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Physicochemical and organoleptic properties of cookies incorporated with legume flours

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Abstract: In developing countries like India, with increasing urbanization, the demand for processed food and bakery products particularly cookies command wide popularity in both urban and rural mass. Hence, an attempt was made to develop functionally and nutritionally improved cookies and the influence of the partial replacement of the wheat flour by legume on the quality characteristic of cookies was analyzed. Six blends were prepared by homogenously mixing chickpea flour, pigeon pea, moong bean flour, and cowpea flour with wheat flour in the percentage proportions: 100, 25:75, 25:75, 25:75, 25:75, and 10:10:10:10:60 (CPF:WWF, PF:WWF, MF:WWF, CF:WWF, and CPF:PF:MF:CF:WWF) and later used to make cookies. Chemical and functional properties of the composite flours and chemical as well as sensory characteristics of cookies made from the above combinations were determined. The incorporation of legume flour significantly affected the physical, chemical, and phytonutrient parameters of the cookies. The results revealed that functional properties, viz. water absorption capacity, oil absorption capacity, and swelling property, increased with addition of legume flours. The physical analysis revealed that the diameter and height increased with the incorporation of legume flour. The results of the proximate composition showed that the A_6 possesses highest percentage of proteins (13.42%) and crude fat (22.90%), A_5 contains maximum value of crude fiber (2.10%) and DPPH radical scavenging activity (55.47%), A_1 showed maximum moisture (10.60%), A_2 total phenolic content (6.14 TAE mg/100 g), and A_3 showed maximum ash (3.66%). Statistical results revealed that the addition of selected pulse flours and a combination of these whole flours do not have a significant effect ($p > 0.05$) on the sensory characteristics of cookies.

Subjects: Bioscience; Environment & Agriculture; Food Science & Technology

Keywords: chickpea; phytonutrient parameters; cookies; legume flour

ABOUT THE AUTHOR

Beenu Tanwar is an assistant professor working at the Lovely Professional University, Phagwara, India. Her research area includes food product development and food quality evaluation. She has several publications related with health food product development, sensory studies, and compositional analysis of foods. The present study focuses on the development of healthy baked products with high nutrient composition utilizing low-cost legumes.

PUBLIC INTEREST STATEMENT

Bakery products have been becoming very popular in all age groups. Among the baked products, cookies are one of the most popular snacks and can be fortified with various nutrients. These can be used as a very easy vehicle for providing the proteins needed by the population. In this regard, legume is a very good source of proteins and abundant quantities of fiber and minerals such as calcium and iron. This study can help industries develop functional foods and gluten-free food products, which will help researchers to further research on the development of functional foods utilizing low-cost legumes.

1. Introduction

Undernutrition and malnutrition are major health problems around the world and the underlying cause is inadequate food intake in terms of both quality and quantity (Black, Morris, & Bryce, 2003; FAO, 2003; Shankar, 2000). Grain legumes play an important role in human nutrition, especially in the dietary pattern of low-income group in developing and underdeveloped countries. Hence, supplementation with legumes is an excellent vehicle for providing proteins, particularly in baked foods like biscuits, cookies, and cakes. which are widely consumed due to their long shelf life and good eating quality (Akubor, 2003; Hooda & Jood, 2005). Also, cereals and legumes are good source of proteins and they complement each other in terms of essential amino acids (Hassan, Mustafa, & Ahmed, 2013). Hence, it is expected that the composite flour produced from cereals and legumes will improve the overall nutrition of the flour.

Legumes are rich in proteins, carbohydrates, many water-soluble vitamins, especially vitamin B complex, and minerals like calcium and iron (Sreerama, Sashikala, Pratape, & Singh, 2012). Some of the locally available legumes which are a good source of proteins but underutilized are *Vigna unguiculata* (Cowpea), *Cicer ariethinum* (Chickpea), *Vigna radiate* (Moong bean), and *Cajanus cajan* (Pigeon pea).

V. unguiculata (Cowpea) is one of the important food legume crops in semi-arid tropics covering Asia, Africa, and South America and is a rich source of proteins, calories, minerals, and vitamins (Singh, Ajeigbe, Tarawali, Fernandez-Rivera, & Abubakar, 2003). *Cicer arietinum* (Chickpea), also known as bengal gram, is one of the earliest cultivated legumes of the family *Fabaceae* and is an excellent source of the essential nutrients, viz. proteins, iron, folate, phosphorous, and dietary fiber (Lev-Yadun, Gopher, & Abbo, 2000. *V. radiate* (Moong bean) is native to the Indian subcontinent and is mainly cultivated in India, Pakistan, China, Thailand, Burma, and Indonesia (Wilczek, 2012). It is a good source of proteins, carbohydrates, vitamins, magnesium, and phosphorous. *C. cajan* (Pigeon pea), a common food grain in Asia, Africa, and Latin America, is a perennial legume of the family *Fabaceae*. It is rich in proteins and amino acids like methionine, tryptophan, and lysine (Singh, Gupta, Jayaswal, & Mahato, 2012).

Keeping in mind the nutritional attributes of the aforementioned pulses, this study was specifically aimed to determine the nutritional value and functional properties of different flour blends and chemical as well as sensory characteristics of cookies made from these blends. The results of this study may provide opportunities to promote and support the use of pulse-incorporated cookies for achieving nutritional and therapeutic food security.

2. Materials and methods

In order to develop the cookies, the required materials were purchased from a local market: chickpea, moong bean, pigeon pea, cowpea, white butter, wheat flour, salt, ammonium bicarbonate, and sugar. The grains were graded, sorted, and cleaned. It was then soaked in water for 24 h. The soaked grains were washed and oven dried at 60°C for 24 h or until the moisture content reached 11.5%. The dried grains were ground in a grinding machine and sieved through a 1-mm sieve. It was then packed in airtight containers and stored at room temperature until used for further analysis (Morton, 1987).

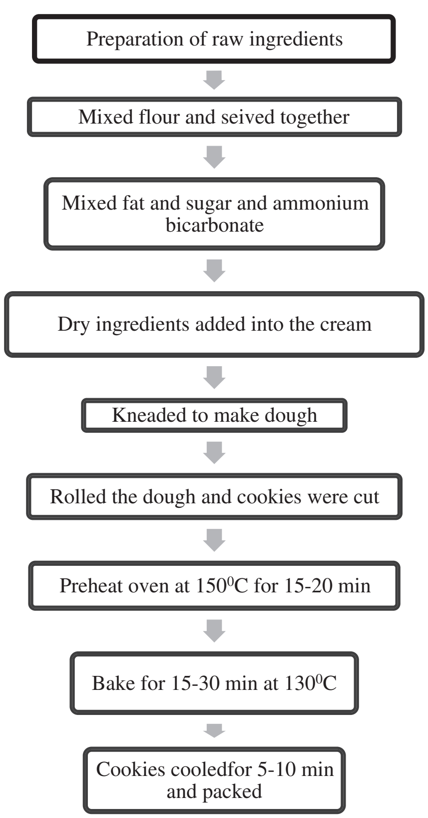
Flour-blend description: different combinations of wheat flour, chickpea flour, pigeon pea, moong bean flour, and cowpea flour for developing cookies. Ingredients used in the preparation of cookies are depicted in Table 1. Flowchart for cookies preparation and composite flour cookie (A6) is depicted in Figures 1 and 2, respectively.

Flour Blend	Wheat Flour(WF), %	Chickpea Flour (CPF), %	Pigeon pea Four (PF), %	Moong bean Four (MF), %	Cowpea Flour (CF), %
T_1	100	0	0	0	0
T_2	75	25	0	0	0
T_3	75	0	25	0	0
T_4	75	0	0	25	0
T_5	75	0	0	0	25
T_6	60	10	10	10	10

Table 1. Ingredients used in the preparation of cookies

S. No.	Ingredients	A_1	A_2	A_3	A_4	A_5	A_6
1	WWF	250	187.5	187.5	187.5	187.5	150
2	KF	0	62.5	0	0	0	25
3	PF	0	0	62.5	0	0	25
4	MF	0	0	0	62.5	0	25
5	CF	0	0	0	0	62.5	25
6	Sugar	125	125	125	125	125	125
7	White butter	125	125	125	125	125	125
8	Ammonium bicarbonate	3.5	3.5	3.5	3.5	3.5	3.5

Figure 1. Flowchart of cookies' preparation.



2.1. Physical characteristics

The cookies were selected randomly; weighed using analytical balance; and the height and diameter were measured with a caliper before and after baking. To measure the diameter of the cookies, four samples were placed next to one another and the total diameter was measured. Diameter was measured for all the prepared cookies. All of them were then rotated at 90° 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 other and restacking four times. The spread ratio was calculated using the formula: diameter of cookies divided by height of cookies. Weight of the cookies was determined by a digital top loading balance which consists of different units of weights like gm and mg. (Mohsenin, 1978). Cookie diameter and height were measured with a vernier caliper method (Mohsenin, 1970). Spread ratio was calculated as diameter/height (Hussain, Anjum, Butt, Khan, & Asghar, 2006).

2.2. Evaluation of functional properties

The oil and water absorption capacities were determined according to the method described by Eke and Akobundu (1993) and swelling power (SP) was determined according to the method described by Erlingen, Jcobs, Win, and Declour (1997).

2.3. Chemical analysis

Moisture, crude protein, ash, fiber, and fat were analyzed as described in AOAC (2000). Carbohydrates were computed by subtracting the moisture, crude protein, ash, fiber, and fat from 100. The results were reported on wet weight basis.

Antioxidant activity: 2,2-diphenyl-1 picryl hydrazyl (DPPH) radical scavenging capacity DPPH was determined according to the method of Brand-Williams, Bondet, and Berset (1997).

Total phenolic content (TPC): The total phenolics content (TPC) of the sample was determined according to Makkar, Becker, Abel, and Pawelzik (1997).

2.4. Sensory evaluation

Sensory evaluation of cookies was done using a nine-point hedonic test based on the color, flavor, taste, texture, and overall acceptability from 15 untrained panelists (Hussain et al., 2006).

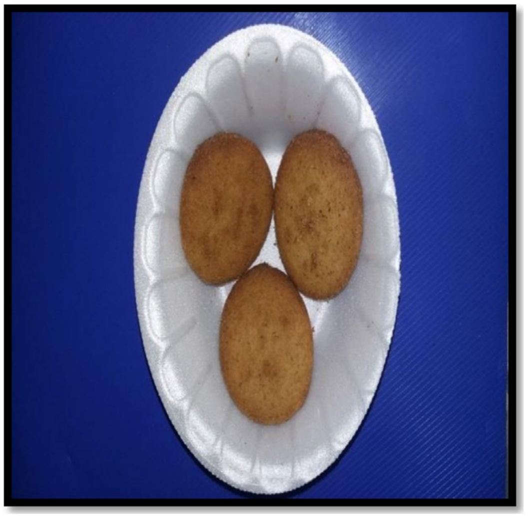
Table 2. Proximate and functional properties of legume flour blends

Parameters (%)	T_1	T_2	T_3	T_4	T_5	T_6
Moisture	10.66 ± 0.61^{a}	7.86 ± 0.70^{b}	11.53 ± 0.80^{a}	10 ± 0.20^{ac}	8.66 ± 0.64^{bc}	10.46 ± 0.83^{ac}
Ash	3.36 ± 0.51^{a}	3 ± 0.50^{a}	3.5 ± 0.86^{a}	3.16 ± 0.57^{a}	1.66 ± 1.25^{a}	3 ± 1.30^{a}
Protein	11.63 ± 0.27^{a}	12.33 ± 0.67^{b}	13.31 ± 0.27^{b}	13.95 ± 0.28^{bc}	14.28 ± 0.27^{bc}	17.82 ± 0.15^{d}
Fat	1.65 ± 0.21^{a}	2.70 ± 0.28^{b}	3.45 ± 0.07^{b}	3.2 ± 0.28^{b}	4 ± 0.28^{bc}	3.37 ± 0.17^{b}
Crude fiber	2.05 ± 0.28^{a}	2.4 ± 0.28^{a}	1.65 ± 0.21^{a}	2.45 ± 0.49^{a}	2.9 ± 0.14^{a}	2.10 ± 0.42^{a}
Carbohydrate	81.11 ± 0.41^{a}	79.62 ± 0.52^{ab}	78.25 ± 0.85^{bc}	77.24 ± 0.48^{c}	77.18 ± 1.20^{c}	73.88 ± 1.25^{d}
Water absorption capacity	185 ± 6.02^{a}	222.33 ± 3.21^{b}	206 ± 11.53^{ab}	250 ± 12.16^{ce}	275.66 ± 6.42^{de}	271 ± 6.08^{e}
Oil absorption capacity	158 ± 6.33^{a}	167.33 ± 6.42^{a}	164 ± 7.54^{a}	162.66 ± 8.32^{a}	170.66 ± 6.65^{a}	171 ± 2.64^{a}
Swelling power	4.7 ± 0.05^{a}	7.53 ± 0.05^{b}	6.66 ± 0.50^{b}	6.6 ± 0.10^{b}	7.6 ± 0.55^{b}	7.2 ± 0.85^{b}

Notes: Values are mean ± SD from triplicate determinations; different superscripts in the same row are significantly different ($p < 0.05$).

T_1 = wheat flour, T_2 = 25% chickpea flour and 75% wheat flour, T_3 = 25% pigeon pea flour and 75% wheat flour, T_4 = 25% moong bean flour and 75% wheat flour, T_5 = 25% cowpea flour and 75% wheat flour, and T_6 = 10% chickpea, 10% pigeon pea, 10% moong bean, and 10% cowpea flour.

Figure 2. Composite flour cookie (A_6: 10% chickpea, 10% pigeon pea, 10% moong bean, 10% cowpea, and 60% wheat flour).



2.5. Statistical analysis

All experiments were performed in triplicates. The results were analyzed using Minitab version 13 software for one-way analysis of variance (ANOVA) with Tukey's test to determine the significant difference between the mean at the 5% level. Differences were measured statistically significant at $p < 0.05$.

3. Results and discussion

3.1. Flour-blend composition

Table 2 shows the results of proximate and functional properties of legume flour blends.

The moisture content of the legume flour blends ranged from 7.86 to 11.53%. The results of the moisture content showed that there was a significant difference ($p < 0.05$) between various flour blends and wheat flour. Cauvain (1998) reported that proteins absorb their own weight in water which means that the high-protein flour will absorb more water than the low-protein flour.

The ash content of the flours ranged from 1.66 to 3.5%. The results of the ash content showed that there was no significant difference ($p > 0.05$) between flour blends and wheat flour which implies that there was not much of a difference in the ash content after the addition of legume flour except in T_3. The low content of ash may be due to milling and soaking which results in leaching of minerals as reported by Chilungo (2013).

The protein content ranged from 11.63 to 17.82%. In this study, it was observed that the protein content was high in the legume flour blends as compared to the wheat flour. The results show that there was a significant difference ($p < 0.05$) between legume flour blends. Supplementation with various legume flours would greatly improve the protein quality of the various flour blends. This could be due to the significant quantity of proteins in various legume flours.

The fat content of the composite flour ranged from 1.65 to 4%. Fat is an important factor which helps in improving the texture as well as rheology and overall quality of the product. The results of the fat content show that there was a significant difference ($p < 0.05$) between the flour blends and wheat flour. The decrease in the fat content of the composite flour as compared to the control may be due to the reason that only 75% of wheat is used in making the composite flours.

Figure 3. Total phenolic content (TAE mg/100 g) of legume flour blends.

Notes: Values are mean ± SD from triplicate determinations; different superscripts in the same row are significantly different ($p < 0.05$), where T_1 = wheat flour, T_2 = 25% chickpea flour and 75% wheat flour, T_3 = 25% pigeon pea flour and 75% wheat flour, T_4 = 25% moong bean flour and 75% wheat flour, T_5 = 25% cowpea flour and 75% wheat flour, and T_6 = 10% chickpea, 10% pigeon pea, 10% moong bean, and 10% cowpea flour.

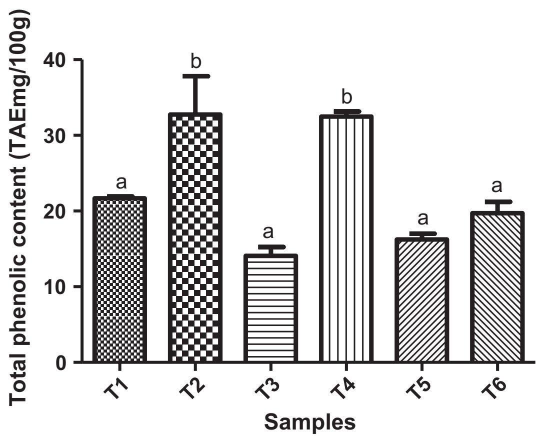
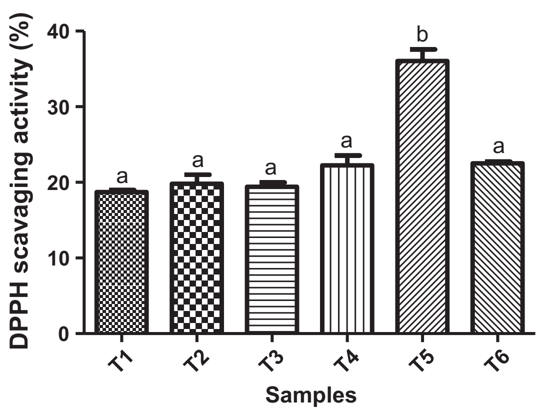


Figure 4. Antioxidant activity of flour blends.

Notes: Values are mean ± SD from triplicate determinations; different superscripts in the same row are significantly different ($p < 0.05$), where T_1 = wheat flour, T_2 = 25% chickpea flour and 75% wheat flour, T_3 = 25% pigeon pea flour and 75% wheat flour, T_4 = 25% moong bean flour and 75% wheat flour, T_5 = 25% cowpea flour and 75% wheat flour, and T_6 = 10% chickpea, 10% pigeon pea, 10% moong bean, and 10% cowpea flour.



The crude fiber of the flours ranged from 1.65 to 2.05% and showed that there was no significant difference ($p > 0.05$). Similar results have been reported by Okpala, Okoli, and Udensi (2012) in which they observed that the crude fiber content in germinated pigeon flour was 1.65% which can be attributed to the use of de-hulled pigeon pea.

The carbohydrate content of the flours ranged from 73.88 to 81.11% (Table 2). The present results show that there was a significant difference ($p < 0.05$) between the carbohydrate content of the different legume flour blends.

The water absorption capacity (WAC) of the flours ranged from 185 to 275.66%. WAC is the capacity of a substance to combine with water under restricted conditions (Singh, 2001). In this study, the results of the WAC showed that there was a significant difference ($p < 0.05$) between flour blends. Echendu, Onimawo, and Somtochi (2004) reported that WAC is generally affected by carbohydrate content. The flour blends which have been prepared from legume flour have different WACs which may be due to the difference in protein content, their degree of interaction with water, and their conformational characteristics.

The oil absorption capacity (OAC) of the flours ranged from 158 to 171%. The high OAC indicates the lipophilic character of the components of the flour (Ubbor & Akobundu, 2009) and so it also helps in increasing the palatability and longer shelf life of the product, especially bakery products like cookies, pan cakes, and cakes. (Seena & Sridhar, 2005). The results of the OAC showed that there was no significant difference ($p > 0.05$) between the flour blends. The high OAC is due to the presence of large quantity of hydrophobic groups in comparison with the hydrophilic groups on the surface of the protein molecules.

The SP of the flours ranged from 4.7 to 7.6%. SP helps determine the type of bonds within starch granules of flour and flour blends. Heating of the flour in the presence of water at 70 or 80°C develops different SP values. The results of the SP showed that there was a significant difference ($p < 0.05$) between wheat and various flour blends. Nwokocha, Williams, Aviara, and Senan (2008) observed that the difference in SP value is due to the difference in the bonding forces within the granules of the flour. According to Balagopalan, Padmaja, Nanda, and Moorthy (2010), the bonds within the granules loosen up due to increased temperature, making the granules assimilate water and swell up.

Figure 3 depicts the total phenolic content (TAEmg/100 g) of legume flour blends. The total phenol content of the flours ranged from 14.09 to 33.04 mg/100 g and results showed that there was a significant difference ($p < 0.05$) between flour blends and wheat flour. The variations in the total phenol content may be due to maturity level at harvest, postharvest storage, climate, genotype, and geographical locations (Zielinski, 2002).

As evident from Figure 4, the antioxidant content ranged from 18.73 to 36.05% and there was a significant difference ($p < 0.05$) between legume flour blends and wheat flour. The free radical scavenging activity was reported to increase with the addition of legume flour as the legume flours contained good amounts of antioxidants.

3.2. Cookie analysis

3.2.1. Physical analysis

Six formulations of cookies were prepared with the incorporation of legume flours, respectively, and their physicochemical properties and sensory characteristics are reported in Table 3.

As evident from Table 3, the weight of the cookies developed from legume flours ranged from 7.33 to 9.90 g and results showed that there was a significant difference ($p < 0.05$) between legume flour blends and wheat cookies. A_2 had minimum weight with 7.33 which can be due to high water holding capacity (WHC) as compared to other cookies as they have high protein content (Aziah, Noor, & Ho, 2012), whereas A_6 had maximum weight with 9.90 g. Hoojjat and Zabik (1984) reported that in non-wheat proteins, WHC was higher than in wheat flour which can lead to low weight of the cookies. So, in this study, it depicts that the cookies have different weights due to different water holding capacities.

The height of the cookies ranged from 0.57 to 0.94 cm. The results of the height showed that there was a significant difference ($p < 0.05$) between wheat and flour-blend cookies. In this study, it was observed that A_3 had maximum height and least spread ratio. Similar results have been reported by Okpala et al. (2012).

The diameter of the cookies ranged from 5 to 5.53 cm as shown in Table 2. Diameter is the measurement of a circle passing through the center and touching the two edges. According to Leon, Rubiolo, and Anon (1996), protein content and diameter have an inverse correlation. When heated, protein gluten present in the flour undergoes glass transition, thus gaining mobility that allows it to interrelate and form a web thereby increasing viscosity and stops the flow of cookie dough. The results of the diameter showed that there was a significant difference ($p < 0.05$) between wheat and legume flour-blend cookies. The maximum diameter was observed in A_5 (5.53 cm) and minimum in A_2 (5 cm).

Table 3. Physicochemical and sensory characteristics of formulated cookies

Parameters	A_1	A_2	A_3	A_4	A_5	A_6
Weight (g)	9.89 ± 0.17^a	7.79 ± 0.25^b	9.04 ± 0.04^c	9.11 ± 0.21^c	7.33 ± 0.31^b	9.90 ± 0.57^a
Height (cm)	0.57 ± 0.03^a	0.68 ± 0.03^b	0.94 ± 0.05^c	0.68 ± 0.04^{bd}	0.59 ± 0.02^{ba}	0.72 ± 0.03^{be}
Diameter (cm)	5.05 ± 0.07^a	5.00 ± 0.17^a	5.11 ± 0.11^a	5.11 ± 0.01^a	5.53 ± 0.07^b	5.15 ± 0.03^a
Spread ratio	9.48 ± 0.21^a	8.2 ± 0.63^a	7.6 ± 0.96^a	7.6 ± 0.51^a	7.6 ± 0.47^a	7.8 ± 0.42^a
Color	7.2 ± 1.22^a	7.29 ± 0.19^b	5.44 ± 0.28^a	7.54 ± 0.45^{bd}	9.27 ± 0.42^a	7.15 ± 0.39^{be}
Flavor	7.9 ± 0.87^a	8.0 ± 0.66^{ab}	7.7 ± 0.79^a	7.4 ± 0.84^a	6.8 ± 1.31^{ac}	7.5 ± 0.52^a
Taste	8.1 ± 0.73^a	7.9 ± 0.73^{ab}	7.8 ± 0.63^{ab}	7.5 ± 0.97^{ab}	6.0 ± 1.39^b	7.6 ± 0.84^{ab}
Texture	7.7 ± 1.00^a	8.1 ± 0.73^a	7.6 ± 0.69^a	7.8 ± 0.78^a	7.1 ± 1.10^a	7.9 ± 0.87^a
O.A.	7.7 ± 0.77^a	7.9 ± 0.37^{ab}	7.6 ± 0.52^a	7.5 ± 0.61^a	7.1 ± 0.80^{ac}	7.6 ± 0.47^a
I.A. (%)	85.77	89.11	85.11	84	76.88	85.33

Notes: Values are mean ± SD from triplicate determinations; different superscripts in the same row are significantly different ($p < 0.05$).

A_1 = wheat flour, A_2 = 25% chickpea flour and 75% wheat flour, A_3 = 25% pigeon pea flour and 75% wheat flour, A_4 = 25% moong bean flour and 75% wheat flour, A_5 = 25% cowpea flour and 75% wheat flour, and A_6 = 10% chickpea, 10% pigeon pea, 10% moong bean, and 10% cowpea flour.

O.A. = overall acceptability; I.A. = index of acceptability.

Spread ratio ranged from 7.60 to 9.48. It is restricted by dough viscosity as dough with lower viscosity causes cookies to spread faster (Miller, Hoseney, & Morris, 1997; Yamazaki, 1959). The results showed that there was a significant difference ($p < 0.05$) between wheat and the flour blends. According to Yahya (2004), low spread ratio suggests that the starches in these cookies are very hydrophilic. Chinma and Gernah (2007) observed a close tendency in cookies produced from cassava/soyabean/mango composite flours and this was due to the hydrophilic nature of the flour used in the products which led to decrease in spread ratio and increased the thickness.

3.2.2. Sensory evaluation

A nine-point hedonic scale was used to evaluate the acceptability of the consumers in the sensory attributes of color, flavor, taste, texture, and overall acceptability. The results are reported in Table 3. Results of color and overall acceptability showed that there was no significant difference ($p > 0.05$) between cookies made from flour blends and wheat flour. The addition of legume flour increased the mean score of color from 7.2 to 8.2. According to Abou-Zaid, Ramadan, & Al-Asklany, 2011; color attribute is a major criterion that affects the quality of the food products. The color of the surface of the cookies was generated due to non-enzymatic browning (Maillard) during baking between reducing sugars and amino acids but also due to starch dextrination and sugar caramelization (Gomez, Oliete, Rosell, Pando, & Fernande, 2008; Zucco, Borsuk, & Arntfield, 2011).

A_2 was ranked the most acceptable with an overall acceptability of 7.9, whereas A_5 with a minimum score of 7.1. The results of the flavor, taste, and texture of the cookies made with flour blends and wheat flour showed that there was a significant difference ($p < 0.05$) between cookies made from flour blends and wheat flour. McWatters and Holmes (1978) reported that the exposure of the material to moist heat reduces the beany flavor of legumes incorporated in cookies and the same was observed even in the present study.

The data for the score of taste of the cookies ranged from 6.0 to 8.1 with A_1 being the tastiest (8.1) and A_5 the least, among all the different-blend cookies (6.0). The reason as described by the panelists was that the cookies made from blended cowpea were having a bitter after taste. The maximum score for texture was observed in A_2 (8.1) and minimum in A_5 (7.1).

3.3. Chemical composition

The chemical analysis including moisture, ash, protein, fat, crude fiber, and carbohydrate content was carried out on the cookies prepared from the aforementioned various legume flour blends (Table 4).

The results showed that the moisture content of the cookies made from flour blends ranged from 6.2 to 10.6%. The results of the moisture content showed that there was a significant difference ($p < 0.05$) between cookies made from legume flour blends and wheat flour. High moisture content can signify short shelf life of the cookies where microbial spoilage can occur due to the presence of moisture.

The ash content of the cookies made from flour blends ranged from 1.16 to 3.66%. The results of ash content showed that there was a significant difference between cookies made from flour blends and wheat flour. The ash content is the amount of inorganic minerals present in a particular food or sample.

The protein content of the cookies made from flour blends ranged from 7.98 to 13.42%. The results showed that there was a significant difference ($p < 0.05$) between cookies made from flour blends and wheat flour. Similar results have been obtained by Okpala et al. (2012).

The fat content of the cookies made from flour blends ranged from 16.75 to 22.90%. The results showed that there was a significant difference ($p < 0.05$) between cookies made from flour blends and wheat flour. In this study, it was observed that the fat content increased after the addition of legume flour which had a good amount of fat as compared to wheat flour. And it is also because of the butter was used during the preparation of the cookies.

The crude fiber content of the cookies made from flour blends ranged from 1.25 to 2.1%. The results showed that there was a significant difference ($p < 0.05$) between cookies made from flour blends and wheat flour. The crude fiber content was highest in A_4 (2%) and lowest in A_3 and A_6 with 1.25% each. There was an increase in fiber content as compared to control except in A_3 and A_6 which may be due to soaking and de-hulling of the seeds which led to the removal of fiber.

The carbohydrate content of the cookies made from flour blends ranged from 61.01 to 70.08%. Carbohydrates are macromolecules which include the groups sugar, starch, and cellulose which provide us with energy. The results of the carbohydrate content showed that there was a significant difference ($p < 0.05$) between cookies made from flour blends and wheat flour.

The data pertaining to the total phenol content of the formulated cookies are presented in Figure 5. As shown in the figure, the total phenol content ranged from 6.14 to 13.65 mg/100 g. There was a significant difference ($p < 0.05$) between cookies made from various flour blends. According to

Table 4. Proximate composition of formulated cookies

Parameters (%)	A_1	A_2	A_3	A_4	A_5	A_6
Moisture	10.60 ± 0.61^{a}	8.00 ± 0.72^{a}	7.66 ± 0.61^{a}	6.80 ± 0.4^{a}	6.69 ± 1.76^{ab}	6.10 ± 0.84^{bc}
Ash	3.36 ± 0.51^{a}	2.66 ± 1.60^{a}	3.66 ± 0.76^{a}	1.16 ± 0.28^{a}	1.33 ± 0.76^{a}	1.16 ± 0.57^{a}
Protein	7.94 ± 0.12^{a}	9.48 ± 0.41^{a}	10.27 ± 0.21^{a}	10.84 ± 0.12^{a}	11.32 ± 0.23^{a}	13.42 ± 0.30^{a}
Fat	18.12 ± 0.17^{a}	20.25 ± 0.35^{ab}	20.75 ± 0.35^{ab}	16.75 ± 0.35^{ab}	18.50 ± 2.8^{ab}	$22.90.14^{ac}$
Crude fiber	1.40 ± 0.28^{a}	1.90 ± 0.14^{a}	1.25 ± 0.35^{a}	2.00 ± 0.70^{a}	2.10 ± 0.14^{a}	1.25 ± 0.35^{a}
Carbohydrate	70.08 ± 0.72^{a}	65.67 ± 1.65^{b}	63.48 ± 1.26^{b}	68.82 ± 0.69^{ab}	66.94 ± 1.76^{ab}	61.01 ± 0.84^{bc}

Notes: Values are mean ± SD from triplicate determinations; different superscripts in the same row are significantly different ($p < 0.05$).

A_1 = wheat flour, A_2 = 25% chickpea flour and 75% wheat flour, A_3 = 25% pigeon pea flour and 75% wheat flour, A_4 = 25% moong bean flour and 75% wheat flour, A_5 = 25% cowpea flour and 75% wheat flour, and A_6 = 10% chickpea, 10% pigeon pea, 10% moong bean, and 10% cowpea flour.

Figure 5. Total phenolic content (TAE mg/100 g) of cookies.

Notes: Values are mean ± SD from triplicate determinations; different superscripts in the same row are significantly different ($p < 0.05$), where A_1 = wheat flour, A_2 = 25% chickpea flour and 75% wheat flour, A_3 = 25% pigeon pea flour and 75% wheat flour, A_4 = 25% moong bean flour and 75% wheat flour, A_5 = 25% cowpea flour and 75% wheat flour, and A_6 = 10% chickpea, 10% pigeon pea, 10% moong bean, and 10% cowpea flour.

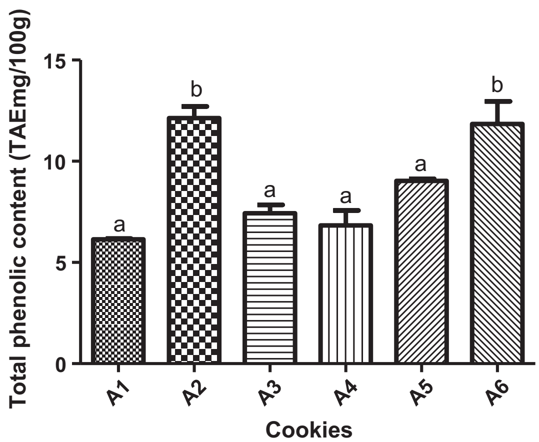
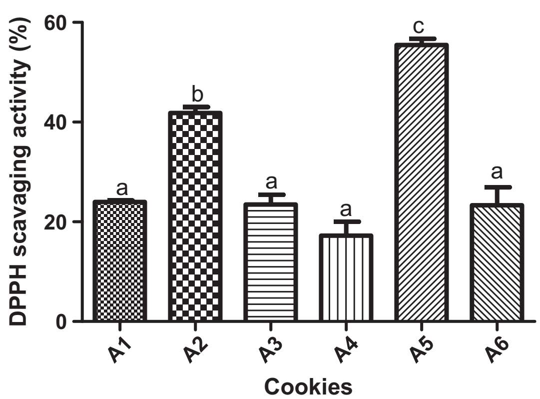


Figure 6. Antioxidant activity of formulated cookies.

Notes: Different superscripts in the same row are significantly different ($p < 0.05$), where A_1 = wheat flour, A_2 = 25% chickpea flour and 75% wheat flour, A_3 = 25% pigeon pea flour and 75% wheat flour, A_4 = 25% moong bean flour and 75% wheat flour, A_5 = 25% cowpea flour and 75% wheat flour, and A_6 = 10% chickpea, 10% pigeon pea, 10% moong bean, and 10% cowpea flour.



Hesham, Hussein, and Mostafa (2007) the anti-radical properties may be due to the hydrogen-donating capacity of the phenolic compounds.

As evident from Figure 6, the free radical scavenging antioxidant activity ranged from 18.73 to 36.05%. The results showed that there was a significant difference ($p < 0.05$) between cookies made from flour blends and wheat flour. It implies that the free radical scavenging activity increases with the addition of legume flour in the wheat flour and the legume flour contains a good amount of antioxidants. The antioxidant activity of cookies was much higher than the flour-blend counterparts which can be attributed to the fact that Maillard reaction products formed during baking of cookies also exhibit antioxidant activity (Açar, Gökmen, Pellegrini, & Fogliano, 2009; Chang, Chen, & Tan, 2011; Chawla, Chander, & Sharma, 2009; Rao, Chawla, Chander, & Sharma, 2011).

4. Conclusion

Bakery products have been becoming very popular in all age groups. Among the baked products, cookies are one of the most popular snacks and can be fortified with various nutrients. These can be used as a very easy vehicle for providing the proteins needed by the population. In this regard, legume is a very good source of proteins and can be used to develop cookies. The present study shows that it is possible to use legume flour to partially substitute for wheat flour in the production of cookies with acceptable physical characteristics. Composite flour cookie, A_6 (10% chickpea flour, 10%

pigeon pea flour, 10% moong bean flour, 10% cowpea flour, and 60% wheat flour), had maximum proteins (13.42%), fats (22.90%) and total energy (503.83 kcal), appreciable free radical scavenging activity, and total phenol content (23.32% and 11.84 mg/TAE/100 gm, respectively) along with acceptability of 7.6 adjudged as the best among the various formulated cookies. Despite the significant differences detected between control and pulse flours, our studies show that it is possible to use pulse flour to totally or partially substitute for wheat flour in the production of cookies with acceptable physical characteristics. Further studies could investigate the consumers' acceptability of the legume flour cookies.

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