International Food Research Journal 19(4): 1539-1543 (2012)

Journal homepage: *http://www.ifrj.upm.edu.my*

Physicochemical and organoleptic properties of cookies incorporated with legume flour

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Article history

Received: 2 December 2011
Received in revised form: 25 April 2012
Accepted:25 April 2012

Keywords

Mung bean flour,
cookies,
chickpea,
legume,
resistant starch

Abstract

This study was to investigate the effects of wheat flour substitution with legume flour (mung bean and chick pea) in cookies in terms of the physicochemical and organoleptic properties. Three formulations of cookies were prepared from (a) Control (100% wheat flour), (b) Mung bean (50% wheat flour + 35% mung bean flour + 15% corn flour) and (c) Chickpea (50% wheat flour + 35% chickpea flour + 15% corn flour). The physicochemical and organoleptic attributes of the three types of cookie were evaluated. Results showed significant different ($p<0.05$) in terms of ash, protein, crude fibre and total carbohydrate among cookies. Chickpea cookies was significantly ($p<0.05$) highest in protein and resistant starch content among the three types of cookies. The mung bean cookies was significantly ($p<0.05$) highest in weight, diameter, height and spread ratio. Textural measurement showed chickpeas cookies was significantly highest ($p<0.05$) in hardness, crispiness, elasticity, gumminess, and chewiness than the other two types of samples evaluated. For sensory evaluation, chickpeas cookies showed significant high difference in flavor , crispiness and aftertaste attributes but insignificant ($p>0.05$) different between mungbean cookies in term of overall acceptability. Chickpea cookies had the best flavour , crispiness and acceptability .

Introduction

Snack food consumption has been on the increase as a result of urbanization and increase in the number of working women. Food based industry can exploit this development by fabricating nutritious snack foods. Cookies have become one of the most desirable snack for both youth and elderly people due to their low manufacturing lost, more convenience, long shelf-life and ability to serve as a vehicle for important nutrients (Akubor, 2003; Honda and Jood, 2005). It represents the largest category of snack item among baked food products throughout the world (Pratima and Yadava, 2000). Cookies are not considered as staple food as in bread, but may be feasible fibre carriers because of their long shelf life and thus enable large scale production and widespread distribution (Vratania and Zabik, 1978). In many countries, cookies are prepared with fortified or composite flour to increase its nutritive value (Gonzalez-Galan *et al*., 1991).

Legumes are high in nutrient especially in protein (18-24%) than cereal grain. Thus it can be used to provide amino acids such as lysine, tryptophan, or methionine (Potter, 1986). Unless certain raw or cooled cooked foods are considered, cooked beans and legumes are the only foods that contain substantial amounts of resistant starch (RS) (Marlett and Longacre, 1996). Resistant starch increases amount of indigestible substances in the colon and demonstrates the physiological benefits of dietary fibre. Annelisse *et al*. (2011) reported that incorporation of RS into a cereal matrix may increase the intake of dietary fibre and hence help against chronic disease such as cardiovascular disease and type 2 diabetes. The purpose of this study is to determine the physicochemical and sensory attributes of wheat flour substituted cookies with legume flours (mung bean and chick pea).

Materials and Methods

The wheat, corn flours and Crisco vegetable shortening were obtained from Sim Company Sdn. Bhd., Pulau Pinang, Malaysia. The mung bean (V*igna radiate*) and chickpea flours (*Cicer arietinum* L.) used were obtained from Alagappa Flour Mills Sdn. Bhd. and Nona Enterprise Sdn. Bhd., respectively.

Cookie formulation and preparation

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

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Table 1. Formulation of cookies

Ingredients	Control (%)	Mung bean cookies (%)	Chickpea cookies (%)
Wheat flour	42.5	21.2	21.2
Corn flour	0.0	6.5	6.5
Mung bean flour	0.0	14.8	0.0
Chickpea flour	0.0	0.0	14.8
Sugar	20.5	20.5	20.5
Shortening	20.5	20.5	20.5
Egg	15.0	15.0	15.0
Baking powder	1.0	1.0	1.0
Salt	0.4	0.4	0.4
Flavour	0.1	0.1	0.1

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. The egg was added 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 cookies were cooled on a wire racks at 27 ºC for 30 minutes before packing in an airtight plastic container prior to physical and chemical evaluation.

Chemical analysis

The moisture, ash, fat, crude protein (% N x 6.25) and crude fibre of the samples were determined by the AOAC method (2000). Moisture was determined based on AOAC Method 934.01: Air Oven Method (AOAC 2000). Crude protein was determined based on AOAC Method 960.52: Micro-Kjeldahl Method (AOAC, 2000). Fat was conducted based on 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 test was carried out based on AOAC Method 923.03: Dry Ashing Method (AOAC, 2000). Carbohydrate content was estimated by difference and caloric value was measured by calculation. The results were reported on wet weight basis. Resistant starch content was determined according to Goni *et al*. (1996).

Physical characteristics

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

Texture

Texture of cookies was measured using Texturometer XTZ version 5.15 (Stable Micro systems, USA) within 24 hours after baking, sharp cutting blade probe type HDP/BS blade set was used. The parameter used was indicated below:

Parameter	Value
Pre test speed	2.0 mm/s
Test speed	1.0 mm/s
Post test speed	5.0 mm/s
Compression distance	3.0 mm
Trigger type	auto

Sensory evaluation

A twelve member panel (4 males, 8 females) comprising of students from the Food Technology Department evaluated the samples using the 9 points hedonic scale method: 9 (excellent) to 1 (very poor). Evaluation of the cookies was conducted 24 hours after baking. Sensory testing was done on all 6 types of cookies. Each panelist was presented with 6 coded randomized samples . Each sample was coded with three random digit numbers and the positions of the samples were randomized. Panelists were seated in individual sensory booths. Each sample was replicated twice. The score were analysed by ANOVA.

Statistical analysis

Data were analyzed with SPSS version 11.0 (Illinois, USA) using one-way Analyses of variance (ANOVA). Significance differences were tested using the Duncan Multiple Range test. Three replications were used for chemical and physical analysis and two replications for sensory evaluation.

Results and Discussion

Flour composition

Proximate composition data of mung bean and chickpea flours was shown in Table 2. Mung bean flour was found to have high moisture, ash, carbohydrate and crude fibre content as compared to chickpea flour. Protein content was higher in the chickpea flour. Similar findings were reported by Navikul and D'Appolonia (1978).

Cookies composition

Table 3 showed that there is significant difference ($p<0.05$) between the cookies samples in terms of

Table 2. Proximate composition of mung bean and chickpea flours

	Mung bean flour (%)	Chickpea flour (%)
Moisture	11.50 ± 0.30[b]	9.53 ± 0.20[a]
Ash	3.70 ± 0.01[b]	2.53 ± 0.03[a]
Fat	0.80 ± 0.01[a]	1.24 ± 0.10[b]
Protein	16.10 ± 0.10[a]	19.90 ± 0.10[b]
Crude fibre	3.70 ± 0.04[b]	2.85 ± 0.02[a]
Carbohydrate[a]	67.90 ± 0.11[b]	66.80 ± 0.10[a]

[a]Obtained by difference
*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. Proximate composition of three types of cookies

	Control (%)	Mung bean Cookies (%)	Chickpea cookies (%)
Moisture	2.44 ± 0.30[a]	2.75 ± 0.20[a]	2.92 ± 0.20[a]
Ash	0.82 ± 0.01[a]	1.28 ± 0.05[c]	1.12 ± 0.01[b]
Fat	24.43 ± 0.09[a]	23.92 ± 0.10[a]	24.36 ± 0.08[a]
Protein	5.65 ± 0.10[a]	6.55 ± 0.20[b]	7.04 ± 0.10[c]
Crude fibre	1.95 ± 0.04[c]	1.69 ± 0.02[b]	1.56 ± 0.02[a]
Carbohydrate	66.66 ± 0.13[c]	65.50 ± 0.09[b]	64.56 ± 0.10[a]
Calorie (kcal/100g)	509.11[c]	503.48[a]	505.64[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. Physical characteristics of three types cookies

Type of cookies	Weight	Diameter	Height	Spread ratio
Control (%)	10.11 ± 0.22[c]	13.13 ± 0.45[b]	74.06 ± 0.19[b]	4.16 ± 0.15[a]
Mung bean (%)	8.68 ± 0.24[b]	11.25 ± 0.26[a]	75.41 ± 0.56[c]	4.06 ± 0.08[a]
Chickpea (%)	7.36 ± 0.13[a]	23.13 ± 0.24[c]	56.11 ± 0.22[a]	5.05 ± 0.10[b]

*Mean values in the same column which are not followed by the same letter are significantly different (p<0.05). Mean ± standard deviation (n=5)

protein, ash, crude fibre, carbohydrate and calorie content. Protein content was shown to be significantly highest (P<0.05) in chickpea cookies at 7.04%. Ash content was significantly highest (P<0.05) in mung bean cookies and this is related to the high mineral content. Mung bean cookies was significantly lower (P<0.05) in calorie content as compared to other samples. In terms of crude fibre, similar result was also reported by Souci *et al*. (1994).

Resistant starch (RS)

Result indicated that mung bean flour was significantly higher in resistant starch (9.95%) as compared to chickpea flour (5.47%) However the RS content showed no significant different between the mung bean(1.84%) and the chickpea (2.09%) cookies. However both legume based cookies differ significantly with the control cookies (1.03%). Azizah and Zainon (1997) stated that heat treatment (roasting) caused the decreased of IDF (insoluble dietary fibre) in cereals and legumes. RS is one of the IDF components.

Marlett and Longacre (1996) also reported that legumes contain high RS beside raw food and chilled-cook food. RS was produced from retrogradation of amylase in legumes. Mung bean and chickpea contain high percentage of amylase i.e 28.8% and 31.8% (Salunkhe and Khadam, 1989).

Physical analyses

The physical characteristics of the three types of cookies are shown in Table 4. Results of these studies indicated that there is significant difference (p<0.05) between each samples in terms of weight, diameter, height and spread ratio. Lowest weight was indicated in chickpea cookies at 7.36%. This result suggested that the chickpea cookies have high water holding capacity (WHC) as compared to mung bean and control cookies due to the high protein content. In non-wheat protein water holding capacity was higher than in wheat flour (Hoojjat and Zabik, 1984).

Mung bean cookies resulted from dough that goes through the apparent glass transition at a lower temperature as reported by Doescher *et al*. (1987) and Miller *et al*. (1996). They suggested that cookie set time is determined by an apparent glass transition of the gluten protein in the flour.

Protein content influences the viscosity of dough cookies. This is because the expansion of protein gluten is not resumed in the making of cookies. Inverse correlation was obtained between diameter and protein content (Leon, 1996). Protein gluten in flour will form a web in cookie dough when heated. 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 cookie dough (Miller and Honeney, 1997). But, chickpea cookies have the highest diameter even though the protein content is high. Barron and Esponiza (1993) reported that addition of 15% chickpea flour or more in the corn flour mixture will decrease it viscosity. This may cause the viscosity of chickpea dough reduce and increase the spread rate. Dough with lower viscosity cause cookies to spread at faster rate (Hoseney and Roger, 1994; Hoseney *et al*., 1988). In this formulation, 35% chickpea flour was added and allows it to reduce the viscosity of cookie dough furthermore increase the spread rate even though the protein content is high.

Significant difference occurs in the spread potential at difference soft flour variaties (Mehri, 2009). Cookie spread rate appears to be controlled by dough viscosity (Yamazaki, 1959, Hoseney *et al*., 1988, Hoseney and Rodger, 1994; Miller, 1997). When more water is present in the dough, more sugar is dissolved during mixing. This lowers the initial dough viscosity and the cookie is able to spread at a faster rate during heating. The flour components that absorb large quantities of water reduce the amount of water that is available to dissolve the sugar in the formula. Thus, initial viscosity is higher and the cookies spread less during baking (Hoseney and

Table 5. Results of texture of three types cookies

	Control	Mung bean	Chickpea
Hardness, N	41.50 ± 1.74[a]	53.00 ± 1.80[b]	61.87 ± 0.34[c]
Crispiness, N	9.38 ± 1.07[b]	4.47 ± 0.34[a]	27.48 ± 0.56[c]
Elasticity, mm	0.87 ± 0.05[a]	0.81 ± 0.04[a]	1.17 ± 0.13[b]
Gumminess, N	0.55 ± 0.07[b]	0.25 ± 0.03[a]	1.27 ± 0.26[c]
Cohesiveness	0.01 ± 0.01[a]	0.01 ± 0.01[a]	0.02 ± 0.01[a]
Chewiness, Nmm	0.48 ± 0.05[b]	0.19 ± 0.03[a]	1.50 ± 0.41[c]

*Mean values in the same row which is not followed by the same letter are significantly different (p<0.05). Mean ± standard deviation (n=5)

Table 6. Results of sensory evaluation of three types of cookies

	Control	Mung bean	Chickpea
Colour	6.46 ± 1.51[a]	7.09 ± 1.45[a]	6.64 ± 1.12[a]
Aroma	7.09 ± 1.38[c]	6.27 ± 1.56[a]	6.64 ± 1.86[b]
Flavour	6.00 ± 1.18[a]	6.91 ±1.38[b]	7.45 ± 1.21[c]
Crispiness	7.09 ± 0.83[a]	7.00 ± 1.26[a]	7.45 ± 0.69[b]
Aftertaste	5.09 ± 1.51[a]	6.45 ± 1.04[b]	6.91 ± 1.22[b]
Overall acceptability	6.64 ± 0.92[a]	7.00 ± 1.27[b]	7.36 ± 1.03[b]

*Mean values in the same row which are not followed by the same letter are significantly different (p<0.05). Mean ± standard deviation (n=12)

Rodger, 1994). The spread in mung bean cookies was the cookies. The chickpea cookies had the highest spread ratio because the flour has low hydration properties. Similar report was also report by Yamazaki (1962) and Rababah *et al*. (2006).

Texture

Texture result of the three types of cookies was shown in Table 5. Hardness differs significantly ($p<0.05$) among samples. The highest value in hardness was found in chickpea cookies at 61.87 N. This might have resulted from incorporation of protein rich flour which need more water to obtain good cookie dough, and the cookies prepared from high-absorption dough tend to be extremely hard (Hoojjat and Zabik, 1984). Similar finding by Lee and Beuchat (1991) reported that more strength was needed to break cookies incorporated with legumes flour.

Crispiness was observed to be the highest value in chickpea cookies with a value of 27.48 N. Del Rosario and Flores (1981) indicate that it might have resulted from the water binding effort in mung bean flour which increased with heating denaturation of protein content. Chickpea cookies had significantly highest ($p<0.05$) value in terms of elasticity, chewiness and gumminess.

Sensory evaluation

The sensory scores of the cookies was presented in Table 6. Cookies prepared from legumes were rated high in flavour, crispiness, aftertaste, colour and overall acceptability with significant difference ($p<0.05$) as compared to control. Although aftertaste was found to be pronounced in the mung bean and chickpea cookies but these cookies are significantly acceptable than the control. McWatters (1978) suggested that the beany flavour in legumes flour could be reduced by exposing the material to moist heat. The aftertaste could have resulted from the beany flavour from the legumes. In spite of 35% legumes flour substitution, the cookies were scored high by the panelists. This was contradicting with the result reported by Hoojjat and Zabik (1984), whereby the cookies were scored low with more than 10% sesame seed.

Conclusion

Incorporation of chickpea flour and mung bean flour into wheat flour did not change the functional properties but increases the protein, RS content and acceptability of cookies.

Acknowledgement

The authors wish to thank USM for funding this research under the incentive grant:1001/PTEKIND/821035

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