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Physicochemical and colour attributes of market samples of North Indian sweet *Pinni*

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Abstract

The present study was aimed to evaluate the quality of *Pinni* in North India. A total of 32 *pinni* samples were collected from four different locations, Karnal, Amritsar, Ludhiana and Delhi of North India. The samples were three times collected and analysed for physico-chemical attributes and instrumental colour characteristics. The composition of *pinni* which is available in market varies widely probably due to absence of any regulatory standard, variation in ingredients quality, recipe and storage temperature of the final product. The moisture, fat, protein, total sugar, ash and water activity of sample collected from different markets varied from 1.56-5.40%, 19.00-24.74%, 8.70-15.13%, 58.07-61.98%, 0.08-1.88% and 0.22-0.45 respectively. Colour characteristics L^* , a^* , b^* values varied from 30.10-59.63, 6.03-18.56, 19.75 to 39.92 respectively. The composition of *pinni* which is available in market varies widely probably due to absence of any regulatory standard, variation in ingredients quality, recipe and storage temperature of the final product.

Keywords: *Pinni*, physical quality, chemical quality, marketing sources

Introduction

Milk based ethnic sweets constitute one of the most promising categories with a lot of market potential to be exploited by the organized sector of Indian dairy industry. To curve a place in competitive processed food market, dairy industry needs to widen its product portfolio and respond to new demands created by upwardly mobile population. India probably has the largest repertoire of milk based sweets and out of them *pinni* is an immensely popular traditional milk-cereal based sweet of Northern states of India viz., Punjab, Haryana and Delhi. *Pinni* usually has dark brown colour, granular texture and is a rich source of nutrients derived from milk solids as well as goodness of wheat flour, gram flour, dry fruits etc. Wheat flour-*khoa pinni* is the most common variant prepared in household as well as by small scale manufactures. For production of this variant, desi ghee is melted in heavy base karahi (pan/wok). On heating up of ghee, wheat flour is added. Roasting of wheat flour is done on medium flame till typical roasted flavour and colour is developed. *Khoa* is added with continuous stirring to break the lumps into small granules. Roasting is continued for another five minutes and after that sugar is added and stirred to properly mix the ingredients. After this stage heating is discontinued and dry fruits e.g., almond, cashew nut or cardamom powder along with raisin is sometimes added. Then the mass is allowed to cool and manually moulded into spherical shape. The manufacture of *pinni* has largely been in the hands of traditional sweetmeat makers or local confectioners. Being prepared at small scale, the hygienic conditions are usually not maintained and thus inferior quality products are manufactured and marketed (Patil, 2002) [12]. The chemical composition and organoleptic properties of milk products such also vary to a great extent and hence these delicacies lack uniformity. Microbiological safety of resulted products is usually not ensured and shelf life is usually less (Chavan *et al.*, 2010) [2]. At the same time, due to lack of any prescribed standards laid down by any of the food standards authority, quality in terms of proximate composition, texture and microbiological count varies a lot. Recently, in order to tap the potential of traditional sweet markets, several dairies in private and co-operative sector have started their organized production. Today, a wide range of fresh as well as packaged ethnic milk products and convenience mixes are available in market. These products are also being exported to countries having large Indian ethnic population. Also, changing scenario offers new opportunities for Indian dairy industry, particularly organized sector, for expanding their product profile. Many of these traditional milk products such as *channa* based sweets, *mishti doi*, *shrikhand*, *basundi* etc. which were manufactured at small scale in specific geographical locations, have been introduced in other parts of the Indian subcontinent. These dairy delicacies have been relished by the consumer as they possess excellent flavour, mouth-feel and exhibit characteristics

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textural profile. In absence of technical know-how, the large scale production of these region specific milk products in organized sector is a challenging task (Singh and Kumar, 2006) ^[19], which requires scientific investigations in terms of their characterization, standardization of technological parameters and strategic interventions for ensuring the safety and enhancing the shelf-life. (Chawla, 2010) ^[3] Due to the differences in the manufacture procedure adopted by the manufactures, the organoleptic and physico-chemical quality of *pinni* vary greatly. Keeping this in view, the present study was undertaken to evaluate the Physico-chemical quality of market *pinni* collected from Northern states of India.

Material Methods

Collection of samples: Thirty-two samples, eight each from four locations of North India, were collected thrice. *Pinni* was procured on the day of manufacture in sterilized rigid containers (to retard physicochemical and microbiological changes) and transported at ambient temperature to the laboratory and subjected to sensory and physico-chemical evaluation on the same day so as to minimize the chances of error in the results.

Physico-chemical analyse

Moisture content: Gravimetric method as described in Indian standard (IS: SP: Part 18 XI, 1981) ^[5] was used for determination of moisture content in *pinni*.

Fat content: Fat content of *pinni* samples was determined with the help of Mojonnier fat extraction apparatus as specified in IS SP Part II, (1967) ^[6].

Protein content: The protein content of *pinni* was determined by micro Kjeldahl method (Menefee and Overman, 1940) ^[10].

Total sugars: Sugars were determined following the method prescribed by IS SP 18 Part XI, (1981) ^[5].

Total ash content: The ash content of *pinni* was determined by method described in IS: SP:18 Part XI, (1981) ^[5].

Water activity: Water activity was measured using water activity meter Aqua Lab (Model Series 3 TE) supplied by M/s Decagon Devices, WA, USA. (Londhe *et al.* 2012) ^[9].

Colour measurement: Colour measurements were conducted using Color Flex (Hunter Associates Laboratory, Inc., Reston VA, USA) colour measurement system equipped with dual beam xenon flash lamp and universal software. The instrument was calibrated prior to sample measurements with standard black, white and green tile as prescribed by the supplier. The results were represented by the L*, a*, b* notation. It is a 3D colour presentation method in which L* is the lightness index of colour and equals 0 for black and 100 for white. a* value is redness and greenness index the amount of red (0 to 60) or green (0 to -60) while b* value is the yellowness (0 to 60) or blueness (0 to - 60) index.

Results and Discussion: A wide variation was noted in the chemical composition of market samples of *pinni* collected from four locations (Table 1).

Moisture content: Moisture is an important constituent of *pinni* and wide variation was observed in the samples procured from markets. Variations in the moisture content of

pinni are likely to cause alteration not only in sensory, chemical and textural characteristics of the product but also in microbiological profile which ultimately influence shelf life of the product. Moisture content of market samples of *pinni* (Table 1) varied from 1.56 to 5.40. Highest moisture content was (5.40%) recorded in the sample D3 procured from Delhi market and lowest (1.56%) was for sample A6 collected from Amritsar market. Statistical analysis revealed significant ($p < 0.05$) differences in moisture content among all four groups studied (Table 3). Chawla, (2010) ^[3] reported that the moisture content of market samples *doda burfi* was in the range of 6.77 to 17.31 %. Rasane and Jha, (2014) ^[16] reported that the moisture content of white *peda* varied from 21.37 to 31.53 %, *lal peda* 15.95-19.38% and yellow *peda* 14.34 – 17.67%. Puri *et al.* (2015) ^[14] observed that moisture content of market sample of *cham-cham* was in the range of 28.95% to 45.78%.

Fat content: Though fat rich dairy products always attract consumers owing to glossy surface-appearance and good flavour, but these are susceptible to oxidation especially at higher storage temperature. It could be observed from Table 1 that fat content of market samples of *pinni* varied from 19.00 to 24.74%. Highest value for fat content of *pinni* was recorded in the sample L4 (24.7%) and lowest value was for K8 (19.0%). Table 3 shows that there were significant ($p < 0.05$) differences in fat content of *pinni* among all four groups studied. Chawla (2010) ^[3] reported that fat content of market sample *doda burfi* was in the range of 4.70 to 41.05%. Similar results were reported by Saxena *et al.* (1996) ^[18] for *pinni* and Ray *et al.* (2002) ^[17] and Patel *et al.* (2006) ^[11] for *peda* (*khoa* based delicacy). Puri *et al.* (2015) ^[14] reported that the fat content of market sample of *cham-cham* was in the range of 2.39% to 9.4 %.

Protein content: The protein content is another important constituent which exerts direct as well as indirect influence on colour and textural attributes of *pinni*. Protein content of market samples of *pinni* (Table 1) varied from 8.70 to 15.1%. Highest protein content was (15.1%) was in the sample K8 procured from Karnal city and lowest (8.70%) was for sample D3 collected from Delhi city. Statistical analysis revealed there were significant ($p < 0.05$) differences in protein content among all four groups studied (Table 3). Similar results on market samples of have been observed in *pinni* by saxena *et al.* (1996) ^[18]. Chawla, (2010) ^[3] reported the protein content of market samples *doda burfi* in the range of 4.31 to 15.09%. Ghodeker *et al.* (1974) ^[4] reported that the protein content of market samples *burfi* and *peda* varied between 12.1 to 20.3 and 6.3 to 11.8%, respectively.

Total sugar content: Total sugar content of market samples of *pinni* is represented in Table 1 and it varied from 58.0 to 61.9 %. Maximum total sugar content in *pinni* was (61.9%) observed in A2 and A4 samples and lowest (58.0%) in K8 and D5 sample. Statistical analysis presented in Table 3 revealed that there were significant ($p < 0.05$) difference in protein content among all four groups studied. As high as 40.16% of total sugars and traces of reducing sugars were reported in *pinni* (Saxena *et al.*, 1996) ^[18]. Ghodeker *et al.* (1974) ^[4] reported that sugar content of market samples *burfi* and *peda* was the range of 48.1 to 55.7 and 52.1 to 60.5%, respectively.

Ash content: Total ash content of market samples of *pinni* is presented in Table 1 and it varied from 0.08 to 1.88 %.

Highest (1.88%) and lowest (0.88%) ash content was found in the samples K6 and L4, respectively. Statistical analysis revealed that there was significant ($p < 0.05$) difference in ash content among all four groups studied (Table 3). *Kalakand* and milk cake, another two traditional milk products of India have been reported to contain 2.78 and 2.28% of ash, respectively (Rama and Goyal 2007; Bajwa *et al.*, 2005)^[15, 1].

Water activity (aw): The water activity value of market sample of *pinni* varied from 0.22 to 0.45 and is presented in (Table 1). The maximum aw value was found in the sample collected from Amritsar market followed by Delhi, Karnal and Ludhiana samples. (Table 1), Table 3 shows that statistically there was no-significant ($p < 0.05$) difference in aw value of *pinni* among all four groups studied. Londhe, (2006)^[8] found the water activity of brown *peda* was in the range 0.75 to 0.80.

Tristimulus colour characteristics of market samples of *pinni*

The mean values of instrumentally measured colour (Hunter colour lab) parameters of market samples of *pinni* are listed in Table 2.

Hunter L* value (Whiteness index): Colour of the product plays an important role in the overall acceptability of the product. The tristimulus colour profile measured in terms of Hunter L*, a* and b* values, where L* value refers to whiteness (or inverse of greyness), a* signifies 'redness' (+ve values) or greenness (-ve value) and b* value indicates yellowness (+ve values) or blueness (-ve values) of the product. The darker the product is, the lower will be the L* value. L* value of market samples of *pinni* is shown in Table 2 and it varied from 30.10 and 59.63. Highest L* (59.63) value was noticed in sample A2, which was collected from

Amritsar market and lowest (30.10) value was for A5 sample collected from Amritsar city. Statistical analysis revealed significant ($p < 0.05$) differences in L* value among all four groups studied (Table 3). Surface colour of a *khoa*-based sweets viz., dietetic *burfi* has been determined instrumentally and L* value varied from 77.3 to 82.9 (Prabha, 2006)^[13]. The lower L* value of *pinni* could be due to intense heat treatment given, heat interactions between sugar (both milk sugar and added cane sugar) and milk constituents, leading to well known Maillard reaction.

Hunter a* value (Redness-Greenness index): The a* values of market samples of *pinni* is shown in Table 2 It could be observed that a* value varied from 6.03 and 18.56 in market samples of *pinni*. Highest a* (18.56) value was reported for A8 sample and lowest (6.03) value was for D5. Statistical analysis revealed that there was significant ($p < 0.05$) differences in a* value of *pinni* among all four groups studied (Table 3). It was well established that the colour of milk and milk products undergoes Maillard browning which is characterized by two primary hues viz., brown and yellow. Kumar *et al.* (2006)^[7] estimated the colour value of *gulabjamun* and found that brownness of *gulabjamun* crust was comprised of brownness and yellowness.

Hunter b* value (Yellowness-blueness index): b* values of market samples of *pinni* is presented in Table 2. It is could be seen that b* values varied from 19.75 to 39.92 in market samples of *pinni*. Highest b* (39.92) value was reported in sample A6 collected from Amritsar market and lowest (19.75) value was for A1 sample collected from Amritsar market. Statistical analysis revealed that there was non - significant difference in b* value of *pinni* among four group studied (Table 3). The b* value for *gulabjamun* samples was reported as 57.34 (Kumar *et al.*, 2006)^[7].

Table 1: Physico-chemical composition of *pinni* procured from different markets

Shop Codes	Moisture (%) (Mean \pm SE)	Fat (%) (Mean \pm SE)	Protein (%) (Mean \pm SE)	Total Sugar (%) (Mean \pm SE)	Ash (%) (Mean \pm SE)	Water Activity (%) (Mean \pm SE)
K1	4.48 \pm 0.23	21.3 \pm 0.80	9.36 \pm 0.55	60.5 \pm 0.82	1.56 \pm 0.70	0.41 \pm 0.00
K2	3.61 \pm 0.39	20.1 \pm 0.68	10.3 \pm 0.67	61.5 \pm 0.90	1.59 \pm 0.33	0.36 \pm 0.01
K3	3.28 \pm 0.24	22.4 \pm 0.87	11.7 \pm 0.37	58.4 \pm 0.53	1.20 \pm 0.69	0.32 \pm 0.01
K4	3.33 \pm 0.42	23.6 \pm 0.84	11.7 \pm 0.62	58.2 \pm 0.85	0.86 \pm 0.17	0.35 \pm 0.01
K5	3.80 \pm 0.20	21.6 \pm 0.49	12.1 \pm 0.45	58.6 \pm 0.59	0.70 \pm 0.13	0.39 \pm 0.01
K6	3.56 \pm 0.21	20.2 \pm 0.63	11.3 \pm 0.53	60.3 \pm 0.78	1.88 \pm 0.99	0.42 \pm 0.00
K7	4.35 \pm 0.38	22.0 \pm 0.22	10.1 \pm 0.71	58.1 \pm 0.32	1.43 \pm 0.39	0.43 \pm 0.00
K8	4.06 \pm 0.12	19.0 \pm 0.34	15.1 \pm 0.66	58.0 \pm 0.37	0.90 \pm 0.06	0.34 \pm 0.01
A1	3.57 \pm 0.52	19.6 \pm 0.51	11.6 \pm 0.51	60.9 \pm 0.63	0.91 \pm 0.55	0.41 \pm 0.00
A2	3.82 \pm 0.66	19.7 \pm 0.68	10.1 \pm 0.78	61.9 \pm 0.42	1.31 \pm 0.75	0.44 \pm 0.01
A3	4.08 \pm 0.92	19.7 \pm 0.85	12.0 \pm 0.37	61.5 \pm 0.61	0.86 \pm 0.51	0.41 \pm 0.00
A4	3.95 \pm 0.69	21.3 \pm 0.84	9.60 \pm 0.96	61.9 \pm 0.97	0.54 \pm 0.94	0.37 \pm 0.00
A5	2.66 \pm 0.52	22.2 \pm 0.82	9.76 \pm 0.51	60.4 \pm 0.82	0.98 \pm 0.10	0.25 \pm 0.01
A6	1.56 \pm 0.50	22.5 \pm 0.70	9.68 \pm 0.35	61.7 \pm 0.58	0.66 \pm 0.57	0.22 \pm 0.00
A7	4.01 \pm 0.60	20.4 \pm 0.71	9.12 \pm 0.51	61.7 \pm 0.75	1.32 \pm 0.30	0.39 \pm 0.03
A8	5.18 \pm 0.89	21.7 \pm 0.55	10.1 \pm 0.711	59.1 \pm 0.66	1.16 \pm 0.96	0.45 \pm 0.01
D1	4.11 \pm 0.94	22.5 \pm 0.76	8.94 \pm 0.27	60.1 \pm 0.71	1.20 \pm 0.43	0.37 \pm 0.01
D2	3.40 \pm 0.44	23.2 \pm 0.65	9.47 \pm 0.31	59.6 \pm 0.73	0.95 \pm 0.49	0.32 \pm 0.00
D3	5.40 \pm 0.90	22.8 \pm 0.65	8.70 \pm 0.25	59.9 \pm 0.48	0.81 \pm 0.12	0.41 \pm 0.01
D4	4.17 \pm 0.77	24.0 \pm 0.35	9.31 \pm 0.34	59.5 \pm 0.76	1.24 \pm 0.97	0.40 \pm 0.04
D5	4.24 \pm 0.59	23.1 \pm 0.98	10.1 \pm 0.56	58.0 \pm 0.70	1.39 \pm 0.26	0.44 \pm 0.01
D6	3.13 \pm 0.86	23.7 \pm 0.76	9.39 \pm 0.78	59.7 \pm 0.99	1.56 \pm 0.78	0.40 \pm 0.02
D7	3.62 \pm 0.71	22.9 \pm 0.90	10.1 \pm 0.79	60.3 \pm 0.90	0.52 \pm 0.41	0.42 \pm 0.01
D8	3.53 \pm 0.46	22.3 \pm 0.55	10.5 \pm 0.69	60.9 \pm 0.62	0.66 \pm 0.35	0.40 \pm 0.01
L1	3.98 \pm 0.68	24.5 \pm 0.66	9.18 \pm 0.38	58.8 \pm 0.65	0.39 \pm 0.52	0.34 \pm 0.00
L2	4.72 \pm 1.22	23.3 \pm 0.82	8.95 \pm 0.63	58.7 \pm 0.89	1.00 \pm 0.77	0.42 \pm 0.02
L3	4.24 \pm 0.80	23.9 \pm 0.76	8.72 \pm 0.39	60.3 \pm 0.90	0.38 \pm 0.49	0.41 \pm 0.00

L4	3.86 ± 0.36	24.7 ± 0.31	9.67 ± 0.10	58.9 ± 0.48	0.08 ± 0.58	0.35 ± 0.01
L5	3.49 ± 0.43	22.6 ± 0.86	11.0 ± 0.72	59.7 ± 0.75	0.23 ± 0.05	0.38 ± 0.00
L6	4.16 ± 0.89	23.1 ± 0.98	10.5 ± 0.99	59.0 ± 2.10	0.34 ± 0.53	0.38 ± 0.02
L7	4.48 ± 0.82	23.8 ± 0.95	10.4 ± 0.45	59.4 ± 0.49	0.21 ± 0.38	0.41 ± 0.00
L8	3.92 ± 0.83	24.4 ± 0.50	9.75 ± 0.39	58.6 ± 0.23	0.78 ± 0.18	0.35 ± 0.00

Mean ±SE (n=3). The lowest and highest values are indicated in bold.

K- Karnal city, A- Amritsar city, D- Delhi city, L- Ludhiana city.

Table 2: Instrumental colour profile of *pinni* procured from different markets.

Shop Codes	L* Value (Mean ± SE)	a* Value (Mean ± SE)	b* Value (Mean ± SE)
K1	49.12 ± 0.46	10.37 ± 0.07	30.42 ± 4.57
K2	51.76 ± 0.06	11.83 ± 0.25	34.57 ± 0.51
K3	53.45 ± 0.05	9.43 ± 0.08	27.06 ± 0.20
K4	52.48 ± 0.06	10.79 ± 0.24	29.66 ± 1.15
K5	43.13 ± 0.37	9.06 ± 0.27	21.64 ± 0.68
K6	45.4 ± 0.54	10.0 ± 0.09	24.8 ± 0.12
K7	45.86 ± 0.46	10.61 ± 2.62	28.81 ± 3.98
K8	53.00 ± 0.13	7.65 ± 0.85	27.3 ± 0.18
A1	33.24 ± 0.69	13.58 ± 0.25	19.75 ± 0.47
A2	59.63 ± 0.12	10.43 ± 0.05	35.20 ± 0.10
A3	56.18 ± 0.11	10.48 ± 0.04	32.44 ± 0.08
A4	53.35 ± 0.30	11.97 ± 0.01	33.6 ± 0.45
A5	30.10 ± 0.53	13.82 ± 1.33	33.81 ± 0.97
A6	46.27 ± 0.07	12.93 ± 0.07	39.92 ± 0.33
A7	40.15 ± 0.22	17.00 ± 0.26	28.57 ± 0.20
A8	38.88 ± 0.14	18.56 ± 0.13	29.67 ± 0.26
D1	52.27 ± 0.13	9.63 ± 0.08	26.59 ± 0.22
D2	52.11 ± 0.05	8.99 ± 0.35	29.38 ± 0.62
D3	55.58 ± 0.21	7.78 ± 0.16	27.27 ± 0.36
D4	58.16 ± 0.26	7.32 ± 0.52	25.43 ± 0.15
D5	57.38 ± 0.32	6.03 ± 0.06	25.55 ± 0.05
D6	54.06 ± 0.34	12.24 ± 0.15	36.80 ± 0.70
D7	52.46 ± 0.09	9.44 ± 0.06	28.02 ± 0.19
D8	51.54 ± 0.22	13.43 ± 0.05	35.45 ± 0.25
L1	50.58 ± 0.11	10.98 ± 0.18	29.80 ± 0.53
L2	49.39 ± 0.26	13.13 ± 0.25	33.38 ± 0.61
L3	52.14 ± 0.06	9.47 ± 0.53	30.55 ± 0.56
L4	50.43 ± 0.08	11.01 ± 0.22	30.20 ± 0.74
L5	53.23 ± 0.13	8.90 ± 0.29	28.93 ± 0.13
L6	53.44 ± 0.04	7.78 ± 0.06	25.21 ± 0.17
L7	49.04 ± 0.31	10.03 ± 0.45	27.74 ± 0.31
L8	45.86 ± 0.46	10.61 ± 2.62	28.81 ± 3.98

Mean ±SE (n=3) The lowest and highest values are indicated in bold.

K- Karnal city, A- Amritsar city, D- Delhi city, L- Ludhiana city

Table 3: Mean value of physico-chemical attributes, instrumental colour characteristics for market samples of *pinni**

Attributes	K	A	D	L
Moisture	3.75ab ± 0.46	3.75a ± 0.88	3.88a ± 0.64	4.00a ± 0.53
Fat	21.25a ± 1.58	21.00a ± 1.19	23.13b ± 0.64	23.88b ± 0.83
Protein	11.38b ± 1.84	10.38ab ± 1.06	9.50a ± 0.75	9.88a ± 0.83
Total sugar	59.25a ± 1.58	61.25b ± 1.16	59.88a ± 0.83	59.25a ± 0.46
Ash	1.38b ± 0.51	1.00b ± 0.00	1.13b ± 0.35	0.25a ± 0.46
Water activity	0.37a ± 0.09	0.36a ± 0.08	0.39a ± 0.06	0.38a ± 0.05
L*	49.27ab ± 3.99	44.72a ± 4.89	54.24b ± 2.55	50.51ab ± 2.49
a*	9.97a ± 1.26	13.59b ± 2.90	9.39a ± 2.54	10.24a ± 1.60
b*	28.03a ± 3.86	31.62a ± 5.91	29.31a ± 4.41	29.32a ± 2.35

*Values with different superscripts in a row differ significantly (p<0.05)

Conclusion

The moisture, fat, protein, total sugar, ash and water activity of the samples collected from different markets varied from 1.56-6.40%, 19.00-24.74%, 8.70-15.13%, 58.07-61.98%, 0.08-1.88% and 0.22-0.45 respectively. The chemical composition of the samples collected from different shops of a same city were expected to show variation, but it was interesting to experience variability even within the different samples collected from same shop. Hence, the variables viz.,

fat, protein, sugar and ash content under investigation were found to be statistically significant (p<0.05). Another reason for variability could be attributed to the use of variable amount of nuts in grated form at intermittent stages of preparation, for garnishing and flavouring purpose. The average composition obtained is quiet similar with the one obtained in brown *peda* (Londhe, 2006) [8], Ghodeker *et al.* (1974) [4] reported moisture content in the range 5.4 to 8.4% for *burfi*, and 6.8 to 10.7% for *peda*, fat content in the range

of 4.1 to 13.2% for *burfi*, and 3.3 to 17.9% for *peda*, protein content in the range of 12.1 to 20.3% for *burfi* and 6.3 to 11.8 for *peda*, and sugar content of market samples *burfi* and *peda* in the range of 48.1 to 55.7% and 52.1 to 60.5% respectively and Saxena *et al.* (1996) [18] reported moisture content in the range of 10.93 to 16.79%, fat content in the range of 13.18 to 29.26%, protein content in the range of 3.94 to 12.25% and sugar content of market sample of roasted pulse-*khoa pinni* in the range of 23.58 to 46.57%.

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