RESEARCH ARTICLE

Sensory characterization of *pinni* - a milk cereal based sweet using quantitative descriptive analysis and principal component analysis

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Abstract: *Pinni* is a popular traditional milk-cereal based sweet of northern states of India viz., Punjab, Haryana and Delhi. Market samples were collected and were evaluated for various quality attributes. Quantitative Descriptive Analysis revealed significant difference ($p < 0.05$) in sensorial, physico-chemical, textural attributes of *pinni* among the market samples. Principal Component Analysis identified key six components comprising of shape, crumbliness, cooked flavour, colour, firmness, oxidized flavour, gumminess, chewiness, cohesiveness, surface appearance and coating and moisture absorption, which governed 78.66% of the variation in the sensory scores of *pinni*. Hence, these attributes may be given prime importance while developing technology for industrial scale production of *pinni*.

Keywords: Quantitative descriptive analysis, Principal component analysis, *Pinni*, Sensory evaluation

Introduction

Pinni is a traditional dessert popular in northern part of Indian subcontinent. It is prepared by roasting cereal flours mainly

wheat, gram, black lentil flour with added *khoa* (desiccated milk) and sugar (Talwar and Brar, 2015). *Pinni* is characterized by light brown colour with grainy texture and pleasant flavour coupled with excellent nutritive value. *Pinni* is usually prepared during winter and consumed as a dense source of energy, especially by lactating mothers, besides being enjoyed by young ones and adults. Traditionally, *pinni* is produced at home, but with urbanization and industrialization, it is now manufactured at small scale by food industries in India. Popularity of this product is increasing day by day and sporadic information is available regarding chemical composition and manufacturing process, but practically nothing is known about the sensorial attributes of this delicacy (Talwar and Brar, 2015). Probably due to the absence of any regulatory standard, variations in ingredients quality, recipe and storage temperature of the final product the composition of *pinni* available in the market widely (Talwar and Brar, 2015). Also, information on the desirable sensory characteristics of this delicacy is also not properly documented. As sensory quality is the driving force for consumer acceptance hence characterization of sensory attributes of the product is crucial to develop a product that meets consumer expectation (Desai et al. 2013).

Quantitative Descriptive Analysis (QDA) approach has been recognized as a tool for measurement and optimization of sensory attributes of various food and dairy products (Stone and Sidel, 1998). In this technique, the panel members are trained to measure the specific quality attributes of the product to obtain quantitative product description which can be analyzed statistically. QDA has been successfully used as technique for sensory evaluation of food products such as UHT milk (Chapman et al. 2001), chocolate milk (Thompson et al. 2004), soy milk (Keast and Lau, 2006), whey and soy proteins (Drake et al. 2007), fermented food products (Ghosh and Chattopadhyay, 2010), yoghurt (Desai et al. 2013) doda burfi (Chawla et al. 2014) and *cham-cham* (Puri et al. 2015).

Principal component analysis (PCA) is a multivariate statistical analytical technique applied to sensory data to reduce the set of dependent variables (attributes) to a smaller set of underlying variables (called factors) based on patterns of correlation among the original variables (Lawless and Heymann, 1998). QDA and PCA studies on doda burfi revealed that two principal

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components explained 80.50% of the total variation (Chawla et al. 2014). PC1 was consisted of colour, glossiness, cohesive texture and caramelized flavour and overall acceptability whereas colour, granularity and gumminess were the factors of PC2. Puri et al. (2015) conducted market survey for *cham-cham* collected from four different locations known for their excellence in *cham-cham* production for sensory characterization using QDA and PCA.

Rapid urbanization and globalization has triggered large-scale marketing of traditional food items like *pinni*, hence the technology for the production of this delicacy is needed to be standardized for producing it on commercial scale. Before this, the key sensorial attributes that contributes to the acceptability of *pinni* needs to be identified as they are mainly determined by the manufacturing process adopted. The objective of this study was to estimate the extent of variation in the product collected from different *pinni* producing centres and to find out the principal sensorial descriptors necessary to explain the desirable sensory attributes of *pinni* using QDA and PCA.

Materials and methods

Sample collection: A total of 32 samples, eight each from four cities of North India i.e., Karnal, Amritsar, Ludhiana and Delhi, known for their excellence in *pinni* production were collected thrice. Product was procured on the day of manufacture in sterilized rigid containers to retard physicochemical and microbiological changes and transported ambient temperature ($30 \pm 2^\circ\text{C}$) to the laboratory so as to minimize the chances of error in the sensory results.

Sensory analyses: The terms for sensory evaluation of *pinni* samples were developed by nine member trained sensory evaluation panelist aged between 28-52 years. They provided independent observations on randomized samples of *pinni* using QDA methodology (Lawless and Heyman, 1998). The judges had previous experience in sensory evaluation of milk products. The ballot development for sensory evaluation was accomplished in seven working sessions. After the terminology development phase, the panelists were trained for the evaluation of *pinni*. Training consisted of evaluating *pinni* by use of the descriptive terms developed to describe and quantify appearance, flavour and texture of *pinni*. Attributes were quantified with an intensity rating scale from 0 to 10; where 0 = attribute not detected and 10 = attribute extremely strong. A line of 10 cm ranging from 0 to 10 points was drawn with marking interval of 1 cm for evaluation and reporting sensory results. Panelists were asked to mark a vertical linear mark indicating the sample number along the horizontal linear scale for a particular attribute. Overall quality rating was measured with a scale of 1 to 10, where <6 was considered “poor”, 6 to 7 was “fair”, and 8 to 10 was “good” (Chapman et al. 2001). This procedure was repeated until panel consensus was achieved. Each sample was served at a time with

deionised water. At each testing period, two intact pieces two intact pieces of samples (tempered to $20 \pm 1^\circ\text{C}$) were presented coded with random three digit numbers in closed glass containers to panel members seated in individual booths. The descriptors used for evaluating appearance were colour, shape, surface appearance, surface coating for flavor, cereal like/doughy, *ghee* aroma, rancid, oxidized, stale, cooked flavor, sweetness, off flavour were used. Texture descriptor used in the study was firmness, crumbliness, sandy/granular, gumminess, chewiness, cohesiveness, moisture absorption. An additional attributes viz., overall acceptability was added along with other descriptors to judge the extent of liking of the product. PCA is a multivariate technique in which a structure is extracted from a correlation matrix, based on the scores obtained by descriptive analysis technique several dependent variables could be correlated using this technique. By identifying the pattern of correlation among the dependent variables, a new variable is generated in PCA which is called as factor for the group of correlated original attributes. In the subsequent stages second and third groups are also identified with derivation of factors for each, based on residual variance. PCA provides factor loading and factor scores. The former is represented as correlations of attribute with new dimensions while the latter as values of products on new dimensions. For interpretation of dimensions, factor loadings are essential and the factor scores illustrate the relative positions among the products in a map (Jolliffe, 2005). Hence, to simplify the data and eliminate descriptor redundancies transformation of original dependent variable into uncorrelated dimensions is carried out using PCA.

Statistical Analysis: of *pinni* samples was analyzed Analysis of Variance (ANOVA) was done on the data generated from market survey to check the difference in means. Duncan's post hoc test was used to determine the difference in individual mean values. Principal Component Analysis (PCA) of the data obtained was carried out using SPSS (version 20.0). The principal components were extracted based on Eigen values which are greater than 1 and the varimax method was used to rotate the solutions. Normalization was done by Kaiser Method following the principle described by Lawless and Heyman, (1998).

Results and discussion

Quantitative Descriptive Analyses (QDA)

Specific terms which were used for QDA to evaluate the samples were generated after discussion held with trained panellists. The lists of terminologies (lexicons) for evaluating sensory attributes of *pinni* were finally refined and are presented in Table 1. In Table 2 the mean panellist ratings of organoleptic quality of market samples of *pinni* related to its appearance, flavour, texture attributes and overall acceptability are provided.

Fig. 1 Sensory profiles of market samples of *pinni* from four different groups. Individual attributes are positioned like the spokes of a wheel around a center zero, or not detected) point, with the spokes representing attribute intensity scales, with higher (more intense) values radiating outward.

Shape, stale, cooked flavour, crumbliness and sandy/granular sensorial attribute of the samples varied significantly ($p < 0.05$) among the four groups studied *i.e.*, sensory scores for shape of the sample varied significantly between Amritsar and other three groups. Shape of the product varied from cylindrical to round, round being the most desirable and common one. Panellists also observed stale flavour as one of the major difference in sensory attributes while marking on descriptive scale. Stale flavour in Amritsar group was significantly different ($p < 0.05$) only from Karnal group. Stale flavour develops due to prolonged storage of samples of *pinni*, the reason of stale flavour is initiation of many undesirable chemical changes *e.g.*, fat oxidation protein degradation etc (Chawla et al. (2015).

‘Cooked flavour’ of Ludhiana group sample was different ($p < 0.05$) from Karnal group, which could be attributed to the processing steps involved in *pinni* preparation. *Pinni* is prepared by roasting wheat flour in *ghee* and roasting is done until typical flavour is developed. This process sometime leads to over cooking of product, which results in development of cooked flavour. Crumbliness textural attribute of Amritsar group of samples was significantly ($p < 0.05$) different from Karnal. Sandy/Granular texture of Amritsar group was significantly different from Karnal and Delhi group. Sandy/granular texture is due to the presence of coarse sand like particle in *pinni* may be due to variation in wheat flour (refined or whole) used in making *pinni* place to place.

To create a visual profile or fingerprinting of product attributes, spider plots was created by plotting average intensity values on an appropriate scale, and then joining the points (Figure 1). This plot illustrates that ‘shape’ of Ludhiana and Karnal group samples

was highly towards round side which is a desirable characteristic of this attribute and samples of Amritsar had deviated from round shape and obtained lowest scores. As can be seen, stale flavour was more in Amritsar group from remaining three groups. Score for ‘cooked flavour’ was highest for Karnal group of samples probably due to the more roasting in case of this group of samples then remaining ones. ‘Crumbliness’ texture was highest in Karnal and Ludhiana group of samples and lowest in Amritsar group samples. ‘Sandy/granular’ texture was also more in Karnal group and lowest in Amritsar group. There was non-significant ($p > 0.05$) difference in ‘colour’, ‘surface coating’, ‘ghee aroma’, ‘rancid’, ‘oxidized’, ‘sweetness’, ‘off flavour’, ‘firmness’, ‘gumminess’, ‘chewiness’, ‘cohesiveness’ and moisture absorption in the samples collected from four different cities. Among the twenty lexicons generated through discussion among the panel members nine *i.e.*, surface colour, doughy, rancid, stale, off flavour, granularity, firmness, chewiness and gumminess are common with sensory lexicon of *doda burfi*. This reveals thereby the organoleptical differences between *doda burfi* and *pinni* and justifies the need for development of product specific semantics for describing optimum sensorial quality. Desirable sensory attributes of *pinni* was found to be round shape with dark brown colour, absence of interstitial spaces or bumps on the surface, presence of moderate degree of coating with dry fruit on product’s surface, free from rancid, oxidized, doughy and stale flavour with moderate degree of firmness, chewiness, cohesiveness and cooked flavour.

Principal components analysis (PCA)

PCA was applied to the mean attribute ratings listed in Table 1 to simplify interpretation of data from 21 attributes measured on 32

Fig. 2 Cumulative variance plot and eigen values of six extracted Principal components generated using PCA

Table 1. Descriptors with definition used to explain the desirable quality parameters for *Pinni*

Attribute name	Attribute definition
Appearance	
Colour	The intensity of brown colour from light to dark brown
Shape	Shape of the sample ranging from cylindrical to round
Surface appearance	Presence or absence of interstitial spaces or bumps on the surface
Surface coating	Presence of dry fruits/edible coating materials on product's surface for garnishing
Flavour	
Cereal like/doughy	Presence of smell of 'unbaked' water and flour mixture
Ghee aroma	Intensity of ghee/milk fat aroma
Rancid	Having the disagreeable odour or taste of decomposing oil and fats
Oxidized	Painty aroma associated with aged oils
Stale	Not fresh, dull due to prolonged storage
Cooked flavour	Flavour associated with heated milk solids and flour mixture
Sweetness	The fundamental taste sensation produced by aqueous sucrose solution
Off flavour	Any abnormal, unappetizing flavour other than the above.
Texture	
Firmness	Force necessary to compress the product between tongue and palate
Crumbliness	The easiness by which the product disintegrates
Sandy/Granular	Present of coarse / sand like particles that reacts while mastication
Gumminess	Having the property of adhering and sticking to the inner surface of mouth
Chewiness	The total amount of energy required to masticate the samples to a state ready for swallowing.
Cohesiveness	Degree to which the sample holds together in a mass
Moisture absorption	Amount of saliva absorbed by the <i>pinni</i> sample before swallowing
Overall acceptability	The total sensorial likeness or dislikeness of the product based on all the sensorial attributes tested

products from four different groups. To acquire specific knowledge about primitive factors having critical importance

Fig. 3 Three-dimensional plot showing factor scores of market samples of *pinni* on Varimax rotated PC axis (a) PC1, PC2, PC3 and (b) PC4, PC5, PC6. Labels: Karnal (1–8), Amritsar (9–16), Delhi (17–24), Ludhiana (25–32).

among the sensorial descriptors *i.e.*, PCs were extracted based on maximum variance values. Among all the PCs extracted, six PCs having eigen values >1 (Kaiser criterion) explaining 78.66% of the total variance in the sensory data set were taken for further analysis. The results revealed that on the basis of eigen vector loadings, first PC with an eigen value of 7.50 was able to explain

37.47 % of the total variation (Fig. 2) whereas second PC with an eigen value 2.28 explained 11.40 % of the variation and third PC with eigen value 2.1 explained 10.31% first three PC's (PC1, PC2 and PC3) explained 59.18% of the total variation. Fourth PC with eigen value of 1.64 was able to explain 8.19 % variation. Fifth PC with eigen value of 1.211 was able explain 6.05% variation and

Table 2. Mean sensory scores showing differences between groups¹

Attributes	Karnal	Amritsar	Delhi	Ludhiana
Colour	5.44 ^a ± 0.61	5.91 ^a ± 0.85	4.34 ^a ± 0.52	5.23 ^a ± 0.52
Shape	6.66 ^a ± 0.74	4.24 ^b ± 0.67	6.16 ^a ± 0.39	6.90 ^a ± 0.29
Surface appearance	6.71 ^a ± 0.39	6.01 ^a ± 0.53	5.53 ^a ± 0.53	5.94 ^a ± 0.46
Surface coating	4.59 ^a ± 0.62	5.50 ^a ± 0.49	3.87 ^a ± 0.92	3.63 ^a ± 0.57
Cereal like/doughy	4.02 ^a ± 0.28	4.14 ^a ± 0.16	3.99 ^a ± 0.18	4.19 ^a ± 0.33
Ghee aroma	4.86 ^a ± 0.16	5.16 ^a ± 0.33	4.48 ^a ± 0.23	4.33 ^a ± 0.39
Rancid flavour	0.77 ^a ± 0.05	1.65 ^a ± 0.69	0.87 ^a ± 0.22	1.01 ^a ± 0.27
Oxidized flavour	0.77 ^a ± 0.07	1.28 ^a ± 0.48	0.85 ^a ± 0.18	0.78 ^a ± 0.25
Stale flavour	0.62 ^a ± 0.06	1.76 ^b ± 0.58	0.94 ^{ab} ± 0.17	1.01 ^{ab} ± 0.29
Cooked flavour	4.28 ^a ± 0.35	3.65 ^{ab} ± 0.69	3.14 ^{ab} ± 0.31	2.43 ^b ± 0.37
Sweetness	6.34 ^a ± 0.21	5.85 ^a ± 0.37	6.04 ^a ± 0.22	6.13 ^a ± 0.12
Off flavour	1.00 ^a ± 0.22	1.85 ^a ± 0.60	0.82 ^a ± 0.17	1.02 ^a ± 0.32
Firmness	4.02 ^a ± 0.23	4.64 ^a ± 0.42	4.89 ^a ± 0.25	4.87 ^a ± 0.22
Crumbliness	5.99 ^a ± 0.33	4.83 ^b ± 0.50	5.62 ^{ab} ± 0.27	5.82 ^{ab} ± 0.26
Sandy/Granular	5.91 ^a ± 0.21	4.33 ^b ± 0.43	5.49 ^a ± 0.25	5.18 ^{ab} ± 0.32
Gumminess	2.77 ^a ± 0.20	3.14 ^a ± 0.80	3.45 ^a ± 0.39	3.03 ^a ± 0.22
Chewiness	3.21 ^a ± 0.24	3.39 ^a ± 0.64	3.49 ^a ± 0.30	3.07 ^a ± 0.23
Cohesiveness	3.17 ^a ± 0.23	4.01 ^a ± 0.46	3.77 ^a ± 0.31	3.61 ^a ± 0.16
Moisture absorption	3.87 ^a ± 0.21	4.29 ^a ± 0.38	4.27 ^a ± 0.17	3.97 ^a ± 0.19
Overall acceptability	6.80 ^a ± 0.21	6.07 ^a ± 0.49	6.70 ^a ± 0.18	6.15 ^a ± 0.22

¹Mean sensory scores of *pinni* samples collected from eight different shops of four cities (Mean ± SE)

ANOVA and Duncan post hoc test was applied to the descriptive sensory score data to obtain difference in means

^{ab}Means in the row followed by different letters represents significant differences (P < 0.05)

Table 3. Varimax rotated principal component factor loadings for *Pinni* attributes

Attributes	PC1	PC2	PC3	PC4	PC5	PC6
Colour	0.199	0.209	0.688*	0.070	-0.129	0.162
Shape	-0.131	-0.086	0.158	-0.147	0.834*	0.150
Surface appearance	-0.139	-0.220	0.275	-0.807*	-0.199	-0.030
Surface coating	-0.037	0.023	0.183	0.780*	-0.374	0.073
Cereal like/ doughy	0.034	0.089	-0.015	0.004	0.064	0.922*
Ghee aroma	0.247	0.192	0.212	0.455	-0.184	0.561
Rancid	0.390	0.755*	0.350	0.217	-0.098	0.039
Oxidized	0.558	0.676*	0.255	0.221	-0.017	0.083
Stale	0.463	0.683*	0.225	0.260	-0.154	-0.002
Cooked flavour	0.408	0.123	0.712*	0.311	-0.042	0.163
Sweetness	-0.129	-0.015	0.638	-0.375	0.245	-0.032
Off flavour	0.376	0.764	0.250	0.146	-0.257	0.173
Firmness	-0.065	-0.327	-0.665*	0.064	-0.134	0.139
Crumbliness	-0.093	-0.340	-0.043	-0.004	0.829*	-0.165
Sandy/ Granular	0.252	-0.640	0.133	0.082	0.253	0.003
Gumminess	0.868*	0.224	0.190	0.139	0.153	0.154
Chewiness	0.898*	0.074	0.130	0.201	0.016	0.188
Cohesiveness	0.849*	0.001	0.008	-0.055	-0.275	0.001
Moisture absorption	0.770*	0.324	0.042	-0.079	-0.180	-0.133
Overall acceptability	-0.118	-0.866*	-0.210	-0.040	0.018	-0.137
Variance explained ¹	20.51%	18.90%	12.14%	9.99%	9.95%	7.13%

Six PC were extracted by applying PCA on the mean values of descriptive sensory scores

* Most important attributes; ¹Refers to percent variance explained

sixth PC having eigen value of 1.047 explained 5.23% variability. PCs were rotated using varimax rotations for closer alignment with original variables (Lawless and Heymann, 1998). Rotation of variables resulted in factor loading which represents correlation between PC and the original attribute measured as shown in Table 3. High factor loading values that are marked with asterisk were found to be of paramount importance. Absolute value of factor loadings corresponding to each sensory attribute decides

the relation between principal component and that specific sensory attribute (Chapman et al. 2001). It could be observed that PC1 was found to be entirely related to the gumminess, chewiness, cohesiveness and moisture absorption as the loadings had maximum absolute values. PC2 had large loadings for rancid flavour, overall acceptability, stale flavour and oxidized flavour. PC3 was found to be related to cooked flavour, colour and firmness. PC4 was found to be related to the surface appearance

Table 4. Factor scores for market samples of *pinni*.

Shop codes	PC1Gumminess/ chewiness/ cohesiveness/ Moisture absorption	PC2 Rancid/ Overall acceptability/ Stale/ Oxidized	PC3 Cooked flavour/ Colour/ Firmness	PC4 Surface appearance/ Surface coating	PC5 Shape/ Crumbliness	PC6 Cereal like/ doughy
K1	-0.862	-0.907	1.015	1.627	0.903	-1.503
K2	0.248	-0.527	-0.253	1.078	1.012	-0.058
K3	-0.188	-0.748	1.141	0.375	0.473	1.804
K4	-0.176	-0.501	1.286	-0.309	0.471	-0.368
K5	0.301	-1.195	1.599	-0.161	0.364	0.474
K6	-1.127	-0.544	1.339	0.163	0.747	-0.543
K7	-0.674	0.019	1.507	-0.308	-0.580	1.235
K8	0.328	-0.400	-0.475	-1.724	-1.593	-0.350
A9	0.691	3.903	2.508	0.288	-0.757	-0.536
A10	-1.082	-0.550	0.671	-0.552	-1.816	0.364
A11	-2.526	0.829	-0.742	-0.656	1.138	0.261
A12	-2.006	0.590	-1.086	-0.006	-2.512	0.674
A13	2.196	1.347	-0.443	1.810	0.126	0.975
A14	0.668	-0.626	-0.769	0.237	-0.271	0.740
A15	0.767	-0.972	-0.849	0.550	-2.022	-0.941
A16	1.248	-0.202	0.522	-0.076	-1.549	-0.147
D17	1.605	-0.424	0.0002	0.096	0.821	0.274
D18	1.747	-0.910	-0.742	-1.260	0.465	0.746
D19	-0.229	-0.003	-0.804	-0.169	0.343	-0.059
D20	-0.771	0.934	-0.715	-1.120	1.372	-0.163
D21	-0.461	0.804	-2.083	2.264	-0.690	-0.629
D22	0.670	-0.661	-0.053	-1.627	-0.237	0.133
D23	0.222	-0.521	0.098	0.807	-0.072	-0.365
D24	0.075	-0.907	0.462	0.987	0.027	-0.830
L25	-0.336	-0.309	-0.815	0.984	0.509	1.396
L26	-0.710	-0.030	-0.119	0.860	0.047	1.027
L27	-0.416	0.204	-0.930	-0.801	0.864	0.332
L28	-0.155	0.284	-0.428	0.437	1.232	-0.575
L29	0.928	1.667	-1.283	-1.428	0.956	-0.264
L30	-0.164	0.465	0.294	-0.234	-0.231	0.062
L31	0.113	-0.321	-0.129	-0.780	0.080	-3.749
L32	0.078	0.217	0.279	-1.352	0.378	0.584
Variance explained ^a	20.51%	18.90%	12.14%	9.99%	9.95%	7.13%

K1-K8: sample codes for Karnal, A9-A16: sample codes for Amritsar, D17-D24: sample codes for Delhi, L25-D32: sample codes for Delhi.

Factor scores were generated by applying PCA on descriptive sensory score data

^aRefers to percent variance explained

and surface coating. PC5 was largely related to shape and crumbliness. While PC6 was found to be influenced only by cereal like/doughy flavour.

The factor scores for market samples of *pinni* are presented in Table 4. Coxon (1982) observed that the factor score values could be utilized for the purpose to position or specify the location of all the samples along the varimax rotated PC. Hence, the three dimensional graphs generated depicting the position of different samples along four PC generated (Fig 3a and 3b). Products that are similar are positioned in close proximity to one another in the graph, and products that are very different are far apart (Jolliffe, 2005).

It can be observed from Fig. 3a that samples from Amritsar and Delhi are in close proximity with each other, having high factor score values ($A_{13} = 2.196$ and $D_{18} = 1.747$) for 'gumminess/chewiness/cohesiveness/moisture absorption' axis as compared to Karnal and Ludhiana groups which had less gumminess and chewiness value. Rancid, stale and oxidized flavour factor score of Amritsar and Ludhiana group was more ($A_9 = 3.903$, $A_{13} = 1.347$ and $L_{29} = 1.667$) which made the sample of these groups less acceptable as compared to Karnal and Delhi groups that had negative factor score values. Cereal/dough like flavour factor score value was more in Ludhiana group as compared to other three groups this factor score value was also undesirable (Figure 3b). Surface appearance was highest factor score value for Karnal at the same time surface coating gained highest value was for Amritsar group. It can also be observed from Fig. 3b that samples of Ludhiana and Karnal groups are in close proximity with each other having high factor score values (0.876 to 1.075) for shape as compared to Amritsar and Delhi groups which deviated from desirable spherical shape as shown by negative score values. Similar to this work concerning characterization of market samples of *pinni*, Chawla et al. (2014) conducted descriptive sensory analysis of *doda burfi*, another *khoa* based traditional Indian dairy product

Conclusions

The results of the study suggested that in PC1 (gumminess, chewiness, cohesiveness and moisture absorption) in PC2 (rancid, stale flavour, oxidized flavour and overall acceptability), in PC3 (cooked flavour, colour and firmness) in PC4 (surface appearance and surface coating) in PC5 (shape and crumbliness) and in PC6 (cereal like/doughy) had explained much of the variation in descriptive sensory data. It can clearly be observed from the three-dimensional graphs axes that samples positioned in close proximity with one of the axis has more influence of that particular PC which in turn requires attention during technology

development and commercialization of optimized product with desired sensory attributes. PCA identified six key components composed of shape, crumbliness, cooked flavour, colour, firmness, oxidized flavour, gumminess, chewiness, cohesiveness, surface appearance and surface coating and moisture absorption, which governed much of the variation in the sensory scores of *pinni*. Hence, these attributes may be given prime importance while developing the product technology for industrial scale production. Analysis of sensorial attributes of market samples of *pinni* revealed significant differences in shape, stale off flavour, cooked flavour, crumbliness and sandy or granular texture among samples from different locations. Among the four cities surveyed, sample collected from Karnal city showed maximum positive loadings and attributes which were undesirable were found either negligible or completely absent.

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