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NUTRITIONAL AND SENSORIAL QUALITY OF COOKIES FOTRIFIED WITH DEFATTED FLAXSEED AND SESAME SEED MEALS

Khattab, R. Y. and A. A. Zeitoun
Food Sci. Dept., Fac. of Agric., (Saba Bacha), Alexandria University.

ABSTRACT

Cookies made of wheat flour (72% extraction) fortified with defatted flaxseed meal (DFM) and defatted sesame seed meal (DSM) (1:1 w/w) at levels of 0, 5, 10, 15, 20 and 25% were nutritionally and organoleptically evaluated. The crude protein contents of DFM and DSM were as high as 38.80 and 40.00%, respectively as compared to that of wheat flour (11.26%) with a highly favorable amino acid profile, with high essential amino acid content. Adding defatted flaxseed-sesame seed meal (DFSM) had significantly increased crude protein, ash, calcium, phosphorus, magnesium and potassium contents of the produced cookies as compared to the control cookies (100% wheat flour). Essential amino acid content and protein quality parameters including protein efficiency ration (PER), biological value (BV), chemical score (CS) and essential amino acid index (EAAI) were also improved obviously in cookies fortified with different levels of DFSM. Results of sensory evaluation of cookies revealed that levels up to 15% substitution of wheat flour with DFSM produced highly acceptable cookies comparable to the control. Therefore, it is strongly recommended that the under-utilized negligible high protein DFM and DSM could be incorporated successfully at 5 – 15% levels into bakery products like cookies to combat protein deficiency and improve the nutrition and health status.

INTRODUCTION

Fortification of foods can be an effective way to combat nutrient deficiencies in the developing countries. The purpose of food fortification is to increase the intake of a specific nutrient or nutrients that have been identified as inadequate in the food supply (Subar *et al.*, 1998).

The increased costs and limited supplies of animal proteins, have necessitated contemporary research efforts geared towards the study of food properties and potential utilization of protein from locally available food crops, especially from under-utilized or relatively neglected high protein oilseeds and legumes (Enujiugha and Ayodele-Oni, 2003).

Flaxseed meal has three major components making it beneficial in human and animal nutrition: (1) a high content of α-linolenic acid (ω-3 essential fatty acid); (2) a high percentage of dietary fiber, both soluble and insoluble; and (3) the highest content of plant "lignans" of all plant or seed products used for human food (Lay and Dybing, 1989). Crude protein content of flaxseed meal was reported to be 48.90% (Madhusudhan and Singh, 1983). Oomah and Mazza (1995) reported that the protein fraction of flaxseed meal contains a favorable ratio of amino acids. It is also a good source of sulfuric amino acids methionine and cystine. Thus, flaxseed meal is considered as a potential source of high-quality plant protein for incorporation into food products. It was found that flaxseed meal protein has biological value (BV), digestibility, protein efficiency ratio (PER) and protein score of 77.40, 91.60, 1.76 and 82.00, respectively (Bell and Keith, 1993). In addition to their nutritional characteristics, flaxseed meal proteins provide prominent functional roles in food including solubility, rheological behaviour, emulsifying capacity and foaming and whipping ability (Oomah and Mazza, 1995). Moreover, flaxseed meal is a good source of a number of minerals and vitamins especially magnesium, phosphorus, potassium, calcium, vitamin C and some B vitamins (USDA, 1999). Compared to all fruits, vegetables and grains tested to date, flaxseed meal is the richest source of lignans, containing between 0.6 to 1.8 g/100g whole flaxseed (Parasad, 1999). Lignans are phytoestrogens which have weak estrogenic and antiestrogenic properties and may, therefore, help prevent hormone-sensitive cancers (Rose, 1993).

It is well investigated that flaxseed has several benefits in the prevention and curing of a large deal of diseases (Hall *et al*, 1993; Haggans *et al.*, 2000; Lemay *et al.*, 2002).

Flaxseed is mechanically pressed to recover its oil fraction which presents about 30 - 45% of seed weight (Madhusudhan and Singh; 1983; USDA, 1999). The oil is directed either for human consumption or processed for industrial uses. The produced defatted flaxseed meal, however, is an under-utilized by-product of flaxseed oil extraction.

Defatted sesame seed meal is an edible, creamy and light brown powder from sesame seeds. It has high protein content (about 47.1%) and about 10 – 12% sesame oil (Janick and Whipkey, 2002). Sesame seeds contain three times more calcium than a comparable measure of milk (Home Cooking 1998). The amino acid composition of sesame seed meal is unique and unusual among the oilseed proteins, due to its high content of sulfur-containing amino acids methionine and cysteine (Johnson *et al.*, 1979). Many nutraceutical uses have been discovered for sesame. Sesame lignans have antioxidant and health promoting activities (Kato *et al.* 1998).

On the other hand, cereal grains are rich in carbohydrates but deficient in essential amino acids such as lysine, the limiting amino acid in wheat (Kent and Evers, 1994), thus making their protein quality poorer than that of animals (Horn and Schwartz, 1961). The total protein content and the contribution that essential amino acids make to the total are the most important factors from a nutritional point of view. The nutritional quality can be improved by increasing protein content and limiting amino acids especially lysine (Anjum *et al.*, 2005). Hence, the enrichment of cereal-based foods with oilseed and legume protein has received considerable attention. Wheat bread and cookies are widely accepted and consumed in many developing countries and therefore offer a valuable supplementation vehicle for nutritional improvement; however, cookies have been suggested as a better use of composite flour than bread because of their ready-to-eat form, wide consumption and relatively long shelf-life (Lorens *et al.*,, 1979). Enriched cookies are attractive for target areas, such as child-feeding programs, low-income groups and disaster relief operations (Claughton and Pearce, 1989). Cookies with these characteristics have been produced from blends of wheat and cowpea (McWatters *et al.*, 2003) or soybean and wheat (Shrestha and Noomhorm, 2002).

Therefore, the aim of this study was to fortify cookies with the highly nutritive defatted flaxseed and sesame seed meals and to evaluate the nutritional and sensorial quality of the fortified cookies.

MATERIALS AND METHODS

Materials

Defatted flaxseed meal (DFM) and sesame seed meal (DSM) (2 kg. each) were obtained from a private commercial press, El-Mahalla El-Kobra, Gharbia Gov., Egypt. Wheat flour (72% extraction) (5 kg. packed in polypropylene bags) was purchased from a local market, Alexandria, Egypt. It was stored at room temperature until using. Casein (analytical grade) was obtained from Sigma-Aldrich.

Experimental Procedures

Blends formulation and preparation of cookies

Defatted flaxseed and sesame seed meals were dried overnight at 40 ± 2°C in an air-draft drying oven (WT-binder labortechnic GMBH). The samples were cleaned, ground, sieved through 32 mesh sieve to get powder with similar characteristics of flour 72% extraction rate. To get use of the tremendous benefits previously mentioned for DFM and DSM, they were equally blended together (1:1 w/w) to form the defatted flaxseed-sesame seed meal (DFSM). Blends of wheat flour and DFSM powder, (containing 0%, 5%, 10%, 15%, 20% and 25% DFSM powder, on a replacement basis), were prepared. The choice of these levels was based on the report of Dreuiter (1978) that the maximum level of wheat flour substitution that would produce an acceptable baked product was 25%. They were then packed in polyethylene bags, sealed and kept at –18°C until using.

Cookies were prepared according to the procedure described by McWatters *et al.* (2003). The basic ingredients used were 190 g of flour blend, 50 g vegetable shortening, 112.50 g of granulated sugar, 10.50 g of beaten whole egg, 1.88 g of salt, and 0.90 g of baking powder. The dry ingredients were weighed and mixed thoroughly in a bowl by hand for 3–5 min. Shortening was added and rubbed in until uniform. The egg was added and dough was thoroughly kneaded in a mixer for 5 min. The dough was formed into different shapes using the cookies machine (Amaizing DT 906, China). The produced dough pieces were baked on greased pans at 160°C for 15 min in a baking oven. The prepared cookies were cooled to room temperature (24 ± 2°C), packed in high density polyethylene bags and stored at room temperature until analysis and sensory evaluation. Results of the sensory evaluation showed that increasing DFSM level over 15% produced cookies with undesirable dark colour. In order to conquer this predicament, cookies were produced according to the procedure mentioned above but with adding cocoa powder (1% of the formula). The produced cookies were sensorially tested for their colour.

Chemical composition of flours and cookies

Triplicate samples of wheat flour, DFM, DSM and produced cookies were tested for their proximate composition in terms of moisture, crude fat, crude protein, crude fiber, and ash contents according to AACC (2000). Nitrogen-free extract (NFE) was calculated by difference. Results were expressed as means of the three replicates.

Amino acid compositions of wheat flour, DFM, DSM, Casein (as a standard protein) and produced cookies were determined according to the Association of Analytical Chemists (1990) using an AAA 400 automatic amino acid analyzer (INGOS, Czech Republic). Prior to analysis, samples were subjected to acid hydrolysis in the presence of 6 M HCl at 105°C for 24 hours. Sulphur-containing amino acids were determined separately in 6 M HCl after oxidative hydrolysis (formic acid + hydrogen peroxide, 9:1 v/v, 20 h at 4°C). Tryptophan was quantified on an alkaline digest according to the method described in the Official Methods of Analysis of the Association of Analytical Chemists (1990).

Minerals were determined after wet ashing by concentrated nitric acid and perchloric acid (1:1, v/v). K and Ca were determined by flame photometer (Corning 410, England), while Mg was determined using an atomic absorption spectrophotometer (Perkin–Elmer, Model 2380, USA). Phosphorus was estimated photometrically via the phosphorus molybdate complex described by Taussky and Shorr (1953).

Evaluation of protein quality

A. Protein efficiency ratio (PER)

PER values were calculated according to the following regression equation proposed by Alsmeyer *et al.* (1974):

$$PER = -0.468 + 0.454\ Leu - 0.105\ Tyr.$$

B. Biological value (BV)

Biological values were calculated according to Eggum *et al.* (1979) using the following regression equation:

$$BV\ (\%) = 39.55 + 8.89 \times lysine.$$

C. Chemical score (CS)

The chemical score (CS) was calculated on the basis of the procedure described previously by Rakowska *et al.* (1978), based on comparison of the concentration ratio of the amino acid having the shortest supply a_i (restrictive amino acid) to the concentration of this amino acid in the standard a_s:

$$CS = (a_i/a_s) \times 100.$$

Casein was used as a standard protein considered a complete and balanced food and fodder protein according to FAO/ WHO (1991).

D. Essential amino acid index (EAAI)

The essential amino acid index (EAAI) was calculated as follows:

$$EAAI = 10^{\log EAA}.$$

Where log EAA has the description (after Rakowska *et al.*, 1978):

$$\log EAA = 0.1(\log a_1/a_{1s} \times 100 + \log a_2/a_{2s} \times 100 + \ldots\ldots + \log a_n/a_{ns} \times 100).$$

Where a_1 ... a_n: the contents of exogenous amino acids including Lys, Meth + Cys, Thr, Ileu, Trp, Val, Leu, His and Phe + Tyr in the sample protein, while a_{1s} ...a_{ns}: the contents of these amino acids in the standard protein.

Sensory evaluation of cookies

Cookies were organoleptically evaluated for their appearance, colour, odour, taste, texture, after-taste and overall acceptability, according to the preference method of Ihekoronye and Ngoddy (1985). Twelve laboratory staff members evaluated the cookies on a 5- point hedonic scale. The triangle test was performed on the cookies produced with adding cocoa powder to examine weather there were differences in colour.

Statistical analysis

Data were statistically analyzed using analysis of variance (ANOVA) according to Steel *et al.,* (1997). Means were separated by least significant difference (LSD). Significance was accepted at $p \leq 0.05$.

RESULTS AND DISCUSSION

Chemical composition of flours used for cookies preparation

Proximate chemical composition (%) and mineral contents (mg/100g) of different flours used for preparing cookies are shown in table (1). Data revealed that wheat flour had the highest moisture content (11.00%) and nitrogen free extract (84.75%) and the lowest crude fat (1.60%), crude protein (11.26%), crude fiber (1.31%) and ash (1.08%) contents.

Table (1): Proximate chemical composition* (%) and mineral contents (mg/100g) of flours* used for cookies preparation.

	Wheat flour	DFM	DSM
Moisture	11.00^{a}	6.60^{b}	5.80^{b}
Crude fat	1.60^{a}	6.20^{b}	9.80^{c}
Crude protein	11.26^{a}	38.80^{b}	40.00^{b}
Crude fibers	1.31^{a}	5.00^{b}	4.60^{b}
Ash	1.08^{a}	7.00^{b}	11.20^{c}
Nitrogen free extract	84.75^{a}	43.00^{b}	34.40^{c}
Calcium	29.20^{a}	306.15^{b}	153.10^{c}
Phosphorus	350.00^{a}	766.15^{b}	774.26^{b}
Magnesium	127.30^{a}	556.92^{b}	346.08^{c}
Potassium	390.10^{a}	1047.70^{b}	406.32^{a}

Means in the same row with different letters are significantly different ($p \leq 0.05$).
*Results are means of three replicates calculated on dry weight basis.
* DFM = Defatted flaxseed meal. DSM = Defatted sesame seed meal.

The proximate composition of both defatted flaxseed meal (DFM) and defatted sesame seed meal (DSM) differed significantly with that of wheat flour. There were no significant differences between DFM and DSM in their moisture, crude protein and crude fiber contents while they had significantly differed between each other in their contents of crude fat, ash and nitrogen free extract. DSM had the highest crude protein (40.00%), crude fat (9.80%) and ash (11.20%) contents. DFM, on the other hand, had the highest crude fiber content (5.00%).

In respect of mineral contents, data showed that DFM had the highest calcium (306.15), phosphorus (766.15), magnesium (556.92) and potassium (1047.70 mg/100g) contents. The lowest values were recorded for wheat flour (29.20, 350.00, 127.30 and 390.10 mg/100g, respectively). Mineral contents of both DFM and DSM differed significantly with that of wheat flour except for potassium content in which there was no significant difference between wheat flour and DSM. Significant differences were found between DFM and DSM in their calcium, magnesium and potassium contents. Results of proximate composition and mineral contents are in conformity with those reported by Madhusudhan and Singh (1983), USDA (1999) and Janick and Whipkey (2002).

Amino acid composition and protein quality of flours used for cookies preparation

The amino acid profiles of wheat flour, DFM and DSM are shown in table (2). Data revealed that DFM was rich in essential amino acids such as lysine, phenylalanine, threonine, leucine, isoleucine, valine and tryptophane compared with the reference protein (casein). DFM had the highest total essential amino acid content (33.57%) followed by DSM (32.25%) while the lowest value was that of wheat flour (25.20%). DSM had the highest content of sulfur-containing amino acids (5.04%) followed by DFM (3.38%) and wheat flour (3.10%).

Table (2): Amino acid composition (%) and protein quality parameters of flours♣ used for cookies preparation.

Amino acids	Wheat flour	DFM	DSM	Casein•
Lysine	2.00	4.14	3.17	6.39
Methionine[a]	1.10	1.66	3.17	2.35
Phenylalanine	5.30	4.98	4.42	4.31
Threonine	2.30	3.56	3.74	3.52
Leucine	6.50	6.96	7.11	7.68
Isoleucine	3.20	4.29	3.74	4.00
Tryptophane	1.20	2.10	1.85	1.17
Valine	3.60	5.88	5.05	5.24
Total Essential amino acids	**25.20**	**33.57**	**32.25**	
Arginine	5.40	9.30	13.19	3.89
Aspartic acid[b]	5.80	9.00	8.15	7.25
Glutamic acid[c]	36.30	21.30	19.28	23.84
Serine	4.50	4.18	5.04	5.86
Proline	8.40	3.98	3.74	11.99
Cystine	2.00	1.72	1.87	0.30
Tyrosine	4.00	2.88	3.74	4.65
Glycine	3.70	5.90	6.29	1.96
Alanine	2.80	5.40	3.96	3.17
Histidine	1.90	2.77	2.49	2.43
Total Non-essential amino acids	**74.80**	**66.43**	**67.75**	
Total sulfur amino acids	**3.10**	**3.38**	**5.04**	
Protein quality parameters*				
PER	2.15	2.21	2.28	
BV	57.33	76.35	67.73	
CS	46.81	70.64	158.12	
EAAI	49.77	66.28	64.44	

♣ DFM = Defatted flaxseed meal. DSM = Defatted sesame seed meal.

• Casein was used as a standard protein.

a = Methionine + Cysteine. b = Aspartic acid + Asparagine.

c = Glutamic acid + Glutamine.

* PER = Protein efficiency ratio. BV = Biological value. CS = Chemical score. EAAI = Essential amino acid index.

Methionine was restrictive in both wheat flour and DFM, while the restrictive amino acid in DSM was tryptophane (1.85%). These results strongly advocate the use of DFM and DSM to complement those protein sources that are low in lysine, sulfuric amino acids and other essential amino acids such as cereal proteins. These obtained results are in agreement with those stated by Johnson *et al.* (1979) and Abdel-Aal and Hucl (2002).

Quality evaluation by amino acid scoring procedures is considered to be more accurate than animal assay used for predicting protein quality of foods (Dillon, 1992). Wheat flour protein had the lowest values for all estimated quality parameters. Protein efficiency ratio (PER), based on leucine and tyrosine availability was 2.15, 2.21 and 2.28 for wheat flour, DFM and DSM, respectively. DFM protein had the highest biological value (76.35) followed by DSM protein (67.73) and wheat flour (57.33).

The chemical protein scores (CS) of the studied flours were calculated from the comparison of less abundant amino acid to a standard. CS values were 46.81, 70.64 and 158.12 for wheat flour, DFM and DSM, respectively. The highest essential amino acid index (EAAI) was estimated for DFM protein (66.28) followed by that of DSM (64.44).

Chemical composition of produced cookies

Chemical composition and mineral contents of the produced cookies are shown in table (3). Data revealed that protein contents of the cookies, prepared from DFSM blends were significantly higher than the protein content of control cookies (100% wheat flour). The protein content of the cookies prepared from these blends was also higher (12.10 – 18.15%) than those (6.00 – 12.00%) reported for conventional cookies (Shrestha and Noomhorm, 2002).

These results are in accordance with those of Inyang and Wayo (2005) who found that the protein content of cookies prepared from blends of wheat flour with 10, 20, 30 and 40% dehulled sesame seed meal increased from 12.52% with wheat flour to 16.86% with 40% substitution. Addition of DFSM resulted in an increase in ash content of cookies up to 3.06% and crude fiber content up to 2.60%. There were no significant differences in moisture contents of cookies.

Supplementation of cookies with DFSM also significantly increased the levels of calcium, phosphorus, magnesium and potassium to 88.10, 453.60, 213.80 and 470.16 mg/100 g, respectively.

All the cookies supplemented with DFSM were found to be nutritious on the basis of these parameters. This was because the consumption of about 100 g of each product formulation would provide more than half of the recommended daily requirement for protein (25–30 g/day), as recommended by FAO/WHO (1973) for children aged between 5 and 19 years. This fact suggests that cookies supplemented with DFSM may be useful as food supplements for the alleviation or prevention of protein malnutrition in developing countries. Shearer and Davies (2005) concluded that using flaxseed meal (at level of 5%) in preparing whole-wheat muffins and batter had enhanced the nutritional value without detrimentally changes in freshness or storage properties.

Table (3): Proximate chemical composition* (%) and mineral contents (mg/100g) of cookies made of wheat flour fortified with different levels of defatted flaxseed- sesame seed meal (DFSM).

	DFSM levels (%)					
	0	5	10	15	20	25
Moisture	8.80[a]	8.88[a]	8.98[a]	9.20[a]	9.52[a]	10.05[b]
Crude fat	14.00[a]	14.12[a]	14.22[a]	14.34[a]	14.40[a]	14.50[a]
Crude protein	11.00[a]	12.10[b]	14.00[c]	15.36[c]	16.68[d]	18.15[d]
Crude fibers	1.86[a]	2.00[a]	2.15[a]	2.32[b]	2.45[b]	2.60[c]
Ash	1.12[a]	1.49[b]	1.87[c]	2.20[d]	2.66[e]	3.06[f]
Nitrogen free extract	72.02[a]	70.29[a]	67.76[b]	65.78[b]	63.81[b]	61.68[c]
Calcium	38.16[a]	49.60[b]	59.06[c]	68.40[d]	77.90[e]	88.10[f]
Phosphorus	348.60[a]	369.00[b]	391.20[c]	410.90[d]	433.00[e]	453.60[f]
Magnesium	132.50[a]	148.30[b]	164.10[c]	180.00[d]	197.10[e]	213.80[f]
Potassium	382.40[a]	400.60[b]	415.90[c]	435.20[d]	452.00[e]	470.16[f]

* Results are means of three replicates calculated on dry weight basis.
Means in the same row with different letters are significantly different ($p \leq 0.05$).

Amino acid composition and protein quality of produced cookies

Amino acid composition and protein quality of produced cookies are shown in table (4).

Table (4): Amino acid composition (%) and protein quality parameters of cookies made of wheat flour fortified with different levels of defatted flaxseed-sesame seed meal (DFSM).

Amino acids	DFSM levels (%)					
	0	5	10	15	20	25
Lysine	1.64	1.78	1.86	1.96	2.01	2.08
Methionine[a]	1.08	1.15	1.21	1.28	1.34	1.42
Phenylalanine	5.38	5.35	5.32	5.30	5.26	5.23
Threonine	2.48	2.56	2.63	2.75	2.77	2.85
Leucine	6.10	6.50	6.53	6.55	6.58	6.61
Isoleucine	3.00	3.04	3.07	3.14	3.15	3.20
Tryptophane	1.16	1.20	1.24	1.31	1.32	1.36
Valine	3.12	3.20	3.29	3.39	3.44	3.53
Total essential amino acids	**23.96**	**24.77**	**25.13**	**25.66**	**25.85**	**26.26**
Arginine	6.79	7.15	7.53	7.89	8.26	8.61
Aspartic acid[b]	5.29	5.42	5.54	5.67	5.80	5.92
Glutamic acid[c]	36.80	35.61	34.80	34.00	33.19	32.36
Serine	4.50	4.51	4.52	4.53	4.54	4.53
Proline	8.80	8.56	8.32	8.08	7.84	7.60
Cystine	2.00	1.99	1.98	1.97	1.96	1.95
Tyrosine	3.86	3.75	3.71	3.68	3.64	3.62
Glycine	3.50	3.61	3.72	3.83	3.94	4.04
Alanine	2.60	2.69	2.78	2.86	2.94	3.03
Histidine	1.90	1.94	1.97	2.01	2.04	2.08
Total non-essential amino acids	**76.04**	**75.23**	**74.87**	**74.34**	**74.15**	**73.74**
Total sulfur amino acids	**3.08**	**3.14**	**3.19**	**3.25**	**3.30**	**3.37**
Protein quality parameters*						
PER	1.896	2.089	2.107	2.119	2.137	2.153
BV	54.13	55.37	56.08	56.97	57.42	58.04
CS	45.96	48.94	51.49	54.47	112.82	116.24
EAAI	47.56	48.91	49.75	50.96	51.39	52.29

a = Methionine + Cysteine. b=Aspartic acid+Asparagine. c = Glutamic acid + Glutamine.
* PER = Protein efficiency ratio. BV = Biological value. CS = Chemical score.
EAAI = Essential amino acid index.

Data revealed that adding DFSM had increased sulfuric amino acids and the total essential amino acids as compared to the control cookies. The total essential amino acids increased gradually with increasing DFSM levels up to 25%. This could be attributed to the high content of these amino acids in both DFM and DSM as shown in table (2).

Lysine, which is considered to be the most heat sensitive amino acid (Civitelli *et al.*, 1992), was decreased by about 18%. Lysine losses can approach 20% depending on the temperature and duration of baking of balady bread (El-Samahy and Tsen, 1981) and pizza crusts (Tsen *et al.*, 1982). Lysine deficiency in wheat products is also aggravated by losses from browning reactions during baking. Quail (1996) described that amino acids are involved in maillard reaction.

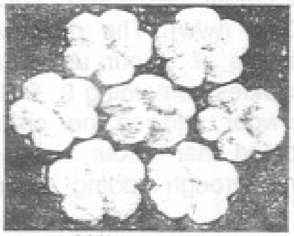
Therefore, high temperature and maillard reaction are the main reasons for lysine losses occurred during baking of cookies. Data also clarified that adding DFSM had obviously improved all quality parameters of the protein including PER, BV, CS and EAAI. This improvement increased with increasing DFSM levels up to 25%.

Sensory evaluation of cookies

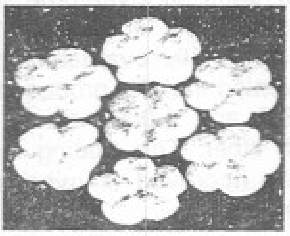
The organoleptic properties of cookies are critical as they are the specific quality attributes that attract the consumer. The various sensory quality attributes of cookies are appearance, texture, taste, colour and odour. Among them, texture is the most important (Bourne, 2002).

Cookies prepared from wheat flour (72% extraction) fortified with different levels of DFSM (Fig. 1) were organoleptically evaluated in terms of appearance, colour, odour, taste, texture, after-taste and overall acceptability. Data of sensory evaluation (Table 5) revealed that acceptable cookies that closely resembled the control (100% wheat flour) cookies were produced from wheat flour containing up to 15% DFSM flour.

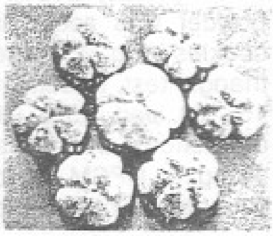
Fig. (1): Cookies produced from wheat flour fortified with different levels of DFSM.



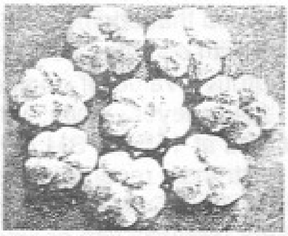
100% wheat flour.



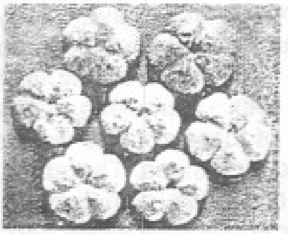
95% wheat flour + 5% DFSM



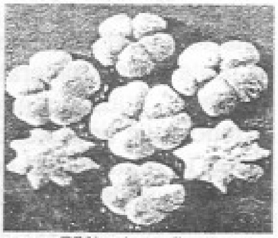
90% wheat flour + 10% DFSM



85% wheat flour + 15% DFSM



80% wheat flour + 20% DFSM



75% wheat flour +25% DFSM

Data showed that adding DFSM up to 25% did not significantly affect the taste of cookies but it had been improved (compared to the control) up to 15% DFSM. Texture of cookies was also improved by adding DFSM up to 15%. The highest texture scores were recorded for cookies containing 10% DFSM. They were described as fragile and easy to swallow. However, increasing DFSM up to 20 – 25% produced unaccepted more flaccid cookies. These textural changes were accompanied by unpleasant after-taste because of the amylaceous slimy sensation caused by the mucilage gum contained in DFM.

Table (5): Mean values of sensory scores* of cookies made of wheat flour fortified with different levels of defatted flaxseed-sesame seed meal (DFSM).

	DFSM levels (%)					
Attributes	**0**	**5**	**10**	**15**	**20**	**25**
Appearance	4.72^{a}	4.90^{ab}	4.47^{ac}	3.98^{d}	3.24^{e}	2.88^{f}
Colour	5.00^{a}	4.83^{a}	4.25^{b}	3.75^{c}	3.02^{d}	2.41^{e}
Odour	4.55^{a}	4.74^{ab}	4.88^{b}	4.07^{c}	3.57^{d}	2.99^{e}
Taste	4.49^{a}	4.64^{a}	4.75^{a}	4.٨9^{a}	٤.39^{a}	4.13^{a}
Texture	4.65^{a}	4.76^{a}	4.٨٠^{a}	4.٧٠^{a}	3.95^{b}	2.05^{c}
After-taste	4.38^{a}	4.76^{a}	4.91^{a}	4.73^{a}	2.69^{b}	1.85^{c}
Overall acceptability	4.68^{a}	4.76^{a}	4.84^{a}	4.69^{a}	3.34^{b}	2.11^{c}

Means in the same row with different letters are significantly different ($p \leq 0.05$).
*1= the lowest score while 5= the highest score.

The overall acceptability of cookies had consequently improved up to 15% DFSM but significantly decreased when increasing DFSM levels over 15%. The low sensory scores of the cookies from blends containing more than 15% DFSM flour was attributed, by the panelists, to a rough flabby texture and darkening. Colour darkening of cookies could be attributed to sugar caramelization and the Maillard reactions between sugars and amino acids (Alobo, 2001). In order to overcome the colour darkening, cocao powder was added into cookies formula as 1.00% (w/w). The produced cookies (Fig. 2) were sensorially evaluated in terms of colour using the triangle test. Results revealed that the produced cookies containing 0, 5, 10, 15, 20 and 25% DFSM and 1.00% cocao powder showed no colour differences among each other. This finding indicated that colour changes owing to DFSM could be improved or over come through adding natural colourants like cocoa powder.

Conclusion

Results of the present study have clearly revealed that adding DFSM flour to wheat flour produced highly nutritious cookies with elevated contents of protein and minerals. This improvement in the nutritive value of cookies exceeds subsequently with increasing DFSM flour level while, the organoleptic acceptance of these cookies was restricted at 15% DFSM level owing to texture and colour changes. Therefore, it is strongly recommended that the under-utilized negligible high protein DFM and DSM could be incorporated successfully at 5 – 15% levels into bakery products like cookies to combat protein deficiency and improve the nutrition and health status.

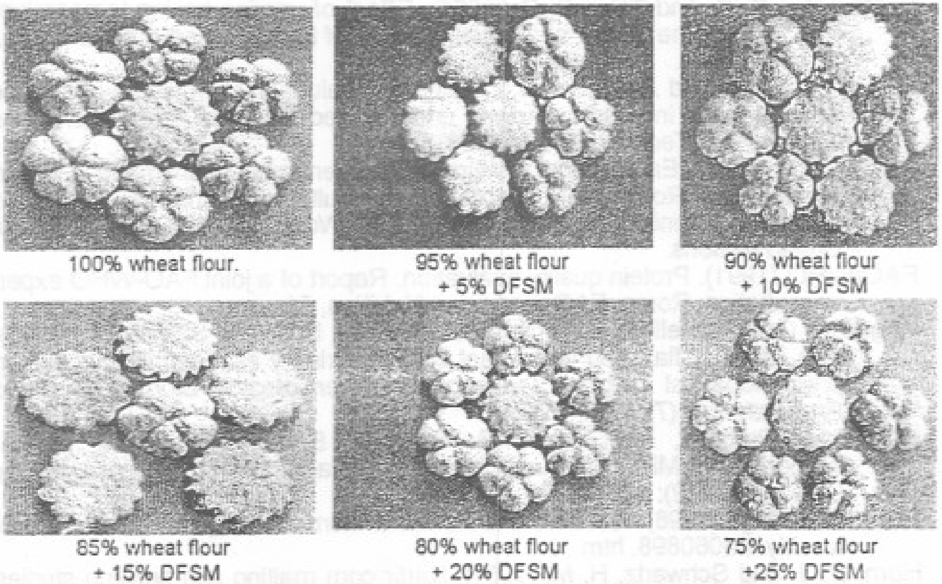


Fig. (2): Cookies produced from wheat flour fortified with different levels of DFSM with added cocao powder.

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الجودة التغذوية والحسية للكعك المدعم بكسب الكتان والسمسم

ربيع يوسف خطاب وأشرف عبد المنعم زيتون
قسم علوم الأغذية – كلية الزراعة – سابا باشا – جامعة الإسكندرية

تم إجراء هذا البحث بهدف تقييم استخدام كسب الكتان والسمسم كمادة مدعمة للكعك. تم تقييم الكعك المصنع من دقيق القمح (استخلاص ٧٢%) والمدعم بكسب الكتان والسمسم (١:١ وزن/وزن) بنسبة ٥ – ٢٥% تغذويا وحسيا. تم دراسة التركيب الكيماوي ومحتوى المعادن وتركيب الأحماض الأمينية ومؤشرات جودة البروتين للمواد المستخدمة (دقيق القمح، كسب الكتان، وكسب السمسم) وكذلك الكعك الناتج، كما تم إجراء التقييم الحسي للكعك الناتج. أوضحت النتائج أن نسب البروتين الخام في كسب الكتان، وكسب السمسم كانت مرتفعة (٣٨,٨٠، ٤٠,٠٠%، على الترتيب) مقارنة بدقيق القمح (١١,٢٦%). كما كان محتواها عالي من الأحماض الأمينية الأساسية والأحماض الأمينية الكبريتية مقارنة بدقيق القمح. أدت إضافة مخلوط كسب الكتان والسمسم الى زيادة معنوية في محتوى البروتين الخام، الرماد، الكالسيوم، الفوسفور، المغنيسيوم، والبوتاسيوم للكعك الناتج مقارنة بالكنترول (المصنع من ١٠٠% دقيق قمح). كما أدت أيضا الى زيادة محتوى الكعك من الأحماض الأمينية الأساسية وحدوث تحسن ملحوظ في معايير جودة البروتين (نسبة كفاءة البروتين PER، القيمة الحيوية للبروتين BV، الـ chemical score (CS) للبروتين، ودليل الأحماض الأمينية الأساسية EAAI) مقارنة بالكنترول. زاد التحسن في جميع الصفات السابقة بزيادة مستويات مخلوط كسب الكتان والسمسم من ٥ – ٢٥%. أوضحت نتائج التقييم الحسي للكعك الناتج أن مستويات مخلوط كسب الكتان والسمسم المضافة حتى ١٥% أعطت كعك مماثل حسيا للكنترول، وقد انخفضت قيم القراءات الحسية بزيادة نسب مخلوط كسب الكتان والسمسم عن ١٥% نظرا للتغيرات في القوام واغمقاق اللون. تم معالجة الإغمقاق الحادث في لون الكعك الناتج بإضافة مسحوق الكاكاو بنسبة ١% من مكونات الخلطة. وقد أظهرت نتائج التقييم الحسي عدم وجود اختلافات محسوسة في اللون للكعك المضاف اليه مسحوق الكاكاو عند المستويات المختلفة من مخلوط كسب الكتان والسمسم (٠ – ٢٥%). نظرا للتحسن الهائل في القيمة التغذوية للكعك المضاف إليه مخلوط كسب الكتان والسمسم، وحيث أن هذه المواد هي نواتج ثانوية منخفضة التكلفة، لذلك توصي الدراسة باستخدام مخلوط كسب الكتان والسمسم بنسبة ٥ – ١٥% في إنتاج بعض المخبوزات كالكعك، وذلك للمساهمة في حل مشكلة نقص البروتين وتحسين الحالة التغذوية والصحية.