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RESEARCH PAPER

Development and Storage Stability of Buckwheat - Chia Seeds Fortified Biscuits

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Abstract

Biscuits are one of the popular convenience, ready-to-eat, easy-to-carry, easy-to-store bakery products consumed by all age groups and a better vehicle for fortification and enrichment with micro and macro nutrients. In the present study, buckwheat and *chia* seed flours were used to prepare composite wheat flour in order to improve the protein, fiber, fatty acids and mineral content in biscuits. Biscuits were prepared from refined wheat flour, buckwheat flour and *chia* flour blends in various ratios (of 100:0:0; 85:10:5; 70:20:10; 55:30:15 and 40:40:20, respectively). The incorporation of buckwheat and *chia* flour, resulted in darkening and hardening of biscuits. Sensory quality and acceptability scores were decreased with the increase in the level of buckwheat and *chia* seed flour. Biscuits containing 30:15 (Buckwheat: *chia*) were acceptable in relation to overall acceptability. The diameter of the biscuit decreased from 62.3 mm to 57.4 mm the spread ratio of biscuits decreased from 10.55 to 6.89 but thickness increased from 5.90 mm to 8.32 mm as the level of incorporation of composite flour increased. There was a considerable increase in protein, fiber and micronutrients in the biscuits by adding buckwheat and *chia* flour. The optimized biscuits had 9.15% protein, 1.48% ash, 5.65% fiber, 74.3mg calcium and 4.4mg iron corresponding to the control about 5.11%, 0.51% and 1.21%, 18.78mg and 0.93mg. These biscuits were chemically and sensorily accpeted upto 60 days of storage in poly proplyne pouches at room temperature.

Keywords: Buckwheat, *Chia* Seed, Biscuits, Composite Flour, Fatty Acid Profile, Breaking Strength

The bakery industry is growing very fast and the products are increasingly becoming popular among all the sections of the people. Among the ready-to-eat snacks, biscuits possess several attractive features including wider consumer base, relatively long shelf-life, more convenient and good eating quality (Hooda and Jood, 2005). Biscuit is prepared from refined wheat flour, fat, sugar and other minor ingredients like salt, leavening agents like sodium bicarbonate and ammonium bicarbonate. But the refined wheat flour is low in protein (7 – 14%) and is deficient in essential amino acids such as lysine and other useful food components like dietary fibre (Shivani and Sudha, 2011). To overcome this, compositing of wheat flour by locally avalible grains has been reported earlier (Oyarekyua and Adeyeye, 2009). Development of fortified biscuits or other composite flour bakery products is the latest trend in the bakery industry. Most of the bakery products are used as a source for incorporation of different nutritionally rich ingredients for their diversification (Hooda and Jood, 2005). In recent years, there is a considerable body of research on biscuit ingredients and proportion which could be modified to make biscuits nutritious and healthy (Yamsaengsung *et al.*, 2012). This approach could not only promotes the development of diversified and nutrient rich bakery products, but also could reduce over exploitation and excessive use of wheat for making bakery products. Composite flour bakery products have manifold advantages, apart from extending the availability of wheat flour, these are looked upon as a carrier of useful functional food components and nutrients.

Buckwheat (*Fagopyrum esculentum* Moench) is a highly nutritious pseudo cereal belongs to the *Polygonaceae* family known for its good dietary source of protein with a favourable amino acid composition mainly lysine, histidine, valine and leucine (Bonafaccia *et al.,* 2003), essential minerals and trace elements (Steadman *et al.,* 2001). Buckwheat flour contains higher lysine, iron, copper and magnesium content than wheat flour (Ikeda and Yamashita, 1994). Buckwheat flour is rich in B-group vitamins and its gluten free nature plays an important role in preventing celiac disease (Li and Zhang, 2001). The high dietary fiber and resistant starch of buckwheat, plays an important role in decreasing the glycemic index level (Skrabanja *et al.,* 2001).

Chia seeds (*Salvia hispanica L.*) belongs to *Lamiaceae* family and is considered as pseudo cereal and also oil seeds due to its high fat content of 25-40%, and out of which up to 68% consisted of omega-3 fat y acids and 20% of omega-6 fat y acids thereby maintains a well balance between two essential fat y acids (Ayerza and Coates, 2011). Besides, *Chia* seeds are gaining at ention due to its high unsaturated fat y acid contents and also all the essential amino acids, particularly lysine, leucine, isoleucine and valine besides, being rich in dietary fiber of branched chain polysaccharides, which absorb more water and allow slower sugar absorption in the body (Lin *et al.,* 1994).

The purpose of the present study was to determine the optimum level of whole buckwheat flour and whole *chia* seed flour, which could be incorporated in biscuits to improve the functionality of the final products, including quality parameters such as taste, texture and nutrition and also to study its storage stability. The results are describe in this paper.

Materials and Methods

Raw Materials

The different raw materials like buckwheat, *chia* seed, commercially available wheat flour, cane sugar, Marvo brand bakery shortening (Bunge India Pvt. Ltd., Mumbai, India), skimmed milk powder (Nandini brand, Karnataka Milk Federation, Mysore, India) and vanilla essence (Bush Boake Allen Ltd, Chennai, India) were procured from the local market in Mysore, Karnataka, India. The buckwheat and *chia* seeds were cleaned and powdered in ultra-centrifugal mill (Retsch ZM 200, Germany), using 200 µm sieve and packed in airtight container.

Preparation of composite flour

The composite flour was prepared by replacing wheat flour with buckwheat flour at 10, 20, 30 and 40% and *chia* seed flour at 5, 10, 15 and 20%, respectively. The flours were mixed in a Hobart mixer (Model N50, Hobart GmbH, Offenburg, Germany) for about 10 min and sieved through 200 µm sieve to get homogenous mixture. The composite flours were packed in an air and moisture tight container, and stored at room temperature for further use.

Preparation of biscuits

The biscuits were prepared from refined wheat flour, buckwheat flour and *chia* seed flour blends in the ratios of 100:0:0; 85:10:5; 70:20:10; 55:30:15 and 40:40:20, respectively according to the method of Kumar *et al.* (2015). The recipe used had: flour 300 g, pulverized sugar 105 g, bakery shortening 60 g, sodium chloride 1.5 g, sodium bicarbonate 1.5 g, ammonium bicarbonate 3 g, skimmed milk powder 6 g, dextrose 6 g and vanilla essence 3 ml.

The method of preparation was as follows: Sugar, bakery shortening, skimmed milk powder, dextrose and vanilla flavor were creamed in Hobart mixer with a flat blade, for 5 min at 61 rpm and to the cream, then separately dissolved sodium chloride, sodium bicarbonate and ammonium bicarbonate in added water and mixed for 5 min at 125 rpm until homogenous cream was formed. Finally, the flour was added and mixed at 61 rpm for 2 min. The dough was sheeted to 3.5 mm thickness using a metal frame of 3.5 mm thickness and cut into round shape of 55 mm diameter using circular cut er. The baking was done at 190°C for 10 min following by cooking and storage in airtight containers.

Chemical composition

The moisture (method 44 – 16), protein (method 46 – 10), fat (method 30 – 10), ash (method 08 – 01), crude fiber (method 32–10), free fat y acid (method 58–15), peroxide value (method 58–16), were analyzed based on AACC (2000) procedures. The carbohydrate content was calculated by the difference method [100-(%moisture+% crude protein + % Crude fat+ %ash + % fiber)]. Energy content was calculated by multiplying protein, fat and carbohydrate contents by factors of 4, 9 and 4, respectively. Fat y acid profile of extracted fat from biscuit samples was determined as AOCS (1990) method by using gas liquid chromatography (Model Chemito 8510 HR, Mumbai, India) with 10% diethylene glycol succinate column (DEGS 8″× 1/8″). The minerals like Na, K, Ca, Fe, and ZN were determined by Atomic Absorption Spectrometer (AAS Varion 6, Analytik Jena AG, Germany) at 422.7, 248.3, 213.9, 589.0 and 766.5 nm wavelength respectively as per the method of Semwal *et al.* (1995). The mean of three independent determinations was reported.

Physical Characteristics

The diameter (D) and thickness (T) in mm of biscuit were measured using Vernier callipers and spread ratio (D/T) of biscuit was calculated. The weight of the biscuits was also noted. The mean of three independent determinations have been reported as described eralier.

Color analysis of biscuits

The color values of biscuits were measured using a Hunter color meter ((Color-flex, CFLX-45-2, Hunter lab, Hunter associates laboratory inc., Reston, VA, USA)) using standard D65 day light illuminate and 10° view angle. A higher L* value indicated a brighter or whiter sample. The positive a* value indicate redness and the negative a* value indicates greenness. The positive b* value indicates yellowness and the negative b* value indicates blueness.

Texture measurement

The breaking strength of biscuit was determined by a texture analyzer using triple beam snap (three point break) techniques as per the method described by Gains (1991). The peak force from the resulting curve indicated the breaking strength of biscuits (Kumar *et al.,* 2015). The mean of three independent determinations has been reported.

Sensory evaluation

Sensory quality of biscuits was evaluated by twenty panellists of age between 25 to 50 years, including male and female, who had earlier experience in quality evaluation of bakery products. Biscuit samples were evaluated in triplicates by each panellist for crust color, surface character, crumb color, crumb texture, taste, mouth feel and overall acceptability on a 9 point hedonic scale (1 = dislike extremely, 5 = neither like nor dislike and 9 = like extremely), according to the method of Larmond (1997).

Storage study of biscuits

Biscuits prepared by the optimized conditions and recipes were packed in polypropylene (PP, 75 μ) pouches; heat sealed and stored under 37°C conditions for further studies. There biscuits were analyzed for every 15 days for moisture, peroxide value, free fat y acid and sensory characteristics.

Statistical analysis

All the experiments were carried out in triplicates and standard deviation of the results was calculated using Excel -2008.

Results and Discussion

Chemical composition of flour and biscuits

Table 1 represents the chemical composition of flours and biscuits. The wheat flour had 12.41% moisture, 9.31% protein, 9.8% dry gluten, 0.74% ash, 1.55% fat, 415 s falling number which was found suitable for biscuit making. The buckwheat flour used in the study was found to be high in moisture content of 13.78% while *chia* seed flour had a moisture content of 3.37%. *Chia* seed flour was found to be very high in protein 17.83%, fat 21.96%, ash 4.92% and fiber

Table 1: Chemical Composition of flours*

Parameters	Moisture (%)	Protein (%)	Gluten (%)	Fat (%)	Ash (%)	Crude fiber (%)	Carbohydrate (%)	Energy (K cal)
Wheat flour	12.41±0.48	9.31±0.18	9.8±0.19	1.55±0.16	0.74±0.19	0.93±0.18	75.94±0.36	354.79±0.93
Buckwheat Flour	13.78±0.14	11.3±0.09	—	2.22±0.11	1.91±0.14	7.49±0.21	70.81±0.33	348.62±1.27
Chia seed Flour	3.37±0.19	17.83±0.16	—	21.96±0.24	4.92±0.23	41.38±0.37	51.89±0.68	476.52±1.11

*Mean ± SD

Table 2: Physical Characteristics of Biscuits*

Sample	Weight (g)	Diameter (mm)	Thickness (mm)	Spread ratio (D/T)	Breaking strength (N)	L*	a*	b*
1	6.86±0.11	62.3±0.46	5.90±0.11	10.55±0.04	9.77±0.87	68.41±0.19	10.04±0.11	35.78±0.18
2	7.38±0.21	60.9±0.55	6.41±0.11	9.51±0.07	11.31±0.56	63.89±0.13	13.79±0.11	29.89±0.22
3	8.17±0.33	60.0±0.71	6.93±0.13	8.75±0.11	13.44±0.67	57.99±0.07	15.35±0.19	25.02±0.17
4	8.61±0.13	58.1±0.45	7.67±0.08	7.57±0.03	17.13±0.37	56.01±0.21	18.23±0.14	23.54±0.09
5	9.23±0.17	57.4±0.85	8.32±0.17	6.89±0.13	23.02±0.88	51.24±0.13	19.35±0.21	21.37±0.10

*Mean ± SD

41.38% as against buckwheat flour of 11.3%, 2.22%, 1.91, and 7.49% respectively.

Effect of composite flour on physical characteristics of biscuits

The effect of incorporation of buckwheat flour and *chia* seed flour on physical characteristics of biscuits is presented in Table 2. It is evident that the increase in the addition of composite flour resulted in an increase in weight of the biscuits. The control biscuits weighed 6.86 g when compared to 9.23 g of composite flour biscuits with 40% buckwheat flour and 20% *chia* seed flour. The increase in weight of biscuits may be due to increase in density of biscuits (Francine *et al.* 2011) and also due to ability of buckwheat and *chia* seed flour to retain oil during biscuit baking (Rufeng *et al.*, 1995). Similar increase in weight of the biscuits when using multigrain flours was reported by Ashwathkumar *et al.* (2015).

The diameter of the biscuit decreased from 62.3 mm to 57.4 mm and thickness increased from 5.90 mm to 8.32 mm as the level of incorporation of composite flour increased. The decrease in diameter and increase in thickness affected the spread ratio of biscuits which decreased from 10.55 to 6.89. Good quality cookies or biscuits should have a high spread ratio (Miller and Hoseney, 1997). Similar decrease in spread ratio of biscuits by adding multigrain flour was reported by Kumar *et al.* (2015).

The breaking strength, which is the force required to break the biscuits increased from 9.77 N to 23.02 N indicating an increase in the hardness of biscuits with the addition of composite flour. An increase in the breaking strength of biscuits may be attributed to addition of fiber rich buckwheat and *chia* seed flour which reduces the gluten content of wheat flour. Fustier *et al.* (2009) have reported an increase in hardness of biscuit or cookies, attributed to increase in protein content and its interaction during dough development and baking. Earlier, Tyagi *et al.* (2007) also found an increase in breaking strength of biscuits when mustard flour was substituted for wheat flour. L* indicates the whiteness of the biscuits decreased from 68.41 in the control biscuits to 51.24 with the addition of 30% buckwheat flour and 20% *chia* seed flour. Similar results of decrease in lightness value of biscuits have been documented by Shivani and Sudha (2011). The redness (a*) value of biscuits increased and yellowness (b*) value decreased with the increasing level of replacement of wheat flour.

Effect of composite flour on sensory evaluation of biscuits

Sensory analysis plays a key role in modification, improvement, development and acceptance of new food products (Kumar *et al.*, 2015). Effect of incorporation of composite flour to wheat flour on sensory characteristics of biscuits is presented in Table 3. With the increase is the level of composite flour, the sensory scores for color, aroma, texture, taste and OAA of biscuits decreased. There was however, no significant decrease in sensory score upto 30% of buckwheat and 15% of *chia* seed flour addition. But a further increase in the addition of composite flour, significantly decreased scores in all parameters of sensory evaluation. The control biscuits were pale yellow in color and had scores of 8.53 on a 9 point hedonic scale and it decreased to 6.30 by the addition of 40% buckwheat and 20% *chia* seed flour. The *chia* seeds are black in color, which affect the color of biscuits. The texture of biscuits containing composite flours is harder and hardness increased as the level of substitution increased, which is on par with the texture analysis of biscuits using Texture analyzer.

Table 3: Sensory Evaluation of biscuits

Variation	Color	Aroma	Texture	Taste	OAA
Control	8.53±0.10	8.5±0.15	8.38±0.08	8.5±0.10	8.59±0.12
10% BW +5% Chia	8.33±0.21	8.41±0.11	8.13±0.15	8.44±0.07	8.37±0.13
20%BW +10% Chia	8.17±0.11	8.27±0.17	8.11±0.16	8.23±0.22	8.11±0.21
30% BW +15% Chia	7.93±0.07	8.07±0.14	7.82±0.13	7.79±0.17	8.07±0.17
40% BW +20% Chia	6.36±0.21	6.38±0.08	6.89±0.14	6.57±0.11	6.41±0.15

*Mean ± SD

Earlier, Singh *et al.* (1993) documented high protein biscuits developed from composite flours of wheat, green gram, Bengal gram and black gram flours had harder texture as well as color of biscuits was also adversely affected. Biscuits prepared using 40% buckwheat flour and 20% *chia* seed flour had a very hard texture. The OAA of biscuits showed that, an acceptable quality of biscuits can be prepared using 30% of buckwheat and 15% of *chia* seed flour to replace wheat flour.

Nutritional analysis of optimized biscuits

The control and optimized biscuits were analyzed for its proximate fatty acid profile and mineral profiles as per the results shown in Table 4. The incorporation of buckwheat flour and *chia* seed flour resulted in a considerably improvement of nutritional characteristics of biscuits mainly protein, fiber and ash contents. The moisture content of biscuits increased from 2.47% for control biscuits to 2.63% for optimized composite flour biscuits. The slight increase in moisture content in optimized biscuits might be due to the higher water binding capacity of buckwheat flour. The similar increase in moisture content of biscuits by addition of composite flour has also been reported by Tyagi *et al.* (2007). The optimized biscuits had higher protein content of 8.15% as compared to 5.51% in control biscuits. There was a slight increase in fat content in optimized biscuits. Earlier, Rufeng *et al.* (1995) also reported increased fat content in buckwheat flour incorporated biscuits and attributed it to high oil retention ability of buckwheat flour during the baking process. The higher retention of oil improves the mouth feel by retaining the flavor of biscuits. An increase in the ash content in optimized biscuits was observed which could be due to the high ash content of buckwheat and *chia* seed flours. The optimized biscuits had considerable high crude fiber content i.e. 5.65% when compared to that of 1.21% in the control biscuits.

The main fatty acid content in both the biscuits was palmitic and oleic acids (Table 2). These are in relation to studies carried out by Vivario and Viviana (2003) on fatty acid profile of Spanish cookies and bakery products. Incorporation of composite flour increased the oleic acid, ω-6 acid and ω-3 acids and decreased the palmitic acid content. The optimized biscuits had 4.88% of ω-3 fatty acid and which is advantageous as there is recommendation for consumption of this fatty acid. Incorporation of composite flour showed a significant increase in mineral content of biscuits. The calcium, iron and zinc were increased to 74.3, 4.4, 2.78 from 18.78, 0.93, 0.22 mg/100g, respectively. The sodium and potassium content of biscuits were comparable.

Table 4: Nutritional Composition of Biscuits

Parameters	Control Biscuit	Optimized Biscuits
Moisture (%)	2.47±0.27	2.63±0.11
Protein (%)	5.11±0.26	9.15±0.18
Fat (%)	17.08±0.31	18.61±0.29
Ash (%)	0.51±0.13	1.48±0.05
Crude fiber (%)	1.21±0.11	5.65±0.18
Carbohydrate (%)	73.53±0.39	69.36±71
Energy (k cal)	447.98±1.98	474.83±1.37
Na (mg/100g)	993±8	1040±5
K (mg/100g)	188±3.8	217±2
Ca (mg/100g)	18.78±2.3	74.3±1.7
Fe (mg/100g)	0.93±0.17	4.4±0.21
Zn (mg/100g)	0.22±0.09	2.78±0.11
Lauric acid, C12:0 (mg/100g)	1.17±0.22	1.12±0.13
Myristic acid, C14:0 (mg/100g)	ND	1.01±0.11
Palmitic acid, C16:0 (mg/100g)	45.33±1.9	33.12±1.67
Stearic acid, C18:0 (mg/100g)	1.82±0.17	ND
Oleic acid, C18:1 (mg/100g)	41.81±1.8	47.77±2.3
Linoleic acid, ω-6 fatty acid, C18:2 (mg/100g)	6.53±0.52	11.53±0.36
Linolenic acid, ω-3 fatty acid, C18:3 (mg/100g)	ND	4.88±0.17

ND-Not determined; *Mean ± SD

Storage study of biscuits

The biscuits were stored in poly propylene pouches at room temperature and stored for 60 days. There was a slight increase in moisture content of biscuits during storage and it increased from 2.64% to 2.81% at the end of 60 days (Table 5). The increase in moisture content might be due to the hygroscopic nature of biscuits, storage environment (temperature, relative humidity) and the nature of packaging material used. Similar report of increase in moisture content of cereal bran incorporated biscuits at the end of 90 days of storage was reported by Nagi *et al*. (2012). Peroxide value, the indicator of rate of auto oxidation, was increased significantly during storage from 7.09 to 22.18 meq O_2/kg fat at the end of 60 days. In packed products, the rate of auto-oxidation is mainly governed by the oxygen retention in the pack, which in turn is related to the headspace and oxygen permeability of the packaging material (Khan *et al.* 2008). The mean free fatty acid content of biscuits was also found to increase from 1.42 to 1.92 % oleic acid. Earlier, Singh *et al.* (2000) reported that the free fatty acid content of soy fortified biscuits was found to increase with advancement of storage period and attributed to greater increase in moisture content which promoted fat hydrolysis during storage. The breaking strength of the biscuits decreased from 17.42 to 14.18 N at the end of 60 days of storage affecting the crispiness. The moisture and water activity plays an important role in dry foods hardness. The decrease in hardness of biscuits might be due to moisture migration and redistribution as well physical changes of main biscuits components and their interaction. The sensory parameters studied during storage showed that there was a only slight reduction in sensory scores of taste and overall acceptability, but were in acceptable levels. Therefore, biscuits are stable chemically and sensory up to 60 days of storage in poly-propylene pouches stored at room temperature.

Conclusion

Composite flour prepared from buckwheat and *chia* seed flour considerably affected the physico-chemical, sensory and nutritional properties of biscuits. It is

Table 5: Storage study of biscuits

Storage Period	Moisture (%)	Peroxide value (PV)	Free fat y acid (FFA)	L*	a*	b*	Breaking strength (N)	Taste	OAA
0^{th} day	2.64±0.13	7.09±0.17	1.42±0.09	53.90±0.17	7.05±0.09	23.49±0.11	17.42±0.89	7.79±0.17	8.07±0.17
15^{th}day	2.69±0.09	10.89±0.21	1.64±0.13	54.51±0.23	6.93±0.12	23.91±0.31	16.71±1.13	7.71±0.16	7.92±0.12
30^{th}day	2.75±0.19	13.99±0.18	1.71±0.11	54.69±0.26	6.90±0.17	24.01±0.27	16.09±0.66	7.69±0.09	7.790.15
45^{th}day	2.79±0.15	18.91±0.11	1.85±0.24	55.14±0.14	6.80±0.06	24.28±0.19	14.52±0.97	7.58±0.17	7.72±0.19
60^{th}day	2.81±0.13	22.18±0.23	1.92±0.17	55.18±0.21	6.72±0.13	24.30±0.13	14.18±0.37	7.48±0.13	7.66±0.22

*Mean ± SD PV; Peroxide content (meq O_2/kg fat); FFA, free fat y acid (% oleic acid); OAA, overall acceptability.

concluded that biscuits with improved nutrition can be prepared by incorporating buckwheat and *chia* seed flour at 30% and 15% level respectively, without affecting the textural and sensory at ributes. Utilization of buckwheat flour and *chia* seed flour resulted in a considerably increase in protein, crude fiber, calcium, iron and poly-unsaturated fat y acid content.

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