Research Article

Impact of storage on functional and sensory quality of nuggets formulated from chickpea, amaranthus and radish leaves

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Abstract

The present study was envisaged to formulate nuggets from chickpea flour and green leaf powder and characterize its functional and sensory quality under ambient conditions. The functional parameters, water activity, pH and sensory parameters of nuggets were analyzed for three months at one month interval. The mean pH, water absorption index, bulk density and rehydration ratio of green leaf powder blended chickpea nuggets decreased from 5.39 to 5.23, 3.34 to 2.56 g per g, 0.630 to 0.505 g per ml and 1.34 to 1.22, respectively, during three months of storage. However, the water activity and oil absorption index of nuggets increased from 0.519 to 0.558 and 0.843 to 0.862 g per g, respectively, during three months storage. The study revealed higher values of water absorption index and rehydration ratio in nuggets formulated from higher levels of green leaf powder ; while the oil absorption index, bulk density, pH and water activity of nuggets decreased. The mean colour, taste, texture and chewiness score of nuggets was recorded highest in case of chickpea nuggets prepared using 6 per cent of green leaf powder.

Keywords: Nuggets, Functional parameters, Blended, Green leaf powder, Sensory parameters

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Introduction

Chickpea (*Cicer arietinum* L.), commonly known as Bengal gram or gram, belongs to the family *Fabaceae,* is one of the most important and widely consumed leguminous crop in India. Chickpea is known to be a good source of carbohydrates, proteins, vitamins and minerals and contains high protein (20.3%-24.5%) and the protein quality is considered to be better than other pulses. It is cholesterol-free and a significant source of both soluble and insoluble fiber. It is considered as a 'functional food' along with its role in providing protein and fiber [1].

India ranks second in vegetable production in the world, after china. Vegetables are important protective foods and most of the locally available vegetables remain underutilized because of inadequate scientific knowledge of the nutritional potentials of such vegetables, [2]. Radish (*Raphanus sativus* L) commonly known as "*Muli*" belongs to family *Brassicaceae* is the one of the most ancient cool season root vegetable [3]. The entire plant of radish (leaves, roots and seeds) is eatable and is helpful as antimicrobial agents [4]. Amaranth (*Amaranthus L.)* belonging to family *Amaranthaceae* and the consumption of amaranth leaves, provide high dietary fibre, protein per calorie consumed, iron, low fats and very high vitamin A, vitamin C, folic acid and calcium [5].

These days consumers are health-conscious demanding for high quality, shelf-stable and ready-to-use processed food products that are convenient and promote health [6]. Food such as nugget is an example of convenience food that is preferred by consumers, [7]. Improving the functional and textural properties of nuggets is needed for biphasic advantage in quality and storage and the formulation and development of complementary foods from locally and readily available raw materials have received a lot of attention [8]. Development of new product from Amaranthus and Radish leaf powder can enrich the nutritional value and expand the utilization of these underutilized vegetables. The present study was aimed to formulate nuggets from from chickpea flour and green leaf powder and characterize their functional quality and sensory evaluation under ambient conditions.

Materials and Methods

Preparation of raw materials

The healthy radish and amaranth leaves were washed, blanched (80^{o}C for 3min), dried (5-6 hrs at 55^{o}C, tray dryer), crushed and mixed to prepared green leaf powder in the ratio of 50:50::radish:green leaf powder. The split dehulled chickpea was cleaned, washed and soaked for 10-12 hrs. The soaked chickpea was steamed (80^{o}C for 10 min), dried (cabinet dryer, 55-60^{o}C) and then finally ground into flour.

Formulation of Nuggets

Seven formulations of nuggets with different percentage of chickpea flour and green leaf powder have been formulated in this study. Nuggets preparation was started by blending chickpea flour and green leaf powder in different ratios (as given in treatment detail) along with 30g corn flour (as binder) and coarse ground spice blend (1g coriander, 1.5g black pepper, 1g zeera, 1.5g coarse red chilli powder, 5g salt). A chickpea nugget was chosen as reference and control sample. The flow sheet for the preparation of nuggets is shown in **Figure 1**.

Treatments	Chickpea flour (%)	Green leaf powder (50:50::amaranth:radish)
T_1 (Control)	100	-
T_2	97	3
T_3	94	6
T_4	91	9
T_5	88	12
T_6	85	15
T_7	82	18

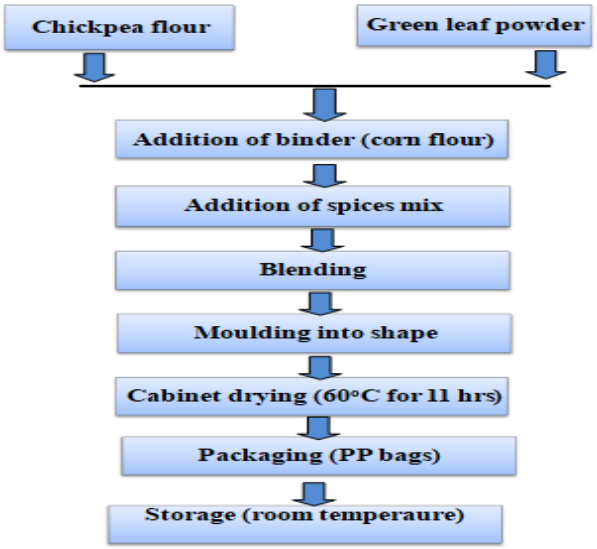

Figure 1 Flow chart for preparation of green leaf powder blended chickpea nuggets

Analysis of functional and sensory parameters

pH and water activity (a_w)

The pH of sample was determined by using pH meter (Model Aqua Lab). Water activity was measured using an Aqua Lab water activity meter (Model series 3TE) and readings were corrected at 20°C.

Rehydration ratio

5 g of sample was taken in a beaker and suspended in distilled water (seven times the weight of sample) for 10 hours at room temperature [9]. The sample was weighed after removing excess water with the help of filter paper (Whatman no.4). Rehydration ratio was calculated using the equation:

$$\text{Rehydration ration} = \frac{\text{Weight of rehydrated sample}}{\text{Weight of dehydrated sample}}$$

Water absorption index (WAI)

1 g of ground sample was suspended in 5 ml of distilled water at room temperature in a pre-weighed centrifuge tube for about 30 minutes [10]. The mixture was gently stirred during this period and then centrifuged at 3000 rpm for 15 minutes. The supernatant was removed and weight of gel was recorded. WAI was calculated using formula:

$$\text{Water absorption index (g/g)} = \frac{\text{Weight of sediment (g)}}{\text{Weight of dry solids (g)}}$$

Oil absorption index (OAI)

5 ml of refined soybean oil was added to 1 g of ground sample in a centrifuge tube [10]. The slurry in the tube was stirred and left for 30 minutes followed by centrifugation at 3000 rpm for 10 minutes. The supernatant was decanted and oil absorption index was calculated as:

$$\text{Oil absorption index (g/g)} = \frac{\text{Weight of sediment (g)}}{\text{Weight of raw material (g)}}$$

Bulk density

The ground sample (10g) was taken in a pre-weight 25 ml measuring cylinder [11]. The bottom of cylinder was gently tapped on a pad till constant volume was observed. The volume occupied by sample was noted and bulk density was expressed as g per ml.

Sensory evaluation

The samples after optimum cooking sample were evaluated on the basis of sensory scores viz. colour, taste, texture, chewiness and overall acceptability by semi- trained panelof judges (9-10 judges) using 9 point hedonic scale assigning scores 9 to 1 (9-like extremely to 1- dislike extremely). A score of 5.5 and above was considered acceptable [12].

Statistical analysis

The results obtained were statistically analyzed using completely randomized design (CRD) and CRD factorial for interpretation of the results through analysis of variance [13].

Results and Discussion

Functional parameters of green leaf powder blended chickpea nuggets

Water absorption index

Water absorption index is used as an index of starch gelatinization since native starch does not absorb water at room temperature [14]. The higher mean water absorption index of 3.32 g per g was recorded in treatment T_7 while as treatment T_1 (control nuggets) observed lowest mean water absorption index of 2.63 g per g (**Figure 2**). Water absorption index decreased with increase in the chickpea powder this might be due to the lower starch gelatinization with increase in protein content [15]. The water absorption index of the snack increased as amaranth concentration increased in feed material as reported by [16]. Kakade [17] also reported an increase in water absorption index with increasing level of beetroot leaf powder. With the progression of storage period, the mean water absorption index of green leaf powder blended nuggets decreased from 3.34 to 2.56 g per g with a non significant interaction between treatment and storage. The reason might be due to increase of hydrophobic amino acid residue during storage [18].

Oil absorption index

The oil absorption is important because oil act as a flavour retainer, improves palatability increase the mouth feel of foods and extends shelf life of food [19]. The highest mean oil absorption index of 0.901 g per g was recorded for T_1 (Control nuggets) while as least value of 0.807 g per g recorded for treatment T_7 as reflected in Figure 2. This decrease in oil absorption index might be because of low protein content in green leaf powder and high in chickpea. The higher protein content enhances hydrophobicity thereby exposing more polar acids to fat [20]. Bashir [21] also reported that the supplementation of partially defatted flaxseed and amaranth decreased the oil absorption index of meat analog nuggets. The mean oil absorption index of green leaf powder blended chickpea nuggets increased from 0.843 to 0.862 g per g during three months of storage periods. Studies have shown that this increase in oil absorption index during storage might be due to increase in the amount of non polar amino acid residue forming complex structure [22].

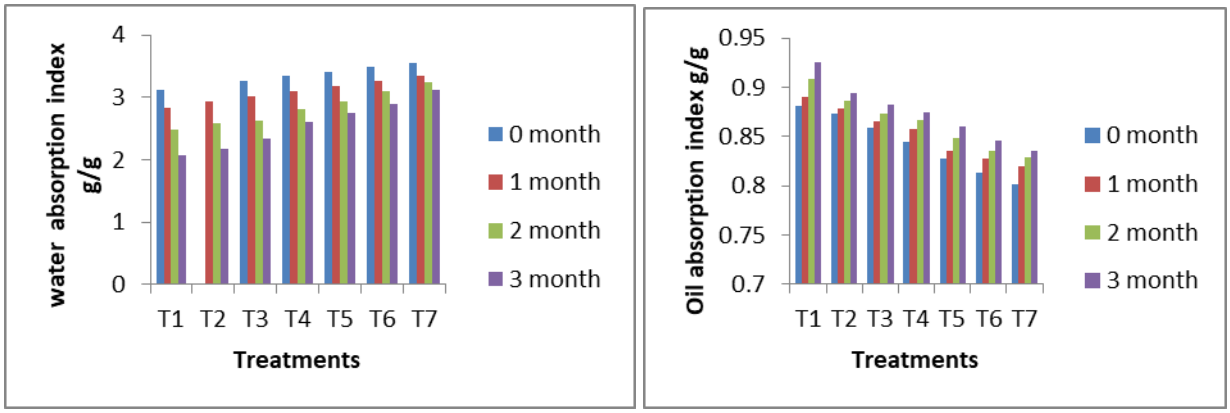

Figure 2 Effect of treatment and storage on water and oil absorption index (g/g) of green leaf powder blended chickpea nuggets

Bulk density

Bulk density is a measure of heaviness of a flour sample and storage space occupied by a food substance. The maximum and minimum mean bulk density of 0.635 and 0.497 g per ml were recorded in T_1 control and T_7 respectively in **Figure 3**. This might be because of greater bulk density and weight of chickpea than green leaf powder as bulk density depends on particle size and initial moisture content of the flour [23]. Similar result has been reported by Baljeet [24] in fibre rich buckwheat flour for biscuit making and Morsey [25] in rice-based extrudates containing dried *Corchorus olitorius* Leaves. The change in particle size and increased in moisture content might be responsible for decreased in bulk density values [18, 26].

Rehydration ratio

Rehydration may be used for the determination of damage during the drying process. It is one of the important quality attribute for prepared foods affecting their eating quality. The mean rehydration ratio of green leaf powder blended chickpea nuggets ranged from 0.96 to 1.62 (Figure 3). According to Gulia [27] the external as well as internal porous structures influences rehydration rate of the noodles. The firmer structure attributed due to higher protein content hinders the rehydration rate and thus, the rehydration rate is lower in foods containing higher protein content [28, 29]. Kuen [30] incorporated chickpea and okara flours into the instant noodles formulation and reported low rehydration ration in noodles containing higher protein content. During three month of storage, the mean rehydration ratio decreased from1.34 to 1.22 with a significant interaction between storage and treatment. The decline in rehydration ratio might be due to decrease in fiber, cellulose and pectin during storage [31]. Decrease in rehydration ratio of nuggets formulated from dehydrated green leafy vegetables and those prepared from mushroom powder, flaxseed and amaranth powder support our findings [32, 33].

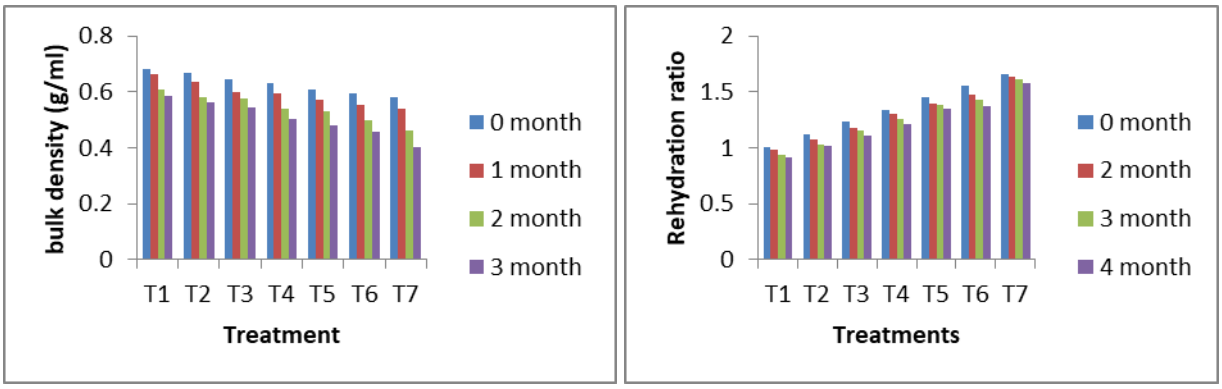

Figure 3 Effect of treatment and storage on bulk density (g/ml) and rehydration ratio (g/g) of green leaf powder blended chickpea nuggets

Water activity

Water has several effects on food stability, palatability and overall quality. The water activity content of green leaf powder blended chickpea nuggets varied significantly with the variation in ingredients and was found to be decrease

in the range of 0.591 to 0.482 (**Table 1**). The decrease moisture content of green leaf powder in contrast to chickpea might be responsible for decreased water activity of nuggets formulated from higher level of green leaf powder. Reduction of a_w affects microbial growth, the predominant microbial culture and it increases shelf life as a result of the reduced availability of water for the microbial growth [34]. Significant reduction of water activity with increase in temperature especially in the fat-rich products may be attributed to enhancement of the solubility of the non-polar solids such as fat in water [35]. During three months of storage period the mean water activity content of green leaf powder blended nuggets increased from 0.519 to 0.558. The gain in moisture by nuggets during storage due to absorption of moisture from the environment might be responsible for increase in water activity content [30, 36].

Table 1 Effect of treatment and storage on pH, water activity (a_w) and colour score (hedonic scale) of green leaf powder blended chickpea nuggets

Treatment	Storage period(months)				Mean	Storage period(months)				Mean	Storage period(months)				Mean
	0	1	2	3		0	1	2	3		0	1	2	3	
T_1 (100:00:: CP:GLP)	5.89	5.83	5.79	5.74	5.81	0.570	0.580	0.595	0.619	0.591	7.89	7.68	7.45	7.25	7.57
T_2 (97:3:: CP:GLP)	5.73	5.66	5.61	5.56	5.64	0.553	0.563	0.577	0.596	0.572	7.79	7.60	7.37	7.18	7.49
T_3 (94:6:: CP:GLP)	5.55	5.49	5.42	5.37	5.46	0.536	0.545	0.550	0.568	0.549	8.05	7.83	7.52	7.35	7.69
T_4 (91:9:: CP:GLP)	5.39	5.33	5.28	5.21	5.30	0.519	0.528	0.542	0.561	0.538	7.80	7.78	7.45	7.21	7.56
T_5 (88:12:: CP:GLP)	5.21	5.16	5.10	5.06	5.13	0.502	0.510	0.525	0.544	0.520	7.66	7.50	7.28	7.09	7.38
T_6 (85:15:: CP:GLP)	5.04	5.00	4.94	4.88	4.97	0.485	0.494	0.501	0.519	0.500	7.63	7.45	7.25	7.07	7.35
T_7 (82:18:: CP:GLP)	4.89	4.85	4.81	4.78	4.83	0.468	0.476	0.481	0.501	0.482	7.60	7.42	7.23	7.03	7.32
Mean	5.39	5.33	5.28	5.23		0.519	0.528	0.539	0.558		7.77	7.61	7.41	7.24	
Effects			$C.D_{(p=0.05)}$			$C.D_{(p=0.05)}$					$C.D_{(p=0.05)}$				
Treatment			0.07			0.007					0.02				
Storage			0.01			0.002					0.01				
Treatment × Storage			0.02			0.002					0.03				
CP: Chickpea flour; GLP: Green leaf powder															

pH

The maximum and minimum mean pH of 5.81 and 4.83 were recorded in T_1 control and T_7 respectively, in Table 1. Banerjee *et al.* [37] and Khursheed [38] reported that higher amount of broccoli powder and knolkhol powder decreased the pH value of meat nuggets. During storage period of three months, the pH decreased from 5.39 to 5.23 in green leaf powder blended chickpea powder. The decreased in pH is due the increase lactic acid fermentation by growth of lactic acid bacteria [39].

Sensory evaluation

With the increase in supplementation of green leaf powder, the mean colour score showed a decreasing trend from 7.69 to 7.32 (Table 1). This decreasing trend might be due to dark green colour pigments of green leaf powder which impart dark shades of greens to the product with the increasing level of green leaf powder in blended chickpea nuggets [2]. Tumuhimbise [19] reported decrease in color score of porridges from composite flour (orange flesh, sweet potato flour) blended with different proportions of amaranth leaves quite compatible with our findings. Elhadi [40] reported that the color of the patties was notably affected and it decreased with the increasing level of moringa leaf powder in the formulation. Storage had significant effect on the colour score and it decreased with the increase in storage period. The highest mean taste score of 8.11 was recorded in T_3 (94:6::CP:GLP) and lowest mean taste score of 7.40 was reported in T_7 (82:18::CP:GLP). The mean taste score decreased from 8.11 to 7.40 with the addition of green leaf powder in **Table 2** [41]. A significant decrease in chewiness and texture scores taste scores were observed with the advancement of storage period. Decrease in chewiness scores of meat analog nuggets containing texture vegetable protein [38] and noddles containing germinated mungbean flour [42] have been observed by other researchers also. This may be probably due to degradation of structural polysaccharide during storage which leads to decrease in fiber content resulting in decreased chewiness in foods [43].

Table 2 Effect of treatment and storage on taste, texture and chewiness scores (hedonic scale) of green leaf powder blended chickpea nuggets

Treatment	Storage period(months)				Mean	Storage period(months)				Mean	Storage period(months)				Mean
	0	1	2	3		0	1	2	3		0	1	2	3	
T_1 (100:00:: CP:GLP)	8.27	8.10	7.87	7.50	7.94	8.37	8.19	7.91	7.61	8.02	8.29	8.12	7.92	7.63	7.99
T_2 (97:3:: CP:GLP)	8.36	8.21	7.99	7.74	8.08	8.13	7.96	7.70	7.37	7.79	8.11	7.90	7.65	7.32	7.75
T_3 (94:6:: CP:GLP)	8.41	8.16	8.07	7.78	8.11	8.45	8.23	7.96	7.64	8.07	8.39	8.25	7.97	7.67	8.07
T_4 (91:9:: CP:GLP)	8.13	7.99	7.74	7.43	7.82	7.94	7.78	7.51	7.20	7.61	8.06	7.84	7.58	7.25	7.68
T_5 (88:12:: CP:GLP)	8.05	7.88	7.64	7.30	7.72	7.82	7.63	7.37	7.02	7.46	7.89	7.72	7.49	7.17	7.57
T_6 (85:15:: CP:GLP)	7.87	7.64	7.36	7.04	7.48	7.75	7.55	7.29	6.95	7.39	7.70	7.59	7.36	7.07	7.43
T_7 (82:18: :CP:GLP)	7.80	7.56	7.27	6.97	7.40	7.70	7.49	7.22	6.87	7.32	7.45	7.26	6.99	6.69	7.10
Mean	8.13	7.93	7.71	7.40		8.02	7.83	7.57	7.24		7.98	7.81	7.57	7.26	
Effects			$C.D_{(p=0.05)}$			$C.D_{(p=0.05)}$					$C.D_{(p=0.05)}$				
Treatment			0.03			0.01					0.02				
Storage			0.02			0.01					0.01				
Treatment × Storage			0.05			0.02					0.03				

CP: Chickpea flour; GLP: Green leaf powder

Thus on the basis of sensory evaluation (colour, taste, texture and chewiness) of developed green leaf powder blended chickpea nuggets, it was concluded that T_3 (94:6::CP:GLP) was adjudged as best treatment. The best composite green leaf powder blended chickpea nuggets i.e T_3 (94:6::CP:GLP) possessed 5.46 pH and 0.549 water activity. During three month of storage the mean water absorption index, rehydration ratio and bulk density decreased from 3.34 to 3.26 g per g, 1.34 to 1.22 g per g and 0.630 to 0.505 g per ml, respectively whereas mean oil absorption index increase from 0.843 to 0.862 g per g. The green leaf powder blended nuggets formulated in this study being highly nutritious can be recommended for malnourished children and expand the utilization of underutilized green leafy vegetable.

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