EVALUATION OF PHYSICO-CHEMICAL AND SENSORY PROPERTIES OF REFINED WHEAT FLOUR BISCUITS SUPPLEMENTED WITH CHICKPEA FLOUR

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ABSTRACT

The feasibility of partially replacing wheat flour with chickpea flour in biscuit making was **evaluated in several formulations, aiming to find a formulation for the production of chickpea** flour incorporated biscuits with better nutritional quality and consumer acceptance. Chickpea flour was incorporated in the traditional recipe to replace wheat flour at levels of 15, 25 and 35 percent in preparation of biscuits with maintaining all other ingredients constant. The protein content increased with an increase in amount of chickpea flour incorporation. Incorporation of chickpea flour also improved sensory scores. Sensory analysis revealed that at 25per cent level of incorporation, overall acceptability of biscuits was highest. An analysis of physical parameters revealed that replacement of refined wheat flour with chickpea flour increased the diameter, volume and spread ratio of biscuits significantly. There was slight decrease in thickness and bulk density of biscuits. Moisture, fat, ash, and protein contents increased significantly during storage. Sensory attributes of the biscuits did not undergo any deteriorative change upto 60 days, hence the biscuits prepared may be eaten till 60 days.

Key Words: Biscuits, Quality, Chickpea flour, High protein, Storage

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Introduction

Nutritional well being is a sustainable force for health and development and for maximization of human genetic potential. Protein deficiency is a major nutritional deficiency in the third world countries such as Malawi, Sudan, Tanzania, Zambia, Indonesia, India and Nepal. This is mainly due to inadequate quantitative and/or qualitative intake of food and, therefore, is an example of social and economic deprivation affecting health. Many countries have made great strides to improve their food and nutrition situation, but hunger and malnutrition remain as a serious problem in many parts of the world especially in third world countries (FAO, 2007). The main reason for this high incidence may be due to low consumption of protein rich foods. This inadequacy in the diet leads to a gap between protein requirements and consumption. Measures to counter protein deficiency in developing countries, especially India do not call for expensive supplementation with protein sources. Instead, it may be solved by developing supplementary foods made with inexpensive local protein rich sources. Dietary interventions using protein rich foods have been recommended as the best measure to improve protein status in individuals. The combination of cereals and pulses makes for balanced composition of amino acids (Jaya and Venkataratnam 1979; Makhmudov 1980; Chavan et al. 1986). Legumes are unique foods because of their rich nutrient content, including starch, vegetable protein, dietary fibre, oligosaccharides, phytochemicals (especially the isoflavones in soy) and minerals. Their carbohydrate and dietary fibre contents contribute to their low glycaemic indices, which benefit diabetic individuals (Bray & Popkin, 1998) and reduce the risks of developing diabetes mellitus (Lewis & Yetley, 1999). Legumes occupy an important place in human nutrition, especially in the dietary pattern of people belonging to low income groups of people. Legumes are normally consumed after processing, which not only improves palatability of goods but also increases the bioavailability of nutrients by inactivating trypsin inhibitors, growth inhibitors and haem-agglutinins (Tharanathan and Mahadevamma 2003). Legumes are a rich source of protein throughout the world and contain approximately three times more proteins than cereals. Legumes regarded as poor man's meat, are generally good sources of slow release carbohydrate. In addition they are rich in minerals and vitamins. Chickpea, is one such legume popular in many parts of the world, particularly in the Indian sub-continent and Middle East countries. Chickpeas are a healthy addition to any diet. They are an important source of macro- nutrients, good source of protein, containing almost twice the amount of protein compared to cereal grains, as well as minerals such as iron, magnesium, molybdenum, folate, copper, and zinc. Chickpeas are highly valuable and economical source of vegetable protein, which includes essential amino acids (Clemente et al., 2000; Menkov, 2000). It is a good source of Vitamin A, omega-3 fatty acids, and fiber. Chavan et al., (1989) reported that chickpea seeds has protein content around 21.5 percent. The chickpea may serve as a more sustainable alternative to meat and is a potential solution to growing soy allergies in developed nations. The main limiting nutritional factors attributed to the low utilization of pulse grains in developed countries are poor digestibility and availability of nutrients, flatulence factors, inherent beany flavor and presence of anti-nutritional factors. The level of several anti-nutritional factors is reduced by heat treatment such as sterilization, micronizing and microwave heat treatment. Among the heat treatment procedures, micronizing and microwave heating can reduce the level of anti-nutritional factors effectively without reduction of lysine, in comparison with original levels in seeds (Tabil et al. 1995).

Food scientists are rediscovering the fact that natural legumes like dry peas, lentils, and chickpeas are highly functional ingredients, adding both flavor and robust nutritional benefits to many dishes. Comprised of natural dietary fibre both soluble and insoluble as well as resistant starch and high-quality protein, they offer a health profile that is hard to match. The use of legumes is also economical, especially when compared with fiber-fortifying gums or soy protein products.

Fortification of foods is of current interest because of nutritional awareness of consumers. Fortification with legumes is one way to meet the needs for protein foods, particularly baked foods. The biscuit industry has been growing at an average rate of 15per cent during the past 3 years and this is expected to be maintained in coming years (IBMA, 2010). Baked food items are widely consumed and they have relatively long shelf life and good eating qualities. Such qualities of these food products make large scale production and distribution possible. Biscuits can be easily fortified (Mishra *et al.*, 1991) with protein rich flours to provide convenient and nutritious protein rich food. Among convenience foods, biscuits are very convenient and inexpensive but have only about 6 to 7per cent protein (Agarwal, 1990). Good eating quality makes biscuits attractive for protein fortification and nutritional improvements, particularly in children feeding programmes, for the elderly and low income groups. Enrichment of cereal-based foods with other protein sources such as oil seeds and legumes has received considerable attention (Ayo and Olawale 2003). The high lysine, low methionine content of legumes complements that of wheat flour proteins, which are poor in lysine and relatively higher in the sulphur-containing amino acids.

This is because of oil seeds and legume proteins are high in lysine, an essential limiting amino acid in most cereals. The objectives of the present study were to optimize the level of incorporation of Chickpea flour into refined wheat flour and its subsequent use in biscuit preparation. In the present investigation, the authors have used composite flour technology for preparation of fortified biscuits. Composite flour technology refers to the process of mixing wheat flour with flours of cereals and legumes. Incorporation of legume flour into wheat flour for baked goods production is expected to enhance the nutritive value of the baked food products. It is one of the additional ways of utilizing legume flours in India.

Materials and Methods

Preparation of raw materials: Chickpea grains were obtained through the local market of Allahabad area. Chickpea was dehusked and milled for getting flour. All materials and ingredients, namely refined wheat flour, salt, baking powder, shortening and sugar were purchased from the local market. The level of each ingredient is depicted in Table 1.

Preparation of chickpea flour: Whole dried chickpea seeds free of dirt, stones and other extraneous materials were ground using a laboratory hammer mill to pass through a 0.4mm screen to obtain fine chickpea flour.

Product Development:

Biscuits were prepared according to the formula from Mitsubishi-Kagaku Foods Corporation, Japan (2001) with slight modification. The formula used is shown in Table 1.

The dry ingredients were weighed using an analytical balance and thoroughly mixed in Kitchen Aid Mixer (Model K5SS, USA). Shortening was added and rubbed in until uniform and the dough thoroughly kneaded for four minutes. The dough was then rolled and cut with a round cutter with a diameter of 32 mm and thickness of 5 mm and baked on greased pan for 5 minutes at 180 ºC in a Turbofan Oven (Bakbar Versatile Bench Top Model E32, Germany).The biscuits were cooled on a wire racks at 27 ^{0}C for 30 minutes before packing in an airtight plastic container prior to physical and chemical evaluation.

Physical characteristics

The biscuits were selected randomly; weighed using analytical balance and the height and diameter were measured with a caliper (Mitiyoto Co. Tokyo, Japan). To measure the diameter of biscuits, four samples were placed next to one another and the total diameter was measured. All of them were then rotated at 90^{o} and the new diameter was measured. The average of the two measurements divided by four was taken as the final diameter of biscuit. Thickness was measured by stacking the biscuits one above the others and restacking four times. The spread ratio was calculated using the formula: diameter of biscuits divided by height of biscuits (Zoulias *et al*., 2000).

Chemical analysis

The moisture, ash, fat, crude protein (per cent N x 6.25) and crude fibre of the samples were determined by the AOAC method (2000). Moisture was determined by AOAC Method 934.01: Air Oven Method (AOAC 2000). Crude protein was determined by AOAC Method 960.52: Micro-Kjeldahl Method (AOAC, 2000). Fat was determined by AOAC Method 963.15: Soxhlet Extraction Method utilizing petroleum ether as solvent (AOAC, 2000). Crude fibre was determined by neutralisation method [(AOAC, 2000 (Method 962.09)]. Ash was determined by AOAC Method 923.03: Dry Ashing Method (AOAC, 2000). Carbohydrate content was estimated by difference. The results are reported on wet weight basis.

Peroxide value

In food, the presence of peroxides will have a pronounced effect on the flavor. Once oxidation has run its course, the oxidized material will have essentially changed to a new substance, chemically different from its original form and potentially toxic, which is why it is considered rancid and unusable. "Free radicals" or peroxides will destroy the normal state of many chemicals in our bodies, in food products, and other biological matter.

It is an indicator of rancidity development during storage. Peroxide value of fresh as well as 30 and 60 days old biscuits samples were determined as per the method described by Sadasivam and Manickam(2008).

Sensory evaluation

Sensory characteristics and overall acceptability of biscuits were assessed by a panel of 10 trained panellists consisting of post-graduate students and faculty members of the Department of Food Technology, College of Agriculture, Engineering and Technology, Sam Higginbottom Institute of Agricultural Engineering and Technology on the basis of 9-point hedonic scale (1=dislike extremely; 5=neither like nor dislike and 9=like extremely). Sensory characteristics studied included flavour, body and texture, appearance and overall acceptability. The scores were given in the decreasing order with 9 for 'like extremely' and 1 for 'dislike extremely'. In spite of trained sensory panels, they were exposed to characteristics biscuits by giving standard biscuits samples at least for 30 days at an interval of 3-4 days. Biscuit samples having sensory scores below 7 were not acceptable and were rejected.

Sensory evaluations were carried out on 0, 30 and 60 days of storage. Samples of biscuits were presented to the panelists monadically and evaluated on a nine point Hedonic scale. Samples were randomly assigned and order of presentation was balanced among panelists. The panelists evaluated all three replicates for each treatment. The results were analyzed according to Hussein *et al*. 2008.

Statistical analysis

All measurements were performed in triplicate for each sample. Data were analyzed using statistical software (SPSS for Windows Version 12.0) using one-way Analyses of variance (ANOVA). Significant differences between the means were estimated using Duncan's multiple range tests. Differences were considered significant at ($p < 0.05$).

Storage

Prepared biscuits were packed in HDPE (200 gauge) and aluminium laminates and kept under ambient conditions. The biscuits were evaluated for shelf life by estimating moisture, fat, ash and protein content at regular intervals of 30 days over the period of 60 days.

RESULTS AND DISCUSSION

Flour composition

Data on proximate composition of chickpea flour are presented in Table 1. The protein content of chickpea flour was 21per cent. The high protein content led credence to our choice of using chickpea flour as a supplementing agent. Hulse, (1991) have also indicated the suitability of supplementation of refined wheat flour with chickpea flour.

Biscuits composition:

Table 2 showed that there was significant difference ($p<0.05$) between the control and treatments in terms of protein, ash, fiber and carbohydrate. Our investigation revealed that the incorporation of chickpea flour in refined wheat flour has a non significant effect on the moisture content (Table 2). Protein content was highest in T_3 treatment with the value of 17.54±0.35 followed by T_2 , T_1 and T_0 (16.67±0.23, 15.15±0.20 and 8.60±0.10 respectively). The increase in protein content of chickpea flour supplemented biscuits might be the result of the appreciably higher protein content of chickpea flour. The ash, carbohydrate and fat content of treatments were significantly different as compared to control but were non- significant among the treatments themselves. The ash content of a food material could be used as an index of mineral constituents of food because ash is the inorganic residue remaining after the waste and organic matter have been removed by heating in the presence of an oxidizing agent (Sanni et al., 2008).

Physical analysis

The effect of level of incorporation of chickpea flour on physical properties of biscuit such as diameter, thickness, volume, bulk density and spread ratio is depicted in Table 3. The treatments showed slight significant ($p<0.05$) increase in volume and spread ratio as compared to control but the treatments did not showed any significant difference among themselves. The chickpea fortified biscuits had the highest spread ratio which may be due to decrease in viscosity. Biscuits having higher spread ratios are considered most desirable (Kirssel & Prentice, 1979). Biscuit spread rate appears to be controlled by dough viscosity. Protein content influences the viscosity of dough biscuits. The chickpea biscuits have high water holding capacity (WHC) as compared to control biscuits due to the high protein content. Hoojjat and Zabik, (1984) reported that in non-wheat protein water holding capacity was higher than in wheat flour. This lowers the initial dough viscosity and the biscuit is able to spread at a faster rate during heating. This is because the expansion of gluten protein is not resumed in the making of biscuits. During baking, the gluten goes through an apparent glass transition, thereby, gaining mobility that allows it to interact and form a web. The formation of continuous gluten web increases the viscosity and stops the flow of biscuit dough. Supplementation with chickpea flour decreased the proportion of gluten protein. This may be responsible for the lowered viscosity of the dough. Similar opinion has been given by Miller et al., 1997; Hoseney and Roger, 1994; Hoseney *et al*., 1988. The weakening effect of foreign proteins on wheat flour dough was the result of a dilution of the gluten structure by the added protein which led to increase in diameter and spread ratio. In contrast, thickness reduced significantly with the incorporation of chickpea flour as compared to control. Similar views were expressed by Eissa *et al*. (2007). Bulk density also reduced significantly which is a function of the closeness of packaging. According to Wilhelm et al., (2004), the density of processed products dictate the characteristics of its container or package product density influences the amount and strength of packaging material, texture or mouth feel. Our results are in agreement with those reported by Mariotti *et al*. (2006).

Sensory evaluation of biscuits:

The sensory scores of the biscuits were presented in Table 4. Sensory attributes were evaluated on 9-point hedonic scale. Biscuits prepared from chickpea flour were rated high in flavor, texture, taste, colour and overall acceptability with significant difference ($p<0.05$) as compared to control. McWatters (1978) suggested that the beany flavor in legumes flour could be reduced by exposing the material to moist heat. In spite of 25% of chickpea flour substitution, the biscuits were scored highest by the panelists.

Shelf life of biscuits

In the present investigation, the shelf-life of the biscuits was evaluated over a period of 60 days at an interval of 0, 30 and 60 days. Chemical studies of biscuits revealed that there were no significant changes in moisture, fat, ash and protein content as showed in Table 5. This may be attributed to better packaging and hygienic storage conditions. Our studies indicated that though the change in fat content was very minute but it had a pronounced effect on the flavor of the biscuit. This is led credence by the increase in peroxide value over a storage period of 60 days (Table 7). The change in flavor value was evident but the product was acceptable on the basis of sensory evaluation (Table 6).

Peroxide values of biscuits

Peroxide number was accepted as a parameter of oxidation and oxidation based staling in all lipids containing food In addition the increase in peroxide content was within acceptable limit.

There was no rancidity development observed in the formulated biscuits up to 60 days. Our results are in agreement with those reported by Aruna (2000). She reported that no rancidity development was observed in biscuits during storage period of 60 days.

CONCLUSION

The study was conducted to find out the best proportion of refined wheat and chickpea flour to formulate the biscuit. Biscuit containing 25 % chickpea flour substitution showed the best performance compared to other proportion of flour used based on mean sensory score. For the large-scale biscuit manufacture, chickpea flour can be incorporated up to 25 percent level, without affecting the sensory characteristics of biscuits as was accepted by the panelists. There was slight increase in peroxide content of biscuits but the sensory profile of biscuits did not show any adverse affect. The biscuits were shelf stable for 60 days.

Conflict of Interest: We do not have any conflict of interest.

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Table 1: Proximate composition of chickpea flour

S.No	Constituents	Per cent value
1	Moisture	11.21
2	Protein	21.00
3	Fat	3.10
4	Ash	5.94
5	Fibre	6.57
6	Carbohydrates	53.4

Table 2: Proximate composition of chickpea flour fortified biscuits

Treatment	**Percent composition**				
RWF/BGF	**Moisture**	**Protein**	**Fat**	**Ash**	**Carbohydrate**
100:0 (T_0)	1.783 ± 0.047^a	8.60 ± 0.10^d	12.13 ± 0.08^c	1.89 ± 0.02^c	85.01 ± 0.54^a
85:15(T_1)	1.865 ± 0.024^a	15.15 ± 0.20^c	13.20 ± 0.14^{ab}	2.02 ± 0.03^{ab}	76.13 ± 0.072^c
75:25(T_2)	1.889 ± 0.006^a	16.67 ± 0.23^b	13.37 ± 0.18^a	2.11 ± 0.04^a	80.09 ± 1.33^b
65:35(T_3)	1.897 ± 0.035^a	17.54 ± 0.35^a	13.76 ± 0.19^a	2.16 ± 0.04^a	81.21 ± 1.35^b

*Mean values in the same row which is not followed by the same letter are significantly different ($p<0.05$). Mean ± standard deviation (n=3)

Table 3: Effect of different treatments on the physical properties of chickpea fortified biscuits.

Treatments	**Diameter (cm)**	**Thickness (cm)**	**Spread ratio**	**Volume (cm^3)**	**Bulk Density (g/cm^3)**
T_0	3.70 ± 0.02^c	0.80 ± 0.001^a	4.625 ± 0.08^b	8.60 ± 0.13^b	0.690 ± 0.012^a
T_1	4.61 ± 0.03^b	0.76 ± 0.006^b	6.065 ± 0.14^a	12.60 ± 0.31^a	0.476 ± 0.018^b
T_2	4.62 ± 0.04^a	0.76 ± 0.012^b	6.078 ± 0.18^a	12.70 ± 0.35^a	0.472 ± 0.024^b
T_3	4.64 ± 0.04^a	0.75 ± 0.006^b	6.186 ± 0.19^a	12.71 ± 0.37^a	0.470 ± 0.018^b

*Mean values in the same row which is not followed by the same letter are significantly different ($p<0.05$). Mean ± standard deviation (n=3)

Table 4: Mean score of sensory evaluation for chickpea fortified biscuits (0 day)

Treatment	Mean Sensory score				
RWF/BGF	**Colour**	**Taste**	**Flavor**	**Texture**	**O.A.A**
100:0 (T_0)	8.00±0.08[a]	8.50±0.19[a]	8.90±0.08[a]	8.30±0.13[a]	8.21±0.08[a]
85:15 (T_1)	6.20±0.14[c]	6.90±0.20[c]	7.80±0.14[b]	7.10±0.05[c]	6.90±0.14[c]
75:25 (T_2)	7.00±0.18[b]	7.50±0.15[b]	8.40±0.18[a]	7.70±0.15[b]	7.77±0.18[a]
65:35 (T_3)	6.50±0.19[bc]	7.10±0.05[bc]	7.60±0.19[b]	7.40±0.10[bc]	6.97±0.19[bc]

*Mean values in the same row which is not followed by the same letter are significantly different ($p<0.05$). Mean ± standard deviation (n=3)

Table 5: Effect of storage period on the means of proximate composition of protein enriched biscuits.

Proximate composition	0 day	30 days	60 days
Moisture	1.799±0.02[c]	1.733±0.03[c]	2.06±0.03[c]
Ash	2.11±0.03[c]	2.09±0.03[c]	2.09±0.04[c]
Fat	13.37±0.18[b]	13.29±0.19[b]	13.27±0.17[b]
Protein	16.60±0.19[a]	16.25±0.20[a]	16.03±0.19[a]

*Mean values in the same row which is not followed by the same letter are significantly different ($p<0.05$). Mean ± standard deviation (n=3)

Table 6: Mean score of sensory evaluation for chickpea fortified biscuits (after 60 days)

Treatment	Mean Sensory score				
RWF/BGF	**Colour**	**Taste**	**Flavor**	**Texture**	**O.A.A**
100:0 (T_0)	8.00±0.02[a]	8.46±0.17[a]	8.80±0.06[a]	8.27±0.13[a]	8.19±0.07[a]
85:15 (T_1)	6.20±0.11[bc]	6.70±0.20[c]	7.60±0.12[c]	7.08±0.05[bc]	6.70±0.14[a]
75:25 (T_2)	7.00±0.09[d]	7.46±0.15[b]	8.20±0.16[d]	7.69±0.10[c]	7.67±0.17[c]
65:35 (T_3)	6.48±0.19[c]	7.00±0.05[d]	7.50±0.15[b]	7.38±0.10[b]	6.89±0.16[bc]

*Mean values in the same row which is not followed by the same letter are significantly different ($p<0.05$). Mean ± standard deviation (n=3)

Table 7: **Peroxide values of biscuit samples (meq O2/kg).**

Days	Peroxide number
0 days	1.58 ± 0.02^{c}
30 days	1.62 ± 0.03^{b}
60 days	1.68 ± 0.03^{a}

*Mean values in the same row which is not followed by the same letter are significantly different ($p<0.05$). Mean ± standard deviation (n=3)