Harina de maní parcialmente deslipidizada: un ingrediente funcional para mejorar el valor nutritivo de productos de panificación

Partially defatted peanut flour: a functional ingredient to improve nutritional value of bakery products

ABSTRACT

Peanut seeds were used to obtain partially defatted peanut flour (PF) by means of a cross-flow solvent extraction process (n-hexane), using a continuous lixiviation apparatus. The chemical composition of PF showed high protein (410 g kg-1) and crude fiber (160 g kg-1) contents; total lipids (115 g kg-1) and minerals (47 g kg-1) were in minor amounts. Physico-chemical properties of PF showed minimum solubility at pH 4 - 5 and maximum at pH 8. Water and oil holding capacities were 2.7 and 2.3 g ml-1, respectively, and presented emulsifying properties suitable for the formulation of bakery products. Breads prepared by replacement of 10 or 20 % wheat flour by PF showed significant increases of both protein and fiber contents, and improved fatty acid profile, with respect to breads made with wheat flour only. Cookies made with PF had three times more protein content and nine times more fiber content than wheat flour-based cookies. The sensory scores of PF-based products were similar to those made with wheat flour. Partially defatted peanut flour provides a rich source of gluten-free protein, fiber and essential minerals. It may be used to enhance the nutritional quality of wheat flour-based bakery products.

Key words: Peanut flour; chemical and functional properties; breads; cookies; protein content; fiber content.

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INTRODUCTION

Peanut ranks as the second-most important grain legume cultivated and the fourth largest edible oilseed crop in the world. Peanut cultivation contributes a sustainable portion of the economy in many countries and plays an important role in global trade.

Peanut is a very nutritious food product mainly due to both high lipid (50-55 g 100 g^{-1}) and protein (25-30 g 100 g^{-1}) contents. In addition, peanuts contain a vast array of compounds having important biological properties. These include primarily fiber (8.5 g 100 g^{-1}), tocopherols (vitamin E, 8.33 mg 100 g^{-1}), essential amino acids and fatty acids, which have been associated with the prevention of type 2 diabetes (3-5), weight status (6), heart related diseases (7-9), age-associated diseases (10) and cancer (11-14).

Peanuts are highly appreciated as snack (fried, roasted or salted-roasted); otherwise they are consumed as components of several edible products. They are also used as raw material for commercial production of edible oil. The defatted pressed cake is an inexpensive and sometimes undervalued by-product that can be further used to obtain peanut flour (15). Choi et al. (16) have evaluated the use of peanut flour as an ingredient in pasta formulation, snack foods and beverages, and have identified optimal usage levels for flavour, texture, and functional characteristics. Other reports (17, 18) have shown that fortification of breads and biscuits with peanut flour resulted in products with increased protein content and high sensorial acceptability.

In many countries where the major staple diet is wheat, and malnutrition and gluten intolerance are widespread public problems, increased research efforts are needed to identify or create ingredients to formulate high quality, health-promoting

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and nutritious baked products. Peanut flour could improve the nutritional quality and the functionality of wheat flour based products. Breads and cookies are valuable vehicles for nutritional improvement to target areas, such as child-feeding programmes. Bakery products containing peanut flour are scarce or are not available in most of the world´s countries. Scientific information about chemical composition and functional properties of peanut flour is needed to optimize its potential application in bakery products.

The objectives of the current study were a) to obtain partially defatted peanut flour; b) to evaluate some of the most important chemical, nutritional and functional properties; and c) to assess peanut flour incorporation on nutritive value and sensorial acceptability of breads and cookies.

MATERIALS AND METHODS

Raw material and peanut flour obtention

De-hulled seeds from Runner market type peanut were used to prepare partially defatted peanut flour (PF). Seeds were ground using a home-made stainless steel roller crusher and particles between 2.4 and 4.8 mm (mesh 8-4, Tyler standard screen scale) were selected using an automated screen. The oil was partially removed with n-hexane by cross flow extraction at room temperature using a continuous lixiviation apparatus acording to a procedure described previously (19). The resulting meal was desolventized under reduced pressure at 30 °C. Peanut flour was obtained by grinding the peanut meal to very fine particles, so that 90 % of the product passed through 100-mesh screen.

Proximate composition of peanut flour

Total protein content of PF was evaluated using a Kjeldahl nitrogen analyzer and it was calculated as % N x 5.46 (20). Fat, moisture, ash and fiber contents were determined using standard AOAC methods (20). All chemical analyses were run in triplicate and results were expressed on dry matter basis (DB).

Functional properties of peanut flour

Protein solubility. Protein solubility was determined as described previously (21). Triplicate determinations were carried out and solubility profile was obtained by plotting average of protein solubility (%) against pH. The soluble protein content was determined according to the Lowry method (22).

Water holding capacity (WHC). The WHC determination was carried out according to Bernardino-Nicanor et al. (23). Briefly, PF was dispersed in distilled water (1 % w/v) by magnetic stirring, and vortex agitation every 10 minutes, for 1 h at room temperature. The final pH reached for the sample was 7.2. The sample was finally centrifuged at 5000 g for 30 min, and the WHC was expressed as milliliters of water retained per gram of flour.

Fat absorption capacity (FAC). FAC was determined as described previously (21), with slight modifications. A sample (0.1 g) of PF was weighed into a pre-weighed 1.5 ml eppendorf tube. One ml of sunflower oil (density = 0.9241 g ml^{-1}) was added, vortex mixed for 1 min and then allowed to stand for 30 min at ambient temperature. The mixture was centrifuged (3000 g, 20 min), the supernatant removed and the weight of the tube was recorded. Fat absorption capacity (milliliters of oil per gram of sample) was calculated as follow:

$$FAC = (W2-W1) / (Wo\ D)$$

Where W2 is the weight of the tube plus the sediment (g), W1 is the weight of the tube plus the dry sample (g), W0 is the weight of the dry sample (g) and D is the density of the oil.

Emulsion properties. Emulsifying activity (EA) and emulsion stability (ES) were investigated by the methods described by Pearce and Kinsella (24) with some modifications. For the emulsion formation, a volume of 50 ml of a 0.5 g/dl aqueous protein solution was blended with 50 ml vegetable oil for 45 s with Brown mixer at maximum speed. An aliquot of 200 ul of the emulsion was taken and diluted to 10 ml with 0.1 g/dl sodium dodecyl sulfate. The absorbance of the resulting sample was read at 500 nm using a UV/VIS Spectrophotometer (Perkin Elmer Lambda 25). The absorbance at time zero was taken as EA, and the time required for the EA to decrease by half as ES (25).

Preparation of peanut flour products

Preparation of breads. Three types of breads were prepared and coded WB (100 % wheat flour), PFB1 (replacement 10 % wheat flour by PF), and PFB2 (replacement 20 % wheat flour by PF). Other basic ingredients were shortening, brewer´s yeast, salt and water. The percentage amounts of each ingredient were as follow: 63.4 % flour, 0.65 % shortening, 0.65 % brewer´s yeast, 1.0 % salt, and 34.3 % water. Flours were mixed with water and salt using a wire whip during 5 min. Shortening and brewer´s yeast were added and all the blend mixed for 35 min. After 3 hours fermentation, the dough was cut in cylinders of 10 cm diameter, and baked in gas-fire oven (190 °C, 1 hour).

Preparation of cookies. The basic ingredients used for peanut flour cookies (PFC) and wheat flour cookies (WFC) were: 10.5 % flour, 15.7 % shortening, 2.2 % water, 42.0 % corn fecula, 11.8 % egg yolk, 15.7 % sugar and 2.1 % baking powder. Shortening, egg yolk and sugar were mixed thoroughly with whip for 5 min. Fecula, flour (peanut or wheat) and baking powder were added and mixed 5 min. Water was added and rubbed in until uniform. The dough was rolled to 5 mm thickness, cut to 60 mm diameter and baked in gas-fired oven (180 °C, 12 min).

Chemical composition of peanut flour products

Total solids content of breads and cookies was calculated by drying 50 g samples at 50 °C for 3 days. The nitrogen, oil, ash and crude fiber contents were determined from dehydrated material using standard methods (20). Protein content was calculated as % N x 5.46 or 5.7, for peanut or wheat products, respectively.

Oils from PF, breads and cookies were extracted separately with n-hexane in a Soxhlet apparatus during 12 hours. The extracted lipids were dried over anhydrous sodium sulphate and the solvent was removed by vacuum distillation at 40 ºC. The fatty acid methyl esters of oils were prepared and analysed by gas chromatography (26).

Mineral analysis was carried out by digestion of dry samples (2 g) with a mixture of 25 ml of 19 g/dl HCl and 5 ml of concentrated HNO_3. The mineral constituents were determined by atomic absorption spectrophotometry (27).

Sensory evaluation

Breads and cookies were subjected to sensory evaluation using fourteen panelists drawn within the University community. Breads products were evaluated for crust and crumb color, aroma, taste, crust and crumb texture and overall acceptability. Cookies were evaluated for color, aroma, taste, texture and overall acceptability. The ratings were carried on a 9-point hedonic scale form 9 (like extremely) to 1 (dislike extremely).

Statistical analysis

All data were obtained by means of independent triplicate measurements. When appropiate, data were statistically evaluated by ANOVA test. The comparison of means was done by the least significat difference (LSD) at a significance level of 0.05.

RESULTS AND DISCUSSION

Proximate composition

The chemical composition of PF is presented in table 1. The most outstanding features were the higher protein and crude fiber contents (410 and 160 g kg-1, respectively), in comparison with those from industrial wheat flour (100 and <5 g kg-1), and data on wheat flour reported by other authors (28, 29). The PF contained 115 g oil kg-1, and a relatively large amount (47 g kg-1) of ash. The oil component showed a desirable fatty acid (FA) composition (45.2 % oleic acid, 42.1 % linoleic acid, saturated FA < 13 %). The mineral composition revealed low sodium content (0.22 mg g-1 PF, DB) and high contents of both potassium and magnesium (6.81 and 2.59 mg g-1 PF, DB, respectively).

Protein solubility and functional properties

Protein solubility. pH dependent solubility profile of PF is presented in Fig. 1. The maximum protein precipitation was at pH 4 – 5; at these pH values about 94 % of the extracted protein was precipitated. This is consistent with earlier studies (25, 30, 31). Protein solubility increased at pH values below 4 and above 5, and the maximun solubility was reached at pH 8.

Water holding capacity (WHC). The ability to absorb water is an essential functional property for foods and requires a good interaction protein-water. The flour obtainment proce-

TABLE 1

Chemical composition of partially defatted peanut flour (PF) and breads made with 10 % peanut flour (PFB1), 20 % peanut flour (PFB2) and 100 % wheat flour (WB).

Component	PF	PFB1	PFB2	WB
Moisture	42.1 ± 2.0	270 ± 7.1a	280 ± 7.2a	285 ± 5.3a
Proteins	410 ± 9.1	124 ± 4.5b	156 ± 5.2c	84 ± 2.1a
Lipids	115 ± 4.3	14 ± 1.1a,b	16 ± 1.6b	10 ± 0.7a
Ash	47 ± 1.6	24 ± 1.3a	25 ± 1.2a	21 ± 1.1a
Crude fiber	160 ± 6.6	19 ± 0.8b	34 ± 1.6c	5 ± 0.05a
Carbohydrate	225.9 ± 6.2	549 ± 14.8a,b	489 ± 16.8b	595 ± 9.9a
Fatty acids				
Capric acid	nd*	tr**	tr	2.3 ± 0.3
Lauric acid	nd	0.6 ± 0.05a	0.5 ± 0.06a	3.4 ± 0.4b
Myristic acid	nd	1.6 ± 0.09a	1.7 ± 0.1a	6.7 ± 0.5b
Palmitic acid	11.0 ± 0.2	20.4 ± 0.4a	20.9 ± 0.5a	27.6 ± 1.1b
Palmitoleic acid	nd	1.9 ± 0.1a	2.2 ± 0.2a	1.7 ± 0.1a
Stearic acid	1.6 ± 0.1	12.9 ± 0.2a	12.4 ± 0.2a	14.8 ± 0.4b
Oleic acid	45.2 ± 0.9	34.1 ± 0.7b	35.6 ± 0.8b	29.5 ± 1.3a
Linoleic acid	42.1 ± 0.8	24.1 ± 0.5b	22.3 ± 0.4b	12.0 ± 0.5a
Linolenic acid	nd	tr	tr	1.9 ± 0.09
Arachidic acid	nd	2.0 ± 0.1a	2.1 ± 0.09a	tr
Eicosenoic acid	nd	2.3 ± 0.1a	2.0 ± 0.08a	tr
Behenic acid	tr	tr	tr	tr
% US	87.3 ± 1.3	62.4 ± 1.1	62.1 ± 1.2	45.1 ± 0.9
PUFA/SFA	3.3 ± 0.3	0.6 ± 0.1	0.6 ± 0.1	0.25 ± 0.08
Minerals				
Sodium	0.22 ± 0.01	0.27 ± 0.02a	0.28 ± 0.02a	0.29 ± 0.01a
Potassium	6.81 ± 0.09	5.66 ± 0.1b	5.99 ± 0.2b	4.22 ± 0.1a
Magnesium	2.59 ± 0.06	1.95 ± 0.05a	2.07 ± 0.08a	1.83 ± 0.06a
Calcium	0.51 ± 0.03	0.41 ± 0.04a	0.43±0.05a	0.43 ± 0.04a
Iron	0.09 ± 0.01	0.05 ± 0.01a	0.06 ± 0.02a	0.04 ± 0.01a
Coper	0.02 ± 0.007	0.009 ± 0.002a	0.01 ± 0.005a	0.005 ± 0.001a
Zinc	0.04 ± 0.009	0.03 ± 0.01a	0.03 ± 0.009a	0.02 ± 0.01a

*nd, not detected. **tr, trace<0.5 %.

Proximate (g kg^{-1} dry matter), mineral (mg g^{-1} dry matter) and fatty acid (% of total fatty acids) compositions, unsaturated fatty acid percentage (% US), and long-chain polyunsaturated fatty acids/saturated fatty acids ratio (PUFA/SFA) of peanut flour (PF), breads containing 10 and 20 % peanut flour (PFB1 and PFB2, respectively), and wheat breads (100 % wheat flour, WB). Mean values ± standard deviations ($s_{(n-1)}$), n=3.

Different superscript letters indicate significant differences (p £ 0.05) among PFB1, PFB2 and WB for each component evaluated.

dure may have an important effect on protein conformation and hydrophobicity. The WHC of PF obtained by using the process described in this study was 2.7 ml g-1 flour (table 2). This represents a value higher than those from peanut flour obtained by other methods (30 - 32).

Fat absorption capacity (FAC). The ability of proteins to bind lipids is related to flavor retention capacity, and it is important for making edible products. Even though PF contained natural oil (115 g kg^{-1}), externally added oil was well absorbed. The FAC value found in PF was 2.3 ml g^{-1} flour (table 2). It was similar to values reported by other authors (30) for unfermented raw and roasted peanut flour, and higher than those informed by Juliana and Zhengxing (31) and Joshi et al. (32).

Emulsion properties. Flours with good emulsifying activity (EA) may enhance physical properties of bakery products by reducing water losses during baking and improving bread texture. Values of EA and emulsion stability (ES) from PF were 0.7 and 92 s, respectively (table 2). The former was lower and the latter was higher than values reported elsewhere (25, 31). Emulsion properties observed in PF may be attributed to two main reasons: proteins reducing surface tension of oil droplets, and carbohydrates stabilizing the emulsion by increasing viscosity.

Chemical composition of breads and cookies

Chemical composition of breads is showed in table 1. The bread made with 10 % peanut flour (PFB1) had 124 g kg^{-1} protein. An increment of 10 % PF in bread formulation raised the total protein content by about 3 %, so that bread prepared with 20 % peanut flour (PFB2) contained almost twice as much protein (156 g kg^{-1}) as the 100 % wheat flour-based bread (WB) (84 g protein kg^{-1}). The use of PF also increased markedly the crude fiber content (up to six times when 20 % PF was used) in relation to breads made with wheat flour only. Fatty acid profiles were also improved. In wheat flour-based bread, the FA composition reflected greatly that of the butterfat, whereas in breads added with PF the contribution of peanut oil increased oleic and linoleic acid contents and enhanced unsaturated/saturated fatty acid ratio. Mineral composition was similar between the varieties of breads. Potassium was the most abundant mineral, followed by magnesium and calcium. Composition of micro minerals showed the major levels of

FIGURE 1

Protein solubility profile of peanut flour.

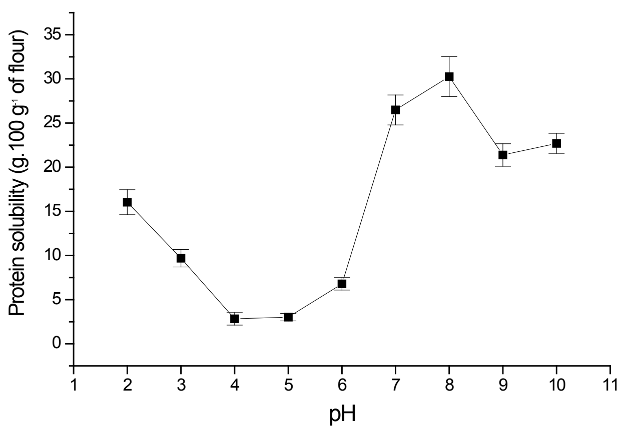

TABLE 2

Functional properties of peanut flour (PF).

Functional properties	PF
Protein solubility[a]	26.48 ± 0.42
Water holding capacity (ml g-1 flour)	2.7 ± 0.03
Oil absorption capacity (ml g-1 flour)	2.3 ± 0.31
Emulsifying activity (s)	0.7 ± 0.08
Emulsion stability (s)	92 ± 0.11

Mean values ± standard deviations ($s_{(n-1)}$), n=3.
[a]Percentage of soluble protein in 0.01 M Na2HPO4 solution at pH 7.
(s) Seconds.

iron, followed by zinc and copper.

In order to maximize the addition of PF in cookies, and to improve the cookie spread, the level of shortening was increased substantially as compared to the standard ACC (33) formula. Such an effect of shortening on cookies has been demonstrated elsewhere (34, 35). Peanut flour cookies (PFC) weighed about 10 g each and showed a good spread (diameter/thickness) ratio (over 5.5). Their chemical composition is presented in table 3. Peanut flour cookies contained 90 g protein kg^{-1} and 36 g fiber kg^{-1}, almost thrice and nine times more than the corresponding levels observed in wheat flour-based cookies (WFC). The lipid content of PFC (271 g kg^{-1}) was not significantly higher than that of WFC (216 g kg^{-1}). With exception of oleic acid content, which was higher in PFC, there were a few minor differences in FA composition. Regarding mineral composition, PFC showed significantly higher amounts of potassium (about nine times) and magnesium (about six times) as compared with WFC.

Sensory evaluation of breads and cookies

Results from sensory evaluation of the different types of elaborated breads and cookies are shown in table 4. Data from all attributes evaluated did not show statistical significant differences between types of breads, thus also indicating similar overall acceptability values. With exception of texture, which was higher in PFC, no significant differences were observed between types of cookies. Cookies made with 100 % peanut flour had high overall acceptability score (8.5).

CONCLUSIONS

Partially defatted peanut flour (PF) provides a rich source of gluten-free protein, fiber and essential minerals. It may be used to enhance the nutritional quality of wheat flour-based bakery products. Results obtained from breads prepared using peanut/wheat flour blends showed that they are compatible ingredients in bread formulations. Partially defatted PF may replace up to 20 % wheat flour without adversely affect dough

TABLE 3

Chemical composition of peanut flour cookies (PFC) and wheat flour cookies (WFC).

Component	PFC	WFC
Moisture	55 ± 5.1a	79 ± 6.3a
Proteins	90 ± 3.9b	32 ± 1.8a
Lipids	271 ± 10.3a	216 ± 8.4a
Ash	17 ± 0.8a	15 ± 0.5a
Crude fiber	36 ± 2.3b	4 ± 1.30a
Carbohydrate	531 ± 22.4a	654 ± 18.15a
Fatty acids		
Capric acid	4.2 ± 0.2a	4.3 ± 0.3a
Lauric acid	4.3 ± 0.2a	4.8 ± 0.4a
Myristic acid	1.2 ± 0.07a	1.3 ± 0.08a
Palmitic acid	11.7 ± 0.3a	12.2 ± 0.3a
Palmitoleic acid	tr*	tr
Stearic acid	3.8 ± 0.2a	4.4 ± 0.4a
Oleic acid	35.2 ± 1.0b	25.8 ± 0.7a
Linoleic acid	36.1 ± 1.3a	42.8 ± 1.6a
Linolenic acid	1.9 ± 0.1a	3.5 ± 0.3b
Arachidic acid	tr	tr
Eicosenoic acid	tr	tr
Behenic acid	tr	0.7 ± 0.05
% US	73.2 ± 1.2	72.1 ± 1.1
PUFA/SFA	1.4 ± 0.1	1.6 ± 0.2
Minerals		
Sodium	1.61 ± 0.07a	1.56 ± 0.06a
Potassium	2.90 ± 0.08b	0.32 ± 0.03a
Magnesium	0.81 ± 0.04b	0.13 ± 0.01a
Calcium	0.27 ± 0.03a	0.21 ± 0.02a
Iron	0.06 ± 0.01a	0.04 ± 0.01a
Copper	0.009 ± 0.001a	0.005 ± 0.001a
Zinc	0.01 ± 0.002a	0.006 ± 0.002a

*tr, trace<0.5 %.
Proximate (g kg^{-1} dry matter), mineral (mg g^{-1} dry matter) and fatty acid (% of total fatty acids) compositions, unsaturated fatty acid percentage (% US), and long-chain polyunsaturated fatty acids/saturated fatty acids ratio (PUFA/SFA) of peanut flour cookies (PFC) and wheat flour cookies (WFC).
Mean values ± standard deviations ($s_{(n-1)}$), n=3.
Different superscript letters indicate significant differences (p £ 0.05) among PFC and WFC for each component evaluated.

handling properties, baking performance, loaf volume, crust and crumb color and texture. Breads prepared with 10 or 20 % PF showed significant increases of both protein and fiber contents, and improved fatty acid profile, with respect to breads made with wheat flour only. By increasing the amount of shortening with respect to that used in standard formulas, PF can totally replace wheat flour in a cookie formulation. Cookies made with PF had three times more protein content and nine times more fiber content than wheat flour-based cookies. Calculated energy content of bread containing 20 % PF indicates that a 100 g serving portion provides 398 Cal and contributes with 26 % of daily protein requirements. Regarding cookies, a 50 g serving portion (5 cookies) contributes about 7.5 % of daily requirements for protein according to FAO/OMS. Values from sensory attributes of breads and cookies elaborated with PF did not differ from those of wheat flour-based products, and showed high overall acceptability scores. In summary, peanut flour has suitable physico-chemical and functional properties to be used in bakery products. It is a rich source of nutrients, primarily proteins and fiber. It can be incorporated to markets of gluten-free products.

RESUMEN

Se obtuvo harina de maní parcialmente deslipidizada (HM) mediante un proceso de lixiviación continua (n-hexano). La composición mostró elevados contenidos de proteínas (410 g kg^{-1}) y fibra cruda (160 g kg^{-1}); los lípidos totales (115 g kg^{-1}) y los minerales (47 g kg^{-1}) se encontraron en menor proporción. La solubilidad mínima de HM se observó a pH comprendido entre 4 y 5, y la máxima a pH 8. Las capacidades de retención de agua y de aceite fueron de 2.7 y 2.3 ml g-1, respectivamente y con valores en las propiedades emulsionantes apropiadas para la formulación de productos de panificación. Panes elaborados con 10 o 20 % HM, en reemplazo de harina de trigo, mostraron incrementos significativos de los contenidos de proteínas y fibra cruda, y mejores perfiles de ácidos grasos y minerales en relación a los preparados sólo con harina de trigo. Galletitas elaboradas a base de HM presentaron contenidos de proteínas y de fibra tres y nueve veces más elevados, respectivamente, que las obtenidas con harina de trigo. Los atributos sensoriales de los productos elaborados con HM resultaron similares a los elaborados con harina de trigo. La harina de maní parcialmente deslipidizada constituye una fuente rica en proteínas libres de gluten, fibra y minerales esenciales, que puede ser utilizada para mejorar la calidad nutricional de productos de panificación basados en harina de trigo.

Palabras clave: harina de mani, propiedades químicas y físicas, pan, galletas, proteínas.

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REFERENCES

1. *Isanga J. Zhang G-N. Biologically active components and nutraceuticals in peanuts and related products: Review. Food Rev Int 2007; 23:123-40.*
2. *USDA National Nutrient Database for Standard References. Release (2009). (Online data bese) http://www.nal.usda.gov/fnic/foodcomp/cgi-bin/list_nut_edit.pl.*
3. *Vessby B. Uusitupa M. Hermansen K. Riccardi G. Rivellese A.A. Tapsell L.C. Nälsén C. Berglund L. Louheranta A. Rasmussen B.M. Calvert G.D. Maffetone A. Pedersen E. Gustafsson I.B. Storlien L.H. Substituting dietary saturated for monounsaturated fat impairs insulin sensitivity in healthy men and women: the KANWU study. Diabetologia 2001; 44:312-19.*
4. *Jiang R. Manson J.E. Stampfer M.J. Liu S. Willett W.C. Hu F.B. Nut and peanut butter consumption and risk of type 2 diabetes in women. J Am Med Assoc 2002; 288:2554-60.*
5. *Jenkins D.J.A. Hu F.B. Tapsell L.C. Josse A.R. Kendall C.W.C. Possible benefit of nuts in type 2 diabetes. J Nutr. 2008; 138:1752S–6S.*
6. *Moreno J.P. Johnston C.A. El-Mubasher A.A. Papaioannou M.A. Tyler C. Gee M. Foreyt J.P. Peanut consumption in adolescents is associated with improved weight status. Nutr Res. 2013; 33:552-6.*
7. *Mukuddem-Petersen J. Oosihuizen W. Jerling J.C. A systematic review of the effects of nuts on lipids profiles in humans. J Nutr 2005; 135:2082-89.*
8. *Kris-Etherton P.M. Hu F.B. Ros E. Sabaté J. The role of tree nuts and peanuts in the prevention of coronary heart disease: Multiple potential mechanisms. J Nutr. 2008; 138:1746S-1751S.*
9. *Li T.Y. Brennan A.M. Wedick N.M. Mantzoros C. Rifai N. Hu F.B. Regular consumption of nuts is associated with a lower risk of cardiovascular disease in women with type 2 diabetes. J Nutr. 2009; 139, 1333-8.*

TABLE 4

Sensory analysis of breads and cookies.

	Breads			Cookies	
Sensory attribute	PFB2	WB	Sensory attribute	PFC	WFC
Crust color	8.3 ± 0.8a	8.6 ± 1.0a	Color	8.0 ± 0.6a	8.2 ± 0.6a
Crumb color	8.2 ± 0.8a	8.5 ± 1.0a			
Aroma	8.3 ± 0.8a	8.9 ± 0.4a	Aroma	8.4 ± 0.8a	8.3 ± 1.0a
Taste	8.4 ± 1.0a	8.6 ± 0.8a	Taste	8.6 ± 0.8a	8.4 ± 1.0a
Crust texture	8.2 ± 0.8a	8.7 ± 0.8a	Texture	8.8 ± 0.1b	7.9 ± 0.1a
Crumb texture	8.3 ± 0.7a	8.7 ± 0.7a			
Overall acceptability	8.3 ± 0.6a	8.7 ± 0.6a	Overall acceptability	8.5 ± 0.6a	8.3 ± 0.6a

PFB2, breads containing 20 % peanut flour; WB, bread containing 100 % wheat flour; PFC, peanut flour cookies; WFC, wheat flour cookies.
Mean values ± standard deviations ($s_{(n-1)}$), n=14.
Different superscript letters indicate significant differences ($p < 0.05$) among breads (PFB2 and WB) and cookies (PFC and WFC) for each sensory attribute evaluated.

10. *Harikumar K.B. Aggarwal B.B. Resveratrol: a multitargeted agent for age-associated chronic diseases. Cell Cycle 2008; 7:1020-37.*
11. *Yeh C.C. You S.L. Chen C.J. Sung F.C. Peanut consumption and reduced risk of colorectal cancer in women: a prospective study in Taiwan. World J Gastroenterol. 2006; 12:222-7.*
12. *Udenigwe C.C. Ramprasath V.R. Aluko R. Jones P.J.H. Potential of resveratrol in anticancer and anti-inflamatory therapy. Nutr Riv 2008; 66:445-54.*
13. *Bishayee A. Cancer prevention and treatment with resveratrol: from rodent studies to clinical trials. Cancer Prev Res. 2009; 2:409-418.*
14. *Mukhopadhyay S. Panda P.K. Behera B. Das C.K. Hassan M.K. Das D.N. Sinha N. Bissoyi A. Pramanik K. Maiti T.K. Bhutia S.K. In vitro and in vivo antitumor effects of Peanut agglutinin through induction of apoptotic and autophagic cell death. Food Chem Toxicol. 2014; 64:369-77.*
15. *Joshi A.U. Liu C. Sathe S.K. Functional properties of select seed flours. LWT-Food Sci Technol. 2015; 60:325-331.*
16. *Choi I.-D. Phillips R.D. Resurreccion A.V.A. Consumer-based optimization of a third-generation product made from peanut and rice flour. J Food Sci. 2007; 72:S443–49.*
17. *Yadav D.N. Thakur N. Sunooj K.V. Effect of partially de-oiled peanut meal flour (DPMF) on the nutritional, textural, organoleptic and physico chemical properties of biscuits. Food Nutr Sci. 2012; 3:471-6.*
18. *Yadav D.N. Thakur N. Sunooj K.V. Singh K.K. Effect of de-oiled peanut meal flour (DPMF) on the textural, organoleptic and physico chemical properties of bread. 2013; 20:1307-12.*
19. *Labuckas D.O. Maestri D.M. Perelló M. Martínez M.L. Lamarque A.L. Phenolics from walnut (Juglans regia L.) kernels: Antioxidant activity and interactions with proteins. Food Chem. 2008; 107:607-12.*
20. *Association of Official Analytical Chemists. Official Methods of Analysis of the AOAC. 15th ed. Arlington. 1990.*
21. *Tang C-H. Functional properties and in vitro digestibility of buckwheat protein products: influence of processing. J Food Eng 2007; 82:568-76.*
22. *Lowry O.H. Rosebrough N.J. Farr A.L. Randall P.J. Protein measurement with the Folin phenol reagent. J Biol Chem. 1951; 193:265-275.*
23. *Bernardino-Nicanor A. Añón M.C. Scilingo A.A. Dávila-Ortíz G. Functional properties of guava seed glutelins. J Agr Food Chem. 2005; 53:3613-3617.*
24. *Pearce K.N. Kinsella J.E. Emulsifying properties of proteins: evaluation of a turbidimetric technique. J Agr Food Chem. 1978; 26:716-23.*
25. *Monteiro P.V. Prakash V. (). Functional properties of homogeneous protein fractions from peanut (Arachis hypogaea L.). J Agr Food Chem. 1994; 42:274-8.*
26. *Maestri D.M. Labuckas D.O. Meriles J.M. Lamarque A.L. Zygadlo J.A. Guzmán C.A. Seed composition of soybean cultivars evaluated in different environmental regions. J Sci Food Agr. 1998; 77:494-8.*
27. *Maldonado E.M. Guzmán C.A. Contenido de algunos elementos y de cenizas totales en semillas de nueve cultivares de maní de la Provincia de Córdoba (Argentina), fYTON 1982; 42:185-9.*
28. *Tortosa Martorell E. (). Cereales Madrid, Alhambra S.A. ed.. Química Agrícola III: Alimentos 1979. p. 26-128).*
29. *Quaglia, G. Ciencia y Tecnología de la Panificación (2nd ed.) Acribia S.A. Ed. Zaragoza, España, 1991.*
30. *Yu L. Ahmedna M. Goktepe I. Peanut proteins concentrate: production and functional properties as affected by processing. Food Chem. 2007; 103:121-9.*
31. *Juliana K.R. Zhengxing C. Effect of processing methods on the physico-functional properties of peanut flour (Arachis hypogaea L.). Biotechnol. 2008; 7:168-74.*
32. *Joshi A.U. Liu C. Sathe S.K. Functional properties of select seed flours. LWT-Food Sci Technol 2015; 60: 325-331.*
33. *Association of Cereal Chemistry. Approved Methods of the American of ACC. 8th ed. American, St. Paul, M.N. 1983.*
34. *Mc Watters K.H. Cookie baking properties of defatted peanut, soybean, and field pea flours. Cereal Chem. 1978; 55:853-63.*
35. *Ranhotra G.S. Lee C. Gelroth J.A. Nutritional characteristics of high-protein cookies. J Agr Food Chem 1980; 28:507-9.*