Physico-chemical and textural properties of *Santra burfi* as influenced by orange pulp content

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Abstract The burfi prepared with addition of orange pulp in sweetened khoa is popularly known as Santra burfi in Maharashtra and it has great commercial potential owing to its typical taste. The present investigation was carried out with a view to generate technological data, which is requisite in product standardization and mechanization. The santra burfi was prepared by varying the rates of orange pulp addition and was tested for various textural properties such as hardness, cohesiveness, gumminess, chewiness, adhesiveness and springiness with TA-XT2i Texture Analyzer using two-bite compression. The data of product composition and quantified properties were analyzed using correlation and regression techniques. The hardness was found to have positive correlation with proteins, fat and ash content while the moisture and level of orange pulp had negative correlation. Similar trends were observed for springiness, gumminess, chewiness and cohesiveness with the exception of ash. On the contrary, the mean adhesiveness showed negative correlation with protein, fat and ash content and shown positive correlation with moisture content and level of orange pulp. The regression equations were also fitted for explaining the interrelationships between the textural properties as functions of product composition.

Keywords Khoa · Santra burfi · Hardness · Cohesiveness · Gumminess · Chewiness · Adhesiveness · Springiness · Karahi

Introduction

About 7 % of the quantity of milk produced in India is converted to khoa and khoa-based products. Burfi is such a *khoa*-based product popular in India. It is prepared by boiling milk in an open pan so as to obtain a semi-solid product called *khoa* to which sugar is added in crystalline, powder or syrup form (BIS 1970). Due to its popularity and wide acceptance throughout India, many versions of burfi with various ingredients and flavours have evolved.

Santra burfi is a type of *burfi* evolved and popular in the Vidarbha region of Maharashtra, which is known globally for oranges. This *burfi* is prepared by blending *khoa* with orange pulp and sugar. Addition of orange pulp imparts a typical refreshing taste to the product. Orange also enriches the *burfi* with potassium, vitamins and other nutrients. *Santra burfi* is gaining demand in other parts of country too, which necessitates its mechanization to meet the demand.

It is well-accepted that the knowledge of rheological and textural attributes is imperative for mechanization, new product development, equipment design and process improvement (Asghar et al. 2009). Also, there is no literature available on the standardization and optimization of orange pulp content in *Santra burfi*. Therefore, the objective of this study was to establish the physico-chemical quality and textural profile of *Santra burfi* of varying orange pulp content and set up relations for predicting the textural properties from the composition.

Materials and methods

Preparation of orange pulp

Fully-ripened oranges from the *Santra* market of Nagpur were procured, washed thoroughly, peeled, cut into pieces and stones/seeds were removed manually. Then the cut pieces were

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crushed in the mixer to get orange pulp. The pulp, which in general tested 12 % total solids, was heated at 60 °C for 3 min to reduce its microbial load (Shelke et al. 2008). The heat-treated pulp was cooled immediately and kept in the refrigerator for 2 h.

Preparation *Santra burfi*

Buffalo milk standardized to 6 % fat and 15 % total solids (TS) was concentrated in a stainless steel *karahi* (pan) by open pan boiling with continuous stirring and scraping until a semi-solid mass of paste-like consistency was obtained. Sugar @ 35 % of *khoa* was added to sweeten the product. When the product showed a tendency to form compact mass, the temperature was lowered to 88–90 °C and selected levels of orange pulp (0, 5, 10, 15, 20 and 25 % w/w of *khoa*+sugar) were added. Finally, this mixture was heated on a low fire with gentle stirring till the desired consistency of *Santra burfi* was obtained. It was then spread uniformly in a tray and allowed to cool. After setting, *Santra burfi* was cut into rectangular blocks of 25×25×25 mm. Shelke et al. (2008) used similar manufacturing process while studying *mango burfi*. These levels of orange pulp addition yielded various proportions of ingredients, which were considered as treatments as shown below.

Treatment details

- T₀: Plain burfi
- T₁: 5 % Orange pulp+95 % (*khoa*-sugar mixture)
- T₂: 10 % Orange pulp+90 % (*khoa*-sugar mixture)
- T₃: 15 % Orange pulp+85 % (*khoa*-sugar mixture)
- T₄: 20 % Orange pulp+80 % (*khoa*-sugar mixture)
- T₅: 25 % Orange pulp+75 % (*khoa*-sugar mixture)

The chemical composition of *Santra burfi* such as titratable acidity, protein and ash contents were determined following the standards described in Bureau of Indian Standards (ISI 1981). The fat content of the product was determined using Gerber method.

Texture profile analysis (TPA)

Textural properties of *Santra burfi* were evaluated using TA-Xt2i texture analyzer (Stable Micro Systems, Surrey, UK) equipped with 5 kgf load cell using two-bite compression. The samples were cut with a cylindrical die to get uniform size of 10 mm diameter and 10 mm height. The P-75 compression platen having 75 mm diameter was used to compress the samples to 50 % of the original height. The pre-test speed was 2 mm/s while the test and post test speeds were 0.5 mm/s. Values of hardness, cohesiveness, gumminess, chewiness, adhesiveness and springiness were obtained from the typical textural profile curve as described by Bourme

(1978). Four replications of each treatment at 25 °C were tested. The texture data were subjected to correlation and regression analyses in order to develop interrelationships between compositional factors and textural attributes in the following form.

$$I = k_0 + k_1 C_1 + k_2 C_2 + \dots + k_n C_n \text{ and}$$

$$I = k_0 \cdot C_1 k_1 \cdot C_2 k_2 \dots C_n k_n$$

where 'I' was the instrumental parameter (textural attribute), C₁, C₂,..... C_n were compositional parameters and k₀, k₁, k₂,..... k_n were constants (Patil et al. 1990). Moreover, one way analysis of variance (Completely Randomized Design) was used to study the effect of orange pulp content on the physico-chemical qualities and textural attributes of *Santra burfi*.

Results and discussion

The mean chemical composition of *Santra burfi* prepared with different concentrations of orange pulp is presented in Table 1. The titratable acidity, moisture, protein, fat and ash contents of *Santra burfi* ranged from 0.36 to 0.81 %LA, 13.4–24.9 %, 12.3–13.9 %, 16.0–20.0 % and 2.4–2.8 %, respectively. One-way analysis of variance revealed that addition of orange pulp significantly affected the physico-chemical qualities such as titratable acidity, moisture, protein, fat and ash contents ($P < 0.01$). The treatment means were compared using critical difference test and Tukey's Test of Honestly Significant Difference with a significance level of 0.05. The differences are indicated as superscripts in Table 1.

Titratable acidity and moisture content increased markedly with increase in orange pulp content in the product. The difference in titratable acidity at any two pulp contents (in *burfi*) was significantly different ($P < 0.05$). The nearly two-fold increase in acidity was due to the fact that the orange pulp had a lower pH (3.2) and higher acidic content. Similarly, the effect of orange pulp content on moisture content of the product was highly significant ($P < 0.01$). Moisture content increased (nearly 100 %) in *burfi* because after addition of orange pulp during processing heat desiccation was done only for a short time, which allowed the moisture in the orange pulp to be retained in the product. Above 10 % pulp content, the moisture content in the product was high enough to cause an unacceptable level of stickiness. Pairwise comparisons revealed that there was significant difference between the moisture content of control sample (0 % pulp) and those containing various concentrations of orange pulp. On the other hand, protein, fat and ash significantly decreased ($P < 0.05$) with increasing pulp content. However, the changes in protein, fat and ash contents were not as drastic as seen with moisture or titratable acidity. The reduction in

Table 1 Chemical composition of *Santra burfi*

Treatments	Acidity(%LA)	Fat(%)	Moisture(%)	Protein(%)	Ash(%)
T ₀	0.36 ^f ±0.022	20.0 ^a ±1.826	13.4 ^f ±0.004	13.9 ^a ±0.033	2.8 ^a ±0.021
T ₁	0.45 ^e ±0.014	19.1 ^a ±0.071	17.1 ^e ±0.022	13.9 ^a ±0.024	2.5 ^e ±0.016
T ₂	0.54 ^d ±0.008	18.2 ^b ±0.214	19.3 ^d ±0.003	13.4 ^d ±0.163	2.6 ^b ±0.033
T ₃	0.63 ^c ±0.020	17.4 ^{bc} ±0.053	22.2 ^c ±0.006	12.8 ^c ±0.122	2.5 ^c ±0.057
T ₄	0.72 ^b ±0.024	16.7 ^{cd} ±0.000	22.9 ^b ±0.033	12.7 ^c ±0.049	2.4 ^d ±0.024
T ₅	0.81 ^a ±0.026	16.0 ^{cd} ±0.816	24.9 ^a ±0.006	12.3 ^d ±0.041	2.4 ^d ±0.038
SEm	0.01	0.411	0.007	0.044	0.017
C.D.	0.03	1.217	0.021	0.132	0.051
C.V.(%)	3.419	4.595	0.07	0.676	1.361

T₀=Plain burfi, T₁=5 % Orange pulp+95 % (Khoa-sugar mixture), T₂=10 % Orange pulp+90 % (Khoa-sugar mixture), T₃=15 % Orange pulp+85 % (Khoa-sugar mixture), T₄=20 % Orange pulp+80 % (Khoa-sugar mixture), T₅=25 % Orange pulp+75 % (Khoa-sugar mixture)

Values with different superscripts in a column differ significantly ($p<0.05$) ($n=4$)

protein, fat and ash contents was due to the replacement of milk solids by orange pulp.

The values of various texture profile descriptors of *Santra burfi* containing different concentrations of orange pulp are summarized in Table 2. In general, the textural values of *Santra burfi* were remarkably less than those reported for *khoa* and *gulabjamun* (Adhikari et al. 1994). Orange pulp had a highly significant negative effect ($P<0.01$) on hardness of the product. The hardness value decreased from 4.846 to 0.796 N as the orange pulp content increased from 0 to 25 %. Even addition of 5 % pulp drastically reduced the hardness score. As discussed above, the reduction in hardness with orange pulp content could be attributed to the retention of higher moisture in the product during processing. Tukey's test of Honestly Significant Difference (pairwise comparison of treatment means) revealed that the hardness score of *Santra burfi* having any two orange pulp concentrations was significantly different ($P<0.05$).

The correlation coefficients between various texture profile descriptors of *Santra burfi* and compositional factors are

presented in Table 3. All the compositional factors affected the hardness of *burfi* ($P<0.01$). In general, the log-linear relationships exhibited greater correlations as compared to linear relationships for all compositional factors. Protein, fat and ash showed highly positive relationships with hardness while equally significant negative correlation was observed for orange pulp (-0.760) and moisture contents (-0.837) (Table 3).

The parameters that were found to be closely correlated were further analyzed for obtaining regression equations as given in Table 4. Similar equations were developed by Gupta et al. (1990) for predicting the texture profile parameters of *khoa* from the compositional variables. Regression analysis showed that orange pulp content alone accounted for 95 % of the variation in hardness (Eq. 1) while the multiple linear regression model containing all the compositional factors explained 97 % (Eq. 2) of the variation (Table 4). Thus, it could be concluded that hardness of *Santra burfi* was strongly dependent on the pulp content. Higher moisture content in the product at higher orange pulp contents progressively increased the inter-particle

Table 2 Texture profile parameters of *Santra burfi*

Parameters treatments	Hardness, N	Cohesiveness	Adhesiveness, N	Springiness	Gumminess, N	Chewiness, N.mm
T ₀	4.846 ^a	0.132 ^c	0.251 ^b	0.237 ^a	0.639 ^a	0.152 ^a
T ₁	1.552 ^b	1.169 ^a	0.251 ^b	0.206 ^b	0.263 ^b	0.054 ^b
T ₂	1.357 ^{bc}	0.149 ^b	0.277 ^a	0.171 ^c	0.202 ^c	0.034 ^c
T ₃	1.144 ^c	0.137 ^{bc}	0.239 ^b	0.165 ^c	0.157 ^c	0.026 ^d
T ₄	0.830 ^d	0.141 ^{bc}	0.203 ^c	0.193 ^b	0.117 ^d	0.023 ^{de}
T ₅	0.796 ^d	0.134 ^c	0.145 ^d	0.195 ^b	0.107 ^d	0.021 ^c
SEm	0.087	0.005	0.007	0.006	0.012	0.001
C.D.	0.258	0.014	0.022	0.018	0.036	0.004
C.V.(%)	9.914	6.43	6.471	6.220	9.871	5.531

Values with different superscripts in a column differ significantly ($p<0.05$) ($n=4$)

Table 3 Coefficients of correlations between composition and textural attributes of *Santra burfi*

Compositional variables	Hardness, N	Cohesiveness	Adhesiveness, N	Springiness	Gumminess, N	Chewiness, N.mm
Orange pulp	−0.760 (−0.973)	−0.207 (−0.062)	0.633 (0.469)	−0.279 (−0.473)	−0.783 (−0.974)	−0.739 (−0.970)
Moisture content	−0.837 (−0.949)	−0.129 (−0.392)	0.557 (0.536)	−0.398 (−0.444)	−0.848 (0.869)	−0.819 (−0.958)
Protein	0.683 (0.813)	0.303 (0.271)	0.628 (0.652)	0.276 (0.282)	0.720 (0.875)	0.677 (0.830)
Fat	0.792 (0.896)	0.179 (0.161)	0.603 (0.645)	0.318 (0.307)	0.810 (0.939)	0.771 (0.893)
Ash	0.863 (0.869)	−0.236 (−0.242)	0.419 (0.423)	0.372 (0.352)	0.830 (0.836)	0.812 (0.817)

($p < 0.01$), figures in paranthesis are coefficients for log linear relationships

distance of the solids and weakened the strength of the solids network, which resulted in correspondingly softer product (Gupta et al. 1990).

The adhesiveness and springiness of *Santra burfi* ranged between 0.145 and 0.251 N and 0.195–0.237 mm/mm respectively (Table 2). Adhesiveness increased with increase in orange pulp and moisture contents and declined with protein, fat and ash contents. It is normal to expect increased adhesiveness in *Santra burfi* with increasing moisture content, whose value in turn was determined by the orange pulp content. When

compared to adhesiveness, the compositional factors had opposite effects on springiness. Springiness decreased with increasing pulp and moisture contents but was positively influenced by protein, fat and ash contents. A more adhesive *Santra burfi* would be sticky and less springy. However, with change in pulp content, both these factors did not change drastically like hardness. Pairwise comparison of treatment means revealed that at least 20 % pulp content was required to cause a significant difference in adhesiveness or springiness score of *burfi* as compared to control.

Table 4 Regression equations for instrumental texture profile parameters as related to chemical composition of *Santra Burfi*

Sr. No	Equation#	Coeff. of correlation (R)	Coeff. of determination (R^2)	Standard error
1.	$H = 4.528818098 P^{-0.5483}$	0.97	0.95	0.14
2.	$H = 4.86890457 \times 10^{-05} P^{-0.719175166} M^{2.102605616} Pr^{-950160232} F^{3.708057895} A^{2.66502775}$	0.98	0.97	0.03
3.	$A = 0.28314674 P^{-0.11725}$	0.47	0.21	0.25
4.	$A = 1.77275461 \times 10^{-5} Pr^{3.661339}$	0.65	0.43	0.22
5.	$A = 2.8962 \times 10^{-4} F^{2.302898}$	0.64	0.42	0.22
6.	$A = 2.891386147 \times 10^{-5} P^{0.30} F^{1.318176} A^{-0.85}$	0.66	0.44	0.23
7.	$Co = 0.141284456 P^{0.00617}$	0.06	0.003	0.11
8.	$Co = 47.73863366 P^{0.432226} M^{-2.26514}$	0.66	0.44	0.089
9.	$Co = 9.455676784 \times 10^{-3} P^{0.273217} M^{-0.95918} Pr^{1.360278} F^{0.514595}$	0.68	0.46	0.093
10.	$G = 0.642113628 P^{-0.54552}$	0.97	0.95	0.14
11.	$G = 9.66.4204616 M^{-2.85358}$	0.97	0.94	0.16
12.	$G = 9.77757308 \times 10^{-14} Pr^{11.01041}$	0.88	0.77	0.31
13.	$G = 8.017575127 \times 10^{-11} F^{7.510524}$	0.94	0.88	0.22
14.	$G = 8.244205236 \times 10^{-6} As^{10.90272}$	0.84	0.67	0.36
15.	$G = 6.29025116 P^{-0.37854} M^{-0.88773}$	0.98	0.95	0.15
16.	$G = 4579406.672 M^{-3.42571} Pr^{-2.62677}$	0.97	0.94	0.15
17.	$G = 3.601249051 \times 10^{-8} Pr^{-7.66188} F^{12.23759}$	0.95	0.90	0.21
18.	$G = 5.819352655 \times 10^{-6} P^{-0.47} M^{0.91} Pr^{-1.43} F^{3.91} As^{1.26}$	0.98	0.96	0.15
19.	$Ch = 0.144227985 P^{-0.62122}$	0.97	0.94	0.18
20.	$Ch = 0.08157683 P^{-0.66291} M^{0.221681}$	0.97	0.94	0.18
21.	$Ch = 195224356.2 P^{-0.2203} M^{-3.13882} Pr^{-4.87557}$	0.97	0.95	0.18
22.	$Ch = 5313518126 P^{-0.23331} M^{-3.54583} Pr^{-2.72733} F^{-2.63694}$	0.97	0.95	0.19
23.	$Ch = 1.067496161 P^{-0.24} M^{-3.61} Pr^{-2.70} F^{-2.76} A^{-0.27}$	0.97	0.95	0.19
24.	$S = 1.684442376 \times 10^{15} P^{0.27} M^{-4.66} Pr^{-1.36} F^{-6.45} A^{-1.41}$	0.73	0.53	0.15

H hardness, *Ch* chewiness, *P* orange pulp, *A* adhesiveness, *S* springiness, *Pr* protein, *Co* cohesiveness, *M* moisture, *F* fat, *G* gumminess, *As* ash

Adhesiveness of *burfi* had a moderate positive or negative correlation with all the compositional factors but a lower strength of relationship than in the case of hardness (Table 5). The correlation between adhesiveness and compositional parameters was linear enough. The relationship between adhesiveness and ash was the lowest as observed from Table 3. Regression analyses revealed that orange pulp described just 21 % in the adhesiveness (Eq. 3). On the other hand, protein and fat as individual compositional parameters were better related with adhesiveness with R^2 of 0.42 and 0.43, respectively (Eqs. 4 and 5). Thus, it could be concluded that this textural descriptor could not be satisfactorily described by the compositional factors (Table 5). Gupta et al. (1990) also did not observe any significant correlation of adhesiveness of *khoa* with similar compositional factors. Similarly springiness also did not seem to be related to the compositional factors ($r < 0.39$). The multiple regression model involving moisture, orange pulp, protein, fat and ash could predict just 53 % of the total variation in springiness. Therefore, it could be concluded that springiness was not adequately dependent on the state of the constituents.

Cohesiveness of *Santra burfi* ranged from 0.132 to 0.169. Analysis of variance showed that the effect of orange pulp content on cohesiveness of *burfi* was significant. Tukey's test of Honestly Significant Difference revealed that just 5–10 % of orange pulp concentration was required to cause an appreciable increase ($P < 0.05$) in cohesiveness. However, at higher pulp contents, the cohesiveness values of the product decreased and were comparable to that of control. The compositional factors were not appreciably related to cohesiveness as evident from low 'r' values (< 0.336). It bore positive correlation with protein & fat and negative correlation with rest of the compositional variables (Table 3). Pulp and moisture together predicted 44 % variation in cohesiveness (Eq. 8) while all the compositional factors combined explained only 56 % of the variation (Eq. 9).

Table 3 shows that gumminess of *Santra burfi* ranged from 0.107 to 0.639 N (Table 2). Increase in orange pulp content markedly ($P < 0.05$) and consistently reduced the gumminess.

Pairwise comparison of treatment means revealed that the gumminess scores of *burfi* containing pulp contents below 15 % was significantly different. Above 15 % pulp content, the reduction in gumminess was not significant. All the compositional factors had strong correlations ($r > 0.720$) with gumminess (Table 3). The log linear correlation coefficients were more than the linear correlation coefficient in each case. Orange pulp and moisture content had negative effect on the gumminess while fat, protein and ash content had positive effects.

The regression Eqs. (10 to 14) showed that all the individual compositional parameters had higher influence on gumminess of *Santra burfi*. Ash had the least effect on the gumminess of *Santra burfi*, which was anticipated as ash is inorganic and would not form complex with other compositional parameters easily especially on macroscopic level leading to structural changes. The gumminess can be described with 96 % predictability by the multiple regression model containing all the compositional parameters (Eq. 18) with an error of 0.15.

Chewiness of *Santra burfi* was also greatly influenced by its composition. It was observed that the variations in the chewiness followed similar trend as that for gumminess. The moisture and pulp content had negative while rest of the constituents has positive correlation, the correlation coefficients being higher for the log-linear model than that for the linear model (Table 3). In regression equations also the effect of combined compositional parameters (Eq. 24) was higher than the respective compositional parameters as individual variables (Eqs. 19 to 23).

The highly significant effects of compositional factors on many of the texture profile parameters of *Santra burfi* suggested the importance of these factors, particularly orange pulp content, in determining the texture of this product. Desai (1988) and Gupta et al. (1990) reported high levels of correlations between moisture content and various textural descriptors for *chhana* and *khoa*, respectively. From the textural data, particularly that of hardness, it could be stated that the optimum content of orange pulp in *Santra burfi* must be less than 10 %.

Table 5 Coefficients of correlations[#] among different texture parameters of *Santra Burfi*

	Hardness	Adhesiveness	Springiness	Cohesiveness	Gumminess	Chewiness	Resilience
Hardness	1 (1)						
Adhesiveness	0.326 (0.506)	1 (1)					
Springiness	0.477 (0.356)	-0.337 (-0.344)	1 (1)				
Cohesiveness	-0.212 (-0.162)	0.219 (0.181)	0.130 (0.161)	1 (1)			
Gumminess	0.985 (0.983)	0.362 (0.551)	0.481 (0.384)	-0.063 (0.018)	1 (1)		
Chewiness	0.982 (0.948)	0.284 (0.379)	0.561 (0.600)	-0.072 (0.052)	0.994 (0.968)	1 (1)	

($p < 0.01$), figures in parenthesis are coefficients of correlations for log linear relationships

Interrelations between textural attributes

The linear as well as log-linear inter-relationships (correlation) observed among the studied textural attributes are presented in Table 5. Hardness of *Santra burfi* was found to be positively correlated with all textural attributes except cohesiveness. Both chewiness and gumminess of *Santra burfi* exhibited very strong positive correlation ($r=0.982$ to 0.985) with hardness. The moderate negative correlation observed between hardness and cohesiveness indicated that as hardness increased, there was a significant decrease in cohesiveness ($P<0.01$). Similarly, the association between chewiness and gumminess was very strong ($r=0.994$). On the other hand, adhesiveness, springiness and cohesiveness showed no strong correlations with all other textural attributes, indicating no significant association between these textural attributes. Gupta et al. (1984) observed such trends in correlation between Instron hardness and other textural parameters for different types of processed cheeses, with the exception of cohesiveness. Additionally, similar trends were reported by Gupta et al. (1990) in their texture studies on *khoa* as influenced by its composition.

Conclusions

The textural attributes such as hardness, cohesiveness, adhesiveness, springiness, gumminess and chewiness of *Santra burfi*, which are requisite for its commercial production, were determined. The hardness was found to be positively correlated with protein, fat and ash contents while it was negatively correlated with moisture and orange pulp contents. Hardness, gumminess and chewiness of *Santra burfi* could be adequately predicted from the chemical composition with substantial accuracy. Springiness, adhesiveness and cohesiveness do not indicate any significant correlation

with any of the individual compositional characteristics. The optimum content of orange pulp in *Santra burfi* must be less than 10 %. These interrelations among the textural attributes can be studied further from future perspective of the field and view point of products' market potential.

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