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Development of Functional Chapatti from Texturized Deoiled Cake of Sunflower, Soybean and Flaxseed

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ABSTRACT
Effect of texturized defatted meal of sunflower, soybean and flaxseed on quality characteristics of chapatti was investigated. Texturized defatted meal of sunflower, soybean and flaxseed was blended at 10%. 20%, 30% and 40% levels with wheat flour (atta) for making chapatti making. Chapattis were evaluated for physical, textural, sensory and functional properties. Proximate analysis of defatted sunflower meal had 2.56% moisture, 2.53% fat, 43.38% protein, 13.07% fiber and 32.54% protein digestibility. The defatted soybean meal had 2.70% moisture, 2.26% fat, 52.86% protein, 3.29% fiber and 56.33% protein digestibility. The defatted flaxseed meal had 2.61% moisture, 2.71% fat, 38.24% protein, 12.24% fiber and 43.77% protein digestibility. The cutting force for chapattis increased with increased level of texturized defatted meal of sunflower, soybean and flaxseed. Sensory, color and overall acceptability of chapattis were negatively affected when level of texturized flour increased as compared with the control. Overall acceptability scores were maximum for control and chapattis with 10% texturized defatted meal of sunflower, soybean and flaxseed. Functional properties such as water absorption index, foaming capacity and protein digestibility were increased while water solubility index and fat absorption capacity decreased with increased levels texturized defatted meal. The result showed that texturized defatted meal serve as good substitute to wheat flour with increased protein content in chapatti production and utilization.

Keywords: *Chapatti, Deoiled cake, Flaxseed, Sunflower, Soybean.*

I. INTRODUCTION

Soybean is a major source of vegetable oil, protein and animal feed. Soybean, with over 40 percent protein and 20 percent oil, has now been recognized all over the world as a potential supplementary source of edible oil and nutritious food. The protein of soybean is called a complete protein, because it supplies sufficient amounts of the kinds of amino acids required by the body for building and repair of tissues. Flax is an important ingredient that has tremendous nutritional potential for cereal products. Sunflower (Helianthus annuus L) is one of the world's leading oilseed crops, second only to soybeanfor total oil production. The major staple foods, such as beans, soybean, lentils, peas and chickpeas, are all legumes. Proteins in legume seeds represent from about 20% (dry weight) in pea and beans up to 38-40% in soybean and lupin [1]. Oilseed proteins and modified or processed oilseed proteins can be incorporated into foods to impart nutritive value and functional properties. Processing of vegetable protein involves physico-chemical and thermal treatments, affecting the nutritional value of the final products, and also the functional properties. Conversely, functional properties (solubility, water and oil retention capacity, foaming capacity and stability, emulsion capacity and stability, viscosity, gelation) influence protein behaviour during processing and storage. Protein content of defatted meals from dehulled oilseeds depends on the seed and ranges between 35% and 60% (d.b.) [2].

From the nutritional viewpoint, all legume storage proteins are relatively low in sulphur-containing amino acids, methionine, cysteine and tryptophan, but the amounts of another essential amino acid, lysine, are much greater than in cereal grains [3]. Therefore, with respect to lysine and sulphur amino acid contents, legume and cereal proteins are nutritionally complementary. These essential amino acid deficiencies have traditionally been overcome by integrating legume-based dishes with cereal foods (pasta, rice, bread, etc.). The total protein content and the contribution that essential amino acids make to the total diet are the most important factors from a nutritional point of view [4]. Due to their nutritional values and high protein content, sunflower, soybean and flaxseed plays a significant role in the manufacturing chapattis. However, very little information is available on the incorporation of texturized defatted flour in making chapattis. In developing new food products, it is important to balance the quality and quantity of protein that offer optimum processing functionality, nutritional value and cost effectiveness. Keeping these points in mind, the present study was planned with the objectives to optimize and to find out the best level on the basis of quality, to find the overall acceptability of the chapattis on the basis of sensory evaluation by panelists and to study the color, textural, functional properties of chapattis prepared after incorporation of texturized defatted flour of sunflower, soybean and flaxseed.

II. MATERIALS AND METHODS

2.1. Raw materials

Wheat, soybean, flaxseed and sunflower were procured from Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana.

2.2. Extrusion process for sunflower, soybean and flaxseed

The sunflower, soybean and flaxseed were cleaned, dehulled and defatted using laboratory oil expeller. The meal was dried and milled into grits using Super Mill (Perten Instruments, Sweeden). After that, the sample was sieved using mesh screen to separate out the large particles of the seed coat.

Texturization of sunflower, soybean and flaxseed were carried out by using Clextral BC 21 twin screw extruder (Clextral, Firminy, France). The operating conditions were 14-20 per cent feed moisture, 300-500 rpm screw speed and 120-180^{o}C barrel temperature. Texturized proteins was milled into flour using cyclotec mill (Newport Scientific, Australia) and packed in suitable packaging material for further study.

2.3. Experimental design

Central composite design was to optimize the process. Extrusion process variables (feed moisture content, screw speed and temperature) were coded to the level of -1, 0, +1 such that one factor at a time of experimental design was as follow [5].

Extrusion parameters	-1.682	-1	0	+1	+1.682
Moisture content (%)	11.954	14	17	20	22.046
Screw speed (rpm)	231.800	300	400	500	568.200
Barrel temperature (^{o}C)	99.54	120	150	180	200.460

2.4. Chemical analysis

Chemical characteristics of defatted meal and chapattis were analyzed using standards procedures [6].

2.5. Treatments

The basic raw material wheat was substituted with developed texturized defatted flour from 0 to 40% level to assess the effectiveness of functional properties.

2.6. Chapatti preparation

Texturized defatted sunflower, soybean and flaxseed flour were added to atta and required quantity of water mixed manually to obtain dough of suitable consistency. The dough was rounded manually and kept for 20minutes at room temperature. The dough was divided into equal parts and moulded into circular chapattis with rolling pin and board [7].

Traditional home baking procedure was followed to bake chapattis on iron plate (Tawa). Chapattis were cooled and evaluation was done using following criteria.

Characteristics	**Score grade**
Dough handling	Non sticky
	Sticky
	Slightly sticky
	Very sticky
Puffing of chapatti	Full
	Partial
	Nil

2.7. Color measurements of chapattis

The crust color of chapatti was evaluated by measuring the L (100=white; 0=black), a (+, red; -, green), and b (+, yellow; -, blue) value and the total color difference (ΔE) was calculated with a standard white tile. A piece of the chapatti sheet was taken in the sample holder and the surface color was measured at three different positions using a Minolta Spectrophotometer CM-508d (Minolta Co., Ltd Japan) [8].

2.8. Texture analysis of chapattis

Texture of the chapattis was evaluated on texture analyzer (TA-XT2i) [9]. Chapattis subjected to cutting force to measure hardness (N) at different levels. Cutting force of chapatti was evaluated by using texture analyser. Strips measuring 4cm × 2cm were cut from each chapatti. One strip at a time was placed on the centre of the sample holder and blade was allowed to cut chapatti strip. The force (N) required to cut chapatti strip into two pieces was recorded. The speed was maintained at 1.70mm/s.

2.9. Sensory evaluation of chapattis

Sensory evaluation of chapattis was done by a semi trained panel for, top grain, texture, flavor and overall acceptability using a 9-point hedonic scale [10].

2.10. Functional properties

2.10.1. Water absorption index (WAI), Water solubility index (WSI) and fat absorption capacities (FAC)

Water absorption index (WAI) was measured [11]. First, 1g of flour was placed in a previously weighed 50 ml centrifuge tube. Then, 10 ml of distilled water was added and stirred homogeneously with a glass rod and centrifuged at 3000 rpm for 10 min at room temperature (22°C) using a Model T-8BL Laby™ centrifuge (Laby Laboratory Instruments, Ambala Cantt, India). The residue was weighed together with the centrifuge tube. The WAI values were expressed as gram of water absorbed/gram of flour. The supernatant was transferred to previously weighed dish which put in hot air oven for evaporation of water. The residue was weighed. A similar method was used to measure fat absorption capacity (FAC), although a 0.5 g sample was used in this case [12].

WAI (g/g) = Weight of residue/dry weight of residue

$$\text{WSI (\%)} = \frac{\text{Weight of dry matter in supernatant x100}}{\text{Dry weight of sample}}$$

$$\text{FAC (\%)} = \frac{\text{Weight of fat absorbed by sample x100}}{\text{Weight of sample}}$$

2.10.2. Foaming capacity

One gram of flour was dissolved in 100 ml of distilled water. Then the suspensions were whipped at a low speed in a blender for 1 min at room temperature (22°C). The resulting foam was poured into a 100 ml cylinder. Total foam volume was recorded and foam capacity was expressed as the percent increase in volume. To determine foam stability (FS), foam volume was recorded 30 min after whipping and calculated [13].

FS = foam volume after 30 min/initial foam volume x 100

2.10.3. Protein Digestibility

The in-vitro protein digestibility was estimated [14]. One gram of dried sample was taken in a conical flask. To this, 50 ml of pepsin solution (5 gm pepsin in 0.1N hydrochloric acid) was added and incubated for 24 hours at 37 °C. The solution was then neutralized by adding 30 ml of 0.2 N sodium hydroxide and then 50 ml of pancreatin solution (4 gm pancreatin in 1000 ml of phosphate buffer of pH 8) was added and again incubated for 24 hours at 37 °C. An enzyme blank was also run under the same prescribed conditions. Few drops of toluene were used to maintain aseptic environment in the system. The contents were centrifuged at a high speed and were filtered through Whatmann filter paper. The residue left was then analyzed for Nitrogen content by Micro-Kjeldhal method. The digestibility coefficient was determined by subtracting the residual protein from the initial protein on the basis of 100 gm of sample.

2.10.4. Statistical analysis

Data obtained was analyzed statistically using techniques of analysis of variance (ANOVA) [15].

III. RESULTS AND DISCUSSION

3.1. Defatted meal characteristics

The defatted sunflower meal had 2.56% moisture, 2.53% fat, 43.38% protein, 13.07% fiber and 32.54% protein digestibility. The defatted soybean meal had 2.70% moisture, 2.26% fat, 52.86% protein, 3.29% fiber and 56.33% protein digestibility. The defatted flaxseed meal had 2.61% moisture, 2.71% fat, 38.24% protein, 12.24% fiber and 43.77% protein digestibility (Table 1).

3.2. Chapattis characteristics

Moisture content of chapattis incorporated with texturized defatted sunflower meal at 10, 20, 30 and 40% level ranges from 32.20%, 32.63%, 33.07% and 33.64%, respectively. Protein, fat, fiber, ash and protein digestibility of chapattis incorporated with texturized defatted sunflower meal increased as compared to control (Table 2). Similarly for chapattis incorporated with texturized defatted soybean (10, 20, 30 and 40%) and flaxseed (10, 20, 30 and 40%) meal showed increased protein, fat, fiber ash and protein digestibility as compared to control (Table 2).

3.3. Color measurements of chapattis

The results obtained are shown in Table 3. There was a decrease in L values for texturized defatted sunflower chapattis from 37.62 to 34.81. Similarly L value was decreased for texturized defatted soybean and flaxseed chapattis from 43.56 to 31.87 and 56.17 to 47.13. Chapattis prepared from texturized defatted flour of sunflower, soybean and flaxseed showed that a and b value increased with increasing levels of incorporation. Scientists [16] concluded that decreasing L and increasing a and b values lead to darkening of biscuits when they supplemented Virgin coconut meal in biscuits. Decline in L values signifies that with increase in percentage incorporation the lightness decreased while a and b values shows an increase in redness and yellowness in chapattis. Similar trend was observed in corn and potato flour [17] virgin coconut meal [16] in biscuits. Thus observed results in this study followed similar trends. The color development is contributed by the maillard reaction that results in brown color [18]. Other factors that may be responsible for color development are time and temperature of baking, composition and humidity in oven [19]. It was reported that with an increase in protein content there is a decrease in L value [20]. In the chapattis significant difference was observed for all L, a and b values.

3.4. Textural properties of chapattis

The results of textural analysis summarized in Table 4. The cutting force of chapattis is important textural properties of chapattis. The average peak force is measure of chapattis hardness. A increasing trend was observed for cutting force of chapattis prepared from texturized defatted sunflower, soybean and flaxseed flour. Cutting force (N) reflects the texture of the chapattis and it stimulates the biting action of the human teeth on chapatti [21]. The cutting force for sunflower, soybean and flaxseed chapattis were ranging from 4.69 to 6.60N, 4.76 to 6.53N and 4.22 to 6.47N. The cutting force (N) for chapattis made from different wheat varieties ranged between 4.22-6.67N [22]. Cutting force increased due presence of more proteins at higher enrichment levels which determine the resistance offered by the sample. This shows that incorporation of texturized defatted sunflower, soybean and flaxseed flour had negative results on textural properties.

3.5. Sensory evaluation of chapattis

The effect of increasing texturized defatted sunflower, soybean and flaxseed flour at 10, 20, 30 and 40% levels on sensory properties of chapattis were depicted in Table 4. Statistical analysis showed that there was significant difference in color, appearance, texture, flavor and overall acceptability of chapattis as compared to control. Overall acceptability scores for chapattis incorporated with texturized defatted sunflower, soybean and flaxseed flour were decreased with increased level which were ranging from 7.85 to 5.90, 8.50 to 6.80 and 7.95 to 6.15, respectively. Chapattis made from 10% texturized defatted sunflower, soybean and flaxseed were given maximum overall acceptability scores as compared to higher levels. Cookies made from deoiled maize flour were acceptable up to 15% by consumer [23]. Cookies made with 15% level of deoiled maize germ flour in wheat flour having acceptable scores [24].

3.6. Functional properties

All functional properties expect fat absorption capacity and water solubility index increased significantly with increase in level of texturized defatted flour of sunflower, soybean and flaxseed (Table 5). Functional properties improved because protein content increased with increased level of texturized defatted flour of sunflower, soybean and flaxseed as these were rich in proteins. Functional properties were lowered with increase in level of finger millet flour as protein content decreased in blend but reverse was case in present study [25].

Water absorption index, foaming capacity and protein digestibility were increased with increased level of incorporation of texturized defatted flour of sunflower, soybean and flaxseed in wheat flour for chapattis making. It has been reported that protein content had an inverse correlation with free lipid level of instant noodles [26], [27]. Therefore chapatti made from protein rich texturized defatted flour of sunflower, soybean and flaxseed were absorb less fat as compared to controls.

IV. CONCLUSION

The addition of texturized defatted sunflower, soybean and flaxseed flour in chapattis making results in significant improvement in crude protein, crude fibre, ash and protein digestibility of chapattis. It can be concluded that although chapattis with 40% levels of texturized defatted sunflower, soybean and flaxseed flour were nutritionally rich but received lower scores for different organoleptic attributes. The textural properties showed that cutting force increased with increased level of texturized defatted sunflower, soybean and flaxseed flour for chapattis making. Incorporation texturized defatted sunflower, soybean and flaxseed flour had significant effect on color value, lightness decreased while a and b increased producing darker color with increased levels of supplementation. As for increasing the amount of texturized defatted sunflower, soybean and flaxseed flour for chapattis making functional properties like water absorption index, foaming capacity and protein digestibility increased proportionally but fat absorption capacity and water solubility index decreased proportionally. Thus chapattis were acceptable for all attributes evaluated upto 10% while higher levels had negative effect. The study demonstrated that deoiled cake a byproduct obtained from sunflower, soybean and flaxseed oil industry offers great potential for supplementation of proteins in food products.

REFERENCES

[1] E Derbyshire, D. J. Wright, and D. Boulter, Legumin and vicilin, storage proteins of legume seeds. *Phytochemistry 15*, 1976, 3.

[2] AMoure, J. Sineiro, H. Dominguez, and J. C. Parajo, Functionality of oilseed protein products: A review. *Food Research International, 39*, 2006. 945-963.

[3] L. B. Rockland, and T. M. Radke, Legume Protein Quality. *Food Technology, 35*, 1981. 79.

[4] F. M. Anjum, I. Ahmad, M. S. Butt, M. A. Sheikh, and I. Pasha, Amino acid composition of spring wheats and losses of lysine during chapatti baking. *Journal of Food Composition and Analysis, 18,* 2005, 523-532.

[5] R. H. Myers, *Response surface methodology*. 1st edition. Boston, Mass: Allyn and Bacon, pp. 247, 1971.

[6] AACC, Approved Methods of American Association of cereal chemists. 10th ed. The Association St. Paul, MN, 2000.

[7] A Austin, and A Ram, Studies on chapatti making quality of wheat. *IindianCouncil of AgriculturalResearch and Technology Bulletin, 31,* 1971, 108.

[8] T. Kimura, K. R. Bhattacharya, and S. J. Ali, Discoloration characteristics of rice during parboiling. *Journal of Society for Agricultural Structure, 24,* 1993, 23-30.

[9] M. C. Bourne, *Principles of objective texture measurement*. In Food Texture and Viscosity: Concept and Measurement. pp 114-17. Academic Press, San Diego, 1982.

[10] E. Larmond, *Methods of sensory evaluation of food*. Canadian Deptartment Agricultural Publications, 1284. Ottawa: 55-57, 1970.

[11] V Stojceska, P. Ainsworth, A. Plunkett, and S. Ibanoglu, The effect of extrusion cooking using different water feed rates on the quality of ready-to-eat snacks made from food by-products. *Food Chemistry, 114,*

2009, 226-232.

[12] M. J. Y. Lin, E. S. Humbert, and F. W. Sosulski, Functional properties of sunflower meal product. *Journal of Food Science, 39,* 1974, 368-370.

[13] M. Kabirullah, and R. B. H. Wills, Characterization of sunflower protein. *Jounal of Agricultural and Food Chemistry, 31*, 1983, 953-956.

[14] W. R. Akeson, and M. A. Stachman, Pepsin pancreatin digestibility index of protein quality evaluation. *Journal of Nutrition, 83,* 1964, 257-260.

[15] S Singh, T. Singh, M. L. Bansal, and R. Kumar, *Statistical methods for research workers*. Kalyani Publishers, New Delhi, India, 1991.

[16] Y Srivastava, A. D. Semwal, G. K. Sharma, and A. S. Bawa, Effect of virgin coconut meal (VCM) on the textural, thermal and physico chemical properties of biscuits. *Food Nutrition and Science, 1,* 2010, 38-44.

[17] R Singh, G. Singh, and G. S. Chauhan, Effect of incorporation of defatted soy flour on the quality of biscuits. *Journal of Food Science and Technology, 33,* 1996, 355-357.

[18] B. Singh, M. Bajaj, A. Kaur, S. Sharma, and J. S. Sidhu, Studies on the development of high protein biscuits from composite flour. *Plant Foods for Human Nutrition, 43,* 1993, 181-189.

[19] H Lingnert, *Development of the maillard reaction during food processing*. In: P. A. Finot, (Eds). Pp 171. Maillard Reaction in Food Processing. Human Nutri Physiology, 1990.

[20] E. S. Gallagher, S. Kenny, and E. K. Arendt, Impact of dairy protein powders on biscuit Quality. *European Food Research Technology, 221,* 2005, 3-4.

[21] J. S. Sidhu, W. Seibel, and J. M. Bruemmer, Measurement of chapatti texture using Zwick universal testing machine. *LWT Journal of Food Science and Technology, 21*, 1988, 147-152.

[22] M. S. Hemlatha, B. T. Manu, S. G. Bhagat, K. Leelawati, and U. J. S. Prasad Rao, Protein characteristics and peroxidase activites of different Indian wheat varieties and their relationship to chapatti making quality. *European Food Research Technology, 225,* 2000, 463-471.

[23] M Nasir, M. Siddiq, R. Ravi, J. B. Harte, K. D. Dolan, and M. S. Butt, Physical quality characteristics and sensory evaluation of cookies made with added defatted maize germ flour. *Journal of Food Quality 33,* 2010, 72-84.

[24] M. U. Arshad, F. M. Anjum, and T. Zahoor, Nutritional assessment of cookies supplemented with defatted wheat germ. *Food Chemistry, 102,* 2007, 123-128.

[25] M. L. Sudha, R. Vetrimani, and A. Rahim, Quality of vermicelli from finger millet (Eleusine coracana) and its blend with different milled wheat fraction. *Food Research International, 31,* 1998, 99-104.

[26] R Moss, P. J. Gore, and I. C. Murray, The influence of ingredients and processing variables on the quality and microstructure of Hokkien, Cantonese and instant noodles. *Food Microstructure, 6,* 1987, 63-74.

[27] C. S. Park, and B. K. Baik, Relationship between protein characteristics and instant noodle making quality of wheat flour. *Cereal Chemistry, 60,* 2004, 433-438.

Table 1: Chemical composition of defatted meal

Defatted meal	Moisture content (%)	±SD	Fat (%)	±SD	Protein (%)	±SD	Fibre (%)	±SD	PD (%)	±SD
Sunflower	2.56	0.332	2.543	0.083	43.378	0.387	13.072	0.017	32.540	0.062
Soybean	2.70	0.273	2.260	0.036	52.862	0.682	3.292	0.289	56.333	0.047
Flaxseed	2.61	0.120	2.707	0.070	38.240	0.578	12.240	0.934	43.770	0.089

Table 2: Chemical composition of chapatti prepared from texturized defatted meal of sunflower, soybean and flaxseed.

Sample	Percent	Moisture (%)	±SD	Protein (%)	±SD	Fat (%)	±SD	Fibre (%)	±SD	Ash (%)	±SD
Control	0	30.800	0.387	9.223	0.309	1.213	0.035	2.567	0.061	1.290	0.036
Sunflower	10	32.207	0.900	12.837	0.401	1.723	0.021	12.303	0.045	1.873	0.031
	20	32.630	0.210	14.437	0.127	2.193	0.040	14.843	0.050	2.510	0.066
	30	33.070	0.098	15.303	0.080	2.423	0.040	17.150	0.080	2.850	0.056
	40	33.637	0.070	16.223	0.153	2.717	0.035	18.363	0.051	3.140	0.085
Soybean	10	31.570	0.148	13.177	0.087	1.927	0.021	9.787	0.071	1.640	0.046

	20	32.430	0.044	16.423	0.059	2.297	0.015	11.917	0.035	2.517	0.060
	30	33.367	0.189	18.650	0.060	2.613	0.061	12.310	0.214	3.033	0.093
	40	34.700	0.111	21.250	0.044	2.807	0.021	14.503	0.104	3.310	0.046
Flaxseed	10	30.963	0.244	11.493	0.042	2.317	0.038	8.450	0.180	1.773	0.025
	20	31.747	0.583	13.560	0.046	2.883	0.015	10.700	0.334	2.657	0.031
	30	33.070	0.602	14.820	0.066	3.620	0.157	12.127	0.157	3.570	0.066
	40	33.483	0.247	16.253	0.093	3.847	0.047	13.360	0.185	3.980	0.174

Table 3: Effect of incorporation of texturized defatted meal on the color (L, a, b values) of chapatti

Sample	Percent	L	±SD	a	±SD	B	±SD	ΔE	±SD
Control	0	49.110	1.584	4.300	0.060	11.203	0.421	50.593	1.385
Sunflower	10	37.623	1.390	1.123	0.752	1.337	0.852	61.187	1.406
	20	38.050	0.835	1.487	0.080	2.887	0.359	62.993	2.046
	30	35.533	0.265	2.340	0.026	3.520	0.098	63.277	0.138
	40	34.817	0.316	3.150	0.040	3.767	0.096	63.800	0.316
Soybean	10	43.563	0.386	2.537	0.326	3.163	0.264	55.933	0.167
	20	35.793	0.663	2.780	0.352	4.483	0.431	62.893	0.625
	30	34.063	0.476	3.693	0.093	7.970	0.125	55.130	0.440
	40	31.873	1.647	5.950	0.557	8.697	0.357	59.780	1.362
Flaxseed	10	56.173	0.599	3.873	0.360	4.013	0.524	60.790	0.587
	20	46.200	2.710	3.917	0.038	7.033	1.417	63.547	0.350
	30	46.233	1.930	4.633	1.101	9.310	0.753	65.830	0.867
	40	47.130	1.502	5.040	0.056	13.703	0.781	61.980	2.366
LSD (p<0.05)		2.208		0.732		1.031		1.944	

Table 4: Effect of incorporation of texturized defatted meal of sunflower, soybean and flaxseed on sensory and textural properties of chapatti

Sample	Percent	Puffing	Dough handling	Color	Appearance	Texture	Flavor	Overall acceptability	Cutting force (N)
Sunflower	0	FP	NS	8.00	8.20	8.00	8.00	8.10	4.60
	10	FP	NS	8.00	8.00	7.60	7.80	7.85	4.69
	20	FP	NS	6.80	7.20	8.00	7.00	7.25	5.36
	30	FP	NS	6.00	5.80	6.80	6.40	6.25	6.54
	40	FP	NS	5.20	5.60	6.60	6.20	5.90	6.60
LSD (p<0.05)				1.16	1.08	0.89	0.77	0.71	0.207
Soybean	0	FP	NS	8.00	8.20	8.00	8.00	8.10	4.60
	10	FP	NS	8.60	8.60	8.60	8.40	8.50	4.76
	20	FP	NS	8.60	8.40	8.80	8.60	8.50	5.74
	30	FP	NS	7.80	7.40	7.40	7.20	7.65	6.28
	40	FP	NS	7.00	6.80	6.40	6.40	6.80	6.53
LSD (p<0.05)				0.98	0.99	0.95	1.19	1.02	0.138
Flaxseed	0	FP	NS	8.00	8.20	8.00	8.00	8.10	4.60
	10	FP	NS	8.00	7.80	8.20	7.80	7.95	4.26
	20	FP	NS	7.40	7.40	8.00	7.40	7.60	5.57
	30	FP	NS	6.60	6.80	7.20	6.40	6.75	5.84
	40	FP	NS	6.00	6.40	6.60	5.60	6.15	6.47
LSD (p<0.05)				0.62	0.77	0.96	0.74	0.61	0.066

NS – non sticky FP – full puffing

Table 5: Effect of incorporation of texturized defatted meal of sunflower, soybean and flaxseed on functional properties of chapatti

Sample	Percent	Functional properties									
		Water absorption index (g/g)	±SD	Water solubility Index (%)	±SD	Fat absorption capacity (%)	±SD	Foaming capacity (%)	±SD	Protein digestibility (%)	±SD
Control	0	2.56	0.02	3.69	0.04	171.30	0.95	7.21	0.10	38.95	3.85
Sunflower	10	3.14	0.09	4.36	0.05	282.85	2.54	9.87	0.57	60.88	0.39
	20	4.06	0.12	3.64	0.03	245.41	3.61	14.40	0.22	63.77	0.38
	30	5.40	0.22	3.12	0.05	197.73	3.49	18.86	0.61	69.17	0.85
	40	6.29	0.07	2.39	0.04	153.78	3.61	22.57	0.34	71.63	0.43
Soybean	10	3.17	0.07	4.57	0.26	171.53	1.59	14.66	0.54	78.13	0.11
	20	3.83	0.07	3.83	0.10	140.78	1.55	17.59	0.24	80.54	0.16
	30	4.43	0.09	2.76	0.04	102.11	0.55	18.26	0.06	83.72	0.23
	40	5.30	0.09	2.47	0.03	85.75	0.26	22.02	0.24	84.44	0.25
Flaxseed	10	3.53	0.23	3.63	0.04	191.28	0.99	8.56	0.25	54.60	0.29
	20	4.59	0.05	3.32	0.35	151.01	1.27	12.07	0.18	57.83	0.46
	30	5.15	0.18	2.61	0.03	120.60	0.45	13.59	0.50	57.83	0.46
	40	5.50	0.12	2.51	0.04	92.52	0.82	15.04	0.38	60.90	0.55
LSD ($p<0.05$)		0.208		0.214		4.328		0.619		1.919	