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SENSORY AND NUTRITIONAL CHARACTERISTICS OF BREAD SUPPLEMENTED WITH LINSEED FLOUR

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ABSTRACT

Effect of supplementation of linseed flour at different levels was assessed on organoleptic acceptability and nutritional quality of bread. Supplementation of wheat flour with linseed flour was done at 10, 20, 30 and 40% levels. Addition of linseed flour up to 30% levels produced acceptable bread in terms of their baking and sensory characteristics. Overall organoleptic acceptability (crumb colour, crumb texture, aroma, appearance and taste) of all supplemented breads were found in the category of 'liked moderately' to 'liked very much'. Among the supplemented breads, 30% linseed flour supplemented bread had highest overall acceptability score in terms of colour, appearance, aroma, crust texture and taste and found in the category of 'liked very much'. Thirty percent linseed fortified bread yielded significantly higher contents of protein (13.62%), total dietary fibre (17.52%), soluble fibre (4.99%), insoluble fibre (12.53%), linoleic acid (11.29% of total fatty acids) and linolenic acid (20.78% of total fatty acids). Calcium, phosphorus, magnesium, iron and zinc were also found significantly higher in supplemented bread as compared to control bread. Supplemented bread can be stored up to 2 days at ambient temperature and 4 days at refrigeration temperature without any adverse effect on sensory evaluation. Improved nutritional quality bread could be developed by supplementation of linseed flour up to 30% level without any adverse effect on baking and organoleptic characteristics.

Key words: Linseed flour, wheat flour, bread, baking, organoleptic, nutritional and storage

INTRODUCTION

Bread is one of the most popular bakery products, generally made from refined wheat flour which is rich source of protein, fat and carbohydrates but limiting in minerals and dietary fibre. Hence, the quality of these products can be improved by supplementing them with other healthy plant based food materials (Maheswari and Devi, 2006; Ganorkar and Jain, 2014). There are many foods which are associated with health benefits and are used or sold under a variety of names like designer, novel, medicinal, nutraceutical and functional foods. Among them, linseed/flaxseed has become popular ingredient for incorporation in bakery products due to its health and nutritional properties.

Linseed/flaxseed is an essential source of high quality protein, soluble fibre, minerals and phytochemicals. The insoluble dietary fiber fraction of linseed plays an important role in the relief of constipation, improves colon health and may have protective effect against colon cancer. The soluble dietary fiber fraction of linseed is found primarily as mucilage gums which have been shown to play a role in lowering serum glucose and cholesterol level (Rubilar *et al*., 2010; Martinchik *et al.*, 2012).

Linseed has a unique fatty acid profile with low level (approximately 9%) of saturated fatty acids (palmitic and stearic), moderate level (18%) of monounsaturated fatty acids (mainly oleic acid) and high concentration (73%) of polyunsaturated fatty acid (PUFA). The PUFA content comprises particularly alpha-linolenic acid (ALA), the essential omega-3 fatty acid and linoleic acid (LA), the essential omega-6 fatty acid. It is the world richest source of omega-3 fatty acid over two times higher the amount of omega-3 fatty acid present in fish oil, which reducing the risk factors for cardiovascular diseases, stroke and inflammatory disorders (Hussain *et al.*, 2012; Parameshwari and Nazni, 2012). Keeping in view the nutritional and health benefits of linseed, present study was conducted to improve the nutritional properties of bread by the incorporation of linseed flour in wheat flour.

MATERIALS AND METHODS

PROCUREMENT OF MATERIAL

A wheat variety (WH-1105) was procured from Wheat and Barley Section of Department of Genetics and Plant Breeding, CCSHAU, Hisar. Linseed and other ingredients for development of bread were purchased from the local market.

PREPARATION OF COMPOSITE FLOUR

Wheat grains and linseed seed samples were cleaned manually to remove dirt particles and other foreign materials. Linseed seeds were lightly roasted and ground to obtain fine flour. Wheat grains were also ground to obtain fine flour. Linseed flour was blended with wheat flour at 10, 20, 30 and 40 % levels.

PREPARATION OF BREAD

The bread making performances of control and composite flour was determined using straight dough method as given by AACC (1984). The bread formula for each loaf included flour 100 g (14% mb), yeast 3.5 g, salt 1.75 g, sugar 8 g and an adequate amount of water to obtain dough of optimum consistency. The following baking schedule was adopted: mixing 3 min; fermentation 1 h 40 min at 30°C ± 1°C and 85% RH; degassing, proofing 55 min at 30°C ± 1°C, 85% RH, and baking for 20 min at 213°C ± 1°C.

BAKING CHARACTERISTICS

Breads from control and linseed fortified flours (i.e. 10, 20, 30 and 40% levels) were baked in replicates. After removing from the oven, loaves were immediately weighed and then placed on a wire grid for 2 h before volumes were determined. Loaf volume was measured by the rapeseed displacement method. Specific loaf volume was calculated by dividing the loaf volume by loaf weight and the results were expressed as ml/g.

ORGANOLEPTIC CHARACTERISTICS

Most acceptable blended breads were selected for nutritional evaluation. Their organoleptic characteristics were determined by a panel of 10 judges for crust colour, appearance, aroma, crust texture, taste and overall acceptability using a nine point Hedonic Rating Scale ranging from like extremely (9) to dislike extremely (1) for each organoleptic characteristics.

NUTRITIONAL EVALUATION OF ACCEPTABLE BREAD

On the basis of organoleptic acceptability, 30% supplemented bread was selected for further nutritional analysis. Proximate composition was estimated by employing the standard method of analysis (AOAC, 2000). Total, soluble and insoluble dietary fibre contents were determined by following the enzymatic method (Furda, 1981). For mineral estimation, the samples were wet acid-digested, using a nitric acid and perchloric acid mixture (HNO_3:$HClO_4$, 5:1 w/v). The total amounts of Ca, Mg, P, Fe and Zn in the digested samples were determined by Atomic Absorption Spectrophotometry (Lindsey and Norwell, 1969). Fatty acid composition such as palmitic, stearic, oleic, linoleic and linolenic was estimated by the method of gas liquid chromatography (Vasudev *et. al.*, 2008).

STORAGE OF ACCEPTABLE BREAD

Control and supplemented breads were packed in polythene bags and stored for 7 days at room temperature as well as at refrigerator temperature. Sensory evaluation of stored breads was carried out at different intervals by a panel of ten judges as discussed earlier. Fat acidity contents were determined by the method of AOAC (2000).

STATISTICAL ANALYSIS

The data were statistically analysed in complete randomized design for analysis of variance according to the standard method (Sheoran and Pannu, 1999).

RESULTS AND DISCUSSION

BAKING CHARACTERISTICS

The results of baking characteristics such as loaf volume, loaf weight and specific loaf volume of bread made from wheat flour and wheat-linseed composite flours are presented in Table 1.

Table 1. Physical characteristics of linseed flour supplemented bread

Bread	Loaf weight (g)	Loaf volume (ml)	Specific loaf volume (ml/g)
Control (100% WF)	160.00±0.59	520.00±0.57	3.25±0.03
Supplemented (WF : LF)			
90 : 10	160.51±0.50	515.00±0.59	3.20±0.02
80 : 20	165.00±0.53	500.00±0.83	3.03±0.09
70 : 30	167.00±0.54	488.00±0.76	2.92±0.06
60 : 40	169.50±0.55	480.00±0.69	2.83±0.02
CD (P<0.05)	2.54	0.90	0.09

Values are mean ± SE of three independent determinations
WF = Wheat flour LF = Linseed flour

The loaf volume of bread made from control (100% wheat flour) was 520 ml. However, a significant reduction in loaf volume was observed as the level of supplementation with linseed flour was increased. The values of loaf volume ranged from 480 to 515 ml of breads prepared from composite flour containing linseed flour at 10, 20, 30 and 40% levels. Maximum reduction was observed at 40% level. This might be due to the dilution effect on gluten content with the addition of non-wheat flour to the wheat flour (Bashir *et al*., 2006). Whereas loaf weight increased with the increase in the level of linseed flour in wheat flour. Loaf weight of control bread was 160 g which increased significantly in the bread prepared from 10, 20, 30 and 40% wheat-linseed composite flours. Loaf weight of bread prepared from 40% wheat-linseed composite flour was significantly higher as compared to control one. These results are in accordance with the previous studies (Hooda and Jood, 2005; Mepba *et al.*, 2007; Chaudhary, 2011). It was reported that blended doughs retained less gas, hence providing a dense texture to final bread which is not desirable.

ORGANOLEPTIC CHARACTERISTICS

The replacement of wheat flour with different proportions of linseed flour resulted in considerable changes in the sensory properties of bread (Table 2).

Table 2- Mean scores of organoleptic characteristics of linseed flour supplemented bread

Bread	Colour	Appearance	Aroma	Texture	Taste	Overall acceptability
Control (100% WF)	8.00±0.12	8.00±0.13	7.80±0.10	7.80±0.09	7.80±0.06	7.88±0.17
Supplemented (WF : LF)						
90 : 10	7.90±0.11	7.80±0.12	8.00±0.11	7.80±0.12	8.00±0.17	7.90±0.18
80 : 20	7.90±0.12	7.80±0.13	8.00±0.12	7.70±0.11	8.30±0.16	8.00±0.19
70 : 30	7.80±0.10	7.80±0.10	8.30±0.09	7.70±0.13	8.30±0.18	8.05±0.20
60 : 40	6.00±0.09	7.40±0.09	7.30±0.16	7.00±0.08	7.20±0.11	6.98±0.18
CD (P<0.05)	0.15	0.12	0.10	0.14	0.17	0.19

Values are mean ± SE of ten panelists WF = Wheat flour LF = Linseed flour

As the level of linseed flour increased, crust colour of the supplemented breads changed from creamish white to dull brown. Similar results were also reported by Hooda and Jood (2005) in wheat-fenugreek supplemented bread, Dhingra and Jood (2006) in wheat-barley-soyabean supplemented bread and Rathi and Mogra (2013) in wheat-linseed supplemented bread. As linseed flour alongwith bread-flour is a contributor of protein, an intense Maillard Browning reaction occurred in the crust. Therefore, increased levels of linseed flour enhanced Maillard Browning reaction as well as due to its brown colour which contributed in darkening the bread crust colour (Whistler and BeMiller, 1997). The work of other researchers also supported the findings of the present study as Koca and Anil (2007) showed that crumb darkness increased by increasing the level of flaxseed flours. Mean scores of appearance and crust texture of supplemented breads were found in the category of 'liked moderately'. Aroma and taste are the important criteria used for sensory evaluation. Control bread received lower mean score (7.80) for aroma and (7.80) for taste which fell in the category of 'liked moderately'. Whereas, aroma and taste of supplemented breads improved on increasing the level of linseed flour supplementation. The scores ranged from 8.00 to 8.30 for aroma and 8.00 to 8.30 for taste up to 30% level, which fell in the category of 'liked very much'. It might be due to nutty flavour of linseed flour. Similar results were also reported in breads prepared from wheat-linseed composite flours (Hussain *et at*., 2011; Kaur *et al*., 2013).

Among the supplemented breads, 30% linseed flour supplemented bread had highest overall acceptability score in terms of colour, appearance, aroma, crust texture and taste. Which was found in category of 'liked very much', therefore these were selected for nutritional and storage studies.

NUTRITIONAL CHARACTERISTICS OF ACCEPTABLE BREAD

Proximate and dietary fibre contents of control and 30% linseed flour supplemented breads are presented in Table 3.

Table 3. Proximate and dietary fibre contents of control and linseed flour supplemented bread (%, on dry matter basis)

Nutritional composition	Control (100% WF)	Supplemented (WF : LF:: 70:30)	't' value
Proximate composition			
Moisture	30.47±0.20	31.83±0.16	2.13*
Protein	10.54±0.19	13.62±0.30	5.74**
Fat	4.38±0.20	16.81±0.40	7.51**
Crude fibre	1.21±0.04	2.49±0.27	3.55*
Ash	1.59±0.02	2.50±0.02	3.14*
Dietary fibre			
Total dietary fibre	8.39±0.21	17.52±0.30	8.62**
Soluble dietary fibre	1.21±0.02	4.99±0.26	5.56**
Insoluble dietary fibre	7.18±0.23	12.53±0.51	3.08*

Values are means ± SE of three independent determinations

Moisture content in control bread was 30.47% which significantly (P<0.05) increased in 30% linseed supplemented bread i.e. 31.83%. This can be attributed due to soluble fibre (mucilage) present in flaxseed which has higher moisture retention property. Similar results were also reported by Morris (2007) and Ganorkar and Jain (2014) in linseed flour supplemented bread and *chapattis*. Protein (10.54%) and fat (4.38%) contents in control bread were found significantly (P<0.01) lower as compared to 30% linseed supplemented bread i.e. 13.62% protein and 16.81% fat. Similarly, crude fibre and ash content in linseed supplemented bread was also found significantly higher as compared to control bread. It might be due to very high content of protein (16-20%), fat (40-45%), crude fibre (9-11%) and ash (3-4%) in linseed varieties as reported earlier by Singh (2009) and Hussain *et al.* (2012).

Linseed flour supplemented bread exhibited higher values of total dietary fibre 17.52%, soluble dietary fibre 4.99% and insoluble dietary fibre 12.53% as compared to control. Dietary fibre contents of supplemented bread were significantly increased with the supplementation of 30% linseed flour might be due to very high percentage of total, soluble and insoluble dietary fibre in linseed as reported earlier by other workers (Singh, 2009; Hussain *et al.*, 2012).

With regard to minerals, control bread contained 57.49, 170.51, 85.74, 5.16 and 2.56 mg/100g, calcium, phosphorus, magnesium, iron and zinc, respectively (Table 4).

Table 4. Mineral and fatty acid profile of control and linseed flour supplemented bread (on dry matter basis)

Nutritional composition	**Control** (100% WF)	**Supplemented** (WF : LF:: 70:30)	**'t' value**
Total minerals (mg/100 g)			
Calcium	57.49±3.20	98.49±3.17	12.78**
Phosphorus	160.51±2.62	223.36±7.26	8.13**
Magnesium	85.74±2.91	121.75±2.81	18.73**
Iron	5.16±0.05	5.88±0.03	1.92^{NS}
Zinc	1.56±0.03	2.80±3.99	4.00*
Fatty acid profile (% of total fatty acids)			
Palmetic acid	41.07±0.06	30.47±0.11	7.11**
Stearic acid	18.73±0.07	10.86±0.09	5.94**
Oleic acid	14.36±0.07	11.76±0.10	2.74*
Linoleic acid	6.74±0.10	11.29±0.06	4.50*
Linolenic acid	ND	20.78±1.80	-

Values are means ± SE of three independent determinations

Whereas, linseed supplemented (30%) bread contained significantly higher contents of all the minerals. The values ranged from 98.49, 253.36, 121.75, 5.88 and 3.80 mg/100g calcium, phosphorus, magnesium, iron and zinc, respectively. The increase in mineral contents of supplemented products might be due to high contents of calcium, phosphorus, magnesium and zinc in linseed flour as compared to wheat flour (Singh, 2009).

Fatty acid profile of control and supplemented breads are given in Table 4. Saturated (palmitic and stearic acid) and monounsaturated (oleic acid) fatty acids were found significantly (P<0.01) higher in control bread than 30% linseed supplemented bread. Whereas, 30% linseed supplemented bread had significantly higher contents of polyunsaturated fatty acids such as linoleic acid (omega-6 fatty acid) and linolenic acid (omega-3 fatty acid). The values of linoleic and linolenic acids were 11.29 and 20.78% of total fatty acids, respectively in supplemented breads. In case of control bread, lonolenic acid (omega-3 fatty acid) was not detected. The results of present study are in line with the findings of Gambus *et al*. (2004) who reported that wheat flour is deficient in linolenic acid which can be improved by many folds with the supplementation of linseed flour. Similar results were also reported by other workers in linseed supplemented *chapatti*, biscuits and *chikki* (Singh, 2009; Moraes *et al*., 2010; Hussain *et al*., 2012).

EFFECT OF STORAGE ON ORGANOLEPTIC ACCEPTABILITY

Control and 30% linseed flour supplemented breads were stored in polyethylene zip bags at ambient room temperature and at refrigeration temperature (Table 5).

Table 5. Effect of storage on overall acceptability of control and linseed flour supplemented bread at room temperature and refrigeration temperature

	Storage days							**CD**
Bread	**Room Temp**				**Refrigeration Temp**			**(P<0.05)**
	0	**2**	**4**	**7**	**2**	**4**	**7**	
Control (100% WF)	7.88 ±0.09	7.84 ±0.12	6.06 ±0.11	4.84 ±0.08	7.90 ±0.11	7.44 ±0.10	4.82 ±0.08	1.56
Supplemented (WF: LF) 70:30	7.98 ±0.12	7.72 ±0.08	6.66 ±0.10	4.68 ±0.13	7.82 ±0.08	7.10 ±0.11	4.78 ±0.13	1.38
't' value	NS	NS	NS	NS	NS	NS	NS	

Values are mean ± SE of ten panelists WF = Wheat flour LF = Linseed flour
NS= Non-significant

The control and 30% linseed flour supplemented breads were stored till consumer acceptability. It was observed that breads (control and supplemented) were found acceptable up to 2 days at room temperature and up to 4 days at refrigeration temperature without any significant change in all sensory attributes. At room temperature, upto 2 days overall acceptability of control and supplemented bread was found in the category of 'liked moderately' but on 4th day of storage, a significant reduction was observed in mean scores of flavour and taste. Whereas at refrigeration temperature till 4th day of storage, mean scores of all sensory attributes of control and supplemented breads were found in the category of 'liked moderately'. But further increase in storage period caused significant reduction in all sensory characteristics. Other workers also reported similar results in stored supplemented breads (Alpaslan and Hyata, 2006; Hussain *et al*., 2011).

EFFECT OF STORAGE ON FAT ACIDITY

The data on fat acidity content of control and supplemented breads at room temperature and refrigeration temperature are presented in Table 6.

Table 6. Effect of storage on fat acidity (mg KOH/100g) of control and linseed flour supplemented bread (on dry matter basis)

Bread	Storage days							CD (P<0.05)
	Room Temp				Refrigeration Temp			
	0	2	4	7	2	4	7	
Control (100% WF)	20.54 ±0.84	24.64 ±0.81	29.74 ±0.73	35.90 ±0.25	23.35 ±0.72	28.50 ±0.73	34.60 ±0.24	1.29
Supplemented (WF : LF) 70 : 30	23.68 ±0.63	32.77 ±0.69	42.87 ±0.54	51.97 ±0.56	30.50 ±0.99	40.45 ±0.41	50.65 ±0.30	1.24
't' value	2.14*	7.92**	12.19**	13.57**	2.15*	7.82**	13.52**	

Values are mean ± SE of three independent determinations   * Significant at 5% level
LF = Linseed flour   WF = Wheat flour

With regard to fat acidity content of control and 30% linseed flour supplemented bread, it was observed that control bread had 20.54 mg KOH/100g on 0 day, whereas supplemented bread had 23.68 mg KOH/100g on 0 day, which found to be increased significantly with the increase in storage intervals. Similar trend was also observed at refrigeration temperature. But increase in fat acidity content of control and supplemented breads at room and refrigeration temperature were found still within the acceptable level on 2nd and 4th days, respectively as per BIS specification (30-50 mg KOH/100g). These results are in agreement with those reported by earlier workers in supplemented breads at ambient temperature and refrigeration temperature (Dhingra, 2001; Chaudhary, 2011). The increase in fat acidity could be attributed to hydrolysis of triglycerides resulting in formation of free fatty acids on storage.

CONCLUSION

It may be concluded from the present study that bread formulated by incorporation of 30% linseed flour in wheat flour not only improved its taste and nutritional quality but could also provide health benefits to the consumers.

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