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Development and Evaluation of Nutritionally Superior Baked Products Containing Flaxseed

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Abstract: The unleavened flat breads were prepared from Whole Wheat Flour (WWF) fortified with 16% Partially Defatted Flaxseed Flour (PDF) and 12% full fat flaxseed flour. Similarly Straight Grade Flour (SGF) used for the production of pan bread was fortified with both 12% PDF and FFF. The resultant unleavened flat breads and pan breads were analyzed for their dietary fiber, amino acid and fatty acid profile. The unleavened flat breads and breads prepared from both PDF and FFF supplemented composite flours yielded significantly higher contents of soluble, non soluble and total dietary fibers. Unleavened flat breads possessed higher dietary fiber content than those of breads. The unleavened flat breads prepared from 16% PDF supplemented WWF possessed significantly the highest content of isoleucine (1.16 g/100 g flour) and the lowest isoleucine content (0.45 g/100 g flour) was found in breads prepared from control flour (100% SGF). The results indicated that contents of all the tested essential amino acids were improved substantially by the supplementation of PDF and FFF in the wheat flours. Unleavened flat breads containing 12% FFF possessed the highest content of palmitic (0.595%) and stearic acid (0.152%). The results further indicate that an excellent ratio of linoleic acid over linolenic existed in the unleavened flat breads and breads prepared from full fat flaxseed supplemented composite flours.

Key words: Flaxseed, unleavened flat bread, amino acid profile, fatty acid profile, dietary fibers, pan bread

INTRODUCTION

The consumers demand has increased for the food products with taste, safety, convenience and nutrition. Thus nutrition has emerged an added dimension in the chain of food product development (Ahmad, 1999; Shahidi, 2002). There are many foods which are associated with health benefits and are used or sold under a variety of names like designer, novel, medical, nutraceutical and functional foods. The prospective health benefits of oil seeds such as flaxseed, especially in relation to cancer and cardiovascular disease has got more consideration by the nutrition workers and food scientists. Many researchers are conducting studies on its role in the cure and prevention of several diseases (Jenkins *et al.*, 1999). Due to health promoting properties and excellent nutrient profile of flaxseed, it has been becoming a popular candidate for incorporation in human diet. Flaxseed is being used extensively for the development of functional foods. The components of flaxseed, identified to exhibit the health benefits are fiber, lignans and linolenic acid (Omega-3 fatty acid). Moreover, flaxseed is a good source of high quality protein, soluble fibers and phenolic compounds (Oomah, 2001).

Wheat is a staple food of Pakistani people and is a leading cereal grain produced and consumed in the country. In Pakistan, about 70% of the total wheat is processed to produce the unleavened flat bread locally known as chapatti and its other culinary variants, “tandoori roti”, “nans”, “prathas” and “poories”. The rest of the 30% is used for other bakery products such as breads, cookies, cakes and pastries. Wheat is the cheapest source of protein and calories for the inhabitants of Pakistan. The quality of wheat based products can be improved by supplementing them with other cheap and healthy plant based food materials.

The incorporation of flaxseed into diet can help to have a superior taste in regularly consumed dishes. The reddish brown flaxseed grains have a pleasant flavour and taste resembling nuts and its utilization is simple in different products. It can be spread over soups, salads, cereals or yoghurt. The baked products can be supplemented with whole flaxseed grains to achieve an attractive and appealing form with enhancement in the texture of final product. The grinding of flaxseed before its addition to products can be more beneficial to obtain the prospective health benefits from its active components like dietary fiber, lignans and Omega-3 fatty

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acids. Several researchers has investigated that ground flaxseed or whole flaxseed grains can be replaced with wheat flour used for the production of pancake, muffins, breads and cookies. Several food products containing flaxseed are available in the market. The energy bars, pasta, bagels, muffins and pancakes are some of the examples of products with added flaxseed either in whole or its ground form (Muir and Westcott, 2000; Manthey *et al.*, 2002). Keeping in view the medicinal and nutritional benefits of the flaxseed, present study was undertaken to improve the nutritional and functional properties of unleavened flat breads and pan breads by the fortification of wheat flour with flaxseed flours.

MATERIALS AND METHODS

Preparation of unleavened flat breads: The unleavened flat breads were prepared from whole wheat flour fortified with 16% Partially Defatted Flaxseed Flour (PDF) and 12% Full Fat Flaxseed Flour (FFF) based on their maximum acceptability in preliminary sensory trials. The dough for unleavened flat bread was made by mixing 200 g of whole wheat flour with predetermined quantity of water for 3 minutes and allowed to rest for 30 minutes. A dough piece weighing 80 g was rolled on a sheet of 2 mm thickness with a wooden roller pin on a specially designed wooden platform and cut into circle of 17 cm diameter. The unleavened flat breads were baked on thermostatically controlled hot plate at a temperature of 210°C for 1.5 min (Haridas *et al.*, 1986).

Preparation of the pan bread: The pan breads were prepared from both 12% PDF and FFF fortified straight grade flours following the straight dough method as described in AACC (2000) method No. 10-10B.

Analysis of bakery products

Dietary fiber analysis: Each product (pan bread or unleavened flat bread) was analyzed for Total Dietary Fiber (TDF), Soluble Dietary Fiber (SDF) and non Soluble Dietary Fiber (NSDF) contents according to their respective gravimetric methods as mentioned in AACC (2000) by employing the Megazyme Assay Kits (Megazyme International, Ireland Ltd; Wicklow, Ireland).

Amino acids profile: The profile of essential amino acids in each selected product was determined by using ion-exchange chromatography with automatic Amino Acid Analyzer, (Hitachi L8500, Tokyo, Japan), by following the method outlined by Adeyeye and Afolabi (2004). Two grams of ground product samples were defatted through soxhlet extraction methods. The defatted sample were re-dried and milled into fine powder. The 30mg ground sample was weighed into glass ampoules and 5 ml of 6 M HCl and 5 µmol norleucine were added. The ampoules were evacuated with liquid nitrogen and sealed with burner flame and hydrolyzed in an oven at 110°C for 24 h. The ampoules were cooled, broken at the tip and the contents were passed through filter. The filtrates were dried in rotary evaporator at 40°C under vacuum. The residues were dissolved to 5 µL (for acid and neutral amino acids) or 10 µL (for basic amino acids) with acetate buffer, pH 2.2 and the solutions were dispensed into the cartridge of amino acid analyzer. The quantification was performed by comparing the peak area of each amino acid in the sample to the area of the corresponding standard amino acid of the protein hydrolysate.

Fatty acids profile: The profile of fatty acids in each selected product sample was estimated according to the method described in AOCS (1998). The fat extracted from each sample was used to estimate the fatty acids profile. The fatty acids were converted to their respective methyl esters prior to analysis through Gas Chromatograph (Agilent Technologies, 6890N). The oil sample (50 µl) was methylated in 4 ml KOH for 1 h at room temperature. The resultant esters were extracted with HPLC grade hexane and analyzed by GC using fused capillary column (Silica 30 m x 0.25), Flame Ionization Detector (FID) and nitrogen gas as a carrier (3.5 ml/min). Operating conditions were maintained as split ratio 50%; injector and detector temperature 260°C and column oven temperature was 222°C for 7.5 min. The fatty acids were identified by retention time comparing them with the fatty acids standards provided by Sigma.

Statistical analysis: The data obtained for each parameter was subjected to statistical analysis using Minitab statistical package (Minitab Quality Companion, 2003). The level of significance was determined by applying analysis of variance technique (one way ANOVA). Significant ranges were further postulated using DMR mean comparison test (Steel *et al.*, 1997).

RESULTS AND DISCUSSION

Analysis of the selected bakery products: The selected bakery products i.e unleavened flat breads and pan breads prepared from flaxseed fortified flours were tested for their total, soluble and insoluble dietary fiber contents. The products were also analyzed for their essential amino acids and fatty acids profile. The results of these analyses are presented in this section.

Dietary fiber: Statistical results revealed a significant ($p \leq 0.05$) difference among different products containing either PDF or FFF. The total dietary fiber content was found to be significantly the highest (17.45%) in unleavened flat breads supplemented with 16% PDF (C_1) as compared to other unleavened flat breads and pan breads (Table 1). The breads prepared from 100% Straight Grade Flour (SGF) i.e (B_0) possessed

Table 1: Dietary fibers contents of selected unleavened flat breads and pan breads

Products	TDF %	SDF %	NSDF %
C_0	12.64c	1.74c	10.90b
C_1	17.45a	3.98a	13.47a
C_2	14.58b	2.68b	11.90b
B_0	3.40f	0.82d	2.68d
B_1	8.30d	2.56b	5.74c
B_2	6.58e	1.86c	4.72c

Means carrying same letters in a column are not significantly different from each other. C_0 = Control unleavened flat bread (100% WWF); C_1 = Selected unleavened flat bread 1 (16% PDF + 84%WWF); C_2 = Selected unleavened flat bread 2 (12% FFF + 88%WWF); B_0 = Control pan bread (100% SGF); B_1 = Selected pan bread 1 (12% PDF + 88%SGF); B_2 = Selected pan bread 2 (12% FFF + 88% SGF); TDF = Total Dietary Fiber; SDF = Soluble Dietary Fiber; NSDF = Non Soluble Dietary Fiber

significantly the lowest (3.40%) content of TDF. The unleavened flat breads contained higher TDF than those of pan breads. It is obvious from the results that significantly the highest (3.98%) Soluble Dietary Fiber (SDF) was recorded in unleavened flat breads containing 16% partially defatted flaxseed flour (C_1). The pan breads prepared from 12% PDF (B_1) and unleavened flat breads containing 12% FFF (C_2) possessed statistically similar contents of SDF. The contents of non soluble dietary fiber also followed the same trend as was observed for total and soluble dietary fibers in different bakery products i.e unleavened flat breads and breads. The unleavened flat breads and breads prepared from both PDF and FFF supplemented composite flours yielded significantly higher contents of soluble, non soluble and total dietary fibers. It is also evident from the results that unleavened flat breads possessed higher dietary fiber content than those of breads. Flax Council of Canada reported that dietary fiber is a major form of non digestible carbohydrates in flaxseed. Daun *et al.* (2003) reported about 28% dietary fiber in flaxseed. The soluble fiber of flaxseed is known as mucilage (Calder, 1998). The addition of dietary fiber in bread can help to improve its nutritional properties (Knuckles *et al.*, 1997). The results of the present study are in line with the earlier studies conducted by Gambus *et al.* (2004) and Gambus *et al.* (2003), who reported that dietary fiber contents of breads, muffins and cookies improved due to the supplementation of flaxseed in wheat flours. The findings of the above mentioned researchers indicated that flaxseed is rich in soluble, non soluble and total dietary fibers and the addition of flaxseed resulted in the improvement of dietary fiber contents of products in which it is present. Thus the improvement in the dietary fibers contents (TDF, SDF and NSDF) of unleavened flat breads and pan breads observed during the present study may be attributed to the higher contents of dietary fibers of flaxseed. Improvement of dietary fiber contents of unleavened flat breads and breads observed during the study can offer a number of health benefits.

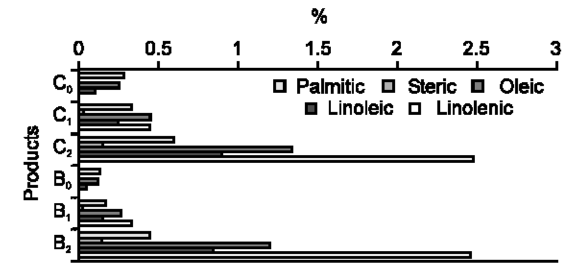
Table 2: Essential amino acid profile of selected unleavened flat breads and pan breads

	Lysine	Isoleucine	Leucine	Threonine
Products	------------- (g/100 g) -------------			
C_0	0.46c	0.61d	1.11c	0.49d
C_1	1.03a	1.24a	1.92a	1.13a
C_2	0.93ab	1.15bc	1.82ab	1.04b
B_0	0.29d	0.45e	0.89d	0.35e
B_1	0.92ab	1.16b	1.81ab	1.03bc
B_2	0.87b	1.09c	1.72b	0.97c
	Valine	Histidine	Methionine	Arginine
Products	------------- (g/100 g) -------------			
C_0	0.75c	0.39c	0.26c	0.78c
C_1	1.45a	0.78a	0.58a	2.36a
C_2	1.36ab	0.73ab	0.53b	2.14b
B_0	0.52d	0.30d	0.23c	0.52d
B_1	1.35ab	0.72ab	0.53b	2.13b
B_2	1.27b	0.68b	0.50b	1.97b

C_0 = Control unleavened flat bread (100% WWF); C_1 = Selected unleavened flat bread 1 (16% PDF + 84%WWF); C_2 = Selected unleavened flat bread 2 (12% FFF + 88%WWF); B_0 = Control pan bread (100% SGF); B_1 = Selected pan bread 1 (12% PDF + 88%SGF); B_2 = Selected pan bread 2 (12% FFF + 88% SGF)

Essential amino acid contents: The unleavened flat breads prepared form 16% PDF supplemented WWF yielded significantly the highest content of lysine (1.03 g/100 g flour) followed by the unleavened flat breads prepared fortified with 12% FFF i.e 0.93 g/100 g flour (Table 2). The lowest content of lysine (0.29 g/100 g flour) was found in breads prepared from 100% SGF (B_0). The unleavened flat breads prepared from 16% PDF supplemented WWF (B_1) possessed significantly the highest content of isoleucine (1.16 g/100 g flour) and the lowest isoleucine content (0.45 g/100 g flour) was found in breads prepared from control flour (100% SGF). The unleavened flat breads containing 12% FFF (C_2) and breads containing 12% PDF exhibited leucine content statistically similar with each other. The threonine, valine, histidine, methionine and arginine contents were 1.13 g/100 g, 1.45 g/100 g, 0.78 g/100 g, 0.58 g/100 g and 2.36 g/100 g, respectively in unleavened flat breads having 16% PDF. The control breads (B_0) possessed significantly the lowest contents of threonine, valine, histidine, methionine and arginine. The results indicated that contents of all the tested essential amino acids were improved substantially by the supplementation of PDF and FFF in the wheat flours. It is also evident that unleavened flat breads possessed higher contents of all the essential amino acids than the breads. The cereal based diets are responsible to divest the indispensable amino acids (Seena *et al.*, 2006). Total lysine variation in common wheat protein has not been found more than 0.5 %, which is less than needed for nutritional balance (Johnson *et al.*, 1985). Lysine is the first limiting amino acid in the breakfast cereals (Meredith and Castor, 1984). Nine essential amino acids: histidine, leucine, isoleucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine are required by humans (Sinclair, 2005). The profile of essential amino acids of flaxseed is similar to the amino acid profile of soy which is balanced as compared to most of other plants proteins (Youle and Huang, 1981). The essential amino acids components of flaxseed has been found as lysine 4.0 mg, valine 4.6 mg, histidine 2.2 mg, methionine 1.5 mg, arginine 9.2 mg, leucine 5.8 mg and isoleucine 4.0 mg/100 g of protein. The composition of same amino acids of soy as compared to flaxseed have been reported as lysine 5.8 mg, valine 5.2 mg, histidine 2.5 mg, methionine 1.2 mg, arginine 7.3 mg, leucine 7.7 mg and isoleucine 4.7 mg / 100 g of protein (Morris, 2004). Madusudhan and Singh (1985) reported that flaxseed is good in lysine, cystein, glutamic acid and glycine. The deficiency of methionine in flaxseed has been reported by McDonald *et al.* (2002). The present study showed that addition PDF and FFF in pan breads and unleavened flat breads improved substantially the level of essential amino acids especially lysine which is first limiting amino acid in cereals including wheat. It is noticed that addition of PDF in both baked products resulted more improvement of essential amino acids as compared to FFF supplementation in both bakery products though in both cases the improvement was evident. The PDF containing more contents of essential amino acids contributed more towards increasing the level of amino acids as compared to FFF. The flaxseed supplemented unleavened flat breads possessed higher contents of essential of essential amino acids as compared to flaxseed supplemented breads which might be due to the reason that WWF contained higher contents of essential amino acids as compared to SGF. The results found in the present study suggested that use of flaxseed either partially defatted or full fat in the wheat flour enhanced the level of all the eight determined essential amino acids. Thus it may be concluded that flaxseed supplemented in wheat flour will provide bakery products with better nutrition and improved level of lysine content. This can help to overcome the malnutrition problem especially due to protein quantity and quality in the diets of developing countries.

Fatty acid contents: The distribution of fatty acids in the oils extracted from different bakery products is illustrated in Fig. 1. The fatty acids like palmitic, stearic, oleic, linoleic and linolenic were found in unleavened flat breads and breads. It is obvious from the results that unleavened flat breads containing 12% FFF (C_2) possessed the highest content of palmitic (0.595%) and stearic acid (0.152%). The lowest palmitic acid (0.132%) and stearic acid (0.004%) contents were recorded in B_0. Oleic acid was found to be highest in unleavened flat breads containing 12% FFF while the lowest oleic acid (0.12%) content was recorded in breads prepared from 100% SGF (control). Figure 1 showed that unleavened



	B2	B1	B0	C2	C1	C0
Palmitic	0.444	0.174	0.132	0.595	0.339	0.283
Steric	0.148	0.023	0.004	0.152	0.034	0.008
Oleic	1.2	1.266	0.12	1.336	0.45	0.256
Linoleic	0.843	0.158	0.051	0.9	0.251	0.108
Linolenic	2.46	0.335	0.001	2.474	0.447	0.002

Fig. 1: Fatty acids profiles of selected unleavened flat breads and pan breads. C_0 = Control unleavened flat bread (100% WWF); C_1 = Selected unleavened flat bread 1 (16% PDF + 84%WWF); C_2 = Selected unleavened flat bread 2 (12% FFF + 88%WWF); B_0 = Control pan bread (100% SGF); B_1 = Selected pan bread 1 (12% PDF + 88%SGF); B_2 = Selected pan bread 2 (12% FFF + 88% SGF)

flat breads having 12% FFF (C_2) possessed the highest linoleic acid (0.9%) and linolenic acid (2.474%) among all bakery products. The linolenic acid is the most important fatty acid which is polyunsaturated fatty acid and has major concern on health from nutritional point of view. Higher contents of this essential fatty acids are well evident in the unleavened flat breads and breads prepared from full fat flaxseed supplemented composite flours. It is clearer from the results that unleavened flat breads possessed substantially higher amount of total unsaturated fatty acids. The mono and polyunsaturated fatty acids content of the unleavened flat breads prepared from 12% FFF supplemented WWF (C_2) were 1.336% and 3.374%, respectively. The results showed that bakery products prepared from flaxseed supplemented composite flours possessed the highest contents of linoleic and linolenic acid) which was found as the most plentiful polyunsaturated fatty acid in these products). The results further indicate that an excellent ratio of linoleic acid over linolenic existed in the unleavened flat breads and breads prepared from full fat flaxseed supplemented composite flours. The medical research has shown that the excessive level of linoleic acid relative to linolenic acid may increase the probabilities of a number of diseases (Hibbeln, 2006). WHO/FAO (2003) has suggested that a 5:1 to 10:1 omega 6 to omega 3 ratios is preferred for better health. However, it has been suggested by Hu (2001) that linoleic to linolenic acid ratio of 10 or less results in reduction of cardiovascular diseases. The unleavened flat breads and breads prepared from 12% FFF supplemented WWF possessed linoleic to linolenic acid ratios as the ranges reported above. The results of the present study showed an excellent ratio of linoleic to linolenic acid in bakery products due to supplementation of full fat flaxseed flour. Nikolic *et al.* (2008) reported that fatty acid profile of wheat flour can be improved by its supplementation with rice flour because wheat flour is deficient in linolenic acid. The results of present study are in line with the findings of Gambus *et al.* (2004) who found that addition of 10-13% flaxseed in bread resulted in the about 800-1000 time enhancement of linolenic acid content of bread as compared to control bread prepared from non flaxseed supplemented flour. Ziemlanski (1997) also observed an increase in linolenic acid content of wheat bread and pastry supplemented with linseed meal. The improvement in fatty acids profile of different bakery products in the present study is due to the higher contents of linolenic acid of flaxseed oil. Eckey (1954) and Daun *et al.* (2003) have reported that traditional flaxseed has very high levels of Alpha Linolenic Acid (ALA), usually making up greater than 50% of the total fatty acids. The other fatty acids include palmitic (5%), stearic (3%), oleic (18%) and linoleic (14%). The study indicated that use of flaxseed in unleavened flat breads and breads results in higher contents of unsaturated fatty acids. This indicates that the use of flaxseed supplemented unleavened flat breads and pan breads can be helpful for the consumers having issues with their cardiovascular health.

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