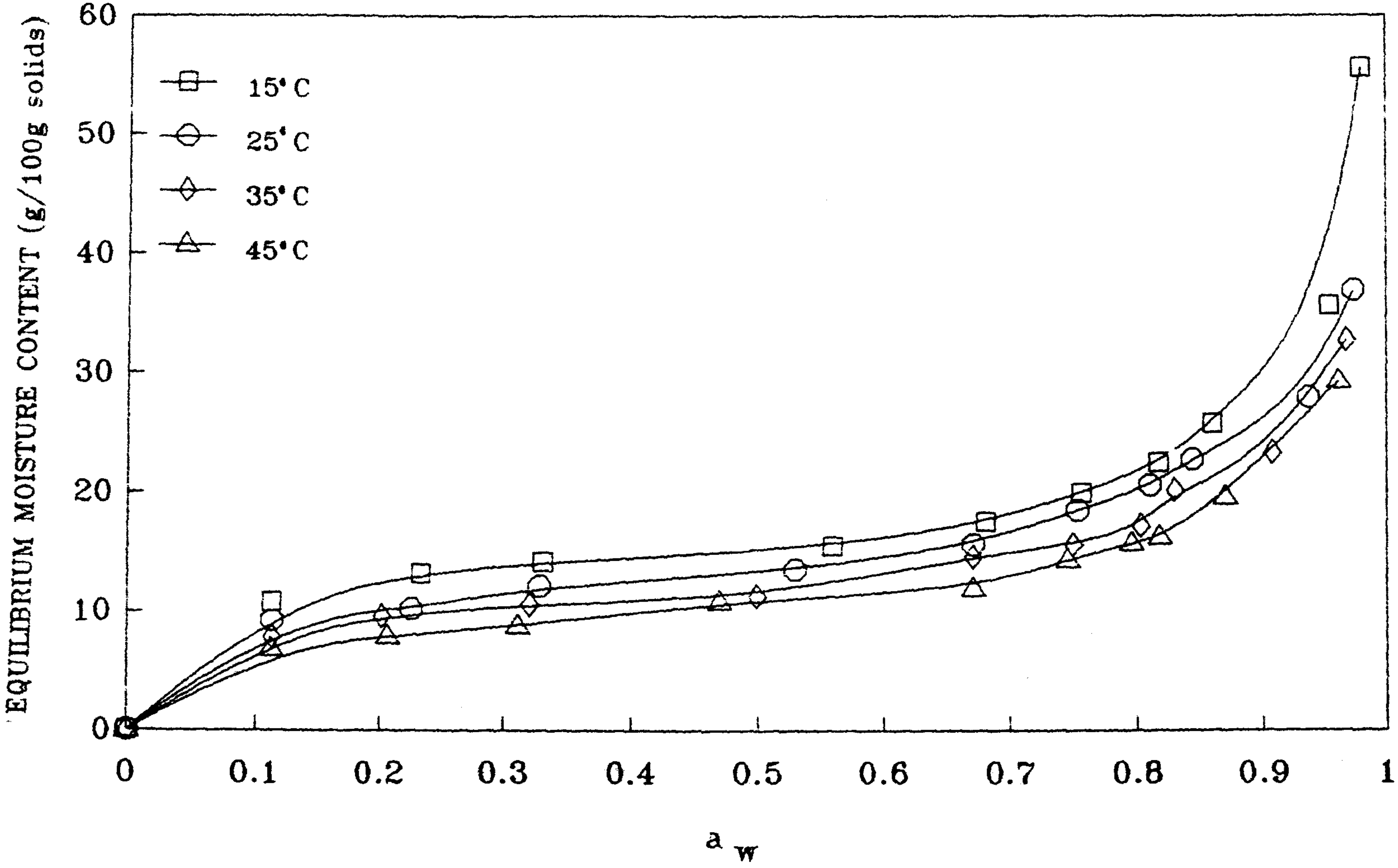

Fig. 25. **Moisture sorption isotherms of dudh churpi as influenced by temperature**

increased rapidly at low a_w (0-0.15), gradually between 0.15 and 0.78 followed by a steep rise above a_w 0.78. The equilibrium moisture content in dudh churpi increased at 0.97 a_w during adsorption.

4.5.2. Equations describing isotherms of dudh churpi

Of the nine equations fitted to the sorption data in the range of 0.1125-0.9790. Bradely, Henderson, Iglesias and Chirife, Khun and Mizrahi equations exhibited high % RMS values. However, these equations seemed to fit well in two ranges, sometimes three ranges with % RMS values ranging from 2.0934-9.4112. The corresponding a_w ranges and constants are given in Appendix 1.

In dudh churpi, four equations gave good fit over the full range of isotherms. They are GAB, modified Mizrahi, Caurie and Oswin. However, Cauries equation showed fairly low RMS values when fitted in full ranges of adsorption data of dudh churpi. Cauries equation was well studied to describe the adsorption of dudh churpi. Monolayer values were determined using these equations. The a_w ranges, equation constants and RMS values of GAB, modified Mizrahi, Caurie and Oswin's equations at 15, 25, 35 and 45°C are shown in the Table 38.

4.5.3. Effect of temperature on isotherms of dudh churpi

Increase in temperature tends to shift the isotherms to right hand (Fig. 25). As the temperature increased, a_w at a given moisture content of dudh churpi increased, but above a_w 0.93, this effect diminished. In other words, as the temperature increased, the equilibrium moisture content of dudh churpi at a

Table 38. Sorption ranges, constants and % root mean square (RMS) values of dudh churpi for selected equations at different temperatures

Equation	Temperature (°C)	a_w	Constants* a	b	c	% RMS
GAB	15	0.2325-0.9530	7.3202	-11.5491	0.8191	4.5493
	25	0.1125-0.9360	8.1048	-44.3188	0.0289	4.9136
	35	0.2013-0.9070	6.4139	-21.5861	0.0561	4.2911
	45	0.1115-0.8695	6.5245	-112.6264	1.4857	5.3148
Modified Mizrahi	15	0.1125-0.9790	-10.0090	-0.4720	9.6321	5.0465
	25	0.1125-0.9730	-7.8351	-3.2597	10.3342	8.5016
	35	0.1125-0.9670	-7.1273	-2.2615	8.6097	7.3936
	45	0.1115-0.9610	-5.8734	-3.2226	8.3639	4.9154
Caurie	15	0.1125-0.9530	1.3599	11.9727	——	6.9631
	25	0.1125-0.9360	1.3153	10.7617	——	5.0246
	35	0.1125-0.9070	1.2345	10.1683	——	6.1110
	45	0.1115-0.8695	1.1839	9.3107	——	5.0554
Oswin	15	0.1125-0.9530	16.2570	0.2272	——	6.9631
	25	0.1125-0.9730	14.1672	0.2528	——	5.1679
	35	0.1125-0.9670	12.6706	0.2570	——	6.6762
	45	0.1115-0.9610	11.1141	0.2725	——	6.2143

*a, b and c correspond to constants M_m, C and K respectively in GAB equation; a and b in modified Mizrahi equation; a and b represent C and M_m respectively in Caurie's equation.

given a_w decreased.

The effect of temperature was evaluated by Caurie's equation whose constants are given in Table 39. The monolayer value and density of sorbed water decreased with the increase in temperature. Monolayer value decreased from 11.9727 to 9.3107 % with the increase in temperature of sorption from 15 to 45°C (Table 38).

A relationship of the Caurie's constants with temperature was established. The corresponding equations are shown in Table 40.

4.5.4. Properties of bound water and surface area of the adsorbent

Several aspects of bound water in dudh churpi are presented in Table 41. The surface area on which adsorption took place was determined by the formula given by Caurie (1981):

$$A = \frac{54.45}{S}$$

where, A = surface area, m^2/g and

S = slope of Caurie's plot

Number of adsorbed monolayers was calculated by the formula (Caurie 1981):

$$S = 2/N$$

where, S = slope of Caurie's plot and

N = number of adsorbed monolayers

Monolayer value and density of bound water are indicated by M_m and C values respectively of Caurie's equation. Percent bound or non-freezing water is the product of monolayer value (M_m) and number of adsorbed

Table 39. Effect of temperature on isotherm parameters of dudh churpi

Equation	Temperature (°K)	Isotherm parameters[a] $M_m(T)$	$C(T)$	% RMS
Caurie	288	11.9022	1.3702	5.0607
	298	10.9145	1.3044	5.1510
	308	10.0652	1.2457	6.1282
	318	9.3294	1.1931	5.2135

[a] $M_m(T)$, monolayer moisture content; $C(T)$, density of the sorbed water

Table 40. List of equations showing relationship of isotherm parameters with temperature of adsorption of dudh churpi

Isotherm equation	Relationship of isotherm parameters with temperature[a]
Caurie	$Mm(T) = 0.9003e^{6181.724/RT}$
	$C(T) = 0.3161e^{3511.6503/RT}$

[a]$M_m(T)$, monolayer moisture content (g/100 g solids) at a specified temperature;

C(T), density of the sorbed water (g/ml) at a specified temperature;

T, temperature(°K); R, universal gas constant (8.31432 Joules/°K/mole)

Table 41. Properties of bound water and surface area of the adsorbent for dudh churpi

Temperature (°C)	Adsorbed monolayers (N)	monolayer moisture (g / 100 g solids)	Density of sorbed water (g/ml)	Bound or non-freezing water (g / 100 g solids)	Surface area of adsorption (m^2/g)
15	8.8039	11.9727	1.3599	105.4064	239.6862
25	8.1820	10.7617	1.3153	88.0523	239.9067
35	8.2365	10.1683	1.2345	83.7512	224.2387
45	7.8644	9.3107	1.1839	73.2230	214.1056

monolayers (N).

With the increase in temperature the number of adsorbed monolayers reduced from 8.8039 to 7.8644 and the monolayer moisture content dcreased from 11.9727 to 9.3107 g/100 g solids. Density of sorbed water and bound water content also declined with the increase in temperature. Although the surface area of adsorbent reduced from 239.6862 at 15°C to 214.1056 m^2/g at 45°C, there was no significant reduction in surface area of adsorbent between 15 and 25°C (Table 41).

4.6. Consumer response to laboratory-made dudh churpi

The consumers' preference trial with the best quality market samples of dudh churpi from Bhutan and those prepared in laboratory indicates their equal acceptance (Table 42).

Out of 127 male and equal number of female respondents from different families, 77 were below the age of 16, 98 within the age group of 16-25 years, 73 within 25-50 years and only 6 were over 50 years old. The respondents were broadly divided into three income groups: 41% below the income level of Rs 2500, 38% within Rs 2501-5000 and 21% over Rs 5000 per month.

All the respondents expressed their frequency of eating dudh churpi either as 'several times a week' or 'several times a month'. None of the respondents mentioned any specific time of eating this product.

Out of total 254 respondents, 105 preferred market samples to laboratory-made ones and 33 accepted both the samples equally. Eighty-five percent and 15% indicated their reasons for preference of market smaples over laboratory-made product as better colour and overall sensory quality,

Table 42. Consumers' response to best available market (Bhutan) and laboratory-made dudh churpi

	No. of consumers*	
Overall response	Market	Laboratory-made
Preferred extremely	20 (7.87)	23 (9.05)
Preferred very much	25 (9.84)	21 (8.27)
Preferred moderately	29 (11.42)	34 (12.20)
Preferred slightly	31 (12.20)	38 (14.96)
No preference	33 (12.99)	

*Percent respondents are indicated in parentheses.

respectively. Out of 116 respondents who preferred laboratory-made samples, 43% indicated better flavour, 27% better texture and 30% both flavour and texture as their reasons for preference.

4.7. Cost of production of dudh churpi

The cost model described in Table 43 is developed on the basis of actual trials conducted under optimized process conditions.

Estimated cost of production of dudh churpi was worked out to be Rs 116.82 per kg i.e. Rs 23.36 per 200 g glass bottle (Rs 182.56 - 56.40 - 9.34) (Table 43 and Annexure - IV)

The business of dudh churpi production is quite remunerative. It can be observed that conversion of 108 l of cow milk per day into dudh churpi with a small amount of by products like ghee and whey, resulting out of standardization and souring of milk, will earn a net profit of about Rs 8048 per month with a total capital investment of Rs 46,300 and the annual operating cost of Rs 3,03,085.

Table 43. Statement of cost for the production of dudh churpi

Sl. No.	Item of cost	Output: 1660.2 kg yield of dudh churpi		
		Annexure	Amount (Rs)	Per Uni (Rs)
1.	Input			
1.1.	Raw materials	I	1,65,462	99.66
1.2.	Labour, utilities, house rent, packaging and others	II	72,342	43.57
1.3.	Depreciation on fixed assets and interest on capital investment	III	65,281	39.33
	Cost of production		3,03,085	182.56
2.	Output	IV	3,99,669	240.74
	Profit (2 - 1)		96,584	58.18

Annexure-I

Raw materials

Sl No.	Particulars	Quantity	Rate (Rs)	Amount (Rs)	Per unit (Rs)
1.	Cow milk				
	(3.5% Fat and 8.7% SNF)	39,420 l	4/l	1,57,680	94.98
2.	Citric acid	84 kg	70/kg	5,880	3.54
3.	Markin cloth	120 m	10/m	1,200	0.72
4.	Sugar	58.5 kg	12/kg	702	0.42
		Total:		1,65,462	99.66

Labour and others

Sl No.	Particulars	Quantity	Rate (Rs)	Amount (Rs)	Per unit (Rs)
1.	Labour charges				
	Unskilled	1	20/day	7,300	4.40
	Skilled	1	30/day	10,950	6.59
2.	Utilities				
	Steam	9,125 kg	0.75/kg	6,844	4.12
	Water	21,900 l	1/1000 l	219	0.13
	Electricity	1,825 kW	1/kW	1,825	1.10
3.	House rent		750/month	9,000	5.42
4.	Packaging charges	8,301 pcs	4/200 g bottle	33,204	20.0
5.	Quality control expenses			2,400	1.45
6.	Miscellaneous expenses			600	0.36
		Total:		72,342	43.57

Annexure - III

Depreciation of fixed assets and interest on capital investment

Sl No.	Particulars	Quantity	Rate (Rs)	Amount (Rs)	Per unit (Rs)
1.	Depreciation on fixed assets @ 10% per annum	46,300		4,630	2.79
2.	Interest on fixed capital investment @ 18% per annum	46,300		8,334	5.02
3.	Interest on working capital investment @ 22% per annum	2,37,804		52,317	31.51
		Total:		65,281	39.32

Annexure - IV

Output

Sl No.	Particulars	Quantity	Rate (Rs)	Amount (Rs)	Per unit (Rs)
1.	Yield of dudh churpi	1,660.2 kg (4.21 kg per 100 kg cow milk)	175/kg	2,90,535	175.00
2.	Surplus fat	936.225 kg (2.7 kg per day) converted into ghee (95% recovery)	100/kg	93,622	56.40
3.	Whey	2,500 l	0.50/l	15,512	9.34
		Total:		3,99,669	240.74

Annexure - V

Detailed list of fixed assets

Sl No.	Particulars	Quantity (Rs)	Rate / unit	Amount
1.	Aluminium milk can	6 pcs	800 / can	4,800
2.	Cream separator	1 pc	3,000 each	3,000
3.	Mini boiler 50 kg / h water evaporation capacity	1 pc	20,000 each	20,000
4.	Heating vessel, 250 l capacity	1 pc	5,000 each	5,000
5.	Drier	1 pc	10,000 each	10,000
6.	Weighing balance	1 pc	1,500 each	1,500
7.	Laboratory equipment			2,000
		Total:		46,300