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Effect of addition of whole seed linseed at different level on rheological properties of dough

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Abstract
The present investigation was undertaken to study its rheological study by addition of whole linseed. The farinograph study reported increase in water absorption (at 500 FU and 14 % moisture content), mixing tolerance index, time to breakdown and farinograph quality number whereas reduction was observed in dough development time and dough stability with increased addition of whole linseed from 5 to 20 %. The extensiograph indicated that the energy, resistance to extension, extensibility, maximum (BU), ratio number and ratio number (max) decreased. The amylograph observation revealed that beginning of gelatinization temperature decreased, gelatinization temperature increased and gelatinization maximum decreased with increased addition of whole linseed flour.

Keywords: Farinograph, extensiograph, amylograph, increase, gelatinization, dough

Introduction
The flax (*Linum usitatissimum*) is a blue flowering rabi crop and is a member of family *Linaceae*, commonly known as “Alsi” (Gujrati, Hindi and Punjabi). The flaxseed and linseed are the other names which are often used interchangeably. This plant grows to a height up to 60 cm, with slender and very fibrous stems, lanceolate leaves having three veins, up to 4 cm long and 4 mm wide, and its bright blue flowers are up to 3 cm in diameter. The fruit contains a seed known as flaxseed or linseed (Pradhan *et al.*, 2010) [12].
The major linseed growing states are Madhya Pradesh, Maharashtra, Chattisgarh, Uttar Pradesh, Bihar, Orissa and Karnataka which contribute about 83 per cent of area and 80 per cent of the total linseed production of the country (Pati, 2009 and Srivastava *et al*., 2009) [11, 14].
The seed is a healthy source of oil containing polyunsaturated fatty acids, digestible proteins, and lignans. Apart from being an affluent source of α-linolenic acid (ALA), flaxseed has a great potential to provide good quality protein, soluble dietary fibers and considerable amount of healthy plant phenolics. Flaxseed contains good amount of α-Linolenic Acid (ALA), a omega-3 fatty acid, protein, dietary fiber, lignan, specifically Secoisolariciresinol diglucoside (SDG) so it constitute a very strong basis for the utilization of flaxseed in various food preparations as a curative agent (Mueller *et al*., 2010) [9].
The purpose of our study was conducted to explore the rheological characteristics of flour with ground flaxseed that could be valuable for processing and developing potential new functional food products having desirable texture and health benefits. Rheological characteristics of different combination of flour were investigated using farinograph, extensograph and amylograph.

Materials and methods
Refined wheat flour
The linseed was procured from local market.

Linseed and linseed flour
The linseed was procured from local market. The linseed was grinded in grinder. Then it was passed through 200 mesh sieve to get uniform particle size.

Rheological properties
Effect of substitution of refined wheat flour with 0, 5, 10, 15 and 20 % of linseed flour were evaluated using farinograph, extensiograph and amylograph according to approved methods of AACC, 1983.

Table 1: Incorporation of whole linseed in cookies

Treatments	Whole linseed (%)
WL_0 (Control)	100% maida + 0% whole linseed flour
WL_1	95% maida + 5% whole linseed flour
WL_2	90% maida + 10% whole linseed flour
WL_3	85% maida + 15% whole linseed flour
WL_4	80% maida + 20% whole linseed flour

Statistical analysis

The data obtained in the present investigation was analyzed for the significance using Factorial Completely Randomized Design (FCRD) and procedure given by Panse and Sukhatme (1985).

Result and discussion

Farinograph characteristics of dough

The data presented in the Table 2 revealed that the farinographic characteristics of dough incorporated with different levels of whole linseed flour showed that the treatment WL_0 i.e., control, reported lowest value of water absorption (59.82 %) for 500 BU at 14% moisture as compared to other treatments. The water absorption was observed from 59.82% (WL_0) to 63.80% (WL_4) in all treatments. Koca and Anil (2007) [7] also observed increased water absorption values with increased flaxseed addition to wheat flour. The water absorption in flaxseed flour containing doughs might be due to the presence of mucilage or gum in flaxseed. The increase of water absorption might be attributed by the ability of proteins to absorb high quantity of water (Des Marchais *et al*., 2011) [4].

Table 2: Influence of whole linseed flour on farinograph characteristics of dough

Treatments	Water Absorption (corrected fort 500 FU) (%)	Water Absorption (corrected fort 14% moisture) (%)	Dough Development Time (min)	Dough Stability (min)	MTI (FU)	Time to breakdown (min)	Farinograph quality number (FU)
WL_0	59.82	59.82	4.82	5.51	28.33	6.70	67.03
WL_1	60.67	60.67	5.66	5.40	32.68	8.49	85.05
WL_2	61.21	61.21	5.54	4.43	35.01	9.11	91.08
WL_3	62.03	62.03	5.18	3.82	41.52	9.59	96.03
WL_4	63.80	63.80	4.62	2.79	61.20	10.03	110.98
SE±	0.307	0.307	0.162	0.142	1.417	0.185	0.762
CD at 5%	0.925	0.925	0.488	0.428	4.271	0.557	2.296

The value of dough development time for WL_0 was 4.82 min and it get increased at starting and later on it decreased. Similar finding was recorded for addition of flaxseed flour by Chetana *et al*. (2010) [1].

Dough stability, which indicates the dough strength, was decreased with increasing whole linseed flour from 5 to 20 per cent. It was observed that, the value for dough stability of control WL_0 (5.51 min) was higher than other treatments and it got declined in upto WL_4 2.79 min. The decrease in stability with increasing proportion of flaxseed flour in the blends was attributed to the dilution or weakening of the gluten matrix. The physical interruption of gluten matrix was likely the cause of the dough weakening as the gluten proteins are responsible for the viscoelastic network and dough strength.

The value for mixing tolerance index (MTI) increased with increasing level of whole linseed flour. The value of mixing tolerance index (MTI) for WL_0 (28.33 FU), WL_1 (32.68 FU), WL_2 (35.01 FU), WL_3 (41.52 FU) and WL_4 (61.20 FU). The higher dough MTI value indicates weaker flour that tends to form doughs that break down rapidly during mixing (Shuey, 1984) [13]. Xu *et al*. (2014) [16] also found similar trend of decrease in MTI value with increased addition of flaxseed flour.

The farinograph quality number differed significantly with the the treatments. Farinograph quality number indicating flour quality increased (in treatment WL_0) 67.03 FU to 110.98 FU (in treatment WL_4). This may be either due to incorporation of non-gluten protein or due to the interaction between the fiber constituents (Lignans) of flaxseed and gluten, thereby affecting the dough mixing properties.

Mathews *et al*. (1970) [8] reported that addition oilseed flours such as cottonseed, peanut, sunflower seed to wheat flour resulted in increased water absorption and decreased mixing tolerance of doughs. Similar results were reorted by Jyotsana *et al*. (2012) [6] and also by Chetana *et al*. (2010) [1] for different farinograph proerties with the increase in the level of roasted ground flaxseed from 0–20% with increasing flaxseed flour.

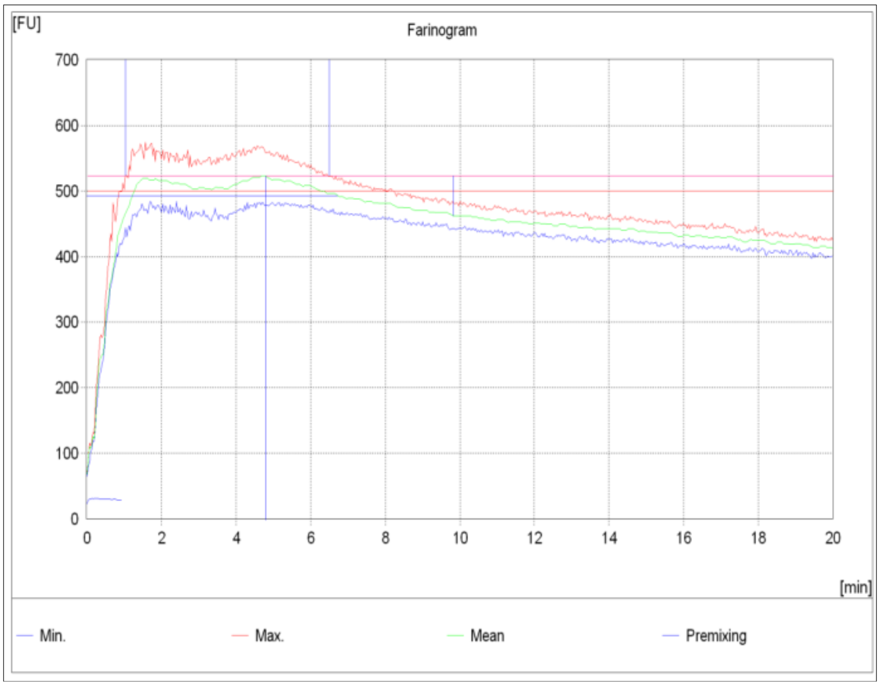

Fig 1: Farinograph of control sample

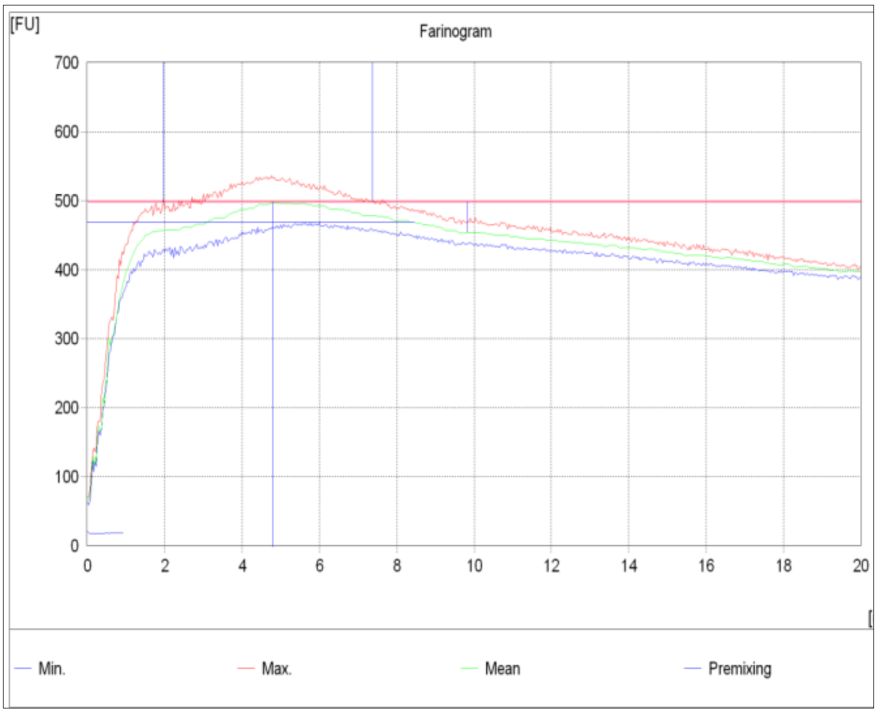

Fig 2: Farinograph of WL_1 sample

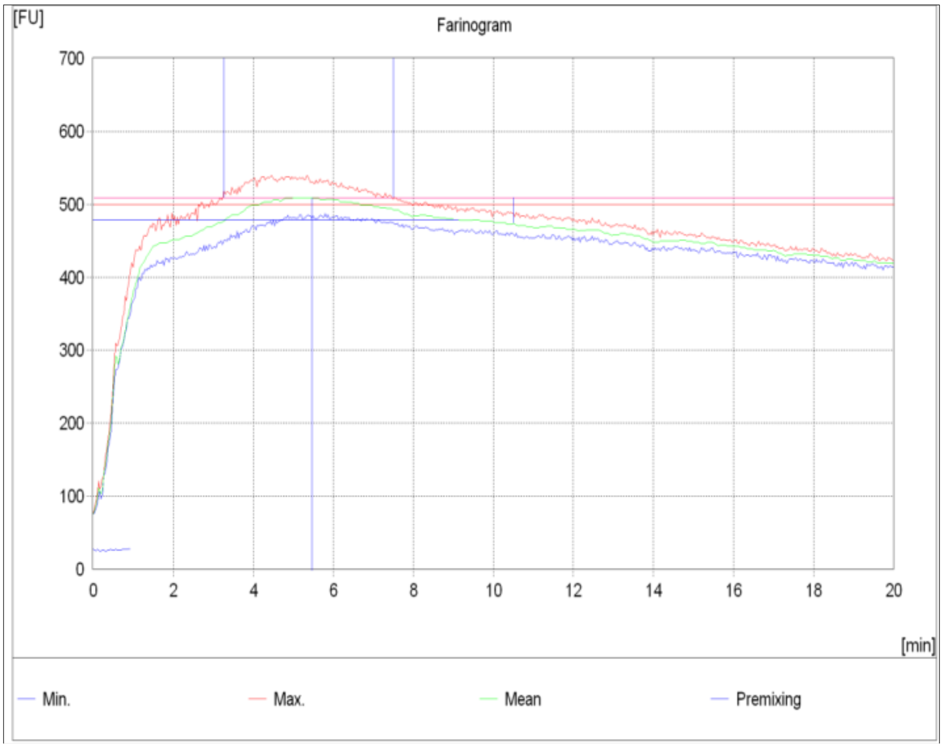

Fig 3: Farinograph of WL_2 sample

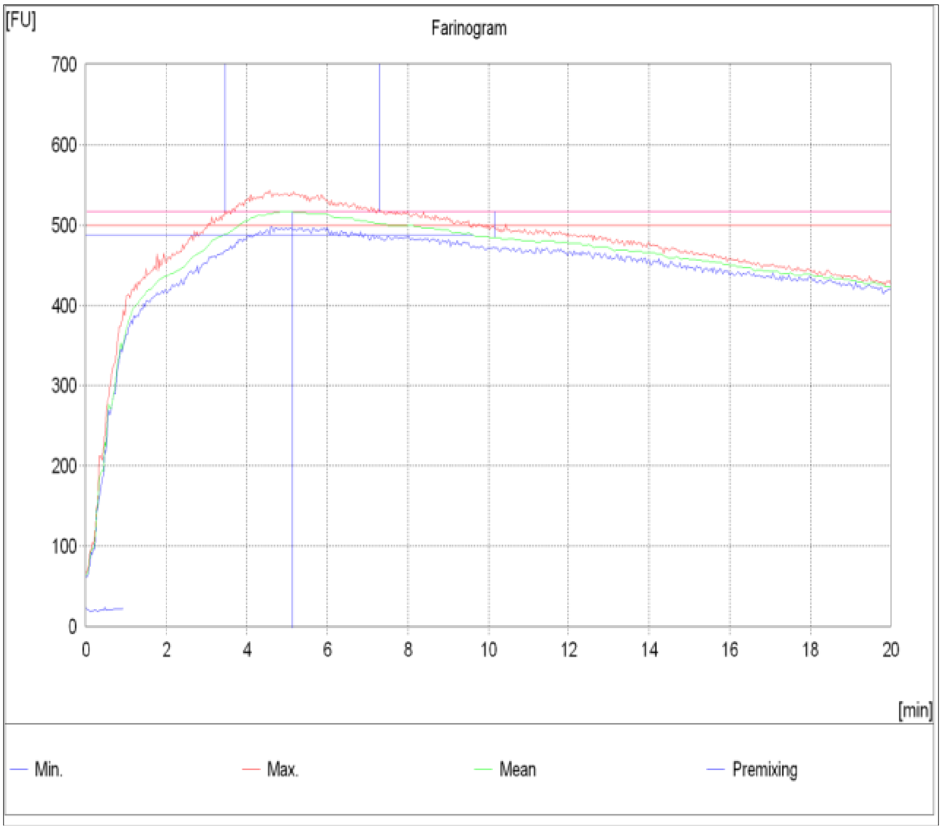

Fig 4: Farinograph of WL_3 sample

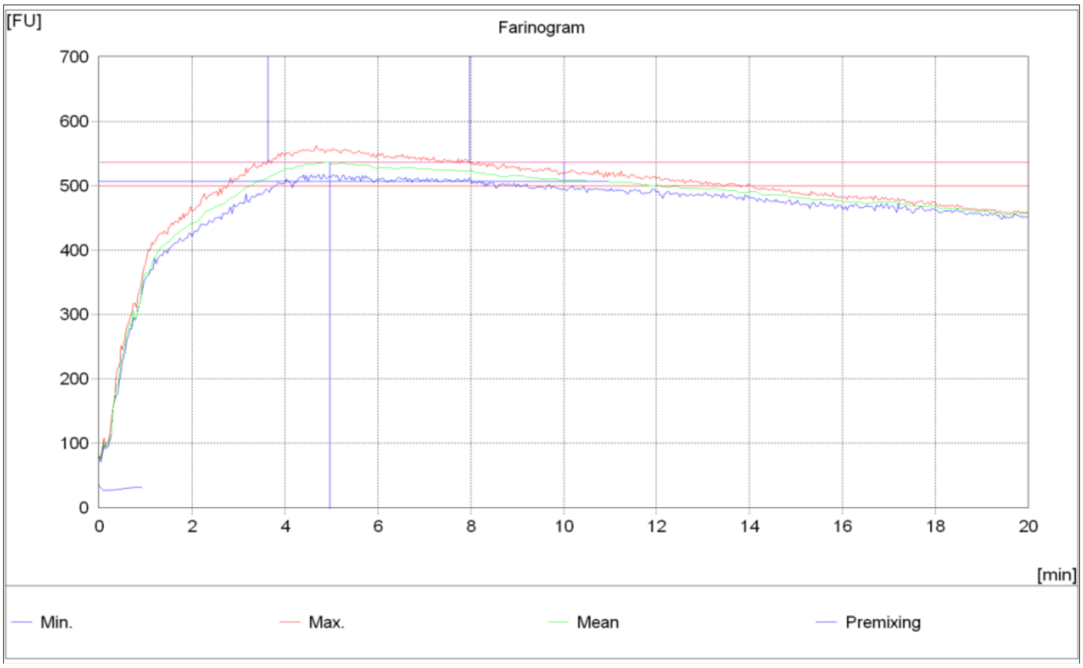

Fig 5: Farinograph of WL_4 sample

Extensiograph characteristics of dough

The data presented in the Table 3 depicted that the energy (cm^2) decreased as the level of whole linseed flour increased from 5 % to 20 %. The significant decrease in energy value was observed in the various treatments for all proving time. The data revealed that resistance to extension decreased from 30 to 90 min proving time i.e. 393.08 BU to 326.88 BU of control treatment WL_0. As compared to control treatment other treatment exhibited decreased resistance to extension at 30 min, 60 min and 90 min proving time, respectively. The extensibility was considerably affected by addition of different levels of whole linseed flour which significantly decreased from 30 to 90 min proving as linseed flour increased from 5 to 20%. All treatments with added whole linseed flour had significantly lower extensibility as compared to control and lowest extensibility was observed in WL_4 treatment.

The highest point of the curve in BU i.e. maximum significantly decreased from 406.08 BU at 30 min to 398.01 BU at 60 min followed by decrease in value of maximum 336.02 BU at 90 min proving time of control treatment WL_0. The significant decreasing trend of maximum BU was found with increased proving time for whole linseed flour incorporation. The significant decrease was observed in the ratio number with increase in the linseed flour 5 to 20 % and with proving time.

The above results may be on addition of flaxseed flour might be due to reduced gluten content as flaxseed is nongluten food source. Similar results were observed by Onyango *et al.* (2015) [10] who reported same data as represented in this research paper for different characteristics, the results were due to extensiograph properties of dough made from wheat and non wheat flours were dependent on the botanical origin of the non wheat flour and the modification it has been subjected to.

Table 3: Influence of whole linseed flour on extensiograph characteristics of dough

Characteristics	Proving time (min)	WL_0	WL_1	WL_2	WL_3	WL_4	SE±	CD at 5%
Energy (cm^2)	30	73.01	72.16	57.87	56.01	45.90	0.728	2.194
	60	68.01	66.13	50.79	46.05	41.08	1.052	3.169
	90	67.88	64.95	50.78	44.25	39.94	1.079	3.253
Resistance to Extension (BU)	30	393.08	390.05	353.50	315.25	305.13	6.954	20.963
	60	373.13	313.25	279.50	260.00	252.50	5.927	17.867
	90	326.88	275.50	243.08	239.75	230.75	6.170	18.598
Extensibility (mm)	30	130.13	126.10	124.25	122.00	99.50	2.422	7.302
	60	129.40	122.25	117.03	116.00	98.88	2.147	6.472
	90	129.10	120.58	114.55	116.05	91.05	1.044	3.146
Maximum (BU)	30	406.08	403.05	362.02	315.05	311.06	0.827	2.492
	60	398.01	314.05	311.10	267.06	264.05	0.819	2.468
	90	336.02	298.05	286.05	263.51	247.03	1.163	3.505
Ratio Number	30	3.20	3.19	3.16	2.36	2.20	0.054	0.162
	60	3.20	3.11	2.41	2.31	1.87	0.042	0.126
	90	2.51	2.39	2.31	1.90	1.81	0.038	0.117

For all dough samples the addition of linseed flour reduced these parameters of the dough compared to control sample, because of decrease of gluten content i.e., dilution of gluten (Dokic *et al*., 2014) [5]. Less gluten content in the structure of dough samples with linseed flour might caused decrease in degree of association. Dervas *et al*. (1999) [3] stated that the extensibility decreased as the substituted level of lupin flour increased from 5–15%. Jyotsana *et al*. (2012) [6] also stated same results for different extensiographic characters with addition of in roasted ground flaxseed flour.

Amylograph characteristics of dough

The data resented in table 4 showed that beginning of gelatinization showed non significant change in treatments. The beginning of gelatinization temperature was observed from 58.10 °C for WL_0 and for WL_1 (58.41 °C), WL_2 (58.33 °C), WL_3 (58.24 °C) and WL_4 (58.12 °C) with increase in linseed flour. The significant increase in gelatinization temperature was observed with increased addition of linseed flour. The gelatinization temperature was observed from 83.05 °C (WL_0), 83.01 °C (WL_1), 83.49 °C (WL_2), 84.09 °C (WL_3) and 84.51 °C (WL_4). Gelatinization maximum in AU, for treatment WL_0 showed highest value (810.98 AU) and lowest value for treatment WL_4 (540.08 AU). The gelatnization maximum value significantly decreased with the increased level of whole linseed flour.

The substitution of wheat starch with barley linseed fiber fractions at 5-20% level and reported a decrease in peak viscosity and break down values, these lower values are an indication of a reduction in starch available for gelatinization. There was also a dilution of starch content with an increase in linseed powder (Sudha *et al*., 2010) [15].

Table 4: Influence of different level of whole linseed on amylograph characteristics of dough

Treatment	Beginning of gelatinization (^{0}C)	Gelatinization temperature (^{0}C)	Gelatinization maximum (AU)
WL_0	58.10	83.05	810.98
WL_1	58.41	83.01	669.02
WL_2	58.33	83.49	598.13
WL_3	58.24	84.09	564.05
WL_4	58.12	84.51	540.08
SE±	0.093	0.372	0.981
CD at 5%	NS	1.120	2.956

Jyotsana *et al*. (2012) [6] reported the peak viscosity, hot paste viscosity, cold paste viscosity, set back and break down values decreased, as the level of roasted ground flaxseed flour increased. The effect of replacement of wheat flour at 25% level with oilseed flours, peanut (raw and roasted), sunflower seed and full fat soy on the amylograph characteristics was studied by Mathews *et al*. (1970) [8]. They reported that the peak viscosity, hot paste viscosity and cold paste viscosity decreased with the replacement of oilseed flours when compared with the value of the control wheat flour. According to Christianson *et al*. (1981) [2], gums affect gelatinization and retrogradation of starch through strong association of amylose with gum resulting in a decrease in retrogradation of starch.

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