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Rheological Study of addition of deoiled linseed at different level of dough

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

Keywords: Farinograph, extensograph, 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 3cm in diameter. The fruit contains a seed known as flaxseed or linseed (Pradhan *et al.*, 2010) [13].
A typical proximate composition in linseed cake is dry matter 96.8%, protein 30.5%, fat 6.6%, nitrogen–free extract 43.2%, crude fiber 9.5%, and mineral matter 7% (Brown, 1953) [3]. The linseed cake is valued for its appetite stimulating and slightly laxative effects and good for animals, both as a feed component and as a nutritional additive. The deoiled cake due to its nutritional value and good source of fibre can be utilized in incorporation of meal in different food products, used as feed and fibre rich product.
The purpose of our study was conducted to explore the rheological characteristics of flour with ground deoiled 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 refined wheat flour and linseed was procured from local market.

Deoiled Linseed Flour
The linseed was defatted using the solvent extraction method using the food grade hexane. The meal after desolventizing 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 deoiled linseed flour were evaluated using farinograph, extensograph and amylograph according to approved methods of AACC, 1983 [1].

Table 1: Treatments for incorporation of deoiled linseed

Treatments	Whole linseed (%)
DL_0 (Control)	100% maida + 0% Deoiled linseed flour
DL_1	95% maida + 5% Deoiled linseed flour
DL_2	90% maida + 10% Deoiled linseed flour
DL_3	85% maida + 15% Deoiled linseed flour
DL_4	80% maida + 20% Deoiled 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 and fig 1 to fig 5 revealed that water absorption for 500 BU at 14% moisture content the difference in the treatment was significant. The water absorption was observed from significantly increased from 59.82% (DL_0) to 79.75% (DL_4). Water absorption increased as the level of fortification of defatted soyabean increased because the higher protein content resulted in a greater water binding capacity (Mashayekh *et al*., 2008) [8]. Naik and Sekhon (2014) [10] reported increase in water absorption as defatted soya flour addition increased due to high protein content. Movahhed *et al*. (2012) [9] reported that addition of defatted corn germ flour to macroni increased water absorption.

It was observed that the value of dough development time for DL_0 was 4.82 min which was lowest among all treatments and it was significantly increasing with increase in deoiled linseed flour addition viz., DL_1 (5.51 min), DL_2 (5.63 min), DL_3 (5.74 min) and DL_4 (6.05 min). Similar finding showed an increased dough development time of dough samples with whole wheat and triticale flour additive, comparing with control flour sample mainly can be due to differences in a chemical composition of whole flour, and its elevated dietary fibre content, especially (Kalnina *et al*., 2015) [7].

It was observed that, the value for dough stability of control DL_0 (5.51 min) and it was found DL_1 (5.81) was higher than other treatments and it got declined upto DL_4 (3.82 min) so it indicated that dough stability was significantly decreased with increasing amount of deoiled linseed flour during dough preparation. The low dough stability might be due to the higher fiber content which destroyed the gluten matrix (Ismail, 2007) [6]. The reduction in DS could be explains due to the interactions between non-wheat proteins, fibres and gluten leading to a delay in the hydration and development of gluten in the presence of these ingredients (Dhinda *et al*., 2011) [5].

Table 2: Influence of deoiled 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
DL_0	59.82	59.82	4.82	5.51	61.20	6.70	67.03
DL_1	63.66	63.67	5.51	5.81	53.22	7.98	79.80
DL_2	69.59	69.60	5.63	4.46	51.42	8.25	82.45
DL_3	74.85	74.86	5.74	4.16	47.20	8.41	84.13
DL_4	79.75	79.76	6.05	3.82	45.20	8.89	88.90
SE±	0.486	0.489	0.105	0.107	1.434	0.166	1.564
CD at 5%	1.466	1.474	0.315	0.322	4.323	0.499	4.715

The value for mixing tolerance index (MTI) decreased significantly with increasing level of deoiled linseed flour. The value of mixing tolerance index (MTI) for DL_0 (61.20 FU), DL_1 (53.22 FU), DL_2 (51.42 FU), DL_3 (47.20 FU) and DL_4 (45.20 FU). Naik and Sekhon (2014) [10] Farinograph studies revealed that the mixing tolerance index decreased from 90 BU to 55 BU as defatted soya flour addition increased. Ribotta *et al*. (2005) [15] and Sudha *et al*. (2011) also reported same results.

For the character farinograph quality number the difference in the treatment is significant. Farinograph quality number indicating flour quality was DL0 (67.03) and increased significantly from DL_1 (79.80 FU) to DL_4 (88.90 FU) with increase in deoiled flour addition. This may be either due to incorporation of non-gluten protein or due to the interaction between the fibers constituents (Lignans) of flaxseed and gluten, thereby affecting the dough mixing properties (Chetana *et al*., 2010) [4].

The above results were in accordance with, Onyango *et al*. (2015) studied changes with the increase in addition of maize to wheat flour. Saleh *et al*. (2012) [16] observed that the replacement of defatted soy flour at all ratios reduced the dough weakening from 100 B.U. for the control sample to 80, 70 and 60 B.U. for those prepared by 5, 10 and 15 % defatted soya flour replacement; respectively. These results are corresponding to those found by Akbari *et al.* (2012) [2] who reported that the increase in supplementation levels of wheat flour with defatted soya flour at different ratio.

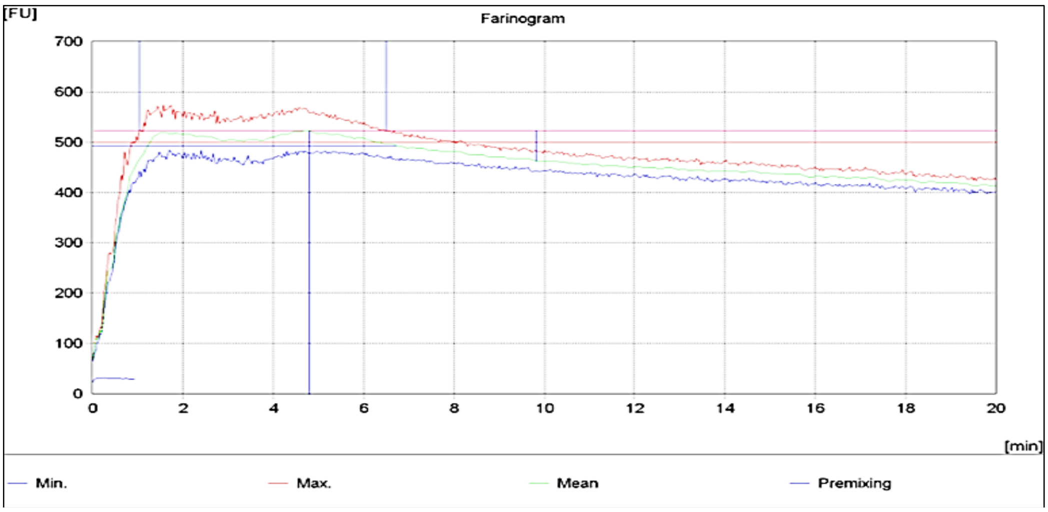

Fig 1: Farinograph of control sample

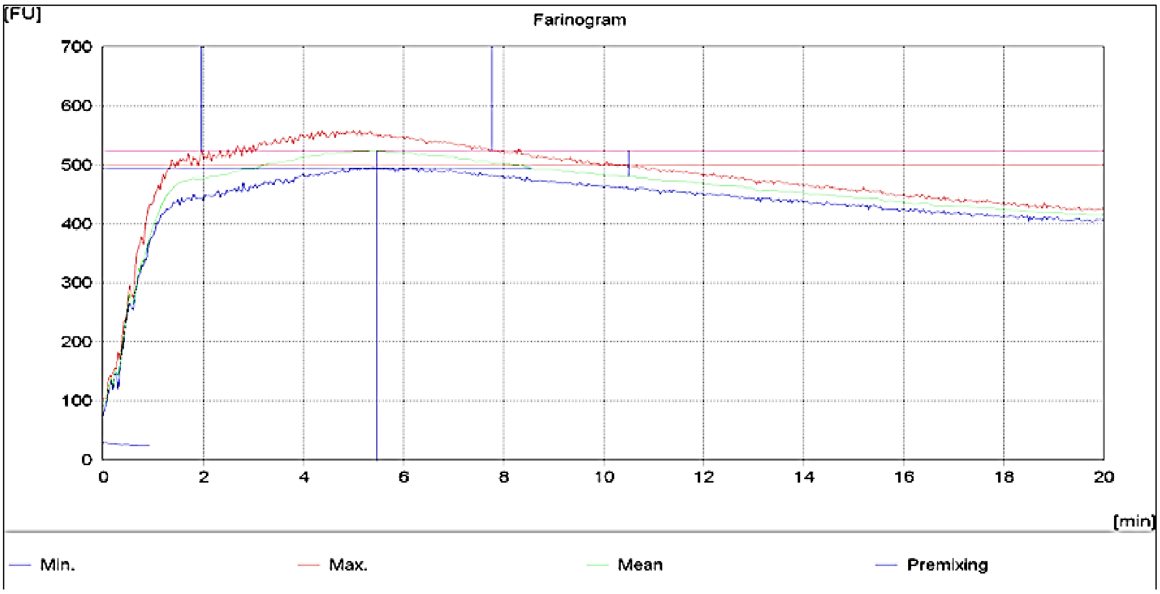

Fig 2: Farinograph of 5% deoiled linseed+95% maida (DL_1) sample

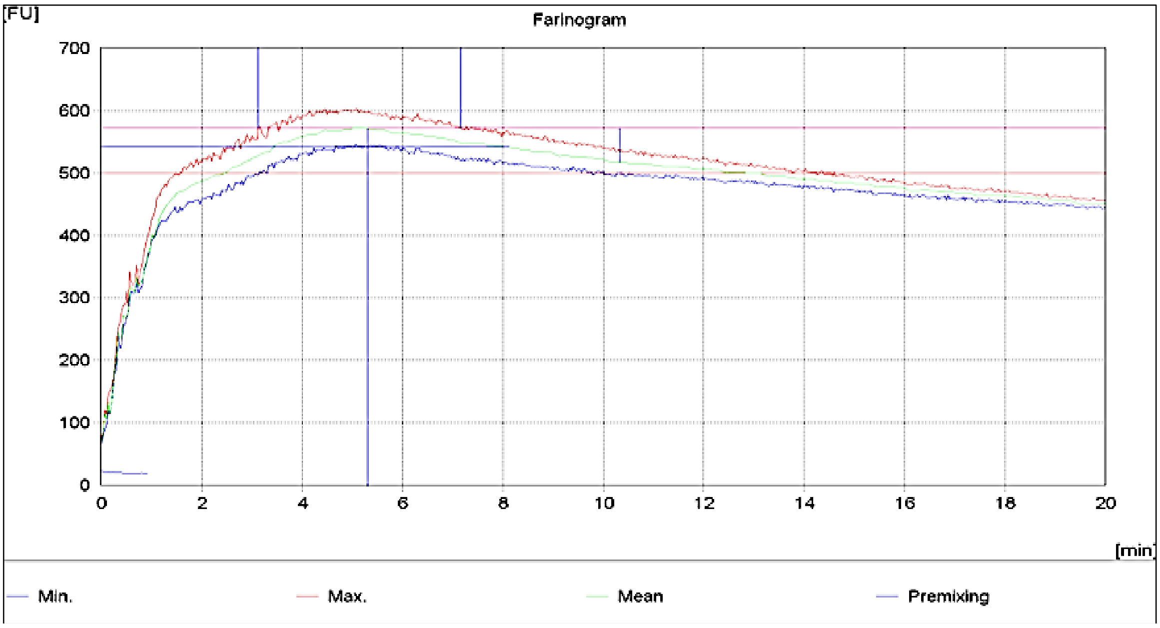

Fig 3: Farinograph of 10% deoiled linseed+90% maida (DL_2) sample

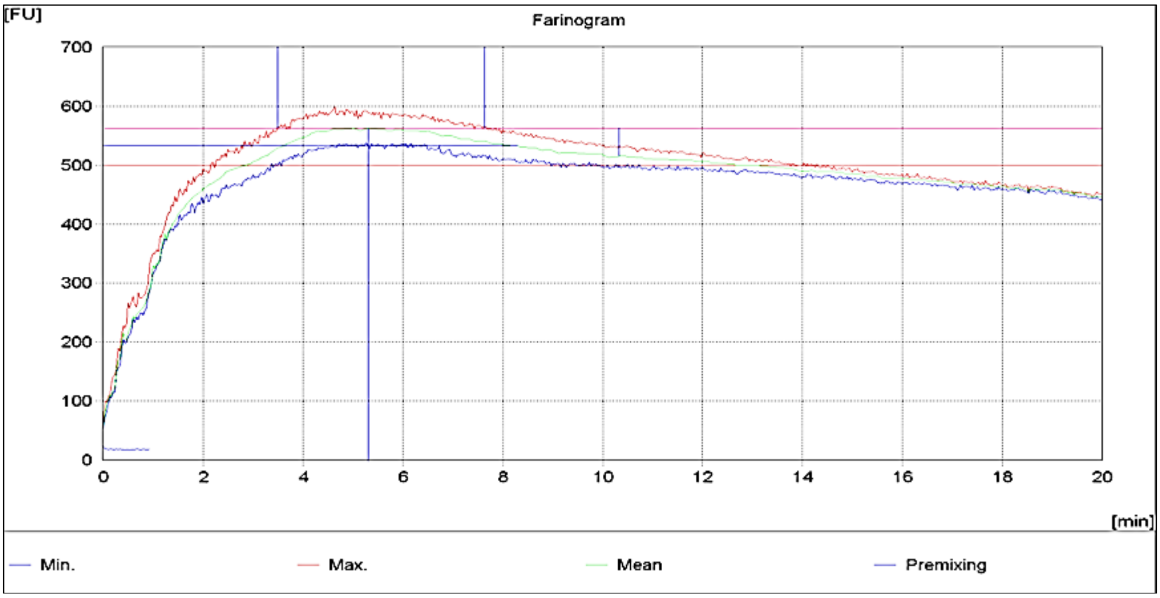

Fig 4: Farinograph of 15% deoiled linseed+85% maida (DL_3) sample

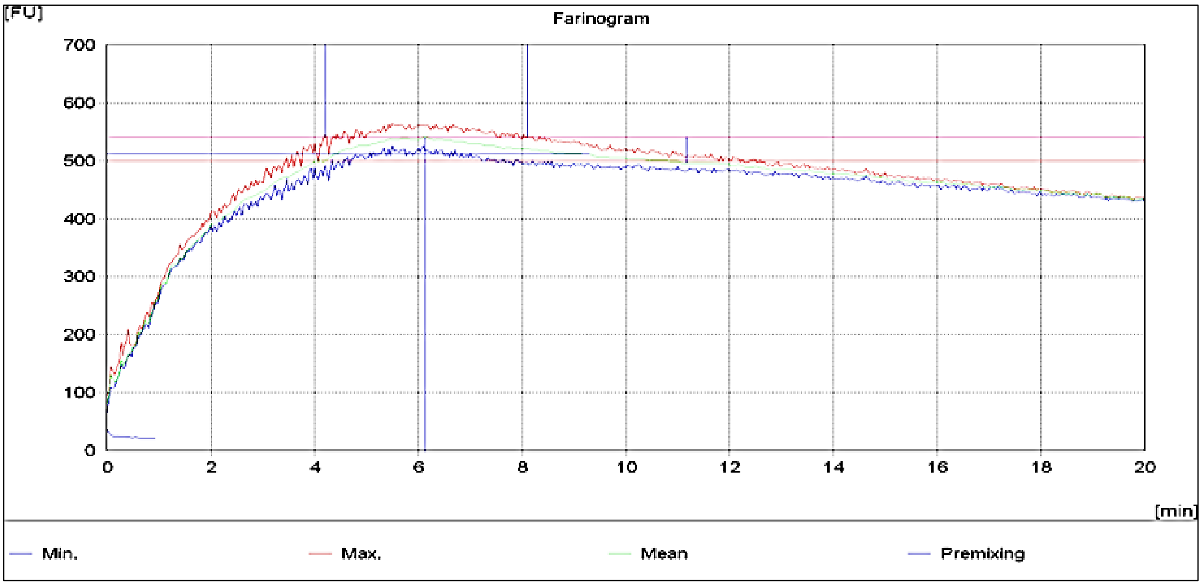

Fig 5: Farinograph of 20% deoiled linseed+80% maida (DL_4) sample

Extensograph Characteristics of Dough

The data in the Table 3 depicted and fig 6 to fig 10 represents extensograph characteristics. The energy (cm^2) significantly decreased as the level of deoiled linseed flour increased from 5% to 20%. It also decreased as the proving time increased. The resistance to extension decreased from 30 to 90 min proving time i.e. 393.08 BU to 326.88 BU of control treatment DL_0. In case of treatments exhibited significant decrease in resistance to extension at 30 min, 60 min and 90 min proving time, respectively. The extensibility was significantly decreased from 30 to 90 min proving as deoiled linseed flour increased from 5 to 20%.

The 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 DL_0. The lowest maximum BU is showed by treatment DL_4 which exhibited 460.05 BU value at 30 min proving time with decreased value i.e., 416.03 BU at 60 min and 409.01 BU at 90 min proving time. The ratio number for DL_0 for 30 min proving time was 3.20, for 60 min proving time it was 3.20 and slightly decreased to 2.51 for 90 min proving time. The significant increase was observed in the ratio number with increase in the deoiled linseed flour 5 to 20 % and decreased with proving time.

The extensograph properties of dough made from wheat and non-wheat flours is dependent on the botanical origin of the non-wheat flour and the modification it has been subjected to (Onyango *et al.*, 2015) [11]. The addition of increased deoiled linseed flour developed poor gluten network and decrease of gluten content as linseed is nongluten oilseed. Mashayekh *et al*. (2008) [8] studied similar trend for different extensograph characteristics in addition of defatted soyabean flour. The results were in accordance with Movahhed *et al*. (2012) [9] in addition of defatted corn germ flour. Results were in coincidence with Saleh *et al*. (2012) [16] observed in the blends at ratio from 5% to 15% of the defatted soyabean flour.

Table 3: Effect of deoiled linseed flour on extensograph characteristics of dough

Characteristics	Proving time (min)	DL_0	DL_1	DL_2	DL_3	DL_4	SE±	CD at 5%
Energy (cm^2)	**30**	73.01	98.03	62.02	55.05	49.05	0.849	2.559
	60	68.01	85.02	58.05	48.03	38.04	0.772	2.326
	90	67.88	75.02	52.02	44.05	36.02	0.733	2.209
Resistance to Extension (BU)	**30**	393.08	610.02	445.62	430.01	378.05	3.037	9.153
	60	373.13	514.53	379.75	349.50	329.25	6.117	18.438
	90	326.88	464.03	355.08	342.25	320.25	5.029	15.160
Extensibility (mm)	**30**	130.13	113.05	107.02	79.08	63.01	1.213	3.657
	60	129.40	112.08	102.01	74.02	52.10	0.771	2.325
	90	129.10	118.01	99.03	65.02	52.05	0.685	2.065
Maximum (BU)	**30**	406.08	614.03	611.01	572.02	460.05	0.754	2.273
	60	398.01	611.05	534.78	516.05	416.03	0.864	2.607
	90	336.02	607.08	532.75	482.75	409.01	1.166	3.515
Ratio Number	**30**	3.20	4.20	5.41	5.51	6.03	0.076	0.229
	60	3.20	3.52	4.61	5.32	6.01	0.062	0.187
	90	2.51	3.60	3.91	5.05	6.00	0.085	0.256

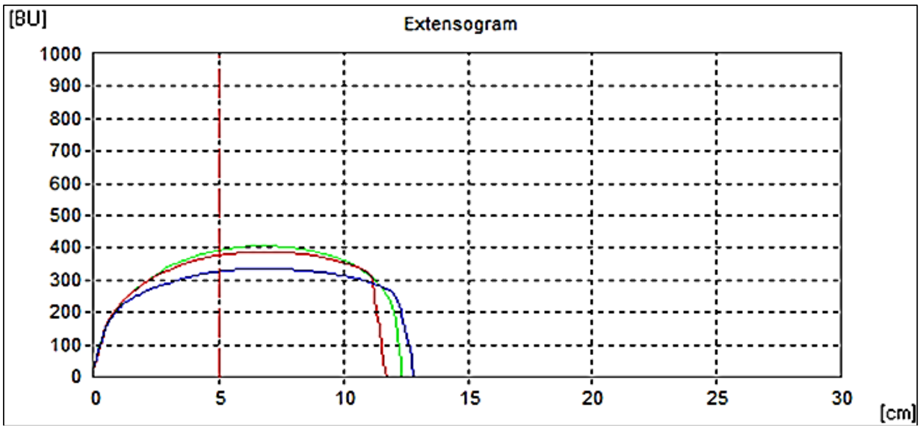

Fig 6: Extensograph of control sample

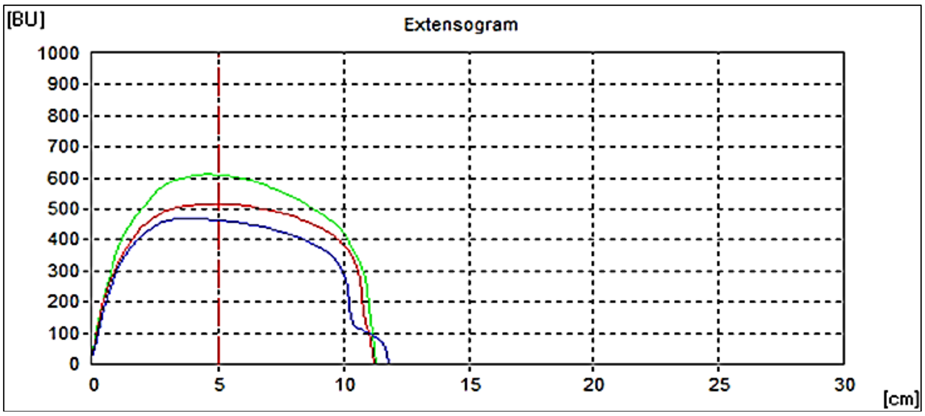

Fig 7: Extensograph of 5% deoiled linseed+95% maida (DL_1) sample

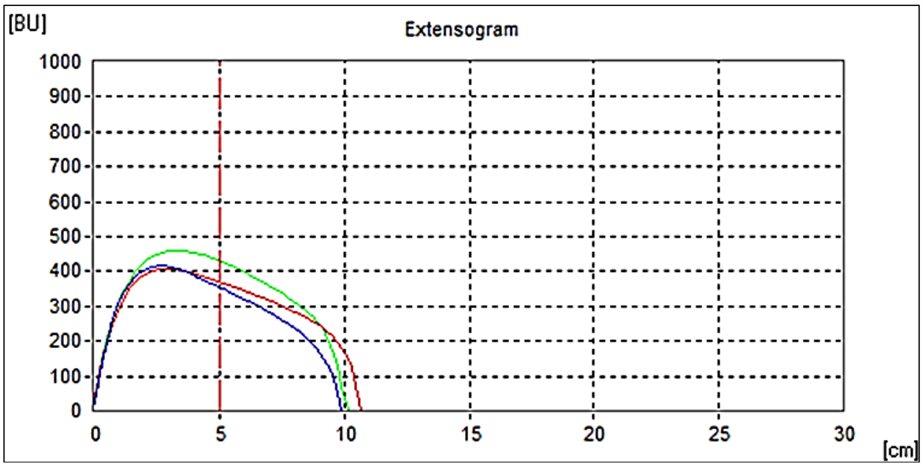

Fig 8: Extensograph of 10% deoiled linseed+90% maida (DL_2) sample

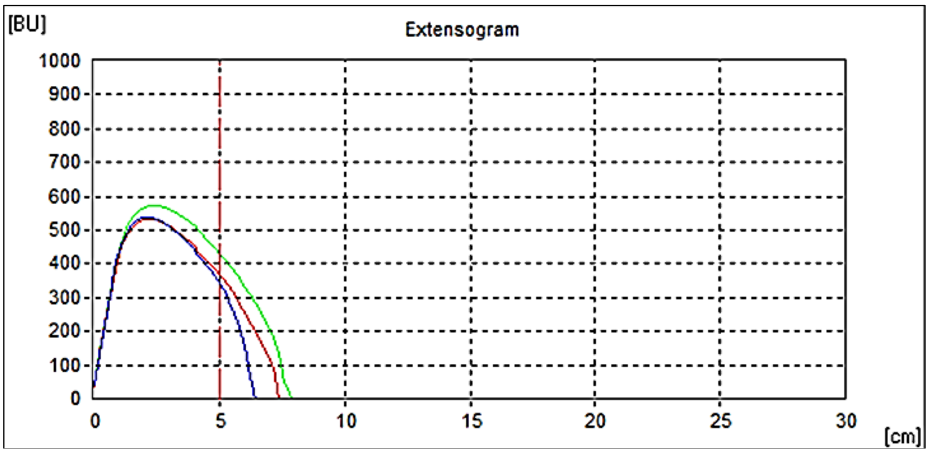

Fig 9: Extensograph of 15% deoiled linseed+85% maida (DL_3) sample

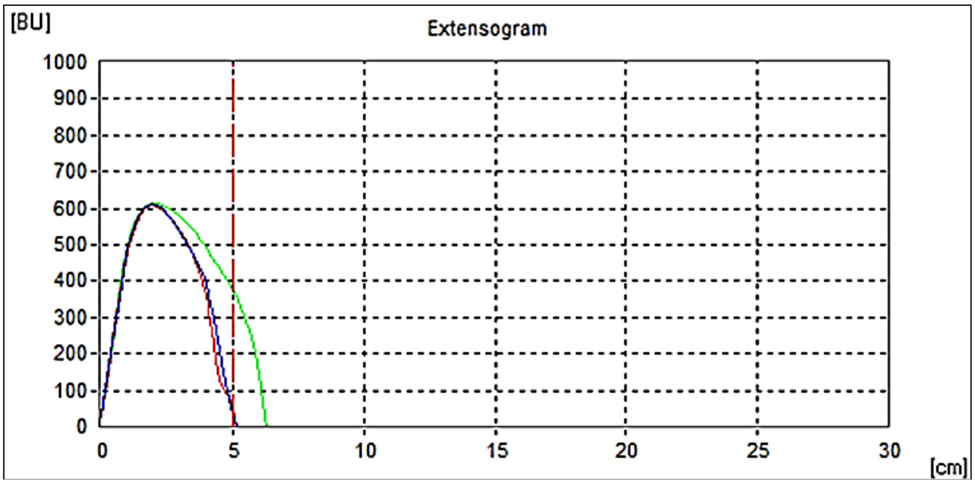

Fig 10: Extensograph of 20% deoiled linseed+80% maida (DL_4) sample

Amylograph Characteristics of Dough

The data in presented in Table 4 revealed amylograph characteristics for different treatments. The character of beginning of gelatinization showed non-significant differences in different treatments. The beginning of gelatinization temperature was observed from 58.10 ˚C for DL_0 and for DL_1 (58.32 °C), DL_2 (57.51 °C), DL_3 (57.06 °C) and DL_4 (56.77 °C). The significant increase in gelatinization temperature was observed with increased addition of deoiled linseed flour. Gelatinization temperature for treatment DL_4 showed highest temperature value i.e. 85.68 °C with lowest value of 82.10 °C given by treatment DL_1. The gelatinization maximum value significantly decreased with the increased level of deoiled linseed flour i.e., 672.25 AU (DL_1), 663.93 AU (DL_2), 651.50 AU (DL_3), and 641.25 AU (DL_4).

Table 4: Influence of different level of deoiled linseed on amylograph characteristic of dough

Treatment	Beginning of gelatinization (^{0}C)	Gelatinization temperature (^{0}C)	Gelatinization maximum (AU)
DL_0	58.10	83.05	810.98
DL_1	58.32	82.10	672.25
DL_2	57.51	82.81	663.93
DL_3	57.06	83.90	651.50
DL_4	56.77	85.68	641.25
SE±	0.505	0.344	6.925
CD at 5%	NS	1.038	20.875

Breakdown values decreased from with an increase in levels of deoiled flaxseed powder indicating that the fiber fraction interacted with wheat starch because there was also a dilution of starch content with an increase flaxseed powder. Naik and Sekhon (2014) [10] studied gelatinization characteristics gelatinization temperature, peak viscosity, peak temperature and viscosity at 95 °C decreased with extended rate of defatted soy flour addition. Watanabe *et al*. found that the brown rice flour had higher gelatinization temperatures and gelatinization maximum than the wheat flour.

Rao and Rao (1991) [14] reported that amylograph peak viscosity gradually decreased when 50% wheat bran was incorporated possibly due to decrease in total starch content. Symons and Brennan (2004) studied the substitution of wheat starch with barley β-glucan fiber fractions at 5% level and reported a decrease in peak viscosity and break down values. This reduction is likely because of water being held from the starch granules by β-glucan and general reduction in starch content of pastes because of replacement of barley glucan fiber.

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