International Food Research Journal 21(1): 217-222 (2014)
Journal homepage: *http://www.ifrj.upm.edu.my*

Effect of incorporation of carrot pomace powder and germinated chickpea flour on the quality characteristics of biscuits

[1*]Baljeet, S. Y., [1]Ritika, B.Y. and [2]Reena, K.

[1]*Department of Food Technology, Maharshi Dayanand University, Rohtak (India)-124001*
[2]*Chaudhary Devi Lal University, Sirsa (India)-125055*

Article history

Received: 18 May 2013
Received in revised form: 8 October 2013
Accepted: 13 October 2013

Keywords

Carrot pomace
Germinated chickpea
Biscuit
Physicochemical properties
Sensory quality

Abstract

The study on utilization of carrot pomace powder (CPP) and germinated chickpea flour (GCF) in biscuits was undertaken to upgrade the nutritional quality and assess the acceptability. The biscuits were prepared from composite flours by incorporating 5, 8 and 10 parts of germinated chickpea flour and similar corresponding parts of carrot pomace powder in to wheat flour. The biscuits were analyzed for their physical properties, chemical composition and sensory properties. The spread ratio of the biscuits increased from 6.1 to 8.4 with the increase of CPP and GCF in the blends. With the increase in the concentration of CPP and GCF, there was an increase in protein, ash and crude fiber contents. The crude fiber content of the biscuits supplemented with 10% CPP and GCF was the highest (3.2%). The biscuits supplemented with CPP and GCF up to 8% level were of acceptable sensory quality.

Introduction

The bakery industry is growing very fast and the products are increasingly becoming popular among all sections of people. Among ready-to-eat snacks, biscuits possess several attractive features including wider consumption base, relatively long shelf-life, more convenience and good eating quality (Hooda and Jood, 2005; Iwegbue, 2012). Soft wheat is the grain of choice for making cookies. However, production of good quality soft wheat is very limited and unevenly distributed globally. Moreover, refined wheat flour is low in protein (7 - 14%) and is deficient in essential amino acids such as lysine and certain other useful food components like dietary fiber. Therefore, compositing wheat flour with the locally available grains other than wheat and root crops has been reported to be desirable (Oyarekyua and Adeyeye, 2009). Most of bakery products are used as a source for incorporation of different nutritionally rich ingredients for their diversification (Hooda and Jood 2005; Sudha *et al.*, 2007). This approach not only promotes development of diversified and nutrient rich bakery products but also reduces 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 flours, these are looked upon as carrier of useful functional food components and nutrients.

The total vegetables production in the world was estimated as 240.8 million tones during the year 2007. Carrot (*Daucus carota* L.) is inexpensive and highly nutritious as it contains appreciable amount of vitamins B1, B2, B6 and B12 besides being rich in carotene (Walde *et al.*, 1992, Manjunatha *et al.*, 2003) and fiber. Carrot juice yield is reported to be only 60 - 70% and up to 80% of carotene may be lost with the pomace (Bohm *et al.*, 1999). The dried carrot pomace has carotene and ascorbic acid in the range of 9.87 to 11.57 mg and 13.53 to 22.95 mg per 100 g, respectively (Upadhyay *et al.*, 2008). The use of carrot pomace as a by-product utilization will decrease the environmental load. The commercial exploitation of carrot has not been so far taken place in most of the developing countries despite having the potential for processing and value addition.

Chickpea (*Cicer arietinum*) is widely consumed throughout the world. Chickpea seeds are rich source of protein ranging from 12.6 to 30.5%. The biological value of chickpea proteins generally ranges from 75 to 85%, which is considerably higher than other legume and cereal proteins. Functional properties, which are assuming greater significance in terms of diversified and novel food uses of crops, play an important role in the utilization of chickpea in the cereal based composite flours (Iyer and Singh, 1997). Processing techniques such as germination and fermentation have been found to improve the quality of cereals and legumes due to chemical changes that enhance contents of free sugars, protein and vitamins, as well as bioavailability of minerals (Helland *et al.*, 2002; Ochanda *et al.*, 2010), and results in the breakdown of some of the anti-nutritional endogenous compounds

*Corresponding author.
Email: *baljeetsingh.y@gmail.com*

(Ahmed *et al*., 2006).

As biscuits need value addition with protein, fibre, minerals and vitamins to improve their nutraceutical properties and to cater to the health/therapeutic needs of various cross-sections of the population, supplementation of refined wheat flour with carrot pomace powder and germinated chickpea flour will upgrade the nutritional quality of biscuits with changed sensory attributes. Thus, the objective of this study was to incorporate carrot pomace powder and germinated chickpea flour in to wheat flour to develop protein and dietary fiber enriched biscuits and assess their quality characteristics.

Materials and Methods

Refined wheat flour, chickpea seeds, carrots, butter fat (brand name "Nova"), sugar and baking powder used for biscuit making were purchased from local market in Sirsa (India). All the chemicals/ reagents used were of analytical grade. Chickpea flour was made from finally ground germinated chickpea seeds. Seeds were washed and soaked in water for 18 h with intermittent change of water at an interval of 4 - 5 h, drained and allowed to germinate under a wet cloth for 24 h. The germinated seeds were sundried, dehusked, milled to flour in a laboratory grinder and sieved with a 0.150 µ sieve. The flour was stored in air and moisture tight container at room temperature for further use and analysis. For making carrot pomace powder, the pomace remaining after extraction of juice was blanched water (80 ± 2°C) for 3 min, immediately cooled by exposing to air and dried at 60 ± 2°C for 5 h. The pomace was spread uniformly and dried in a tray drier at 50°C for 18 h. The dried pomace was ground to fine powder and sieved with a 0.150 µ sieve.

Product development

Biscuits were prepared from different blends of refined wheat flour, germinated chickpea flour and carrot pomace powder in the respective ratios of 100:0:0, 90:5:5, 84:8:8 and 80:10:10. Refined wheat flour biscuits were considered as control. The standardized formulation for the biscuits had the ingredients as 100 g flour, 50 g sugar, 45 g butter fat, 1.5 g ammonium bicarbonate and required amount of milk. Butter fat and ground sugars were creamed for about 3 min achieve a uniform consistency. The flour, required amount of milk and ammonium bicarbonate were added to the creamed mixture and mixed for 8 min at medium speed in dough mixer to obtain a homogenous mixture. The dough was rolled out into thin sheet of uniform thickness and cut into desired shape using mould. The cut pieces were placed over a perforated tray and transferred into a baking oven at 190°C for 10 - 15 min. The well baked biscuits were cooled to room temperature and stored in air tight container till further use.

Analytical methods

Protein (Kjeldahl nitrogen estimation, Nx6.25), fat (soxhlet extraction), moisture, ash and crude fiber content of flours and biscuits were determined by using standard methods of AOAC (1990). The carbohydrate content was determined by subtraction method.

Functional properties of flours

Water and oil absorption capacity

The water and oil absorption capacities were determined using method of Sosulski *et al.* (1976). The sample (1.0 g) was mixed with 10 ml distilled water or refined soybean oil, kept at ambient temperature for 30 min and centrifuged for 10 min at 2,000×*g*. Water or oil absorption capacity was expressed as percent water or oil bound per gram of the sample.

Bulk density

Bulk density was determined according to the method as described by Okaka and Potter (1977). The sample (50 g) was put into a 100 ml graduated cylinder and tapped 20 - 30 times. The bulk density was calculated as weight per unit volume of sample.

Least gelation concentration

The least gelation concentration was determined using method of Coffman and Garcia (1977) with some modifications. The flour dispersions of 2 - 30% (w/v) at an interval of 2% were prepared in 5 ml distilled water and heated at 90°C for 1 h in a water bath. The contents were cooled under tap water and kept for 2 h at 10 ± 2°C. The least gelation concentration was determined as that concentration when the sample from inverted tube did not slip.

Swelling capacity

The method of Okaka and Potter (1977) with some modifications was used for determining the swelling capacity. The sample filled up to 10 ml mark in a 100 ml graduated cylinder was added with water to adjust total volume to 50 ml. The top of the graduated cylinder was tightly covered and mixed by inverting the cylinder. The suspension was inverted again after 2 min and allowed to stand for further 30 min. The volume occupied by the sample was taken after 30 min.

Foaming capacity and foam stability

Foaming capacity and foam stability were determined as described by Narayana and Narasinga Rao (1982) with slight modifications. Sample (1.0 g) was added to 50 ml distilled water at 30 ± 2°C in a graduated cylinder. The suspension was mixed and shaken for 5 min to foam. The volume of foam after whipping for 30 s was expressed as foaming capacity. Foaming capacity was determined as

$$\text{Volume of foam (AW) - Volume of foam (BW)/ Volume of foam (BW) x 100}$$

Where, AW: After whipping, BW: Before whipping
The volume of foam was recorded 1 h after whipping to determine foam stability as percent of the initial foam volume.

Physical parameters of biscuits

Diameter of biscuits was measured by laying six biscuits edge to edge with the help of a scale, rotating them 90° and again measuring the diameter of six biscuits (cm) and then taking average value. Thickness was measured by stacking six biscuits on top of each other and taking average thickness (cm). Weight of biscuits was measured as average of values of four individual biscuits with the help of digital weighing balance. Spread ratio was calculated by dividing the average value of diameter by average value of thickness of biscuits. Spread factor was calculated as the ratio of the spread factor the control sample to that of the composite samples.

Sensory analysis of biscuits

Sensory quality characteristics of biscuits were evaluated by a panel of 10 semi-trained members using a 9-point hedonic scale. Before starting analysis, panelists were made well acquainted with the sensory attributes. The biscuits were evaluated for their color, appearance, flavor, texture, taste and overall acceptability.

Statistical analysis

The data were reported as average of triplicate observations. The data were analyzed statistically in a completely randomized design using one factor analysis of variance with the help of OPSTAT statistical analysis software.

Results and Discussion

Proximate composition

The chemical composition of refined wheat flour, germinated chickpea flour and carrot pomace powder is given in Table 1. The ash content ranged from 0.7 to 3.2% with carrot pomace powder showing the highest value. Germinated chickpea flour showed the highest fat content (5.3%) agreeing with the observations of William and Singh (1987) who reported variation in fat content of various genotypes of chickpea ranging from 3.8 to 10.2%. Carrot pomace powder had the highest crude fiber content (18.5%) being in agreement with the value reported by Kumari and Grewal (2007). Carbohydrate content varied from 63.5 to 74.1%, being the lowest for germinated chickpea and highest for refined wheat flour.

Functional properties of flours

The functional properties of refined wheat flour and germinated chickpea flour are presented in Table 2. Refined wheat flour exhibited significantly higher ($p < 0.05$) water absorption capacity (WAC) (149.3%) as compared with chickpea flour. Higher WAC of refined wheat flour could be attributed to the presence of greater amount of hydrophilic constituents like soluble fiber and lower amount of fat content. The OAC ranged from 163.2 to 169.7% and refined wheat flour showed greater OAC. The fat absorption can also be influenced by the lipophilicity of protein (Kinsella, 1976). The high OAC could suggest the presence of a large proportion of hydrophobic groups as compared with the hydrophilic groups on the surface of protein molecules (Subagio, 2006). Swelling capacity determines the extent to which a flour sample increases in volume in relation to its initial volume when soaked in water. The swelling capacity (SC) ranged from 16.5 to 17.2 ml with refined wheat flour showing the higher value. The foaming capacity of flour samples ranged from 12.8 to 40.5%. Proteins can help the foaming because of their surface active property. The foam stability which is measured by the rate at which foam volume decreases is generally determined by loss of liquid resulting from destabilization (leakage). The germinated chickpea flour showed greater foaming capacity and stability. This may be due to high protein content in chickpea flour. Food ingredients with good foaming capacity and stability are required in bakery products (Akubor *et al.*, 2000; Akubor and Ukwuru, 2003; Alobo, 2003). The LGC of germinated chickpea and refined wheat flour were 12 and 20%, respectively. The variation in the gelling

Table 1. Proximate composition (%) of refined wheat flour, germinated chickpea flour and carrot pomace powder

Parameter	Refined wheat flour	Germinated chickpea flour	Carrot pomace
Moisture	$11.3^{c} \pm 0.24$	$9.8^{b} \pm 0.04$	$4.0^{a} \pm 0.01$
Ash	$0.7^{a} \pm 0.03$	$3.0^{b} \pm 0.03$	$3.2^{b} \pm 0.03$
Fat	$1.4^{b} \pm 0.02$	$5.3^{c} \pm 0.01$	$0.5^{a} \pm 0.02$
Crude fiber	$0.8^{a} \pm 0.04$	$1.3^{a} \pm 0.03$	$18.5^{b} \pm 0.11$
Protein	$11.7^{b} \pm 0.31$	$17.1^{c} \pm 0.25$	$1.0^{a} \pm 0.06$
Total carbohydrate	74.1	63.5	72.8

The values are mean ± S.D of three independent determinations. The values with different superscripts in a row differ significantly ($p \leq 0.05$).

Table 2. Functional properties of refined wheat flour and germinated chickpea flour

Property	Refined wheat flour	Germinated chickpea flour
WAC (%)	149.3 ± 0.88^{b}	101.5 ± 0.65^{a}
OAC (%)	169.7 ± 3.18^{b}	163.2 ± 2.15^{a}
SC (ml)	17.2 ± 0.72^{a}	16.5 ± 0.63^{a}
FC (%)	12.8 ± 0.49^{a}	40.5 ± 0.21^{b}
FS (%)	85.2 ± 0.28^{a}	90.2 ± 0.24^{b}
BD (g/ml.)	0.7 ± 0.01^{a}	0.7 ± 0.02^{a}
LGC (%)	20.0	12.0

The values are mean ± S.D of three independent determinations. The values with different superscripts in a row differ significantly ($p \leq 0.05$).
WAC = Water absorption capacity; OAC = Oil absorption capacity; SC = Swelling capacity; FC = Foaming capacity; FS = Foaming stability; BD = Bulk density; LGC = Least gelation concentration

properties of flours was attributed to the relative ratio of protein, carbohydrates and lipids that make up the flours and interaction between such components (Sathe *et al*., 1982). The bulk densities of the flour samples were similar. The bulk density is generally affected by the particle size of the flour and it is very important in determining the packaging requirements and material handing in food processing industry (Ajanaku *et al*., 2012).

Nutritional composition of biscuits

The proximate composition of biscuits is given in Table 3. Moisture content in the supplemented biscuits ranged from 2.8 to 3.1%, significantly higher ($p < 0.05$) than that of control biscuits (2.5%). Mustafa *et al.* (1986) reported an increase in moisture content of bakery products with increase in protein content. With the increase in the concentration of carrot pomace powder (CPP) and germinated chickpea flour (GCF) in the refined wheat flour, there was an increase in protein, ash and crude fiber contents. The ash content of biscuits increased as the substitution level increased and it was the highest (1.2%) at 20% (10% carrot pomace + 10% germinated chickpea flour) substitution level. The fat content of biscuits varied significantly ($p < 0.05$) and it ranged from 34.6 to 37.1%. The decrease in fat content was observed with increasing extent of substitution as it might be due to low oil absorption capacity of carrot pomace powder and germinated chickpea flour in comparison with wheat flour. The protein content increased from 7.1 to 7.9% with increasing the concentration of germinated chickpea flour in the blends. The increase in protein content of supplemented biscuits might be the result of the higher protein content of chickpea

Table 3. Proximate composition (%) and physical properties of biscuits

	A	B	C	D
Ash	$0.8^{a} \pm 0.03$	$0.9^{a} \pm 0.01$	$1.1^{b} \pm 0.16$	$1.2^{b} \pm 0.02$
Moisture	$2.5^{a} \pm 0.03$	$2.8^{b} \pm 0.01$	$2.9^{b} \pm 0.16$	$3.1^{c} \pm 0.02$
Fat	$37.1^{a} \pm 0.75$	$36.1^{b} \pm 1.01$	$35.5^{c} \pm 0.95$	$34.6^{d} \pm 1.05$
Crude fiber	$0.5^{a} \pm 0.05$	$2.2^{b} \pm 0.06$	$2.9^{c} \pm 0.03$	$3.2^{d} \pm 0.16$
Protein	$7.1^{a} \pm 0.04$	$7.4^{b} \pm 0.03$	$7.9^{c} \pm 0.02$	$7.8^{d} \pm 0.08$
Carbohydrate	52.0	50.6	49.7	50.1
Diameter* (cm)	5.5±0.11	5.6±0.12	5.8±0.16	5.9±0.09
Thickness* (cm)	0.9±0.11	0.8±0.12	0.8±0.16	0.7±0.09
Spread ratio	$6.1^{a} \pm 0.11$	$7.0^{b} \pm 0.12$	$7.3^{c} \pm 0.16$	$8.4^{d} \pm 0.09$
Spread factor	----	0.87	0.83	0.73
Weight (g)	$8.1^{a} \pm 0.11$	$7.7^{b} \pm 0.12$	$7.5^{b} \pm 0.16$	$7.1^{c} \pm 0.09$

The values are mean ± SD (n = 3); the carbohydrate content was determined by subtraction method
Values with similar superscripts in a row do not differ significantly ($p < 0.05$)
*Non significant difference
A = Control; B = 90 RWF: 5 CPP: 5 GCF; C = 84 RWF: 8CPP: 8GCF; D = 80 RWF: 10 CPP: 10 GCF
RWF = Refined wheat flour; CP = Carrot pomace powder; GCF = Germinated chickpea flour

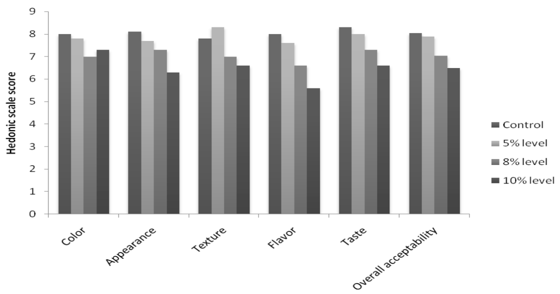

Figure 1. Sensory characteristics of biscuits

flour. In the case of supplemented biscuits, the crude fiber content increased significantly ($p < 0.05$) and it ranged from 0.5 to 3.2%. The increase in crude fiber content might be due to higher content of crude fiber in carrot pomace and chickpea flour than refined wheat flour.

Physical characteristics of biscuits

The physical properties of biscuits prepared from different blends of flours are also shown in Table 3. There were no significant differences ($p < 0.05$) between diameter as well as thickness of control sample compared to those of composite formulation biscuits. The diameter of biscuits varied from 5.5 to 5.9 cm. The biscuits of type D i.e. made from 20% (10% each of carrot pomace and germinated chickpea flour) showed the highest diameter of 5.9 cm. The weight of biscuits decreased as the concentration of carrot pomace powder and germinated chickpea flour increased in the blends. This was probably due to low OAC of the germinated chickpea flour. The changes in diameter and thickness were reflected in spread ratio of biscuit. Spread ratio increased with the addition of carrot pomace powder and germinated chickpea flour in the blends. The spread ratio of the cookies decreased significantly ($p < 0.05$) from 6.1 to 8.4 as the incorporation of carrot pomace powder as well as germinated chickpea flour increased from 0 to 10% level. Hence, results indicated that incorporation of CPP and GCF increased the diameter and decreased the thickness of biscuits thereby increasing the spread ratio. The higher fiberous content of the chickpea flour and carrot pomace powder could have contributed to lesser water absorption in the blend flours in comparison to that of control sample. Rao and Leelavathi (1993) also reported increase in spread ratio of biscuits prepared with incorporation of wheat bran. These results are however contrary to the findings of Mridula *et al.* (2007) who reported a significant reduction in the spread ratio of wheat-soybean and sorghum composite biscuits. It implies that the quality of protein may also affect the water absorption characteristics of flour and hence spread ratios of biscuits. The main hydrophilic components of a cookie formula are flour and sugar. Lower water absorption by flour provokes higher water absorption by sugar that increments syrup and decreases dough viscosity during baking; consequently dough could spread farther producing larger diameter cookies (Slade and Levine, 1994).

Sensory characteristics of biscuits

Fig. 1 depicts the effects of carrot pomace and germinated chickpea flour incorporation on the sensory characteristics of biscuits. With the increase in the level of carrot pomace and germinated chickpea flour in the formulation, the sensory scores for color, appearance, taste and flavor of biscuits decreased. However, the biscuits prepared by replacing refined wheat flour up to 5% carrot pomace and 5% germinated chickpea flour were more or less similar to control biscuits with respect to color, taste, flavor, texture and overall acceptability. Increasing the levels of incorporation of carrot pomace or germinated chickpea flour above 8% resulted in significantly decreased ($p < 0.05$) score for sensory quality characteristics. Replacement of refined wheat flour with up to 8% carrot pomace and germinated chickpea flour produced protein and fiber enriched biscuits with desirable overall acceptability.

Conclusion

The outcome of the present research can be used as valuable information for the development of high protein and fiber biscuits. The studies on wheat-chickpea-carrot pomace composite biscuits have indicated that incorporation of germinated chickpea flour and carrot pomace at 8 to 10% level of each could produce the value added biscuits of acceptable quality.

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