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Effect of de-oiled peanut meal flour (DPMF) on the textural, organoleptic and physico chemical properties of bread

[1]Yadav, D.N., [2*]Thakur, N., [2]Sunooj K.V. and [3]Singh, K.K.

[1]*Central Institute of Post-Harvest Engineering and Technology, PAU Campus, Ludhiana 141004, Punjab, India.*
[2]*Department of Food Science & Technology, Pondicherry University, Kalapet, Puducherry 605014, India.*
[3]*ADG, Process Engineering KAB-II, ICAR, New Delhi*

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Abstract

Bread was prepared by incorporating de-oiled peanut flour (DPMF) into refined wheat flour at 0-20% level and evaluated for physical, chemical, textural, colour and sensory attributes. The bread with 10% addition of DPME had about 1.5 times higher protein as comparison to control. With the incorporation of DPMF, hardness of bread increased (27.7 N to 55.1 N). Sensory evaluation revealed that the sample containing 15% DPMF scored highest in most of the attributes including overall acceptability. Incorporation of DPMF had significant ($p \leq 0.05$) effect on colour values of bread. As the level of DPMF was increased, L values decreased from 75.2 to 65.2 for crumb and 71.8 to 63.3 for crust. The study revealed that incorporation of 15% de-oiled peanut flour gave desirable results in terms of nutritional, sensory and textural attributes.

Introduction

Peanut (*Arachis hypogaea* L.) is fourth important oilseed crop grown all over the world (Zhang *et al*., 1988). China and India leads in peanut production followed by Nigeria, U.S.A and Indonesia. Peanut has assumed significance in the recent years as a protein source due to its high protein content (approx. 25.80%). Food scientists and nutritionists have gained interest in development of nutritionally balanced protein foods to feed growing populations. Plant materials are expected to play an important role, in supplying proteins for both human and animal consumption. Oilseeds are an excellent source of protein (Conkerten and Ori, 1976).

Fortification of white bread with oilseeds protein product has been extensively studied and reported by various scientists (Khan *et al*., 1975; Khan and Lawhon 1976, 1980). Soy flour bread and other bakery products is used from past many years but recently peanut and cotton seed protein have been fortified in various foods (Yadav *et al*., 2012). It is reported that up to 40-50% protein content of white pan bread can be increased with the addition of oilseed protein made from soy or other oilseeds (Rooney *et al*., 1972; Khan *et al*., 1975). Peanut flour, concentrates and isolates have received a great attention in recent years (Siddiq *et al*., 2009) to fulfill the increasing demand for protein rich food at low price.

Animal protein is getting beyond the reach of many people in developing countries. So, peanuts being cheaper source of protein are an alternative that can serve the purpose up to a great extent. Peanut meal, a by-product left after oil extraction is a rich source of protein. Peanut meal can be dried and ground in a flour form that can be added to various daily consumed foods (Zhao *et al*., 2011). Purohit and Rajyalakshmi (2011) incorporated peanut cake flour in various products like biscuits, noodles and extruded snacks. Peanut meal flour remains underutilized and research is needed to develop new value added products from this by-product that is mainly used for livestock feed. Bread is consumed in large quantity in all over the world. So, fortifying bread with peanut meal flour will help for better utilization of peanut meal as well as serve the consumers with protein. The objective of present study was to optimize addition of de-oiled peanut meal for bread preparation so that its protein content can be significantly improved.

Materials and Methods

Bread was prepared using DPMF with various other ingredients such as wheat flour (100 g) yeasts

*Corresponding author.
Email: *neharika.thakur@gmail.com*
Tel.+91 8769190533

(3 g), fat (6 g), sugar (5 g), salt (1 g) and water (50 mL). DPMF was substituted in place of wheat flour at different levels i.e. 5%, 10%, 15% and 20%. DPMF was prepared from peanuts procured from local market of Ludhiana, Punjab, India. Peanut flour replaced the wheat flour to the extent of 5, 10, 15 and 20% levels without altering the total flour content of the preparation. DPMF was analyzed for moisture, protein, fat and ash content. DPMF was prepared by oil extraction of Peanut meal flour and pressed cake then dried at 60°C for 4-6 h to remove moisture content. The meal was then ground into flour using pulverizer. Individual mixing and baking of the five samples of bread was prepared and evaluated for its nutritional, textural and sensory characteristics.

Method for preparation of bread

All the required ingredients were procured from local market of Ludhiana, India. Ingredients were weighed and then refined wheat flour, DPMF and salt were sieved three times to enhance mixing and for incorporation of air in the mixture. Compressed yeast (Sacharomyces cerevisae) was activated in water at 40ºC. Sugar and fat were creamed together. Later all the ingredients were mixed in a dough mixer to form a soft dough. The dough was kept for proofing (40°C at 85% RH for 60-90 min) in a greased baking tray. After first proofing the dough was knocked back and kept for second proofing (30-45 min, till the volume get doubled). The tray was then placed in oven at 165°C for 45 min. After baking, tray was removed from oven and cooled. Slices were cut of 1 mm thickness for evaluation.

Chemical analysis

The chemical parameters such as moisture, carbohydrate, protein, fat and ash content were determined using AOAC method for DPMF fortified bread.

Loaf weight, volume and specific volume

The weights of bread samples were determined after sufficient cooling using a digital balance (0.01 g accuracy) and the loaf volumes were determined using bean displacement method (Wang *et al*., 2002). The specific volume of each loaf was then calculated as

$$\text{Specific Volume (cm}^3\text{/g)} = \text{Loaf Volume/ Loaf Weight} \quad \textbf{(1)}$$

Density

Bread density was determined (Shorgen *et al*., 2003) as

$$\text{Specific Volume (cm}^3\text{/g)} = \text{Loaf Volume/ Loaf Weight} \quad \textbf{(2)}$$

Weight loss

The dough and the baked loaf were weighed and percent weight loss calculated as shown in equation below

$$\%\,Weight\ loss = \frac{Weight\ of\ dough - Weight\ of\ bread\ loaf)}{Weight\ of\ dough} \quad (3)$$

Textural characteristics of bread

Texture of bread was evaluated with texture analyzer. The slices were first cut into wedges of 2 cm. Texture Profile Analysis (TPA) of bread was determined using P/75 cylindrical probe. Wedges were kept on the centre of the stage. The probe was used to compress the centre of the wedges at a test speed of 2 mm/s. Slice from each composition of sample were used for texture measurements, and there were a total of three measurements for each composition. Graph was recorded in terms of force versus time. Maximum force was recorded using the Texture Expert software. Similarly, for measuring cutting strength blade set with knife (HDP/BSK) probe was used.

Colour measurement of bread

The difference in colour of the bread slices were measured by Hunter colorimeter D-65 illuminant and 10° observer. The colorimeter was calibrated using the standard white and black tiles. Samples were taken and pressed one by one against instrument (sample) port, making sure that it is completely covered by the area to be measured. Four readings for each composition of sample were taken. Both crust and crumb colour was taken. L^*, a^*, and b^* values were recorded at the 2 cut surfaces of each slice. Measurement was made at the four points on the bread loaf. The results were expressed as a mean value of all the samples.

Sensory evaluation of bread

Sensory characteristics of bread samples were evaluated for different sensory attributes by a group of ten semi trained panelists. Sensory attributes like appearance, colour, texture, odor, flavor/taste and overall acceptability for all samples were assessed using nine point hedonic scales. Hedonic scale was in the following sequence: like extremely -9, like very much -8, like moderately -7, like slightly -6, neither like nor dislike -5, dislike slightly -4, dislike moderately, -3, dislike very much -2, dislike extremely -1 .

Statistical Analysis

Statistical analysis was performed with SPSS software (SPSS Inc. 1996) and used to test the significant effect of various parameters at 5% level of significance ($p > 0.05$).

Results and Discussion

Chemical composition of DPMF fortified bread

The chemical composition of DPMF and fortified bread is given in Table 1. An increase in ash content, crude fat and proteins was observed with an increase in DPMF level while moisture content and carbohydrate was found to decrease (Table 1). The statistical analysis revealed that there was a significant change in moisture content, ash, protein, fat and carbohydrates for all the samples. The increased amount of ash shows a higher mineral content of bread which could be due to peanut meal, since peanut has higher minerals content. A lower value for carbohydrate was observed since oilseeds have energy stored in the form of fat. Hence, fat content increased while carbohydrates decreased with an increase in DPMF level of bread. Serrem *et al*. (2011) had reported a substantial decrease in level of carbohydrates while an increase in fat and protein in case of de-oiled soy flour added to wheat biscuits. Rooney *et al.* (1972) studied the effect of autoclaving on the protein content of some oilseeds and reported that heated and non heated samples were not significantly different. The results in DPMF fortified bread were comparable to the composition of bread fortified with sesame seed flour (Adawy, 1995).

Table 1. Chemical composition of DPMF and its fortified bread

	DPMF	Control	5% DPMF	10% DPMF	15% DPMF	20% DPMF
Moisture content (%)	2.72	33.36[a]	33.02[b]	29.11[b]	28.42[c]	28.25[c]
Protein (%)	30.26	7.67[a]	9.68[b]	10.92[c]	11.87[d]	12.75[e]
Crude fat (%)	10.1	5.46[a]	5.51[a]	5.58[a]	5.59[a]	7.43[b]
Carbohydrates (%)	43.65	52.05[a]	51.98[a]	51.34[a]	50.14[b]	49.27[c]
Total Ash (%)	3.265	1.46[a]	1.58[a]	1.73[a]	1.91[a]	2.10[a]

Mean values with the same superscript letters within the same column do not differ significantly ($p > 0.05$)

Table 2. Physical parameters of bread with different levels of DPMF

DPMF (%)	Loaf Weight before baking (g)	Loaf weight after baking (g)	Weigh loss (g)	Loaf volume (cm.^{3})	Density (g/cm^3)	Specific volume (cm^3/g)	Slice height (mm)
0	330.9[a]	294.1[a]	36.8[a]	540[a]	0.545[a]	1.836[a]	34.3[a]
5	330.7[a]	293.9[a]	35.1[b]	520[b]	0.568[b]	1.759[b]	28.0[b]
10	327.3[a]	294.8[a]	32.5[c]	510[c]	0.578[c]	1.729[c]	27.5[b]
15	318.4[b]	286.5[b]	31.9[c]	495[d]	0.579[c]	1.727[c]	26.5[b]
20	316.7[b]	285.7[b]	31.0[c]	490[d]	0.583[c]	1.715[d]	24.0[c]

Mean values with the same superscript letters within the same column do not differ significantly ($p > 0.05$)

Weight loss and loaf weight of bread

Loss in weight of bread during baking is a common phenomenon. This depends on baking temperature as well as time (Eggleston, 1993). During proofing, the CO_2 trapped in bread expands the air pocket and later during transformation of dough into elastic bread crumb, the starch gelatinizes leading to weight loss (Keetels *et al*., 1996; Hathorn *et al*., 2008). There was a significant decrease in weight loss from 36.8 to 31 g as the percentage of DPMF was increased (Table 2). Peanut meal has high protein content and also substantial percentage of fat, which may have formed a complex with water, thus prevented it to get removed from the loaf during baking. Ayres and Davenport (1977) have reported that DPMF flour influence the crumb structure due to retention of higher moisture content. Loaf weight was not affected much upto 10% addition of DPMF, however it decreased significantly after 20% addition. The retention of moisture depends on the extent of starch gelatinization and gluten network formation. Thus, in case of higher level of DPMF there will be lack of starch for gelatinization (i.e. mainly responsible for structure of bread) and a distorted gluten network. Also, DPMF has higher water absorption capacity than wheat flour similar to de-fatted maize germ flour (Siddiq *et al.*, 2009) and sesame flour (Adawy, 1995). Hence, it can also contribute to less weight (at 20% DPMF) of bread loaf.

Loaf volume, Density and specific volume

Loaf size and volume are important quality criteria in selection of bread by consumers as they desire for larger and softer bread. It is generally seen that larger the volume more is the softness otherwise it becomes dense and hardens. The loaf volume decreased significantly from 540-490 cm^3 as the level of DPMF increased from 0-20% (Table 2). Loaf volume is affected by protein quantity and quality in flour along with the baking time (Ragaee and Abdel 2006; Shittu *et al.*, 2007). Since the proofing time given to all the dough was same hence, the volume got affected due to protein in flour. Peanut meal has high protein content but the quality differs from usual wheat flour protein. Specific volume was found to decrease while density increased as the level of DPMF increased from 0-20% (Table 2). Gluten is responsible for increase in bread volume which decreased with higher percentage of wheat flour replacement. Banks *et al*. (1997) had reported that partial replacement of wheat flour with non-glutinous flour results in lower bread volume. They observed that a significant decrease in baked volume of muffins made with de-oiled soy flour. Wang *et al.* (2002) observed that bread supplemented with different dietary fibers had decrease in loaf volumes between 719 and 906 cm^3. Siddiq *et al.* (2009) also observed the same trend for their de-fatted maize germ flour incorporated bread. As specific volume is directly related to volume hence an expected decrease in specific volume was observed while density being inversely proportional decreased significantly from 0-20% DPMF substitution. There was no significant difference in specific volume after 10% substitution. Density reflects the size and ratio of air cells to solid product (Hathorn *et al*., 2008). Siddiq *et al.* (2009) observed a similar trend in all three parameters and suggested that it could be probably due to higher water absorption capacity of de-fatted germ flour and as it does not contain gluten thus it contributed in higher density. Loaves were progressively smaller in volume and showed a coarse, dense and compact grain.

Textural changes in bread

Texture is an important quality of bread for consumer as well as manufacturer. Bread is expected to be firm up to a certain extent beyond which it becomes unacceptable. Torbica *et al.* (2010) reported that maximal force is a common parameter describing the system texture of bread i.e. hardness. There was a significant difference in hardness of bread as the level of de-oiled peanut flour increased (values range from 27.7 to 55.1 N) (Table 3). Higher the force required, harder is the bread. Keetels *et al*. (1996) reported that starch gelatinization resulted in elastic bread crumb but DPMF lacks in starch hence deteriorating that property. Similarly, addition of rye flour resulted in a firmer bread as reported by Esteller *et al.* (2008). The high protein content of defatted maize germ flour has affected the 'polymerization of proteins', resulting in more plasticized dough, which was eventually reflected in the increased hardness of the crumb (Siddiq *et al*., 2009). As the protein content of DPMF is high, so it may be the possible reason for hardness.

The cutting strength increased significantly from 22.8 to 33.7 N-mm up to 20% addition (Table 4). The increase may be attributed to change in protein quantity, quality and water absorption. The harder crumb will result in higher cutting strength. Many studies have indicated that starch polymers are responsible for the ultimate structure of crumb that will cause firmness of loaf with time (Scanlon and Zghal, 2001). Also, structure is highly dependent on flour composition that has been altered here with respect to DPMF. Hence, it will change the cell wall properties that lead to hardening of bread thus will result in higher cutting strength.

Other textural properties such as springiness, gumminess, chewiness and cohesiveness of bread were also evaluated from graph obtained in texture profile analysis. Springiness signifies that the product retained its original shape once compressed and the values for DPMF substituted bread were 0.999 to 0.993 in which up to 10% there was not a significant difference but above 10% values were significantly different. Although all the values were less than 1.0, it can be concluded that substitution of DPMF did not affect springiness. However there was an increase in values for other properties. Gumminess and chewiness are both related parameters. Cohesiveness is that how well a product withstands at second deformation and behaves at first deformation. All these properties signify basically the behaviour of food in the mouth. The texture was affected greatly with an increasing level of DPMF and the bread became unacceptable at higher levels.

Colour

Colour is an important parameter for selection of a food product. The colour of bread signifies its freshness. The colour development is contributed by non enzymatic browning (maillard and caramelization) that produces brown coloured compounds that are accumulated during baking (Purlis, 2011). Both crumb and crust colour of bread were evaluated (Table 4). The L value that is concerned with lightness of colour decreased significantly both for crumb and crust that shows that control was lighter compared to DPMF added bread. For L values it has been classified that value around 50 as dark, 60 as optimum, and 70 as light in colour (Hathorn *et al.*, 2008). The values were above 60 for both crust and crumb, hence are light in colour. Since the colour of DPMF was darker compared to wheat flour, it affected the overall colour of bread. Since no colour improver was supplemented, it resulted in darker bread compared to control. Various studies have shown that supplementation of flours other than wheat flour greatly affects the colour of bread

Table 3. Textural parameters of bread containing different levels of DPMF

DPMF (%)	Hardness (N)	Springiness	Gumminess	Chewiness	Cohesiveness	Cutting strength (N-mm)
0	27.7^{a}	0.999^{a}	11.9^{a}	11.8^{a}	0.43^{a}	22.8^{a}
5	30.9^{b}	0.998^{a}	14.5^{b}	14.4^{b}	0.47^{a}	25.7^{b}
10	36.4^{c}	0.997^{a}	17.8^{c}	17.7^{c}	0.49^{a}	30.3^{c}
15	42.4^{d}	0.995^{b}	23.3^{d}	23.1^{d}	0.55^{a}	32.1^{d}
20	55.1^{e}	0.993^{b}	31.4^{e}	31.1^{e}	0.57^{a}	33.7^{d}

Mean values with the same superscript letters within the same column do not differ significantly ($p > 0.05$)

Table 4. Effect of different levels of DPMF on colour values of bread

	Crumb			Crust		
DPMF level (%)	L	a	b	L	a	b
0	75.2±1.14^{a}	1.5±0.03^{a}	21.1±0.03^{a}	71.8±1.30^{a}	6.00±0.04^{a}	28.0±0.08^{a}
5	72.0±1.16^{b}	1.6±0.03^{b}	21.1±0.02^{a}	66.4±1.22^{b}	6.09±0.06^{a}	30.7±0.06^{b}
10	70.1±1.15^{b}	1.6±0.05^{b}	19.8±0.03^{b}	65.9±1.28^{b}	7.77±0.03^{b}	30.8±0.05^{b}
15	68.5±1.14^{b}	1.8±0.04^{c}	18.6±0.05^{c}	64.8±1.29^{b}	9.57±0.08^{c}	30.8±0.09^{b}
20	65.2±1.14^{c}	2.3±0.02^{d}	17.9±0.05^{d}	63.3±1.26^{b}	9.68±0.07^{d}	31.3±0.06^{b}

Mean values with the same superscript letters within the same column do not differ significantly ($p > 0.05$)

Table 5. Sensory parameters of bread containing different levels of DPMF

Parameters	Appearance	Color	Aroma	Texture	Flavor taste	Overall acceptability
Control	8.5^{a}	8.5^{a}	8.3^{a}	8.4^{a}	8.3^{a}	8.5^{a}
5%	7.7^{b}	7.8^{b}	7.6^{b}	7.7^{b}	7.7^{a}	7.9^{b}
10%	7.2^{b}	7.1^{c}	7.2^{c}	7.2^{c}	7.4^{a}	7.3^{c}
15%	6.5^{c}	6.5^{d}	6.7^{d}	6.8^{c}	6.6^{b}	6.7^{d}
20%	6.1^{c}	6.2^{d}	6.2^{e}	6.1^{d}	6.1^{b}	6.1^{e}

Mean values with the same superscript letters within the same column do not differ significantly ($p > 0.05$)

(Kent and Evers, 1994; Banks *et al*., 1997; Sidhu *et al*., 2001; Greene and Benjamin, 2004). In case of crumb, an increase in ‘a’ and decrease in ‘b’ values were observed with increase in level of DPMF. Decrease in ‘a’ value signifies the colour towards greenness and increase in ‘b’ was the indicator for increase in yellowness. The result clearly indicated that with increase in DPMF level lightness decreased and yellowness increased for crumb. Similar trend was observed by Siddiq *et al.* (2009) for de-fatted maize germ flour supplemented bread. Banks *et al.* (1997) reported that muffins containing partially de-oiled soy flour were lighter and reddish in colour than control. Esteller and Lannes (2008) observed that during baking, amount of water on the dough surface quickly decreased providing favorable conditions for Maillard reactions resulting in darker brown colour.

Sensory parameters

All the formulations were acceptable as the scores given by panel members were above 6 (Table 5). However, the addition of 15% DPMF, typical peanut flavor was observed. Sabanis *et al*. (2009) prepared gluten free bread and received scores above 5 and concluded that the bread as acceptable. The sensory scores were in relation with the results observed instrumentally such as for texture and colour. In case of flavor and taste there was no significant difference up to 10%. A mixed trend in scores was observed but ultimately all were in range of acceptability. Siddiq *et al.* (2009) reported that above 15% the sensory attributes were not found in acceptable range but that can be improved by optimizing the formulations or by altering processing conditions.

Conclusion

Protein rich bread was prepared by incorporating DPMF. The results showed that there was a decrease in physical parameters such as loaf weight, volume, specific volume, etc. with an increase in level of DPMF. The bread became harder and required higher cutting strength as the level of DPMF replacement increased from 0-20%. The colour of bread was darker than the control. The result further supports that up to 15% the quality was acceptable as no difference was noticed for most of the sensory attributes. Addition of higher levels of DPMF is not recommended as it results in unacceptable in terms of sensory. This problem can be overcome by optimizing the formulation, altering the processing condition or addition of suitable additives to improve the quality attributes. A significant increase in protein was observed with an increase in DPMF percentage as peanuts are a very good source of protein that was evident in the analysis. The study demonstrated that DPMF a by-product obtained from peanut oil industry offers a great potential for supplementing protein.

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