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Development of peanut and chickpea nut brittle *(Chikki)* from the incorporation of sugar, jaggery and corn syrup

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Abstract

The commercial market lacks standard procedure of the product prepared from the incorporation of chickpea for improvising the nutritional significance of jaggery based nut brittles. The study was planned to incorporate chickpea in nut brittle preparation along with peanut *chikki* and to standardize the processing method. The syrup prepared in the ratio of 1:1:0.3 for sugar, jaggery syrup and corn syrup along with butter 2.5 g (g/100 g of syrup) and sodium bicarbonate ($NaHCO_3$) 0.2 g (g/100g of syrup) was used for the preparation of nut brittle. The protein and water activity showed that the product was stable and rich in protein. Total phenol content and radical scavenging activity in blended *chikki* was the maximum amongst three samples. The hardness (breakage strength) of different *chikki* varied from 15 to 26 kg. The addition of chickpea in nut brittle produced slightly darker product. Sensory parameters for chickpea and blended *chikki* were above 6.8 indicating the acceptability of the product.

Introduction

Sweets and sweet snacks are being prepared for joyful and celebratory occasions (Panneerselvam *et al*., 2015). Nut brittle is a sweet snack prepared using sugar or jaggery as sweetener and roasted nuts such as peanuts, puffed bengal gram, sesame, puffed rice, beaten rice, copra (desiccated coconut), cashew nuts, almonds and pistachio alone or in combination. Peanut nut brittle is most common due to its delicious taste and cost effectiveness. Groundnut or peanut *(Arachis hypogaea)* is generally referred as a poor man's nut and contains 49.66 g fats, 23.68 g protein per 100 g of groundnut and supplies about 2448 kJ per 100 g of groundnut in roasted form (Settaluri *et al*., 2012). It is also considered a basic ingredient of nut brittle.

Jaggery is one of the ancient and natural sweetening agents known to man and is an integral part of rural diet in many countries. It has sweet winy taste and it is mostly prepared by concentrating sugar cane juice. It contains 0.6-1.0 g minerals, 11 g iron, 0.4 g calcium, 0.045 g magnesium and phosphorous, 10-15 g reducing sugars, 0.25 g protein and 0.05 g fat per 100 g of jaggery (Kumar, 1999). The magnesium, potassium and iron found in jaggery strengthen the nervous system; conserve acid balance in the cells and help in prevention of anaemia (Rao *et al*., 2007). It works as a potential protective agent for working in dusty and smoky environment (Sahu and Saxena, 1994; Preedy *et al*., 2013). It also helps in purifying blood and also avoids the rheumatic afflictions and disorders of bile (Zenten, 1999). Sweets or confections with jaggery are gaining popularity due to the awareness of its health benefits (Chetana and Sunkireddy, 2011).

Chickpea *(Cicer arietinum)* is consumed as whole dehulled grain, sprouted grain, immature pods, mature green seed, or as dhal and flour. The starch, crude protein and fat contents were reported to vary from 41-50 g, 12.4 to 31.5 g, and about 6 g per 100 g of chickpea cultivars respectively. The digestibility of its protein varies from 76 to 78%, and of carbohydrate from 57 to 60% (Eser *et al*., 1987; Dawar *et al*., 2007). Chickpea contains nutritionally important minerals, notably calcium (1.2 g/ 100 g) and iron (0.018 g/ 100 g) (Yadav *et al*., 2007). Among common legumes, chickpea is the most hypocholesteremic agent followed by black gram and green gram (Soni *et al*., 1982). Debnath *et al.* (2003) and Gomez *et al.* (2008) also studied the effect of various processing conditions for the preparation of chickpea based snacks and cake respectively. Furthermore, chickpea is reported as one of the most important legume crops in Asian continent and its protein quality is better than other legumes such as

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pigeon pea, black gram and green gram (Narasimha *et al*., 2003).

Knechtel (1978) obtained a patent for the mechanized manufacturing of peanut nut brittle. Patented process of nut brittle preparation (Shelesky and Anderson, 2000) described the use of sugar syrup only. McKee (2013) reported the use of sodium bicarbonate for the lighter and yellowish product. Peanut and sesame seed *chikki* with bengal gram was developed by Chahal and Sehgal (1996). Textural characteristics of sunflower-seasame kernel *chikki* were also studied (Gupta *et al*. 2007). Preparation of peanut *chikki* with flaxseed has also been reported by Chetana and Sunkireddy (2011). Soya protein isolates, calcium carbonate, ferrous fumerate, vitamin A and folic acid was used to prepare nutra rich *chikki* by Pallavi *et al*. (2014). In spite of all the nutritive significance of jaggery, peanut and chickpea; the commercial market still lacks the standard procedure of the product prepared from the incorporation of these raw materials. Therefore, the study was planned to standardise the process of nut brittle preparation based on the peanut and chickpea using sugar, jaggery and corn syrup and to evaluate quality of developed product.

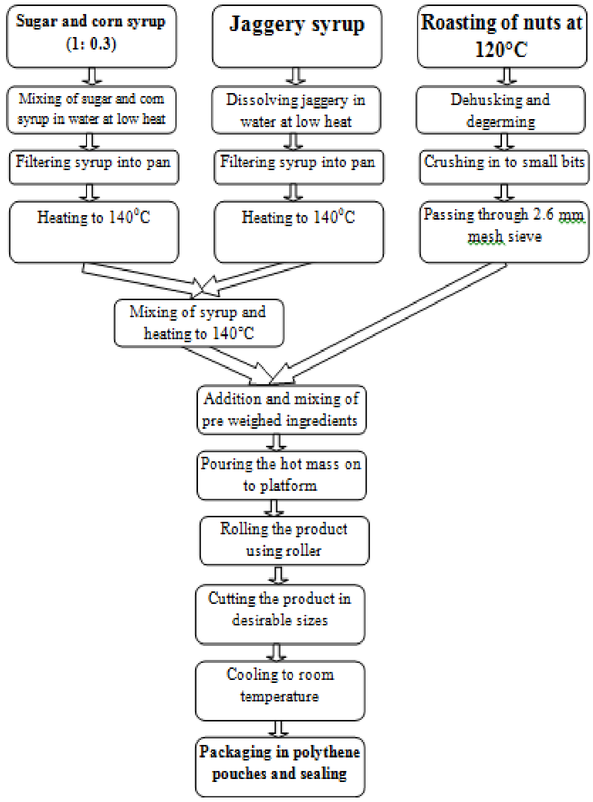

Figure 1. Process flow chart of nut brittle preparation

Materials and Methods

Materials

All the materials required for nut brittle preparation i.e. pea nut, chickpea, jaggery, sugar, corn syrup, butter and sodium bicarbonate ($NaHCO_3$) were procured from the local market, Sangrur, Punjab, India.

Preparation of syrup

Patented process of nut brittle preparation (Shelesky and Anderson, 2000) described the use of sugar syrup only. Jaggery was incorporated to increase the nutritive value of the product and to check the acceptability of jaggery in the syrup. The syrup prepared in the ratio of 1:1:0.3 for sugar, jaggery syrup and corn syrup along with butter 2.5 g (g /100 g of syrup) and sodium bicarbonate ($NaHCO_3$) 0.2 g (g /100 g of syrup) was used for the preparation of nut brittle (Tidke *et al.*, 2016). The syrup was heated and filtered to obtain a homogenized mixture. The clear jaggery syrup was heated to a temperature of 140°C. Both the syrups were mixed at heated again at 140°C.

Nut brittle preparation

Peanuts and chickpea were roasted at 120°C till the desired golden brown colour was obtained followed by cooling, dehusking, removal of germ and crushing into small bits (Figure 1). The syrup was added according to the formulation in Table 1 and mixed thoroughly for thick coating of syrup over nuts (Tidke *et al*., 2016). The pan was immediately removed from the heat (140°C) and then $NaHCO_3$ was added for neutralizing acidity produced during nut brittle preparation to avoid in pH change, which was expected to delay the Maillard reaction and may lead the formation of more intermediate yellow compounds and less final brown colour. The mixture was stirred for 20 s using a folding motion to prevent air loss. Hot mix was then transferred to a wooden board, which was smeared with oil to prevent sticking of the mix. The product was then spread uniformly using a roller followed by cutting in to individual slabs, cooling at room temperature and packing in polythene pouches. The nut brittle prepared with all three combinations was further analysed for physico-chemical and sensory evaluation.

Analysis of various responses in nut brittle

The estimation of moisture, protein, fat and ash content was carried out by standard methods (AOAC, 2000). The total carbohydrates content was performed by Anthrone methods (Hedge and Hofreiter, 1962). Crude fiber was estimated using the method reported by Maynard (1970).

Table 1. Product Formulations

Product	Amount of syrup, g	Peanut, g	Chickpea, g	Butter, g/100g of syrup	$NaHCO_3$, g/100g of syrup
Peanut *chikki*	100	100	0	2.5	0.2
Chickpea *chikki*	100	0	100	2.5	0.2
Blended *chikki*	100	50	50	2.5	0.2

Fatty acid estimation

Gas chromatographic (GC) analysis of fatty acid methyl esters was carried out using a NUCON SERIES 5700 of data station 0-2.5 mV range and < 1.5s response rate. A 2 m x 2 mm stainless steel 10% Silar 7C column packed with 60-120 mesh Gas Chrom Q was used. The injector and detector temperatures were maintained at 240°C. The column temperature was set at 160°C for 5 min and then ramped at a rate of 5°C per min to a final temperature of 220°C and kept there for 20 min. The total time for analysis was 37 min. Fatty acids were identified by comparison with retention times of authentic reference samples (Sharma *et al*., 2006).

Determination of total phenolic content and DPPH

Total phenolic content was determined using the standard procedure adopted by Mongkolsilp *et al*. (2004). The effect of different sugar varieties on DPPH (2’2’-diphenyl-1-picryl hydrazyl) radical was estimated as per the method reported by Singh *et al.* (2002).

Physical analysis: texture, colour and water activity

The texture profile analysis (TPA) was conducted on the prepared nut brittle using Texture Analyzer (model TAHDi, Stable Micro Systems Ltd.). Probe (P75) having 75 mm diameter was used at speed of 0.55 mm/s up to 1 mm of test distance. The compression generated a curve with the force over distance. Hardness is the highest peak force measured during the first rupture of the product i.e. first bite (Kumar *et al*., 2010, Dar *et al*., 2014).

The colours of the nut brittle were assessed using a Hunter / CIE – lab colorimeter (Gretag Mecbath, USA). Processes are commonly evaluated through changes in the scale parameters (L^*, a^* and b^*) and/or through the total colour difference parameter, which evaluates the overall colour difference of a processed sample compared to syrup (a reference one indicated by the index r in the following expression):

$$\Delta E = \sqrt{(L^* - L^*_r)^2 + (a^* - a^*_r)^2 + (b^* - b^*_r)^2}$$

Sensory evaluation

The sensory attributes of nut brittle, prepared from the incorporation of peanut, chickpea and blend of both were analyzed on a 9 point (1 – Dislike extremely, 5 – Neither like nor dislike and 9 – Like extremely) Hedonic rating scale (Ranganna 2010, Ganorkar *et al*., 2014). The nut brittles were served to 15 semi-trained panelists, formed from the department of Food Engineering and Technology, SLIET, Longowal. Panelists evaluated the sample for their colour, hardness, crunchiness, sweetness, mouth feel, nut flavour and overall acceptability.

Statistical analyses

Statistical analysis of the results was done with SPSS version 16, Statistica 7. Data were analyzed using one way analysis of ANOVA (Analysis of variance). Mean separation was done by Duncan’s multiple range test using SPSS 16 (Harter, 1960). All the experiments were conducted in triplicate. In reporting the data, the results of individual samples are expressed as the mean ± standard deviation (SD).

Results and Discussion

Proximate analysis of raw material

The fat and protein values obtained for the peanut were 48 and 23.12g/100g, which are comparable to the findings of Savage and Keenan (1994). The chickpea contained good amount of protein (21.4 g/100g of sample) and carbohydrate (50.9 g/100g of sample). The protein content was in agreement with the results reported for most of the legumes (17-30 g/100g) by Reddy *et al.* (1984).

Composition of nut brittle

The product prepared with chickpea had higher moisture content 3.2g/100g, of sample as compared to *chikki* prepared with peanut 2.9 g /100g of sample under same conditions (Table 2). However blended *chikki* had moisture content 3.0 g /100g of sample. Ash content of all the *chikki* samples ranged from 3.5 to 4.0 g /100g. Peanut *chikki* had lower ash content (i.e. 3.5 g /100g of sample). Blended *chikki* had ash content, 3.6 g /100g of sample whereas chickpea *chikki* had 4.0 g /100g of sample. However, ash content in all the finished *chikki* samples was slightly

Table 2. Proximate composition of nut brittles

Sample	Peanut *chikki*	Chickpea *chikki*	Blended *chikki*
Moisture (%)	2.9 ± 0.18[c]	3.2 ± 0.40[a]	3.0 ±0.15[b]
Ash (%)	3.5 ± 0.16[b]	4.0 ± 0.20[a]	3.6 ± 0.18[b]
Protein (%)	14.2 ± 0.80[a]	13.3 ± 0.90[a]	13.8 ± 0.90[b]
Carbohydrates (%)	53.1 ± 2.00[c]	67.9 ±2.40[a]	60.29 ± 2.10[b]
Fat (%)	23.8 ± 0.90[a]	7.7 ± 0.60[c]	14.28 ± 0.80[b]
Fiber (%)	2.0 ± 0.10[c]	3.6 ± 0.18[a]	3.0 ± 0.15[b]
Water activity	0.26± 0.02[b]	0.35 ± 0.02[a]	0.27 ± 0.03[b]

Values are means ± standard deviation. Means in the same rows with different superscripts letters are significantly different p ≤ 0.05.

more than their respective raw materials; which may be due to the addition of jaggery in the product.

Protein content of the peanut *chikki*, chickpea *chikki* and blended *chikki* were 14.2, 13.3 and 13.8 g /100g of sample respectively. Peanut *chikki*, chickpea *chikki* and blended *chikki* had fat content 23.8, 7.7 and 14.28 g /100g of sample respectively, which are significantly different ($P < 0.05$). The total carbohydrate content in peanut *chikki*, chickpea *chikki* and blended *chikki* were 53.17, 67.9 and 60.29 g /100g of sample respectively and showed significant difference ($P < 0.001$). *Chikki* prepared from chickpea had higher amount of carbohydrates as compared to peanut and lower level of protein and fat content.

The fiber content of chickpea *chikki* was higher 3.6 g/100g of sample, followed by blended *chikki* 3.0 g/100g of sample and the least fiber content was observed in peanut *chikki* 2.0 g/100g of sample. The result of fiber content in peanut *chikki* was similar to Pallavi et al. (2014), who reported 1.4 g/100g of sample in control *chikki* prepared from peanut. Fiber content in raw chickpea was reported as 5.3-5.9 g/100g of sample (Dhiman *et al.*, 1983). The water activity of peanut *chikki*, chickpea chikki and blended *chikki* observed as 0.26, 0.35 and 0.27 respectively and were significantly different ($P < 0.05$). Water activity should be below 0.62 to retard all chances for mould growth. Water activity of *chikki* was lower, indicating the all the *chikki* samples were microbiologically shelf stable due to non availability of most of the water for microorganisms and enzymes.

Fatty acid composition

It was observed from Table 3 that in peanut *chikki*, oleic acid was highest i.e. 59.3 g/100g whereas in blended *chikki*, oleic acid amount decreased to 48.5 g/100g. The linoleic acid was highest in chickpea *chikki* 40 g/100g followed by blended *chikki* 30.7 g/100g, while in case of peanut *chikki*, linoleic acid content was lower i.e. 22.5 g/100g. The *chikki* from chickpea contains significant amount of saturated fatty acid i.e. palmatic acid as 12.9 g/100g, followed by blended *chikki* 9.7 g/100g but in case of peanut *chikki*, the palmatic acid content was lower i.e. 7.5 g/100g. The obtained results of fatty acid content of peanut *chikki* were similar to fatty acid composition of peanut oil reported by Muhammad *et al*., (2012). The fatty acid compositions of chickpea are in accordance with the fatty acid composition of chickpea seed oil (Muhammad *et al*., 2007). The predominance of oleic and linoleic acid, adds to the nutritional value of *chikki*. Linoleic acid is the most important essential fatty acid for growth, physiological functions and maintenance.

Functional properties

It was observed from Table 3 that the phenolic content in peanut *chikki*, chickpea chikki and blended chikki was significantly different ($P<0.05$). Total phenolic content of different *chikki* samples varied from 6.07 to 7.08 mg GAE/g. The phenolic content in blended *chikki* was highest i.e. 7.08 mg GAE/g, whereas total phenolic content in peanut *chikki* was 6.65 mg GAE/g. The higher total phenolic content of peanut skin may be attributed to the presence of phenolics compounds such as proanthocyanidins. The roasting of peanut results in the loss of moisture content, due to which chemical reactions occur in soluble proteins and amino acids and forms Maillard derivatives including pyrroles and furans, which may contribute in increase of total phenolics compounds of roasted samples (Yanagimoto *et al*., 2002). Similar increase in total phenolic content in peanut hulls due to heat treatment is reported by Lee *et al.* (2006). The increase in total phenolics content, in the finished *chikki* may be due to the generation of Maillard reaction products and the liberation of phenolics compounds during processing. The predominant antioxidants appeared to be the low molecular weight fraction of Maillard reaction products containing compounds such as reductones and maltol (Alfawaz *et al*., 1994), whose formation can occur at any stage of the Maillard reaction. The stronger antioxidant activity can render protection to the DNA, induced by hydroxyl radicals. Free radical scavenging activity of *chikki* ranged from 13.54 to 28.28%.

Table 3. Properties of nut brittles

Sample	Peanut *chikki*	Chickpea *chikki*	Blended *chikki*
Fatty acids			
Palmitic (C16:0)	7.5 ± 0.40^c	12.9 ± 0.80^a	9.7 ± 0.50^b
Stearic (C18:0)	4.1 ± 0.17^a	2.8 ± 0.14^b	3.1 ± 0.14^b
Oleic (C18:1)	59.3 ± 2.90^a	36.6 ± 1.80^c	48.5 ± 2.10^b
Linoleic (C18:2)	22.5 ± 1.50^c	40 ± 2.20^a	30.7 ± 1.30^b
Arachidic (C20:0)	3 ± 0.15^a	1.3 ± 0.06^c	2.1 ± 0.10^b
Functional properties			
Total phenolics content (mg GAE/gm)	6.65 ± 0.35^{ab}	6.07 ± 0.30^b	7.08 ± 0.30^a
Free radical scavenging activity (%DPPH)	27.50 ± 1.30^b	13.54 ± 0.50^c	28.28 ± 1.50^a
Texture			
Hardness (Force, kg)	18 ± 0.90^b	15 ± 0.70^c	26 ± 1.30^a
Colour			
L*	60.23 ± 2.90^a	54.07 ± 2.80^b	59.5 ± 2.5^{ab}
a*	15.10 ± 0.99^a	14.7 ± 0.36^a	12.67 ±0.63^b
b*	32.69 ± 0.70^a	13.78 ± 1.00^b	23.7 ± 1.10^c
ΔE	6.727 ± 0.36^a	13.78 ± 0.68^b	10.33 ± 0.51^c

Values are means ± standard deviation. Means in the same rows with different superscripts letters are significantly different p ≤ 0.05.

The % DPPH activity of syrup was more in blended *chikki*. In raw chickpea, free radical scavenging activity has been reported to be 2.94% (Baojun and Chang, 2008) but the chickpea nut brittle had the DPPH scavenging activity of 13.54%. The higher scavenging activity may be due to the heat treatment given to the ingredients at different stages. Heat treatment of syrups can develop formation of some of the intermediate compounds during the Maillard reaction, which may increase the overall antioxidant capacity.

Hardness

Texture of *chikki* is often related to the sound that produced by *chikki*. The hardness (breakage strength) of different *chikki* varied from 15 to 26 kg (Table 3). The lowest hardness was observed for chickpea *chikki* i.e. 15 kg, Peanut *chikki* had intermediate hardness i.e. (18kg), whereas the highest hardness was observed for blended *chikki* i.e. 26kg. Gupta *et al.* (2007) reported hardness of sunflower-sesame *chikki* as 17.8kg. The hardness of blended *chikki* was higher than both *chikki* i.e. peanut *chikki* and chickpea *chikki*, which may be due to comparatively more variation in the size of ingredients. More variation in size may contribute in less void space availability, which results in more compacted texture. This may also be due to change in moisture and fat content. The fat and moisture content also play a role in the measurement of texture.

Colour evaluation

The colour values, L*, a*, b* of different nut brittle *(chikki)* are shown in Table 3. The L* values for different *chikki* varied from 54.07 to 60.23. The colour values, a* and b* for different *chikki* were in range of 12.67 to 15.10 and 13.78 to 32.89 respectively. The results showed that L* values which represents the lightness of the product, decreased in chickpea *chikki* to 54.07. The results indicate that chickpea in *chikki* produced slightly darker product. Lightness values of blended *chikki* fall in between the values of peanut *chikki* and chickpea *chikki*. The lightness of peanut *chikki* was closer to control *chikki* prepared from peanut as reported by Pallavi *et al.* (2014). Peanut *chikki* showed the highest a* value 15.10. The colour a* value gradually decreased in chickpea *chikki* (14.7) and blended *chikki* (12.67). The colour value, b* of peanut chikki was highest (32.69) and it decreased gradually in blended *chikki* (23.7) and chickpea *chikki* (13.78). The difference in total colour difference (ΔE) was observed among the samples, which may be due to the difference in the ingredients and their quantity.

Sensory evaluation

It was observed from Figure 2 that nut brittle prepared from peanut achieved highest scores for all the sensory attributes, which may be due to the taste appeal of peanut in comparison to chickpea. The nut brittle prepared from blend acquired the middle response. It may also be noted that the mouth feel was almost similar in all the cases. The nut brittle prepared from chickpea obtained the minimum score; however all the scores (colour, hardness, crunchiness, chewiness, sweetness, mouth feel, nut flavor and overall acceptability) were above 6.8, indicating the nut brittle prepared from chickpea and blends of chickpea and peanuts are also liked moderately; whereas nut brittle prepared from peanuts are liked

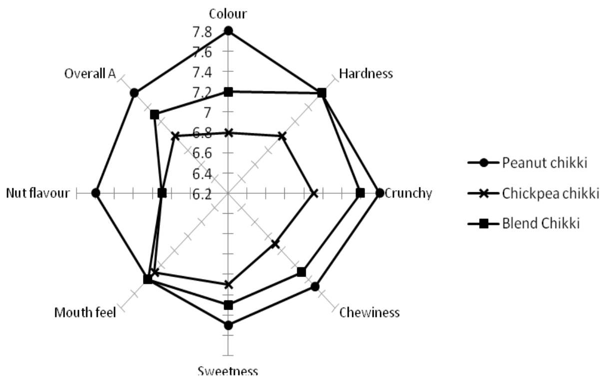

Figure 2. Sensory score of *Chikki* (nut brittle)

very much by the panelists.

Conclusion

The protein and water activity varied from 13.3-14.2% and 0.26-0.35 respectively. The fat content in peanut *chikki* (23.8%) can be brought down by incorporating chickpea by replacing peanut partially (14.28%) or completely (7.7%). All *chikki* samples were stable due to low water activity. The oleic and linoleic acid present in the *chikki* samples were 36.6-59.3 g/100g and 22.5-40 g/100g of total fatty acid respectively, indicating good nutritional value. Total phenol content and radical scavenging activity in blended *chikki* was the maximum amongst three samples. The chickpea in *chikki* produced slightly darker product, though, sensory parameters for chickpea (6.8) and blended *chikki* (7.2) were close to sensory score received by peanut *chikki* (7.8).

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