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Research Article

DEVELOPMENT OF READY TO USE OMEGA-3 ENRICHED *CHAPATI* FLOUR THROUGH VALUE ADDITION TO LINSEED (*LINUM USITATISSIMUM*)

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ABSTRACT
Linseed (*Linum usitatissimum*), a minor oilseed has gained interest for its nutraceutical components. The study was undertaken to formulate omega-3 enriched chapati flour and analyse its quality during storage at ambient temperature by evaluating the sensory parameters, moisture content and peroxide value at regular intervals. The omega-3 enriched chapati flour had an enhanced nutritive value with regard to protein (12.48%), dietary fiber (13.31%) and omega-3 fatty acids (1.91%) compared to the control (12.20%, 12.50% and 0.17%, respectively). One serving of omega-3 enriched chapati was able to meet 87 to 100 per cent of omega-3 fatty acid requirement of adults and children. The addition of linseed to the flour resulted in a chemical score of 0.54. The enriched chapati flour was storable up to two months at ambient conditions, with the moisture (9.52%) and peroxide value (0.76) ranging within the BIS specifications.

Keywords: *Linseed-Linum usitatissimum- Chapati Flour- Omega-3 Fatty Acids - Storability*

INTRODUCTION
Linseed is an ancient crop cultivated in temperate zones of Asia and Europe since seven thousand years for its fiber, seeds and oil. Linseed is a treasure trove of nutrients and nutraceuticals, containing protein (20%), fat (45 %) and dietary fiber (28 %). The abundance of polyunsaturated fatty acids, particularly omega-3 (n-3 or a–linolenic series) amounting to 23 g/100 g and omega- 6 (n-6 or linoleic series) fatty acids to an extent of 7.2g/100g has attributed to the nutritional significance of linseed. Hypoglycemic and hypolipemic effects due to soluble dietary fractions, omega-3 fatty acids and lignans have been documented (Ratnayake *et al.*, 1992; Ranhotra *et al.*, 1993; Cunnane *et al.*, 1993, 1995; Allman *et al.*, 1995; Jenkins *et al.*, 1999; Lucas *et al.*, 2002; Yamashita *et al.*, 2003; Prasath and Ramaswamy, 2005; Mitra and Bhattacharya, 2006; Nazni *et al.*, 2006).
A daily intake of omega-3 fatty acids of 500mg for infants, 750 mg for 1 to 3 years children and 900 mg for 4 to 8 years children are recommended for good health. The suggested intake for boys and girls aged 9 to 13 years are 1200mg and 1000 mg/day, respectively. There commended intake of omega-3 fatty acids for boys more than 13 years and adult males and girls more than 13 years and adult females are 1600 mg and 1000 mg/ day, respectively.
WHO/FAO (2003) has recommended a ratio of omega-6 to omega-3 fatty acids of 5:1 to10:1in dietary intake. In the present day, this ratio is approximately 10: 1 to 25: 1 (Simopoulus, 1991). Excessive amount of omega-6 polyunsaturated fatty acids and a very high ratio of omega- 6:omega-3 promote pathogenesis of many diseases including cardiovascular diseases, cancer, inflammatory and autoimmune diseases, whereas increased levels of omega- 3 fatty acids exert suppressive effects. This imbalance could be rectified by the consumption of omega-3 rich foods such as linseed. Studies have been conducted to isolate the nutraceutical components of linseed and its oil (Nasirullah *et al.*, 2009). However the whole seed is more beneficial as it also contains lignans, dietary fiber, and the like.
Although linseed is produced in many states the food uses are limited except in northern Karnataka and parts of Maharashtra. But, linseed as a food ingredient is not familiar all over, despite its large production due to the lack of awareness about the nutritive value of linseed. There is a need to promote the utilization of linseed in non-traditional linseed areas in day- to-day life owing to its health promoting characteristics. Chapati as a staple food of the Indian subcontinent was selected aptly for enrichment to reach the different sections of the population. Reports have indicated good heat stability of a-linolenic acid of linseed (Chen *et*

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al., 1994; Lee *et al.,* 2003). In the present investigation an attempt was made to develop omega-3 enriched chapati flour and evaluate the storage quality.

MATERIALS AND METHODS

Procurement of raw materials

Raw materials required for the development of omega-3enrichedchapatiflour were procured in a single lot from the local market.

Formulation of omega-3 enriched* chapati *flour

Wheat was milled with suitable quantities of linseed to obtain omega-3 enriched flour, such that one chapati would provide at least one- third the daily suggested omega-3 fatty acid intake. The chapatis were prepared following the procedure of Austin and Ram (1971).

Sensory evaluation

The chapatis prepared from the flour, of both control and omega-3enriched were evaluated for sensory quality by a semi trained panel of 8 to 10 judges from the Department of Food Science and Nutrition of College of Rural Home Science using a nine point hedonic scale. The prepared chapatis were allowed to attain room temperature, wrapped in aluminium foil and stored in stainless steel box at ambient temperature in two batches. The stored chapatis were drawn after 8 and 24 hours of storage and were subject to sensory evaluation as described.

Nutrient computation

The nutrient composition of the control and omega-3 enriched supplementary foods were computed using Annapurna software (Chandrashekara, 1996). The values foromega-3 fatty acid content were obtained from Flax Council of Canada (Anon, 2003). Protein quality of the samples in terms of chemical score was determined by the methods described by Pellet and Young (1980).

Storage quality

The chapati flour was packed in 200 gauge polyethylene pouches, sealed and stored at ambient. The products were drawn periodically, once in fifteen days for visual, chemical and sensory evaluation.

Statistical analysis

Students ‘t’ test was used to compare the means and sensory scores were analyzed using Factorial Randomized Complete Block Design.

RESULTS AND DISCUSSION

The recipe for the preparation of omega-3 enriched chapati was standardized. The results revealed that 8 per cent linseed incorporated chapatis were acceptable as rated by the pane lists. The omega-3 enriched chapati was creamish brown in colour and scored significantly lower than (P=0.05) the control chapati. The brownish colour of the omega-3 enriched chapati was due to the addition of linseed. The other sensory parameters were however on par with the control. The dough of omega-3enriched flour was slightly sticky which may be due to the presence of mucilage in linseed. The dough was less elastic compared to the control which could be due to the disruption of the gluten network by linseed particles which were also observed in macaroni (Lee *et al.,* 2003). The omega-3 enriched chapati exhibited partial puffing and irregular baking spots were observed, the texture was soft.

Nutrient composition of omega-3 enriched chapati in comparison with control chapati is depicted in Table 1. It was observed that the incorporation of linseed resulted in the improvement of the nutrient profile of the product as a whole. The value addition resulted in an increased protein, fat, dietary fiber and fatty acid content compared to the control. The calorific value was slightly higher than the control, meeting6 to 8 per cent of the daily recommendations for children and adults. The total dietary fiber content of omega-3 enriched flour met approximately 12.65 per cent of the suggested intakes for adults per day. Two omega-3 enriched chapatis met 87 to 100 percent of the requirements of omega-3 fatty acid of adults and children. The ratio of omega-6 to omega-3 was shifted favourably from 6.47: 1.00 to 0.76:1.00. The protein quality of the chapati also improved due to enrichment.

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Table 1: Nutrient composition of omega-3 enriched ready-to-use chapati flour

Particulars	Control		Omega-3 enriched		Change over control (%)
	Per 100 g	**Per serving**	**Per 100 g**	**Per serving**	
Protein (g)	12.20	4.48	12.48	4.72	3.14
Fat (g)	1.70	3.59	4.53	4.44	166.47
Carbohydrates (g)	69.40	25.68	66.40	24.73	-4.32
Energy (Kcal)	341	152	356	157	4.39
Total dietary fiber(g)	12.50	4.59	13.61	5.06	8.88
Insoluble fiber	9.60	3.52	10.37	3.86	9.65
Soluble fiber	2.90	1.07	3.24	1.20	12.31
Fatty acids (g)					
Saturated	0.50	0.50	0.72	0.56	44.00
Monounsaturated	0.30	0.62	0.81	0.76	170
Polyunsaturated					
Omega-6	1.10	2.58	1.46	2.56	32.72
Omega-3	0.17	0.06	1.91	0.70	1023.52
Omega-3: omega-6	6.47:1	43:1	0.76:1	3.65:1	
Chemical Score	0.53		0.54		

One chapati equivalent to 40g

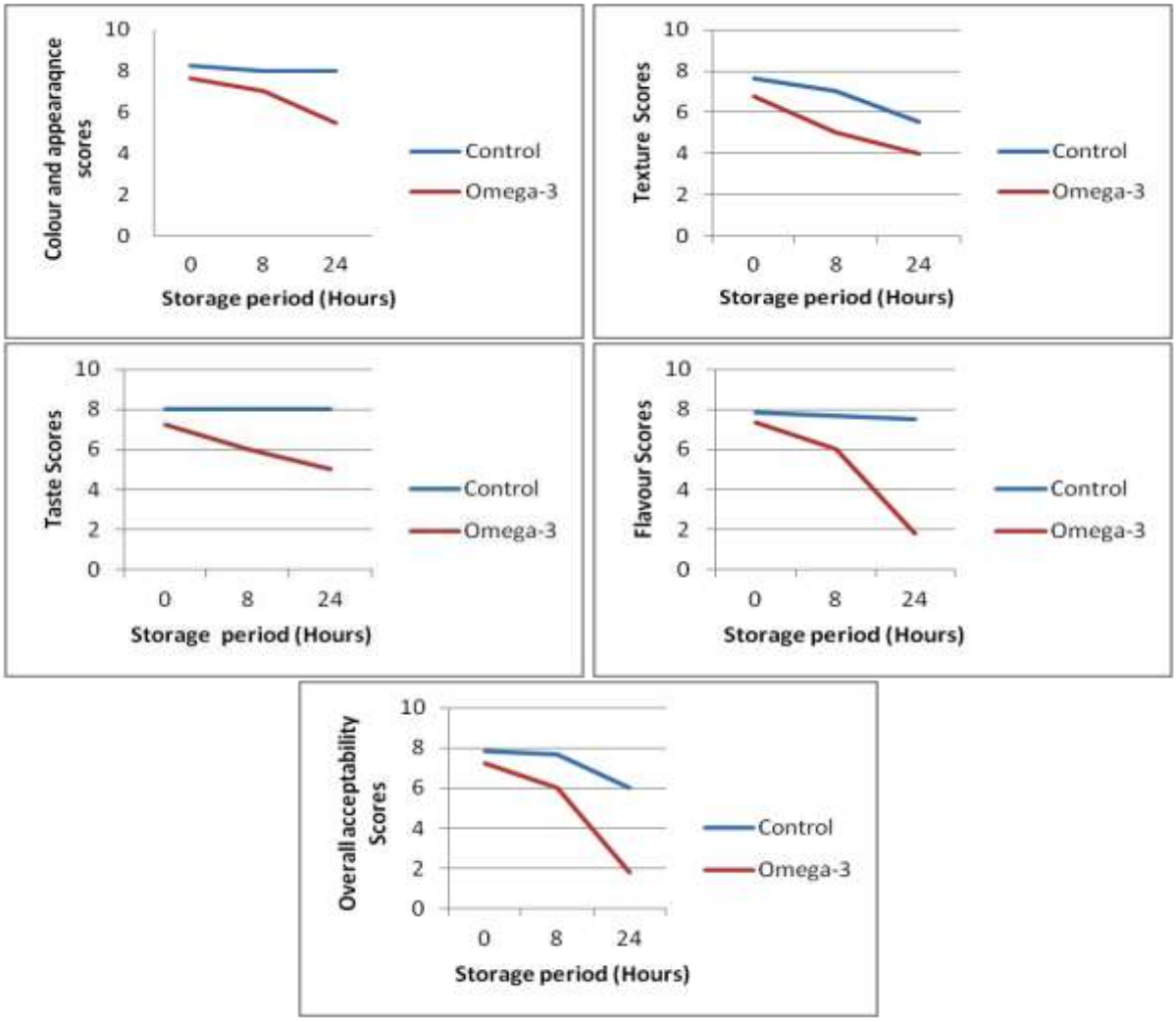

Figure 1: Effect of storage on the sensory parameters of stored omega-3 enriched chapatis

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Chapati is consumed fresh and also after storage in households. Both control and omega-3 chapatis (Figure 1) could be stored up to 24 hours. Rao (1998) reported that water absorption capacity bears a significant positive correlation with acceptability, mouth feel and texture of chapati and suggested that water absorption capacity of 73 to 81 percent resulted in good chapatis. In the present experiment both the control and omega-3enriched flours absorbed 80 and 75 per cent water, respectively to make a suitable dough to yield well puffed, baked chapati. Beyond 8 hours a significant difference in texture could be observed in the omega-3 enriched chapatis which might be due to the lower water absorption during dough preparation compared to the control. The ambient storage affected the sensory parameters of chapati prepared from the ready to use chapati flours, both control and omega-3 enriched. The texture of the omega- 3 enriched chapati was comparable with the control throughout storage. Significant difference in the sensory parameters was observed beyond one month of storage, however the chapatis were acceptable up to two months.

The shelf -life of chapati flours in terms of moisture uptake (Figure 2) and peroxide value were illustrative of good storability.

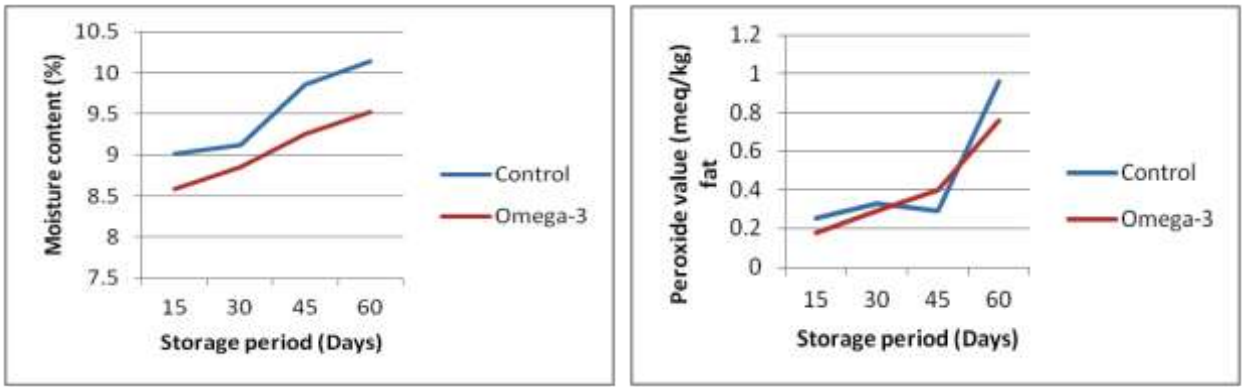

Figure 2: Change in moisture content (%) and peroxide value (meq/kg fat) during storage of omega-3 enriched chapati flour

The values for the two parameters were within BIS (moisture <10 %, peroxide value <10 meq/kg of fat) specification till the end of experiment of 60 days of storage. The peroxide value ofomega-3 enriched flour was initially lower than the values for control which might be due to the presence of antioxidant nutraceutical components of linseed which was also demonstrated by Kelawala and Ananthanarayan (2004). Similar trend in peroxide value during storage of ground linseed was observed by Przybylski and Daun (2001). The authors suggested that the tocopherols present in linseed could have regenerated in some way.

Conclusion

The omega-3 enriched chapati flour had an improved nutrient profile with a shelf- life of 2 months. It could be consumed to increase the omega- 3 fatty acid content of daily diets to meet the suggested intakes for different age groups even in areas where linseed is not grown.

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