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Study of Addition of Defatted Moringa Seed Flour on Rheological Properties of Dough

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ABSTRACT:
The present investigation was undertaken to study its rheological study by addition of defatted Moringa seed flour at different level. Increasing addition of defatted Moringa seed flour from 5 to 25 %, caused decrease in water absorption (at 500 FU and 14% moisture content), dough stability, time to breakdown and farinograph quality number up to 15% defatted Moringa seed flour whereas dough development time and mixing tolerance index increased up to 15 % defatted Moringa seed flour. 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, gelatinization temperature increased and gelatinization maximum decreased with addition of defatted Moringa seed flour.

Keywords: Defatted Moringa seed flour, Farinograph, Extensograph, Amylograph

I. INTRODUCTION

Moringa oleifera belonging to the family Moringaceae, native of sub-Himalayan region of northwest India and now grown worldwide within the tropics and sub-tropics. In some regions Moringa oleifera is known as drumstick or horse radish tree. Moringa oleifera is additionally called as 'Shevga' in Marathi, 'Saguna' in Hindi, 'Shobhanjana' in Sanskrit, 'Murungai' in Tamil, 'Munaga' in Telegu, 'Sainjna' in Punjabi languages and it's a very important medicinal crop in India (Jed, 2005). The seeds of Moringa contain 38-42 per cent oil, which is edible vegetable oil. This oil possesses physico-chemical properties similar to those of other vegetable oil and contains high level of tocopherols like olive oil (Tsakniset al., 1999).Moringa seed has high nutritional value as reflected within appreciable amount of nutrients thus it may be included in diets to supplement human's daily nutritional needs of foods lacking protein, carbohydrate and lipid.The seed cake remaining after oil extraction isalso used as a fertilizer (Rashid et al., 2008).Moringa seed has been known to combat malnutrition in infant and nursing mothers. Seed flour from Moringa oleifera has a powerful range of medicinal uses with high nutritional value. Moringa seed content crude protein, crude fat, ash, crude fiber and carbohydrate were 28.04, 45.84, 4.10, 7.73 and 10.59 per cent respectively. Mineral content calcium, iron and zinc were 203.85, 31.03 and 8.08 respectively (Abiodun et al., 2012) where as defatted cake contain crude protein, crude fat, ash, crude fiber and carbohydrate were 50.80, 3.06, 10.00, 12.96 and 18.15 respectively. Mineral content of defatted cake calcium, iron and zinc were 249.85, 37.32 and 12.09 respectively. The defatted Moringa seed cake due to its nutritional value and good source of fibre can be utilized in different food products, used as feed and fibre rich product.

The purpose of our study was investigated the rheological characteristics of wheat (Var. Trimbakand Samadhan) flour with defatted Moringa seed flour 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.

II. MATERIALS AND METHODS

Wheat grains and Moringa seeds

The raw materials such as wheat varietiesTrimbak (NIAW 301)and Samadhan (NIAW-1994) are obtained from Wheat Research Station Niphad, Dist.- Nashik. Moringa seeds variety PKM-1 procured from S. K. International, Vadodara, Gujrat.

Defatted Moringaseed Flour

The Moringa seed was defatted using the solvent extraction method using the food grade petroleum ether. The meal after desolventizing was

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passed through 200 mesh sieve to get uniform particle size.

Rheological Properties

Effect of substitution of refined wheat flour with 0, 5, 10, 15, 20and25% of defatted Moringa seed flour were evaluated using farinograph, extensograph and amylograph according to approved methods of AACC, 1983.

Table 1: Treatments for incorporation of defatted Moringa seed flour (DMSF)

Treatments	Defatted Moringa seed flour (DMSF)
T_0	100% Wheat flour + 0% Defatted Moringa seed flour
T_1	95% Wheat flour + 5% Defatted Moringa seed flour
T_2	90% Wheat flour + 10% Defatted Moringa seed flour
T_3	85% Wheat flour + 15% Defatted Moringa seed flour
T_4	80% Wheat flour + 20% Defatted Moringa seed flour
T_5	75% Wheat flour + 25% Defatted Moringa seed flour

III. STATISTICAL ANALYSIS

The result obtained in present investigation were statistically analyzed by using factorial completely randomized design (Rangaswamy, 2009; Bradley and Douglas, 2020).

IV. RESULT AND DISCUSSION

Farinograph Characteristics of Dough

The data presented in the Table 2 and fig 1 to fig 12 revealed thatthe water absorption at 14% moisture content showedsignificant differences among treatments and varieties.The treatment control T_0 86.70 (Trimbak) and 85.40 (Samadhan) reported lower value of water absorption at 500 BU at 14% moisture where higher value of water absorption at T_1 88.80 (Trimbak) and $T_3$88.60 (Samadhan) and $T_5$88.10 (Trimbak) and 87.90 (Samadhan). Incremental addition of defatted Moringa seed flour resulted in decreased in water absorption. The effects of replacing wheat flour with 0 to15 per cent debittered Moringa seed flour decreased farinograph water absorption (Ogunsinaet al. 2011).Incremental addition of flaxseed flour in wheat flour reduced the water absorption capacity of dough and dough stability (Ana-Maria et al. 2020).

Dough development time of control samples of Trimbak and Samadhan wheat flour was 4.40 and 5.00 min respectively(Table 2). Wheat flour blended with defatted Moringa seed flour recorded lowest dough development time of T_3 was 3.30 min (Trimbak) and 3.50 min (Samadhan) where as highest dough development time of T_4 and T_5 was 4.30 min (Trimbak) showed in fig 5 and 6.The dough development time significantly different as compared to control.The combined effect of wheat variety and different levels of defatted Moringa seed flour showed mean dough development time of 4.01 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 (Kalninaet al., 2015).The dough development time also varied with different cultivars of wheat. Dough development showed a positive correlation with water absorption(Farooq et al., 2014).

It was observed that, the value for dough stability of control $T_0$2.20 min (Trimbak) and 2.10 min (Samadhan). It was found that T_5showed 1.50 min (Trimbak) was higher than other treatments among varieties and it got declined upto T_3 0.90 min (Trimbak) and 1.10 min(Samadhan). So it indicated that dough stability was significantly decreased with increasing amount of defatted Moringa seed flour up to 15% DMSF. Majzoobiet al. (2012) also showed that dough stability decreased with

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Table 2.Interaction effect of wheat variety (Trimbak and Samadhan) flour with defatted Moringa seed flour on farinographic characteristics of dough

No.	Treatment	Water absorption (%)			Development time (min)			Stability			Tolerance index			Time to breakdown			Farinograph quality number		
		V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_0	Control	86.70	85.40	86.05	4.40	5.00	4.70	2.20	2.10	2.15	87.0	92.00	89.50	5.90	5.80	5.85	59.00	58.00	58.50
T_1	5% DMSF	88.80	87.40	88.10	3.90	4.00	3.95	1.30	1.40	1.35	124.0	130.0	127.0	4.80	4.80	4.80	48.00	48.00	48.00
T_2	10% DMSF	88.60	88.30	88.45	3.90	3.80	3.85	1.30	1.30	1.30	130.0	130.0	130.0	4.80	4.70	4.75	48.00	47.00	47.50
T_3	15% DMSF	88.20	88.60	88.40	3.30	3.50	3.40	0.90	1.10	1.00	150.0	140.0	145.0	4.30	4.20	4.25	43.00	42.00	42.50
T_4	20% DMSF	88.20	88.10	88.15	4.30	3.80	4.05	1.10	1.20	1.15	111.0	130.0	120.5	4.80	5.40	5.10	48.00	54.00	51.00
T_5	25% DMSF	88.10	87.90	88.00	4.30	3.90	4.10	1.50	1.30	1.40	101.0	93.00	97.00	5.00	5.50	5.25	50.00	55.00	52.50
	Mean	**88.10**	**87.62**	**87.86**	**4.20**	**4.00**	**4.01**	**1.38**	**1.40**	**1.39**	**117.17**	**119.17**	**118.17**	**4.93**	**5.07**	**5.00**	**49.33**	**50.67**	**50.00**
	Factor	V	T	V × T	V	T	V × T	V	T	V × T	V	T	V × T	V	T	V × T	V	T	V × T
	SE±	0.016	0.501	0.200	0.017	0.052	0.211	0.014	0.044	0.178	0.269	0.809	3.237	0.023	0.071	0.287	0.362	1.086	4.346
	CD @ 5%	0.047	0.143	0.575	NS	0.156	NS	NS	0.024	NS	NS	2.128	9.287	NS	0.206	NS	NS	3.116	NS

All results are mean of three replications, DMSF= Defatted Moringa seed flour, NS= Non-significant.**V_1** = Trimbak,**V_2** = Samadhan

Increasing percentage of oat flour in the formulation. Mahmoud et al. (2018) evaluated the effect of FFF and DFF at different addition levels (5, 10 and 15 %) on the flour characteristics, showed that flour water absorption and dough stability were decreased as FFF or DFF addition levels increased.

The mixing tolerance index (MIT)indicates the degree of softening during mixing. Degree of softening for control treatment of Trimbak and Samadhan varieties, which were 87.00 and 92.00 FU (Table 2). Blend of wheat flour with defatted Moringa seed flour recorded lowest degree of softening for T_5 93.00 FU (Samadhan) showed in fig 12. Blend of wheat flour with defatted Moringa seed flour recorded higher degree of softening for T_3 150.00 FU (Trimbak) followed by T_3 140.00 FU (Samadhan).Reduction of MTI can be observed due to interactions between fibre and gluten (Wang et al., 2002; Bouazizet al., 2010). Farinograph studies revealed that the mixing tolerance index decreased from 90 BU to 55 BU as defatted soya flour addition increased. Ribottaet al., (2005) and Sudha et al., (2010) also reported same results.

Control samples of Trimbak and Samadhan wheat variety flour had highest farinograph quality number, viz. 59.00 and 58.00, respectively (Table 2). Blend of wheat flour with defatted Moringa seed flour recorded lowest farinograph quality number of (Trimbak) T_3 43 FU and (Samadhan) T_3 42 FU.Farinograph quality number decreased from control as level of defatted Moringa seed flour in wheat flour increased. The combined effect of wheat variety and different levels of defatted Moringaseed flour showed mean farinograph quality number was 50.00 FU.

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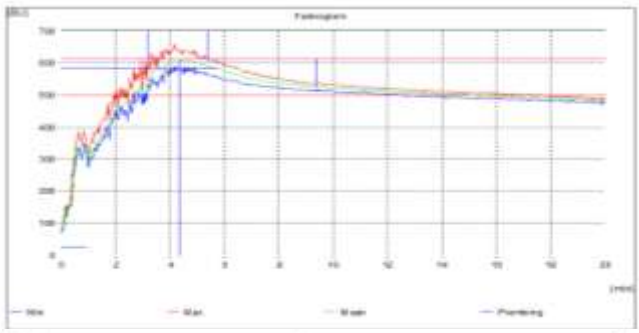


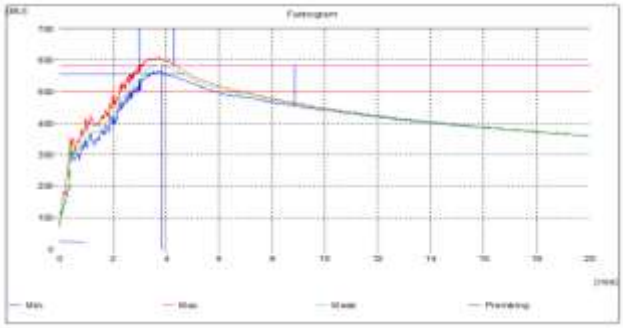
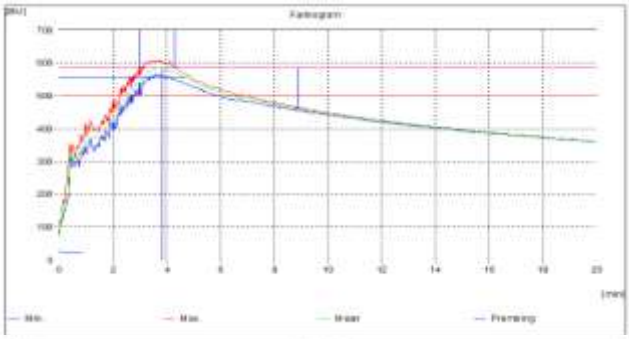


Fig. 1 Treatment T_0 control (Trimbak)Fig. 2Treatment T_1 (Trimbak) (5 % DMSF)



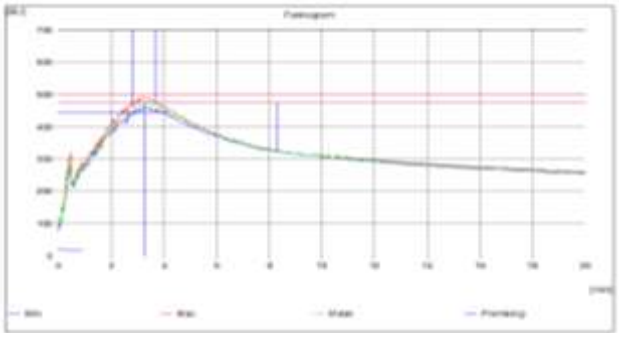


Fig. 3Treatment T_2 (Trimbak) (10 %DMSF)Fig. 4 Treatment T_3 (Trimbak) (15 %DMSF)

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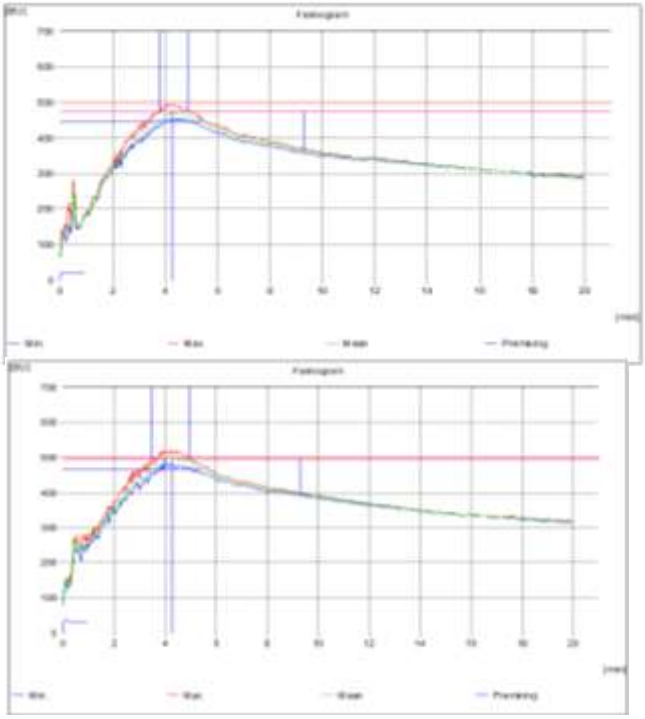

Fig. 5 Treatment T_4 (Trimbak) (20 %DMSF)Fig. 6 Treatment T_5 (Trimbak) (25 %DMSF)

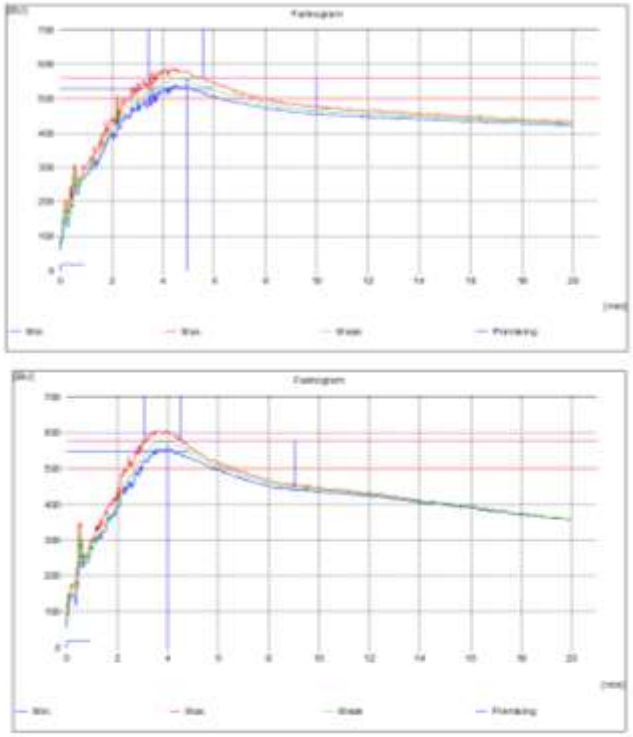

Fig. 7 Treatment T_0 control (Samadhan)Fig. 8 Treatment T_1 (Samadhan) (5 %DMSF)

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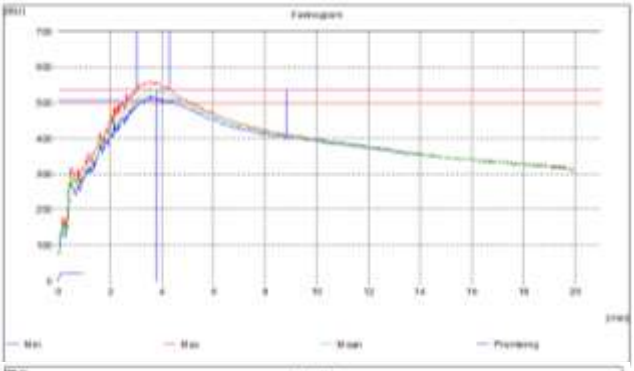

Fig. 9 Treatment T_2 (Samadhan) (10 %DMSF)Fig. 10 Treatment T_3 (Samadhan) (15 %DMSF)

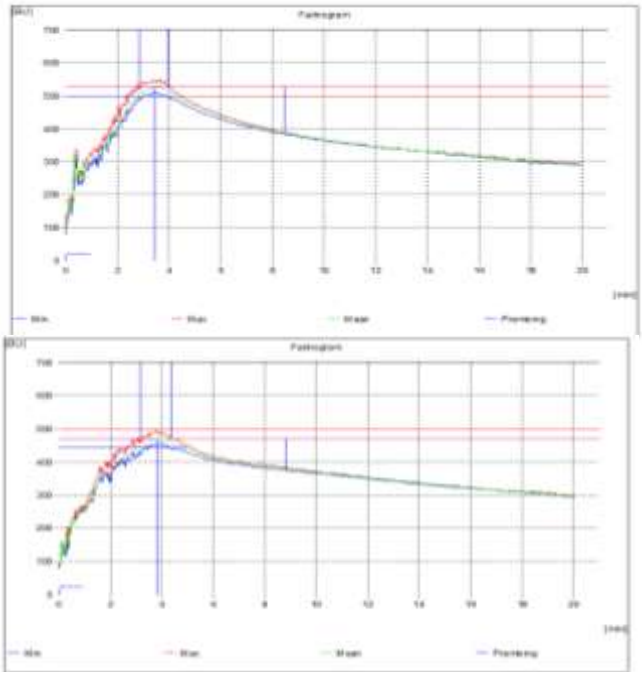

Fig. 11 Treatment T_4 (Samadhan) (20 %DMSF)Fig. 12 treatment T_5 (Samadhan) (25 % DMSF)

Extensograph characteristics of dough

The data in the Table 3 depicted and fig 13 to fig 24 represents extensograph characteristics.Energy value differences of all treatments significant were found to be statistically significant for all the proving time.Area under curve or energy, which indicates the dough strength, of the control samples at 30 min of proofing was 48.00 and 46.00 cm^2 for Trimbak and Samadhan wheat variety flours respectively (Table 3). Time analysis showed that energy gradually increased with increase in proofing time from 30 to 90 min. In control wheat

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flour, it was observed that the energy value increased from 47 cm^2 at 30 min to 49 cm^2 at 60 and 90 min.Addition of defatted Moringa seed flour caused changes in the energy values. At 30 min of proofing, blend of wheat flour with defatted Moringa seed flour recorded lowest energy value 14.83 cm^2 (Trimbak) and 15.00 cm^2 (Samadhan). The time analysis showed that the energy gradually increased with increasing proofing time from 30 to 90 min. The combined effect of wheat variety and different levels of defatted Moringa seed flour showed mean energy value increased from 14.92 cm^2 at 30 min, 16.29 cm^2 at 60 min and 16.75 cm^2 at 90 minIt was observed that as with the increased concentration of defatted Moringa seed flour the energy was decreased might be due to reduced gluten content in 25 per cent replacement of defatted Moringa seed flour with both the varieties of wheat.Zanwar, (2020) reported that the increasing addition of deoiled linseed flour from 5 to 20 per cent the extensograph parameters revealed reduction in the energy.

Table 3. Interaction effect of wheat variety (Trimbak and Samadhan) flour with defatted Moringa seed flour on energy (cm^2)

No.	Treatment	30 min			60 min			90 min		
		V_1 :Trimbak	**V_2 :Samadhan**	**Mean**	**V_1 :Trimbak**	**V_2 :Samadhan**	**Mean**	**V_1 :Trimbak**	**V_2 :Samadhan**	**Mean**
T_0	Control	48.00	46.00	47.00	52.00	46.00	49.00	53.00	45.00	49.00
T_1	5% DMSF	19.00	18.00	18.50	20.00	19.00	19.50	23.00	19.00	21.00
T_2	10% DMSF	8.00	10.00	9.00	13.00	10.00	11.50	11.00	13.00	12.00
T_3	15% DMSF	7.00	10.00	8.50	8.00	9.00	8.50	8.00	10.00	9.00
T_4	20% DMSF	4.00	4.00	4.00	5.00	4.50	4.75	5.00	5.00	5.00
T_5	25% DMSF	3.00	2.00	2.50	4.00	5.00	4.50	5.00	4.00	4.50
	Mean	**14.83**	**15.00**	**14.92**	**17.00**	**15.58**	**16.29**	**17.50**	**16.00**	**16.75**
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.10	0.30	1.23	0.10	0.31	1.24	0.12	0.37	1.49
	CD @ 5%	NS	0.88	NS	NS	0.89	NS	NS	1.07	4.28

*All results are mean of three replications, DMSF= Defatted Moringa seed flour, NS= Non-significant

The results (Table 4) revealed that highest resistance to extension was observed for control samples of wheat varieties Trimbak and Samadhan i.e., 396.00 and 377.00 BU respectively at 30 min proofing time. Addition of defatted Moringa seed flour caused changes in the resistance to extension. At 30 min of proofing, blend of wheat flour with defatted Moringa seed flour recorded resistance to extension of 104.50 BU (Trimbak) and 103.83 BU (Samadhan). The differences in resistance to extension values (Table 4) among all treatments to be significantly different at all the proving time. The combined effect of wheat variety with defatted Moringa seed flour showed mean resistance to extension value increased from 104.17 BU at 30 min, 107.46 BU at 60 min and 112.25 BU at 90 min. Hussein and Abdalla (1976) reported that addition of maize and sorghum significantly decreased the resistance to extension of dough.Hassan et al., (2015) studied that ratios of starch used in wheat flour were 5, 10 and 15with 5 per cent lentil flour.

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Table 4. Interaction effect of wheat variety (Trimbak and Samadhan) flour with defatted Moringa seed flour on resistance to extension (BU)

No.	Treatment	30 min			60 min			90 min		
		V_1 :Trimbak	V_2 :Samadhan	Mean	V_1 :Trimbak	V_2 :Samadhan	Mean	V_1 :Trimbak	V_2 :Samadhan	Mean
T_0	Control	396.00	377.00	386.50	417.00	382.00	399.50	429.00	382.00	405.50
T_1	5% DMSF	122.00	118.00	120.00	119.00	119.00	119.00	142.00	137.00	139.50
T_2	10% DMSF	35.00	27.00	31.00	63.00	48.50	55.75	46.00	37.00	41.50
T_3	15% DMSF	29.00	42.00	35.50	21.00	29.00	25.00	25.00	38.00	31.50
T_4	20% DMSF	25.00	26.00	25.50	27.00	23.00	25.00	27.00	20.00	23.50
T_5	25% DMSF	20.00	33.00	26.50	21.00	20.00	20.50	31.00	33.00	32.00
	Mean	**104.50**	**103.83**	**104.17**	**111.33**	**103.58**	**107.46**	**116.67**	**107.83**	**112.25**
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.14	0.43	1.75	0.36	1.09	4.39	0.17	0.52	2.08
	CD @ 5%	NS	1.259	5.03	1.05	3.15	12.60	0.49	1.49	5.98

*All results are mean of three replications. DMSF= Defatted Moringa seed flour, NS= Non-significant

Extensibility indicates elasticity of the dough which has significant effects on quality of bakery product.Differences of extensibility values in all the treatments with variety of wheat flour were significant for all proving time. At 30 min proving time treatment T_1 (77.00 mm) of variety Samadhan was statistically superior over the all treatment (Table 5). Treatment T_1 (73.00 mm) of variety Trimbak shows nearest significance. Addition of defatted Moringa seed flour affected on extensibility of dough. At 30 min of proving, blend of wheat flour with defatted Moringa seed flour recorded extensibility of 49.17 mm (Trimbak) and 52.33 mm (Samadhan). The time analysis showed that the extensibility gradually increased with the increased in proving time from 30 to 60 min but decreased from 60 to 90 min. The combined effect of wheat variety and defatted Moringa seed flour showed mean extensibility value increased from 50.75, 54.08 and 52.92 mm at 30, 60 and 90 min respectively. It was revealed that extensibility was reduced with increased level of defatted Moringa seed flour.The all interaction effects showed statistically significant among the treatments and varieties. T_0 produce bread with good volume dough should have a high viscosity and extensibility to prevent sudden breakage in gas cell membranes (Sliwinskiet al., 2004).

Table 5. Interaction effect of wheat variety (Trimbak and Samadhan) flour with defatted Moringa seed flour on extensibility (mm)

No.	Treatment	30 min			60 min			90 min		
		V_1 :Trimbak	V_2 :Samadhan	Mean	V_1 :Trimbak	V_2 :Samadhan	Mean	V_1 :Trimbak	V_2 :Samadhan	Mean
T_0	Control	72.00	72.00	72.00	79.00	84.00	81.50	70.00	74.00	72.00
T_1	5% DMSF	73.00	77.00	75.00	71.00	72.00	71.50	72.00	69.00	70.50
T_2	10% DMSF	58.00	53.00	55.50	66.00	55.00	60.50	60.00	63.00	61.50

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T_3	15% DMSF	41.00	58.00	49.50	43.00	53.00	48.00	42.00	55.00	48.50
T_4	20% DMSF	28.00	33.00	30.50	33.00	35.00	34.00	31.00	38.00	34.50
T_5	25% DMSF	23.00	21.00	22.00	26.00	32.00	29.00	31.00	30.00	30.50
	Mean	**49.17**	**52.33**	**50.75**	**53.00**	**55.17**	**54.08**	**51.00**	**54.83**	**52.92**
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.12	0.38	1.55	0.14	0.43	1.72	0.16	0.50	2.03
	CD @ 5%	0.37	1.11	4.44	0.41	1.23	4.95	0.48	1.46	5.84

*All results are mean of three replications, DMSF= Defatted Moringa seed flour

The ratio number for control samples of wheat varieties Trimbak and Samadhan was recorded as 6.50 and 5.30 respectively at 30 min proving time (Table 6). Time analysis showed that the ratio number gradually decreased with increasing proving time from 30 to 60 min but increased from 60 to 90 min. Addition of defatted Moringa seed flour caused changes in the ratio number. At 30 min of proving, the blend of wheat flour with defatted Moringa seed flour recorded ratio number of 1.88 and 1.73. Ratio number gradually decreased as level of defatted Moringa seed flour increased up to 10 per cent then eventually increased ratio number. Samadhan wheat flour showed lower ration number as compared to Trimbak.Rosellet al. (2001) also found lower values for the control sample while evaluating the rheological characteristics and quality of bread.

Table 6. Interaction effect of wheat variety (Trimbak and Samadhan) flour with defatted Moringa seed flour on ratio number

No.	**Treatment**	**30 min**			**60 min**			**90 min**		
		V_1 :Trimbak	**V_2 :Samadhan**	**Mean**	**V_1 :Trimbak**	**V_2 :Samadhan**	**Mean**	**V_1 :Trimbak**	**V_2 :Samadhan**	**Mean**
T_0	Control	6.50	5.30	5.90	5.30	4.60	4.95	6.10	5.20	5.65
T_1	5% DMSF	1.70	1.50	1.60	1.70	1.70	1.70	2.00	1.80	1.90
T_2	10% DMSF	0.60	0.50	0.55	1.00	0.70	0.85	0.80	1.00	0.90
T_3	15% DMSF	0.70	0.70	0.70	0.50	0.50	0.50	0.60	0.70	0.65
T_4	20% DMSF	0.90	0.80	0.85	0.80	0.70	0.75	0.90	0.50	0.70
T_5	25% DMSF	0.90	1.60	1.25	0.80	0.60	0.70	1.00	1.10	1.05
	Mean	**1.88**	**1.73**	**1.81**	**1.68**	**1.47**	**1.58**	**1.90**	**1.72**	**1.81**
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.013	0.040	0.160	0.011	0.035	0.141	0.012	0.038	0.154
	CD @ 5%	NS	0.114	0.459	0.033	0.101	NS	0.036	0.110	0.443

*All results are mean of three replications, DMSF= Defatted Moringa seed flour, NS= Non-significant

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The ratio number maximum for control samples of wheat varieties Trimbak and Samadhan was recorded as each 6.80 at 30 min proving time (Table 7). At 30 min of proving, the blend of wheat flour with defatted Moringa seed flour recorded maximum of 3.92 and 3.93. Time analysis showed that the ratio number maximum gradually increased with increasing proving time from 30 to 90 min.Addition of defatted Moringa seed flour caused changes in the ratio number (max). Control sample had ratio number maximum 6.80, 6.20 and 7.20 at 30, 60 and 90 min of proving time, respectively.The combined effect of wheat variety and defatted Moringa seed flour showed mean ratio number (max) value increased from 3.93 at 30 min to 4.02 at 60 min and increased to 4.35 at 90 min, respectively.These results indicated that the ratio number maximum decreased up to 10 per cent thereafter it was increased but not more than control. As concentration of defatted Moringa seed flour increases resulted in reduction of extensibility and elastic properties of dough.

Table 7. Interaction effect of wheat variety (Trimbak and Samadhan) flour with defatted Moringa seed flour on ratio number max

No.	**Treatment**	**30 min**			**60 min**			**90 min**		
		V_1 :Trimbak	**V_2 :Samadhan**	**Mean**	**V_1 :Trimbak**	**V_2 :Samadhan**	**Mean**	**V_1 :Trimbak**	**V_2 :Samadhan**	**Mean**
T_0	Control	6.80	6.80	6.80	6.70	5.70	6.20	8.00	6.40	7.20
T_1	5% DMSF	3.10	2.50	2.80	3.50	3.50	3.50	3.80	3.70	3.75
T_2	10% DMSF	2.30	3.00	2.65	2.70	3.10	2.90	3.00	2.80	2.90
T_3	15% DMSF	3.30	3.20	3.25	3.50	3.50	3.50	4.00	3.70	3.85
T_4	20% DMSF	3.90	3.60	3.75	4.00	3.70	3.85	4.30	3.50	3.90
T_5	25% DMSF	4.10	4.50	4.30	4.20	4.10	4.15	4.90	4.10	4.50
	Mean	**3.92**	**3.93**	**3.93**	**4.10**	**3.93**	**4.02**	**4.67**	**4.03**	**4.35**
	Factor	**V**	**T**	**V × T**	**V**	**T**	**V × T**	**V**	**T**	**V × T**
	SE±	0.015	0.047	0.18	0.014	0.04	0.17	0.03	0.09	0.39
	CD @ 5%	NS	0.13	0.54	NS	0.12	0.51	0.09	0.28	NS

*All results are mean of three replications, DMSF= Defatted Moringa seed flour, NS= Non-significant

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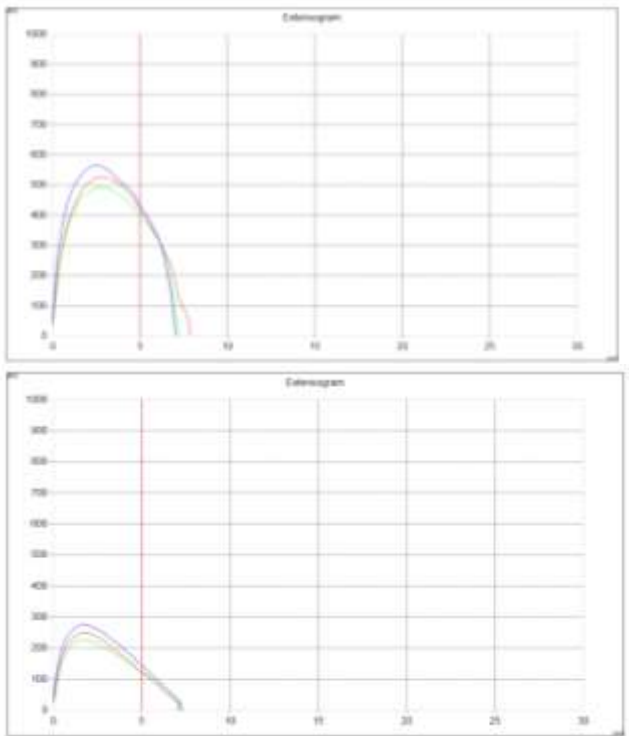

Fig. 13 Treatment T_0 control (Trimbak)Fig. 14 Treatment T_1 (Trimbak) (5 % DMSF)

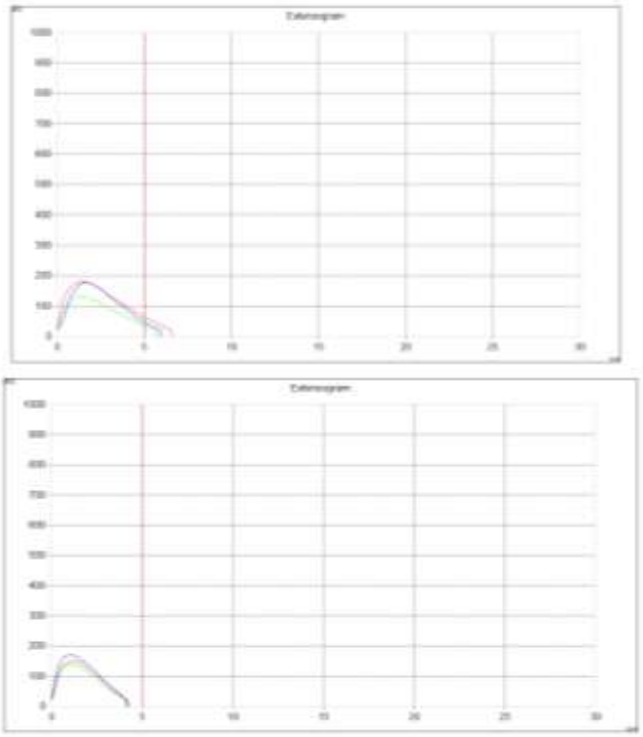

Fig. 15 Treatment T_2 (Trimbak) (10 %DMSF) Fig. 16Treatment T_3 (Trimbak) (15 % DMSF)

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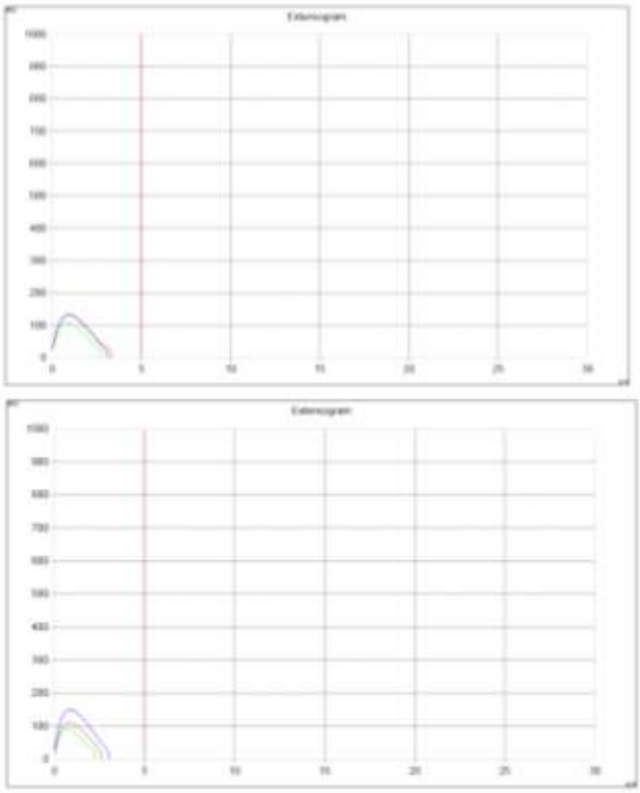

Fig. 17Treatment T_4 (Trimbak) (20 %DMSF)Fig. 18 Treatment T_5 (Trimbak) (25 % DMSF)

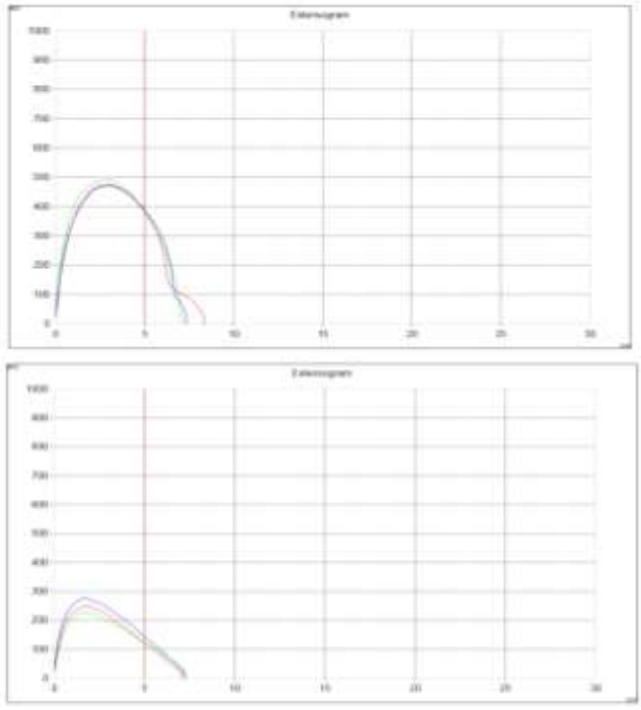

Fig. 19 Treatment T_0 control (Samadhan)Fig. 20 Treatment T_1 (Samadhan) (5 % DMSF)

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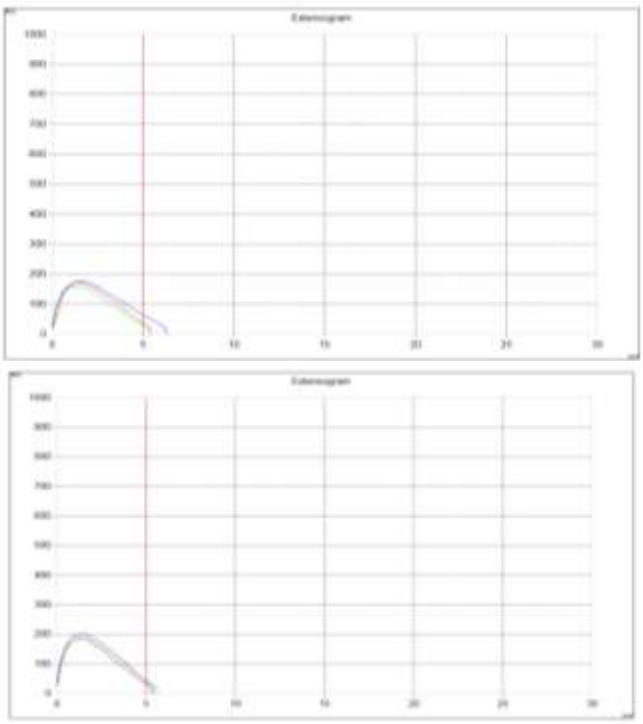

Fig. 21 Treatment T_2 (Samadhan) (10 %DMSF) Fig. 22 Treatment T_3 (Samadhan) (15 % DMSF)

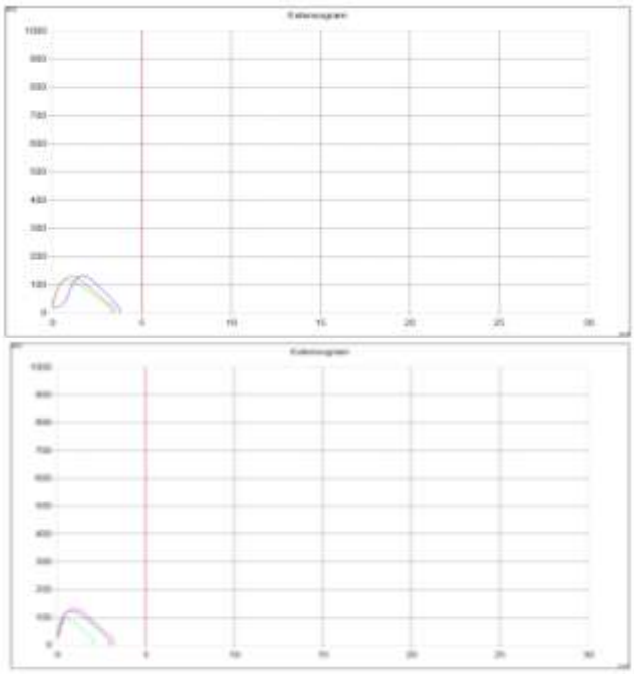

Fig. 23 Treatment T_4 (Samadhan) (20 % DMSF)Fig. 24 Treatment T_5 (Samadhan) (25 % DMSF)

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Amylograph characteristics of dough

Amylograph readings of dough with wheat variety flour by various combinations of defatted Moringa seed flour are presented in Table 8-10.Beginning of gelatinization temperature for Trimbak and Samadhan wheat flour without defatted Moringa seed flour was 60.00 and 59.30 respectively (Table 8). Blend of wheat flour with defatted seed flour recorded gelatinization temperatureof 58.85°C (Trimbak) and 60.17°C (Samadhan). The results presented in Table 8 revealed that treatment T_5 obtained lower value of beginning of gelatinization temperature 58.40 °C (Trimbak) as compared to control treatment T_0 which exhibited highest value of beginning gelatinization temperature (60°C). The T_3 showed significantly different for gelatinization temperature (61.40°C) among all treatments. The character of beginning gelatinization decreased significantly as the defatted Moringa seed flour percentage increasedmay be attributed to dilution of starch and gluten of wheat flour. It was observed that there was inverse relation of beginning gelatinization temperature and levels of defatted Moringa seed flour. The combined effect of wheat variety and the different levels of defatted Moringa seed flour showed mean beginning gelatinization temperature of 59.51°C. The effect of gelatinization on dough rheological properties was mainly due to the effect of temperature on gluten (Gelinas and Mckinnon, 2004).

Table 8. Interaction effect of wheat variety (Trimbak and Samadhan) flour with defatted Moringa seed flour on beginning of gelatinization (°C)

No.	Treatment	Beginning of gelatinization (°C)		
		V_1 :Trimbak	**V_2 :Samadhan**	**Mean**
T_0	Control	60.00	59.30	59.65
T_1	5% DMSF	58.60	59.30	58.95
T_2	10% DMSF	58.60	59.60	59.10
T_3	15% DMSF	58.90	61.40	60.15
T_4	20% DMSF	58.60	61.30	59.95
T_5	25% DMSF	58.40	60.10	59.25
	Mean	**58.85**	**60.17**	**59.51**
	Factor	**V**	**T**	**V × T**
	SE±	0.050	0.15	0.61
	CD @ 5%	0.14	NS	NS

*All results are mean of three replications, DMSF= Defatted Moringa seed flour, NS= Non-significant

Gelatinization temperature for Trimbak and Samadhan wheat flour without defatted Moringa seed flour was 89.40 and 89.50^{0}C respectively (Table 9).The gelatinization temperature decreased significantly with increased amount of defatted Moringa seed flour.The higher gelatinization temperature was recorded for T_1(Trimbak) might be due to intact starch which requires high temperature for disfolding of native structure followed by T_2 where as lowest gelatinization temperature for T_4 (86.60^{0}C) might be due to degradation of starch.The gelatinization temperature was significantly different for wheat flour Samadhan among all treatment as compare to wheat flour Trimbak. The gelatinization temperature varies among the wheat variety might be due to the variation in makeup of starch, its intactness and other structural variations of damaged starch (Leon et al., 2006).The combined effect of wheat variety and the different levels of defatted Moringa seed flour showed mean gelatinization temperature of 88.08^{0}C. From the pasting point of view, compared to the control sample, the samples in which flaxseed were incorporated in wheat flour presented a lower falling number value and a higher peak viscosity one (Ana-Maria et al. 2020).

Table 9. Interaction effect of wheat variety (Trimbak and Samadhan) flour with defatted Moringa seed flour on gelatinization temperature (°C)

No.	Treatment	Gelatinization temperature (°C)		
		V_1 :Trimbak	**V_2 :Samadhan**	**Mean**
T_0	Control	89.40	89.50	89.45
T_1	5% DMSF	89.10	88.10	88.60

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T_2	10% DMSF	88.40	88.10	88.25
T_3	15% DMSF	87.50	88.00	87.75
T_4	20% DMSF	86.60	88.00	87.30
T_5	25% DMSF	86.80	87.50	87.15
	Mean	**87.97**	**88.20**	**88.08**
	Factor	**V**	**T**	**V × T**
	SE±	0.01	0.037	0.15
	CD @ 5%	0.036	0.10	0.43

*All results are mean of three replications, DMSF= Defatted Moringa seed flour

Gelatinization maximum for Trimbak and Samadhan wheat flour without defatted Moringa seed flour was 1090 and 1169 AU respectively (Table 10).Wheat flour blended with defatted Moringa seed flour recorded highest gelatinization maximum T_1 1046 AU (Samadhan) whereas lowest gelatinization maximum i.e. T_5 760 AU (Samadhan). The gelatinization maximum was decreased as defatted Moringa seed flour per cent increased might be due to reduction in hydrogen bond between starch and gluten. It was observed that there was inverse relation of gelatinization peak and level of defatted seed flour. The combined effect of wheat variety and the different levels of defatted Moringa seed flour showed mean gelatinization maximum of 920.42 AU. The effect of temperature on dough rheological properties was mainly due to its effect on gluten rheological properties as resistance to mixing increases in heated gluten (Anusooyaet al., 2010).

Table 10. Interaction effect of wheat variety (Trimbak and Samadhan) flour with defatted Moringa seed flour on gelatinization maximum (AU)

No.	Treatment	Gelatinization maximum (AU)		
		V_1 :Trimbak	**V_2 :Samadhan**	**Mean**
T_0	Control	1090.00	1169.00	1129.50
T_1	5% DMSF	1041.00	1046.00	1043.50
T_2	10% DMSF	916.00	948.00	932.00
T_3	15% DMSF	828.00	878.00	853.00
T_4	20% DMSF	814.00	791.00	802.50
T_5	25% DMSF	764.00	760.00	762.00
	Mean	**908.33**	**932.00**	**920.42**
	Factor	**V**	**T**	**V × T**
	SE±	0.41	1.23	4.94
	CD @ 5%	1.18	3.54	14.19

*All results are mean of three replications, DMSF= Defatted Moringa seed flour

Starch gelatinization is a process that breaks down the intermolecular bonds of starch molecules in presence of water and heat, resulting in exposure of hydrogen bonds (hydroxyl hydrogen and oxygen) which eventually leads more absorption of water. Starch granules should not disrupt and fuse together during gelatinization forming an impermeable gas membrane. Granules should gelatinize individually as wheat starch does, causing a disruption of cell membranes which prevents shrinkage of the loaf during cooling after baking (Kusunoseet al., 1999).

Differences in protein composition are also known to affect pasting viscosities and properties (Batey and Curtin, 2000).Rao and Rao (1991) reported that amylograph peak viscosity gradually decreased when 50% wheat bran was incorporated possibly due to decrease in total starch content.

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