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Nutritional quality and storage stability of *chikki* prepared using pumpkin seed, flaxseed, oats and peanuts

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A novel pumpkin seed *chikki* (PSC) and pumpkin chocolate *chikki* (PCC) with enhanced nutritional quality by incorporating flaxseed, oats and peanuts was studied. The ingredients of the *chikki* were pumpkin seed (25%), flaxseed (8.0%), oats (8.0%), peanut (9.0%) and jaggery (50%). The protein and fat contents were 12 and 15% in PSC and PCC and phosphorous was found to be 186 and 206 mg/100 gm, respectively. Equilibrium moisture content – Relative humidity studies showed the *chikkis* were non-hygroscopic in nature and hence can be stored at ambient temperature in polyethylene pouches. The fatty acid composition of the total lipid showed that *chikkis* were rich in oleic and linoleic acids with unsaturated fatty acids constituting 65 and 63% in PSC and PCC, respectively. The overall sensory quality determined on 9 point Hedonic scale indicated that PCC was the preferred one, with sensory score of 8.0 during three months storage at RT.

Keywords: Pumpkin seed *chikki*, Chemical analysis, ERH studies, Fatty acid composition, Sensory evaluation
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Ethnic foods are savoured by people all over the world. In India large numbers of traditional foods are known to impart nutritional well being for all age groups. These products are categorized under sweetmeats, savoury or snack products and are generally prepared using locally available raw materials with good protein and carbohydrates. Among such foods, *chikki* is a popular sweetmeat product enjoyed all over India. It is prepared using peanuts, sesame and puffed rice or puffed Bengal gram individually. Now-a-days premium products made with cashews and almonds are also available though they are highly expensive. Sesame *chikkis* are popular among rural populations, which are now available in attractive flexible packaging materials.

Generally, jaggery is used traditionally as a sweetener in the preparation of these products. However, sugar is also used partially or fully to improve the colour of the product. Jaggery is a natural product prepared from sugar cane juice which is the potential source of minerals such as iron[1]. Peanuts are reported to be rich in monounsaturated fatty acids (MUFA) which is essential for healthy heart in humans[2]. A novel concept of replacing a part of the peanuts by flaxseed to enhance n-3 PUFA content to yield a balanced fatty acid profile was applied[3]. Flaxseed chutney powder was prepared by incorporating spice ingredients to avail the n-3 PUFA and fibre from flaxseed as a functional food adjunct[4]. The *chutney* powder can be conveniently consumed with rice for receiving the daily allowance of α-linolenic acid which is useful in preventing cardiovascular diseases. Flaxseed is the richest source of oil (40%), of which linoleic and linolenic acids are the major fatty acids. It also contributes 30% of dietary fibre[5]. Oat is an excellent source of dietary fibre and minerals[6]. The total dietary fibre ranged between 10.2–12.1%. Soluble fibre was greater than 40% of the total dietary fibre. It was reported that the health benefits of dietary fibre were associated with soluble fibre[7-10]. Cocoa (*Theobroma cacao*) is a popular raw material for chocolate manufacture owing to its special fat (coco butter) and quality of the powder for its peculiar taste and flavour. Cocoa powder is rich in polyphenols specially, catechins and procyanidins which inhibit the LDL oxidation and increase the HDL in human plasma[11]. A large number of pumpkins are produced annually in India and they are consumed generally as a vegetable. Pumpkin can be used to prepare excellent dried vegetable leather, relishes and chutneys[12]. It is also utilized in making pickles and sweets. Pumpkin seed is a byproduct used

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for garnishing cakes. The seeds are a rich source of nutrients, can be consumed as food or as supplementary ingredients. Physico-chemical composition, processing, its supplementation in bakery products and pumpkin seed lipid composition were reviewed[13]. Roasting of pumpkin seeds significantly reduces anti-nutritional components namely tannic and phytic acids[14]. Pumpkin seeds are known to be good source of fat, minerals and protein[15]. Functional properties such as water absorption, fat absorption, emulsification properties and foam stability of defatted pumpkin seed flour has a good potential to food systems as bakery products and ground meat formulations. Pumpkin seeds are rich source of protein and lipid. The kernel flour possesses higher chemical score, essential amino acid index, and in vitro protein digestibility than paprika and watermelon seed[16]. Roasted pumpkin seeds help to relax nerves and muscles, strengthen bones and help with circulation. Phytosterol, present in the seeds helps to reduce LDL cholesterol levels, enhance the immune response and decrease the risk of cancers particularly prostate and ovarian. L-tryptophan, a compound which improves mood naturally and may even be effective against depression[17].

In the present investigation, an attempt is made to prepare *chikki*, a traditional nut bar using pumpkin seed. Peanuts, flaxseed and oats were also included in the recipe to enhance the nutritional value of the *chikki*. Jaggery was used as the sweetener and a chocolate type product using cocoa solids and vanilla flavor were also tried to enhance the storage stability and organoleptic acceptability.

Methodology

Materials and chemicals

Pumpkin seed (*Cucurbita maxima* Duchesne), Flaxseed (*Linum usitatissimum* L.), Oats (*Avena sativa* L.), Peanuts (*Arachis hypogaea* L.), cocoa (*Theobroma cacao* L.), vanilla and jaggery were procured from a local market in Hyderabad, India. A commercial peanut *chikki* was purchased from the market. The laboratory and analytical grade chemicals were purchased from M/s. Loba Chemie, Mumbai, India.

Preparation of *chikkis*

The nuts, seeds and grains were roasted individually in a pan and allowed to cool to room temperature. Jaggery (50 parts) was added with minimum quantity of water and heated to make a thick solution. The heating of the solution was continued till the temperature of the syrup reaches 115°C. All the roasted ingredients (pumpkin seed 25 parts, peanuts 9 parts, flaxseed 8 parts and oats 8 parts) were then mixed with the hot jaggery syrup and poured into an aluminum plate, earlier smeared with peanut oil. The product was spread uniformly and allowed to cool to room temperature. The cooled product was cut into 8 cm × 8 cm × 2 cm cuboids. Another variant of pumpkin seed chikki was prepared by addition of cocoa solids (5 parts and vanilla 0.5 parts) partially replacing flaxseed and oats in equal quantities.

Packaging, chemical, mineral and sensory evaluation of *chikkis*

The *chikkis* were packed in 100 gm unit packs of polyethylene (PE, 7.5 µ) pouches of 14 cm × 12 cm and stored for three months at room temperature (28±2°C). The chemical composition and certain minerals were analysed initially. Parameters such as moisture, total ash, crude fat, crude protein and crude fibre were analysed by using standard methods. The protein content of the sample was calculated by multiplying the nitrogen content by the factor of 6.25. Carbohydrate content was calculated by difference and the calorific values were calculated and expressed as kcal/100 gm *chikki*. Calcium (Ca), iron (Fe) and phosphorous contents were estimated by using standard methods[18]. Commercial peanut *chikki* (CPC) procured from the market was used as control for comparison. The storage stability of the *chikkis* was carried out by subjecting to sensory evaluation initially and after 3 months storage at RT. Sensory attributes like appearance, colour, texture, taste, flavour and overall acceptability of *chikkis* were evaluated by a semi trained panel of 10 judges on a 9 point Hedonic scale[19].

Fatty acid composition by GC and GC-MS

The lipid was extracted from the *chikkis* and converted to their fatty acid methyl esters (FAME) by refluxing with methanol containing 2% sulphuric acid. The FAMEs were analysed by Gas chromatography (GC) and Gas chromatography - Mass spectrometry (GC-MS) as per the method reported in literature[20]. The GC-FID analyses were performed with an Agilent 6850 series gas chromatograph equipped with an FID detector. The chromatographic conditions for GC-FID were adjusted according to the class of compound. For fatty acid methyl esters (FAME), a DB-225 capillary

column (30 m × 0.25 mm i.d) was used. The column temperature was initially maintained at 160°C for 2 min, increased to 220°C at 6°C/min, and finally maintained for 10 min at 220°C. The carrier gas was nitrogen at a flow rate of 1.5 mL/min. The injector and detector temperatures were maintained at 230 and 250°C, respectively with a split ratio of 50:1.

The GC-MS analyses was performed using an Agilent (Palo Alto, USA) 6890N gas chromatograph equipped with a HP-5 MS capillary column (30 m × 0.25 mm i.d.) connected to an Agilent 5973 mass spectrometer operating in the EI mode (70 eV; *m*/*z* 50 - 550; source temperature 230°C and a quadruple temperature 150°C). The column temperature was initially maintained at 200°C for 2 min, increased to 300°C at 4°C/min, and maintained for 20 min at 300°C. The carrier gas was helium at a flow rate of 1.0 mL/min. The inlet temperature was maintained at 300°C with a split ratio of 50:1. Structural assignments were based on interpretation of mass spectrometric fragmentation and confirmed by comparison of retention times as well as fragmentation pattern of authentic compounds and the spectral data obtained from the Wiley and NIST libraries.

EMC-RH studies

Equilibrium relative humidity data of the *chikkis* were collected to assess the effect of various humidity conditions on the storage behavior of product. Moisture sorption isotherm was plotted by exposing the PSC, PCC and CPC sample to varying conditions ranging between 10 - 100% relative humidity (RH) in glass desiccators maintained using sulphuric acid[18] at room temperature (28±2°C). The moisture uptake or losses in *chikki* samples were measured at regular intervals by weighing 5 gm of mix in petri plates exposed to the above conditions until equilibrating to constant weight or till appearance of fungal growth. Lump formation, discoloration or mold growth in the samples during the experiment was carefully monitored for determining the critical moisture content.

Results and discussion

Standardization of pumpkin seed *chikki*

Prepared *chikkis* from pumpkin and chocolate are shown in Fig.1. The standardized *chikki* recipes are reported in Table 1.

Chemical and mineral composition

The chemical composition and mineral contents of PSC and PCCs are presented in Table 2. It was observed that the *chikkis* were rich in protein (12%), fat (15%) and crude fibre (2.5%). The acid insoluble ash (0.056-0.089%) content in both the *chikkis* were as per the reported specifications[21]. Minerals such as Ca, Fe and P were found to be 102 and 109, 3.41 and 3.60, 186 and 206 mg/100 gm in PSC and PCCs, respectively. The calculated theoretical calorific values for 100 gm of PSC and PCCs were 428 and 419 kcal, respectively. The control sample (CPC) showed higher fat, protein contents and lower ash. Identical protein contents, lower fibre (1.6%), calcium (83 mg /100 gm) and iron (1.5 mg/100 gm) values and higher crude fat (21%) were reported for peanut *chikki*[22].

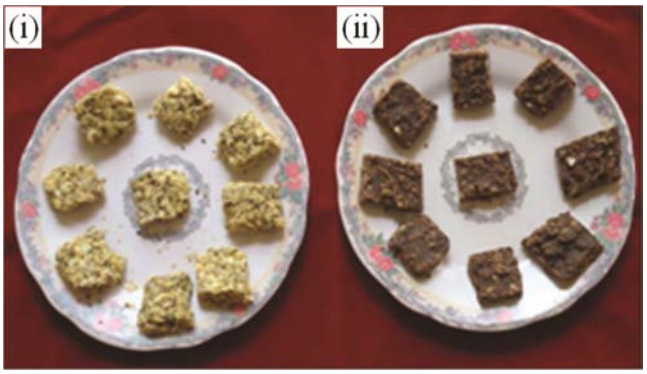

Fig. 1—*chikkis* (i) pumpkin seed *chikki*, (ii) pumpkin chocolate *chikki*

Table 1—Composition of the standardized recipe for pumpkin seed *chikki* (PSC)

Ingredient	%
Pumpkin seed	25
Flaxseed	8
Oats	8
Peanuts*	9
Cocoa solids	5
Vanilla solids	0.5
Jaggery	50

*In PCC peanuts are partially replaced by 5% cocoa solids

Sorption isotherms for *chikkis*

The sorption isotherms of *chikkis* are presented in Fig. 2. The initial moisture content (IMC) of CPC, PSC and PCC were 4.50, 6.93 and 9.33%, which equilibrated at 50, 59 and 73% RH. It was observed that the critical moisture content (CMC) of CPC, PSC and PCC were 3.5, 21.49 and 29.87%, which equilibrated at 33, 88 & 96% RH. The sudden rise in moisture content was observed at > 70% RH. These studies showed their non-hygroscopic nature and

Table 2—Chemical composition and mineral content of *chikkis**

Parameter, %	PSC	PCC	CPC (control)
Moisture	6.93 ± 0.59	9.33 ± 0.28	2.90 ± 0.75
Total ash	2.84 ± 0.33	3.08 ± 0.11	1.99 ± 0.31
Acid insoluble ash	0.056 ± 0.006	0.089 ± 0.01	0.57 ± 0.12
Crude protein (% N x 6.25)	11.77 ± 0.63	12.00 ± 0.46	15.26 ± 0.61
Crude fat	15.30 ± 0.72	15.83 ± 0.73	22.48 ± 0.33
Crude fibre	2.29 ± 0.20	2.47 ± 0.12	1.6 ± 0.32
Carbohydrates by difference	60.87 ± 1.49	57.29 ± 1.14	55.77 ± 2.39
Energy, kCal/100gm	428 ± 4.58	419 ± 4.16	486 ± 3.11
Minerals (mg/100gm)			
Calcium	102 ± 0.40	109 ± 0.36	77.0 ± 1.13
Iron	3.41 ± 0.20	3.60 ± 0.34	1.55 ± 0.27

*The chemical parameters of *chikkis* were analysed in triplicate and mean values ± SD are presented, n = 3, PSC : Pumpkin seed *chikki*, PCC : Pumpkin chocolate *chikki*,CPC: Commercial peanut *chikki*

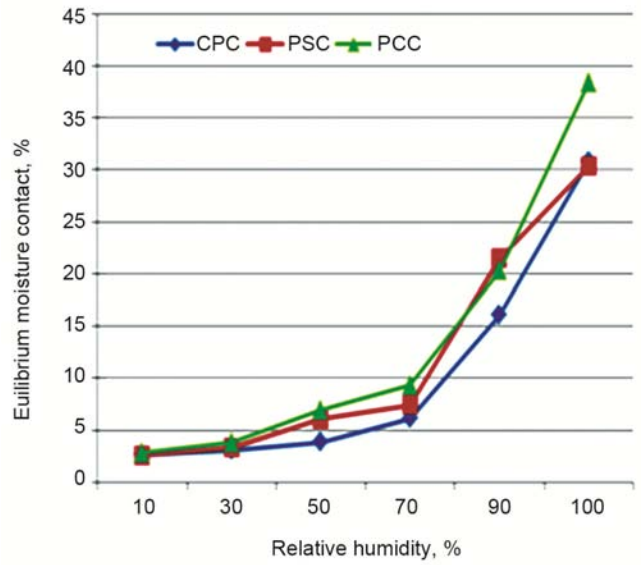

Fig. 2—Sorption isotherms of *chikkis*: Commercial peanut *chikki* (CPC), Pumpkin seed *chikki* (PSC) and Pumpkin chocolate *chikki* (PCC)

stability at RT in PE pouches. Tomato pickle mix had an initial moisture content 7.89%, which equilibrated at 26% RH reported to be hygroscopic in nature[23]. Instant pulihora mix also reported to be hygroscopic nature and stable at room temperature in MPE pouch[24].

Fatty acid composition of extracted lipid from *chikkis*

The fatty acid composition of the lipid extracted from *chikkis* based on gas chromatography and mass spectrometry are presented on *chikki* basis (Table 3). It was found that the *chikkis* were rich source of oleic acid (36.92%), linoleic acid (25.80%) and linolenic acid (2.57%) in PSC. The other major fatty acids were palmitic acid, stearic acid and behenic acid. Marginal

Table 3—Fatty acid composition of pumpkin seed *chikki* (PSC)*

Fatty acid	% composition
Palmitic acid (16:0)	22.95
Stearic acid (18:0)	10.48
Behenic acid (22:0)	1.28
Saturated	34.71
Oleic acid (18:1)	36.92
Mono Unsaturated	36.92
Linoleic acid (18:2)	25.80
Linolenic acid (18:3)	2.57
Polyunsaturated	28.37

*The lipid fatty acid composition of *chikkis* were analysed in duplicate and presented average %

change was observed in the fatty acid composition of total lipids of PSC and PCC. It was reported that the binding of low-density lipoprotein (LDL) with 18:0, 18:1, 18:2 and 18:3 was suggested to be the major action in lowering LDL-cholesterol levels[25]. Substitution of dietary saturated fat by oleic acid and/or polyunsaturated fatty acids (PUFA) has been described to reduce the cardiovascular risk by reducing blood lipids, mainly LDL-cholesterol and triglycerides[26]. n-3 Fatty acids were increased to an extent of 9% by substitution of peanut with 20% flax seed in *chikki* preparation[3].

Effect of storage on organoleptic quality

The scores of organoleptic evaluation of the *chikkis* during the storage period of 3 months are presented in Table 4. Sensory quality of CPC was not recorded as they were observed to be hygroscopic and became sticky immediately after exposure to ambient air. The overall acceptability of PSC and PCC were 8.1 and 8.5 initially (0 month) and decreased to 7.3 and 8.0 after a

Table 4—Sensory quality of *chikkis* during storage*

Parameter	Storage period (months) PSC		PCC	
	Initial	Three	Initial	Three
Appearance	8.1 ± 0.73	7.9 ± 0.73	8.6 ± 0.69	8.2 ± 0.78
Colour	8.3 ± 0.67	7.5 ± 0.81	8.6 ± 0.69	8.2 ± 0.78
Texture	8.0 ± 0.66	7.6 ± 0.69	8.3 ± 0.67	7.9 ± 0.56
Flavour	7.2 ± 0.42	6.8 ± 0.63	8.0 ± 0.66	8.0 ± 1.05
Taste	8.1 ± 0.73	7.5 ± 0.52	8.5 ± 0.52	8.0 ± 0.66
Overall acceptability	8.1 ± 0.73	7.3 ± 0.48	8.5 ± 0.52	8.0 ± 0.66

*Mean values ± SD are presented, n = 10 panelists, Initial: 0, month

storage period of 3 months. Among the 2 *chikkis* the pumpkin chocolate *chikki* was more acceptable to panelists in terms of organoleptic parameters during storage. Similarly, decrease in overall organoleptic quality was also observed in peanut *chikki* prepared with 20%. Addition of functional ingredient such as resistant starch did not affect the sensory quality of cereal based granola bars[27].

Traditional significance of the study to farmers and researchers and some constructive recommendations

The present study provides basic insight into the traditional preparation of *chikki* with enhanced nutritional gains by incorporation of new ingredients such as pumpkin seed, flaxseed, oats along with peanuts. Increasing awareness on health and nutritious food is driving food processors to explore possible ways to enhance the nutritional values of traditional foods. Peanuts are known for monounsaturated fatty acids (MUFA) which are traditionally used in the preparation of *chikki* and addition of pumpkin seed, flaxseed and oats help improve the fibre, ω-3 PUFA and minerals apart from modifying the flavor and taste. The study provides opportunity for better utilisation and value addition to pumpkin seed and flaxseed grown in the Indian subcontinent. Popularisation and commercialization of the product will result in remunerative prices to farmers growing these grains and nuts.

Conclusion

Production of pumpkin seed *chikki* and pumpkin seed chocolate *chikkis* are very simple and viable. The seed, which is the by-product of pumpkin processing can be used to prepare a stable, nutritionally rich, organoleptically acceptable and health promoting *chikkis*. The addition of other ingredients alongwith peanuts improved the sorption behaviour by reducing the hygroscopicity. These studies showed that the pumpkin seeds are rich in protein and lipid, which can be utilised to produce a value added product like *chikki* with incorporation of functionally important ingredients like flaxseed, oats and peanuts.

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