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Effect of incorporation of Jamun leaf powder on rheological characteristics of dough

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Abstract
Jamun (*Syzygium cumini* L.) is an evergreen tropical tree, enriched with ample nutritive values and medicinal properties like anti-diabetic, antioxidant and anti-inflammatory, etc. Application of Jamun leaf powder (JLP) at the levels of 0 (T_0), 4 (T_1), 6 (T_2), 8 (T_3), 10 (T_4) and 12% (T_5) on the rheological characteristics of cookies was studied.
Investigations were carried out to study the rheological characteristics of dough incorporated with Jamun leaf powder-wheat flour blend in the various proportions. Different instruments were used for rheology study *viz*. Amylograph, Farinograph, Extensograph. Amylographic study revealed that, beginning of gelatinization for Jamun leaf powder-based composite flour was found to be in between (61.05-61.35 °C) with the various proportion of Jamun leaf powder. Moreover, consistent reduction in gelatinization temperature and gelatinization maximum was observed, it was varied between 88.90 to 87.40 °C and 1282.00 to 886.00 AU, respectively. The farinograph results showed that the composite flour's water absorption capacity (74.30-49.70%) and dough stability time (6.60-5.50 min) decreased significantly with the increasing proportion of Jamun leaf powder. While, dough development time (5.70-6.60 min) was observed to be increased at higher Jamun leaf powder incorporation. According to extensographic study, an increase in Jamun leaf powder proportion in composite flour resulted in reduction of dough's energy value to 46, 42 and 40 cm^2 for proving time of 30, 60, 90 min, respectively. Furthermore, with the higher inclusion of Jamun leaf powder, for 30, 60, 90 min of proving time, resistance to extension and extensibility of dough reduced to 55, 30, 26 BU and 39, 39, 41 mm, respectively. The ratio number for composite dough with higher percentage of Jamun leaf powder incorporated flour was increased to 10.7, 11.4 and 10.5 for proving time of 30, 60, 90 min, respectively.

Keywords: Jamun leaf powder, wheat flour, cookies

1. Introduction

Jamun (*Syzygium cumini* L./Eugenia Jambolana Lam) is an evergreen tropical tree, which belongs to family '*Myrtaceae*' (Bukya and Madane, 2018) [4]. It is commonly known as Ram Jamun (Hindi), Nerale (Kannada), Neredu pandu (Telugu), Naaval pazham (Tamil) and Jambul (Marathi). The tree is grown widely in India, Sri Lanka, Malaysia and Australia. It is widely cultivated as a horticultural plant for its fruits, timber and ornamental value in native South Asian region (Tripathi, 2020) [17].

Jamun leaf consist of the 4.3 g fat, 9.1 g crude protein, 17.0 g crude fiber, 0.19 mg phosphorus, 1.3 mg calcium per 100 g and essential oils which are contributing the pleasant smell (Chaudhary *et al*., 2017) [6]. Also, it contains 58.5±1.8 mg GAE/100 g per 100 g and essential oils which are contributing the pleasant smell. The leaves of Jamun were found to contain β-Sitosterol, betulinic acid, mycaminose, crategolic (maslinic) acid, n-hepatcosane, nnonacosane, n-hentriacontane, noctacosanol, n-triacontanol, n-dotricontanol, quercetin, myricetin, myricitrin and the flavonol glycosides myricetin3-O-(4"-acetyl)-αLrhamnopyranosides. Essential oils (α-terpeneol, myrtenol, eucarvone, muurolol, αmyrtenal, 1, 8-cineole, geranyl acetone, α-cadinol, pinocarvone) (Swami and Kalse, 2020) [14].

Most of the beneficial effects of Jamun leaves are associated with phytochemical found in Jamun leaves such as gallic acid, tannins, mallic acid, flavonoids, essential oils, jambolin, ellagic acid, jambosine, antimelin and betulinic acid. It possess curative activities like anticancer, antidiabetic, antifertility, anti-inflammatory, antidiarrheal, antimicrobial, antioxidant, antiradiation and gastroprotective. Jamun leaves can be used as potential constituent in the formulation of pharmacological drugs (Kumari *et al*., 2023) [12].

Tray dryer have many advantages such as cost effective, more efficient, uniform drying and ability to retain nutrients in material. Dried Jamun leaves were ground by grinding machine (hammer mill-1.5 HP) at laboratory.

Recently, natural plants have received much attention as sources of biologically active substances including antioxidants, antimutagens and anticarcinogens (Dillard and German, 2000) [8]. Several authors have used green leaves such as dried Moringa oleifera leaves to increase protein, minerals, fiber and β-carotene in cookies (Dachana *et al*., 2010) [7]. With this background work was undertaken to study the influence of Jamun leaf powder (JLP) on rheological characteristics of cookies.

2. Material and methods

2.1 Samples

The harvested Jamun leaves were cleaned by immersed it in saltwater solution for removal of dirt and foreign particles. The drying of Jamun leaves were done in tray dryer Once cleaned, the leaves were spread evenly on trays of a tray dryer to initiate the drying phase. Jamun leaf powder and wheat flour were prepared in crop processing laboratory, department of agricultural process engineering, Dr. A. S. C. A. E. & T., MPKV, Rahuri, Maharashtra, India.

2.2 Treatment details of Wheat flour-Jamun leaf powder blend

Composite flour was prepared by blending wheat flour with Jamun leaf powder in ratio of 100:00 (T0), 96:04 (T1), 94:06 (T2), 92:08 (T3), 90:12 (T4), 88:12 (T5), respectively and keeping the level of other ingredients constant in all combinations.

Table 1: Treatment details of Jamun leaf powder-Wheat flour blend

Treatment	Wheat (%)	Jamun leaf powder (%)
T_0	100	0
T_1	96	4
T_2	94	6
T_3	92	8
T_4	90	10
T_5	88	12

2.3 Rheological characteristics of composite flour

2.3.1 Amylograph

The parameters like beginning of the gelatinization (°C), gelatinization temperature (°C) and gelatinization maximum (AU) were evaluated with the help of amylograph which was equipped with its own programming software. Depending on the viscosity of the suspension, a measuring sensor into the bowl gets deflected. This deflection was measured as viscosity over time vs. temperature and recorded on software (A. A. C. C., 2000).

2.3.2 Method

1. A sample of 80 g of flour was combined with 450 mL of distilled water and mixed to make slurry (weight of sample and volume of water may changes as per moisture content of sample).
2. The slurry was stirred while being heated in the amylograph, beginning at 30 °C and increasing at a constant rate of 1.5 °C per minute until the slurry reaches 95 °C.
3. The amylograph recorded the resistance to stirring as a viscosity curve on graph paper.

2.3.3 Farinograph

The instrument most frequently used all over the world for determining the water absorption and mixing characteristics of wheat flour. It consists of a drive unit with continuous speed control and an attached measuring mixer for mixing the dough to be tested. It measures and records the mechanical resistance of the dough during mixing and kneading. Physical properties of dough were measured by placing a defined mass of flour in a tempered (30 °C) mixing bowl equipped with two Z type kneaders. The tests were performed using 300 g sample. In order to obtain the dough, of which rheological properties are actually measured, water was added to the flour in amount which ensures the dough consistency of 500 BU (Arbitrary Brabender units). Water absorption (%), dough development time (min), dough stability (min) and the mixing tolerance index (BU) were determined using already installed software in the Farinograph machine (A. A. C. C., 2000).

Method

1. A flour samples of 300g each on a 14% moisture basis were weighed and placed into the corresponding farinograph mixing bowl (weight of sample may changes as per moisture content of sample).
2. Calculated amount of distilled water from a burette was added to the flour and mixed to form a dough.
3. As the dough mixed, the farinograph recorded a curve on graph paper.
4. The amount of water added (absorption) which affected the position of the curve on the graph paper. Less water increased dough consistency and moved the curve upward or vice versa.
5. The curve was centered on the 500-brabender unit (BU) line±20 BU by adding the appropriate amount of water and it was ran until the curve leaves the 500-BU line.

2.3.4 Extensograph

Brabender Extensograph is an internationally accepted standard method. The extensograph showed the exerted force as a function of stretching length (time). The shape of measuring curve, its variation during the individual proving times, the area below the curve as well as the numerical values of different evaluation points, ensures to make reliable statements about the flour quality and suitability of the flour for baking. The energy (cm^2), resistance to extension (BU), extensibility (mm), ratio number were determined with the help of Extensograph through in-built software system (A. A. C. C., 2000) [1].

Method

Preparation

1. A 300 g flour sample on a 14% moisture basis was combined with a 2% salt solution and mixed in the farinograph to form dough.
2. After the dough was rested for 5 min, it is mixed to maximum consistency (peak time).

Analysis

1. A 3×150 g sample of prepared dough was placed on the extensograph rounder and shaped into a ball.
2. The ball of dough was removed from the rounder and shaped into a cylinder.
3. The dough cylinder was placed into the extensograph dough cradle, secured with pins, and rested at interval of 30, 60 and 90 minutes respectively in a controlled environment.
4. After each respective interval (30, 60, 90 min) put the dough cradle (tray) onto the holder arm, then start the test.
5. A hook was drawn through the dough, stretching it downwards until it breaks.
6. The extensograph recorded a curve on graph paper as the test was run.

Based on the results from the above rheological characteristics, i.e., gelatinization properties of starch (amylograph), dough developing characteristics (farinograph), and stretching characteristics of dough, we decide the flour is stronger or weaker and is it suitable for making cookies.

3. Results and Discussion

The study of deformation and flow properties in solid, semi-solid, and liquid is known as rheology. The textural qualities of baked goods and the dough's machinability are greatly influenced by its viscoelastic properties. When flour is mixed with water to be handled with, the protein in wheat flour i.e., gluten, allows the dough to stretch and flow. It has been found that these properties are get influenced by variables like another flour addition, temperature, time, and salt addition, and that these variables can be used to predict the quality of the finished product. The following section discusses the findings for the Amylograph, Fairnograph, and Extensograph.

3.2 Amylographic characteristics

The pasting and starch qualities of composite flour (wheat flour + Jamun leaf powder) were evaluated using the Brabender amylograph. The parameters like beginning of gelatinization (°C), gelatinization temperature (°C) and gelatinization max (AU) were investigated. Results obtained from amylograph after incorporating Jamun leaf powder at various levels in wheat flour are shown in Table 2.

The results showed that the composite flour's beginning of gelatinization temperatures initially increased significantly then slightly decreased with the increasing proportion of JLP. The treatment T_5 exhibited the lowest temperature of 61.05 °C. While, the highest beginning of gelatinization was observed for the treatment T_3 i.e., 61.35 °C. The gelatinization temperature of flour observed to be decreased consistently from 88.90 °C for treatment T_0 to 87.40 °C for treatment T_5. Moreover, amylograph study showed a consistent reduction in gelatinization maximum value of composite flour with increasing millet proportion. The treatment T_0 observed to have the highest gelatinization maximum of 1282.00 AU. Whereas, treatment T_4 exhibited lowest value of 886.00 AU.

Table 2: Effect of incorporation of JLP with wheat flour on amylographic characteristics

Treatment	Beginning of Gelatinization (°C)	Gelatinization Temperature (°C)	Gelatinization Max. (AU)
T_0	61.25	88.90	1282.00
T_1	61.16	88.43	991.33
T_2	61.20	88.05	962.50
T_3	61.35	87.75	927.00
T_4	61.25	87.65	886.00
T_5	61.05	87.40	927.00
S.E.	0.28	0.06	36.67
C.D.@5%	0.58	0.13	76.49

Similar findings were reported by Chandra *et al*. (2015) [5], who observed that the gelatinization temperature of composite flours significantly increased with the enhanced incorporation of non-wheat flours, such as rice, green gram, and potato, into wheat flour. Similar results have been reported by Khating *et al*. (2014) [11] and Thorat *et al*. (2016) [16] with the incorporation of millet like sorghum and finger millet flour, respectively, resulted in a decrease in the gelatinization temperature of composite flours. The gelatinization properties of starch largely depend on amylose-amylopectin ratio (Govindaraju *et al*., 2020) [9]. Similar explanations for why gelatinization maximum (AU) decreases when adding spinach leaf powder to a composite dough at a percentage of 0-10% were provided by Yadav *et al*. (2008) [18] and Symons and Brennan (2004) [15].

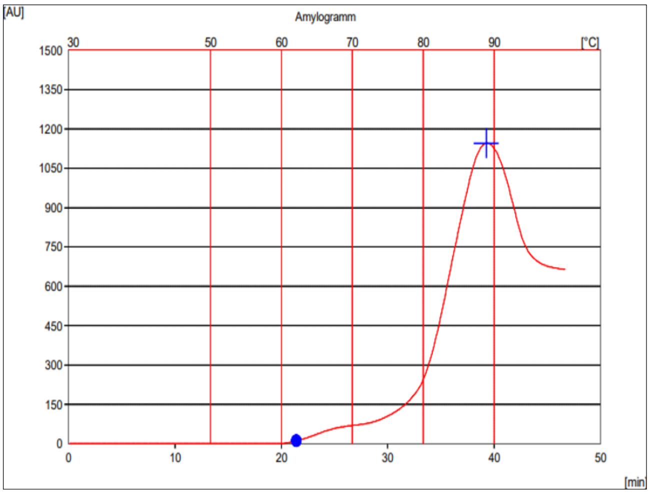

Fig 1: Treatment (T_0) (100:00)

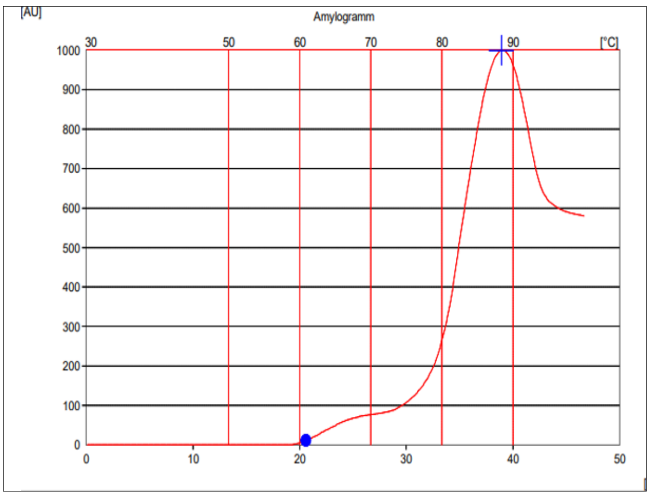

Fig 2: Treatment (T_1) (96:04)

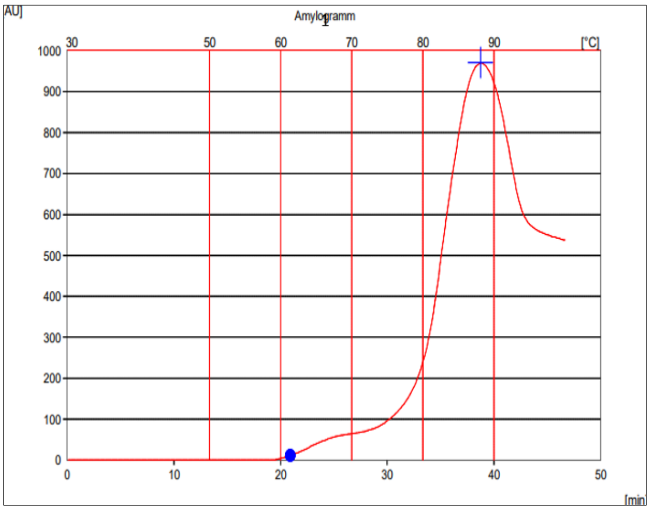

Fig 3: Treatment (T_2) (94:06)

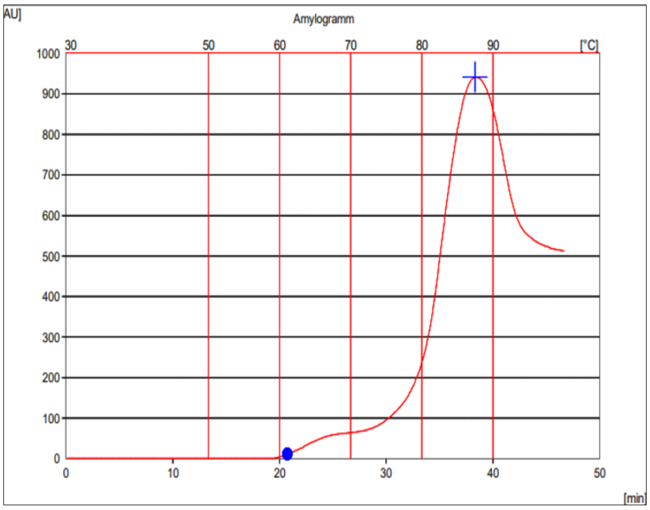

Fig 4: Treatment (T_3) (92:08)

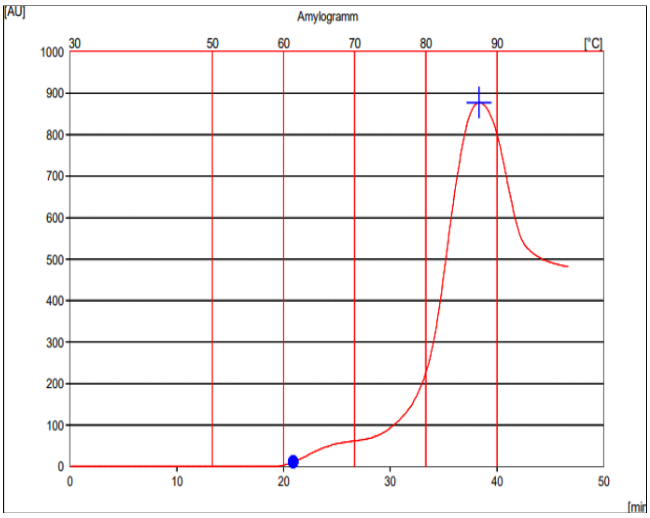

Fig 5: Treatment (T_4) (90:10)

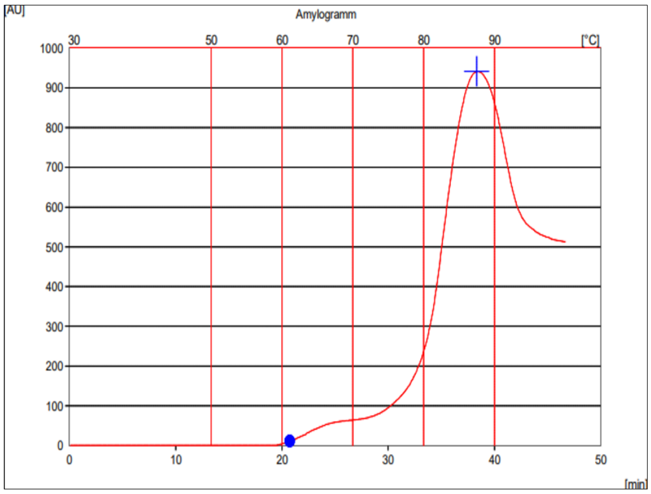

Fig 6: Treatment (T_5) (88:12)

3.3 Fairnographic characteristics

Dough characteristics of composite flour (wheat flour + Jamun leaf powder) were evaluated using the Brabender farinograph. The parameters like water absorption (%), dough development time (min), dough stability (min), and mixing tolerance index (BU) are investigated. Results obtained from farinograph after incorporating millet flour at various levels in wheat flour are shown in Table 3.

The obtained results showed that the composite flour's water absorption capacity decreased significantly with the increasing proportion of JLP. The control treatment T_0 exhibited the highest water absorption of about 74.30%. While, the lowest water absorption capacity was observed for the treatment T_5 i.e., 49.70%. The dough development time for composite JLP-based flour observed to be increased consistently from 5.70 min for treatment T_1 to 6.60 min for treatment T_5. Furthermore, farinograph study showed a consistent decrease in stability time of composite flour with increasing JLP proportion. The treatment T_0 observed to have the longest stability time of 6.60 min. Whereas, treatment T_5 exhibited lowest stability time of about 5.50 min. The mixing tolerance index of composite JLP flour was observed to be initially decreased significantly then rise at the higher JLP incorporation. Control treatment T_0 showed the MTI of 34 BU. The highest MTI value was observed for the treatment T_5 i.e., 63 BU. While treatment T_2 showed the lowest value of about 13 BU.

Khan *et al*., (2013) [10] found that adding 1-10% spinach leaf powder to the composite dough may lengthen the dough's development time because it weakens the dough and increases the fibre content, which dilutes and breaks the gluten's continuity. Dachana *et al*., (2010) [7] reported that that the addition powdered dried moringa leaves (from 0-15%) in composite dough decreased dough stability of dough, due to gluten dilution and a decline in the amount of available gluten gelatinization of starch. Decreased MTI offers convenience in dough handling, as it corresponds to the stronger flour (bakerpedia.com, 2024).

Table 3: Effect of incorporation of JLP with wheat flour on Fairnographic characteristics

Treatment	Water Absorption (%)	Dough Development Time (min)	Dough Stability Time (min)	Mixing Tolerance Index (BU)
T_0	74.30	6.70	6.60	34
T_1	73.70	5.70	6.50	29
T_2	72.80	6.00	5.70	13
T_3	64.20	6.30	5.70	26
T_4	50.20	6.50	5.60	56
T_5	49.70	6.60	5.50	63
S.E.	0.3430	0.1016	0.0577	1.2909
C.D.@5%	1.0119	0.2998	0.1703	3.8084

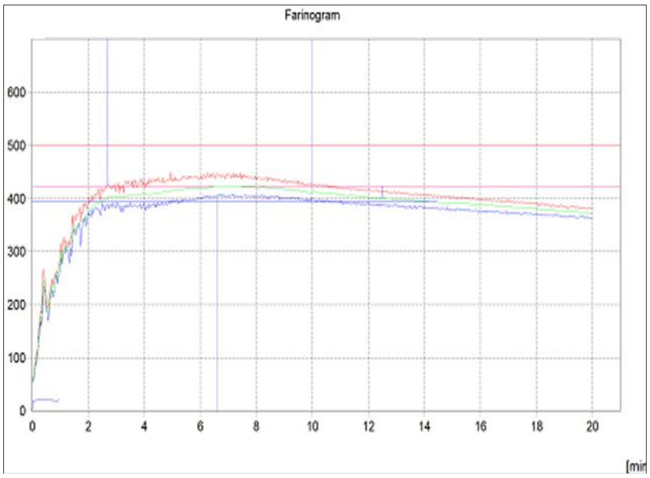

Fig 7: Treatment (T_0) (100:00)

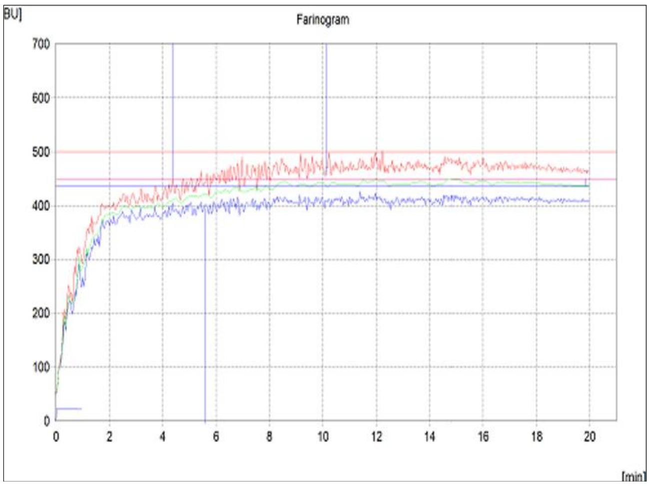

Fig 8: Treatment (T_1) (96:04)

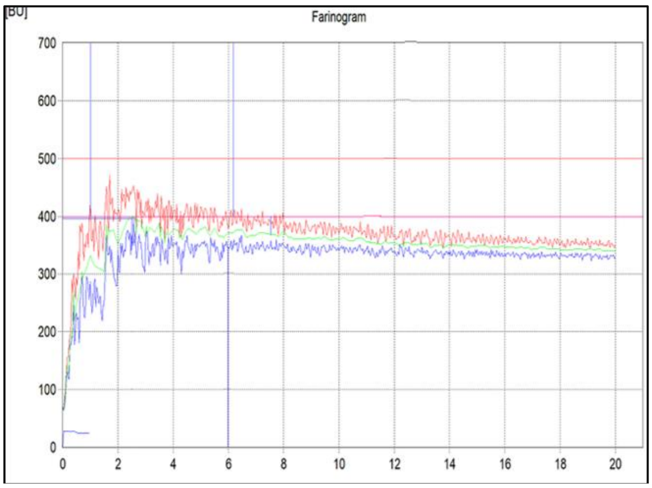

Fig 9: Treatment (T_2) (94:06)

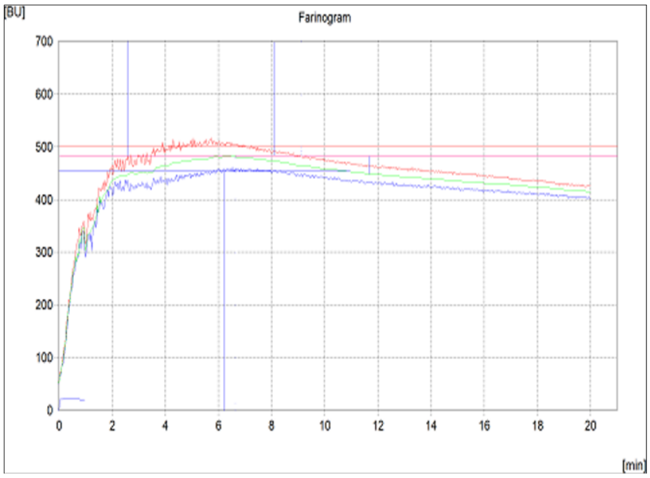

Fig 10: Treatment (T_3) (92:08)

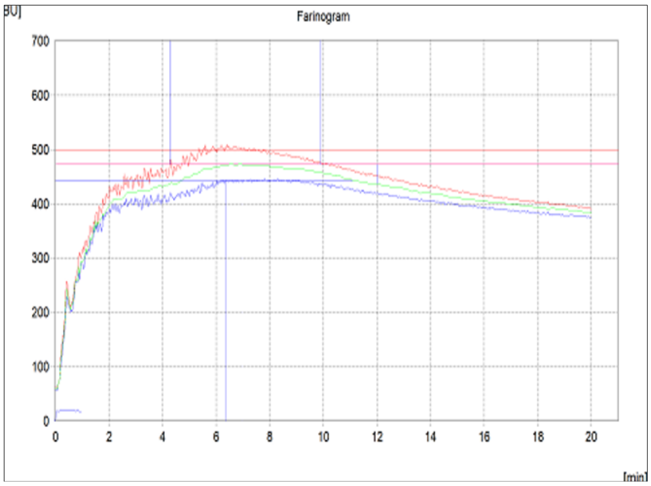

Fig 11: Treatment (T_4) (90:10)

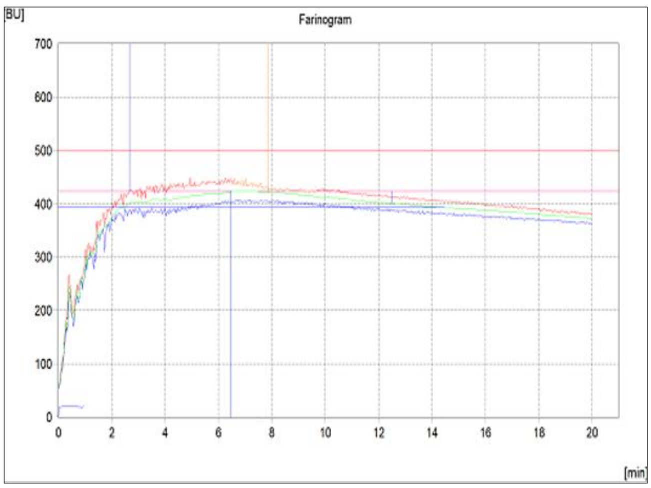

Fig 12: Treatment (T_5) (88:12)

3.4 Extensographic characteristics

Dough's stretching characteristics of composite flour (wheat flour + Jamun leaf powder) were evaluated using the Brabender extensograph. The parameters like energy (cm^2), resistance to extension (BU), extensibility (mm), and ratio number (R/E) were investigated. Results obtained from extensograph after incorporating millet flour at various levels into wheat flour are shown in Table 4, 5 and 6.

The results showed energy required to stretch the dough decreased significantly with the increasing proportion of JLP. The control treatment T_0 exhibited the highest energy of about 95, 78 and 77 cm^2 for each 30, 60, 90 min proving time, respectively. While, the lowest energy value was observed for the treatment T_5 i.e., 46, 42 and 40 cm^2, respectively. For 30, 60, 90 min of proving time, resistance to extension for composite JLP-based dough observed to be decreased consistently from 893, 772 and 743 BU for treatment T_0 and 55, 30 and 26 BU for treatment T_5, respectively. Furthermore, extensograph study showed a consistent decrease in extensibility of composite dough with the increasing amount of JLP incorporation. The treatment T_0 observed to have the highest extensibility of 132, 123, 120 mm for each proving time i.e., 30, 60, 90 min. Whereas, treatment T_5 exhibited shortest extensibility of about 39, 39 and 41 mm, respectively.

Table 4: Effect of incorporation of JLP with wheat flour on energy required to stretch the dough (cm^2)

Treatment	Proving Time (min) [Energy (cm^2)]		
	30	60	90
T_0	95	78	77
T_1	72	70	67
T_2	73	66	62
T_3	69	67	53
T_4	62	54	49
T_5	46	42	40
S. E.	1.667	0.8165	1.1055
C. D. @ 5%	1.1355	2.5159	3.4065

Table 5: Effect of incorporation of Jamun leaf powder with wheat flour on resistance to extension of dough (BU)

Treatment	Proving Time (min) [Resistance to extension (BU)]		
	30	60	90
T_0	893	772	743
T_1	558	539	491
T_2	504	491	440
T_3	263	247	231
T_4	110	38	34
T_5	55	30	26
S. E.	7.7853	3.0732	4.3970
C. D. @ 5%	23.9889	9.4694	13.5484

Table 6: Effect of incorporation of JLP in wheat flour on extensibility of dough (mm)

Treatment	Proving Time (min) [Extensibility (mm)]		
	30	60	90
T_0	132.00	123.00	120.00
T_1	101.00	93.00	87.00
T_2	99.00	94.00	93.00
T_3	78.00	72.00	70.00
T_4	56.00	51.00	48.00
T_5	39.00	39.00	41.00
S. E.	2.8577	2.2973	2.3688
C. D. @ 5%	8.8056	7.0788	7.2989

Similar results were given by Lee *et al*., (2008) [13] that energy levels of the dough decreased when adding concentrated sweet pumpkin powder (CSPP) content from 0-15% in composite dough and due to increasing testing time of dough energy levels decreased. The data indicate that addition of MOLP in the dough decreased resistance to extension due to the protein and fibre content of MOLP and these results was found by Dachana *et al*., (2010) [7] for the addition of MOLP and fenugreek leaf powder from 0 to 15% in composite dough. Also, Lee *et al*., (2008) [13] reported that the extensibility decreased with increasing testing time and concentrated sweet pumpkin powder content from 3-15% in the composite dough. Similar results for ratio number (i.e., increasing ratio number) for above study was given by Anjum and Walker (2000) [2] and they revealed that the Pakistani wheat variety Barani-83 had higher gluten content, resulting in an increase in ratio number when fortified with maize and sorghum.

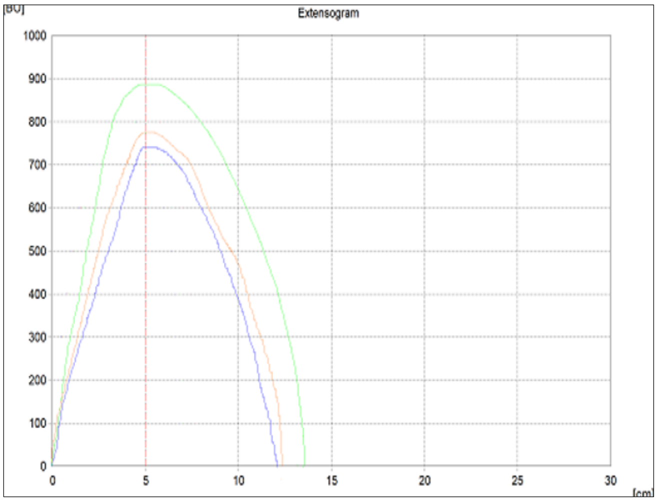

Fig 13: Treatment (T_0) (100:00

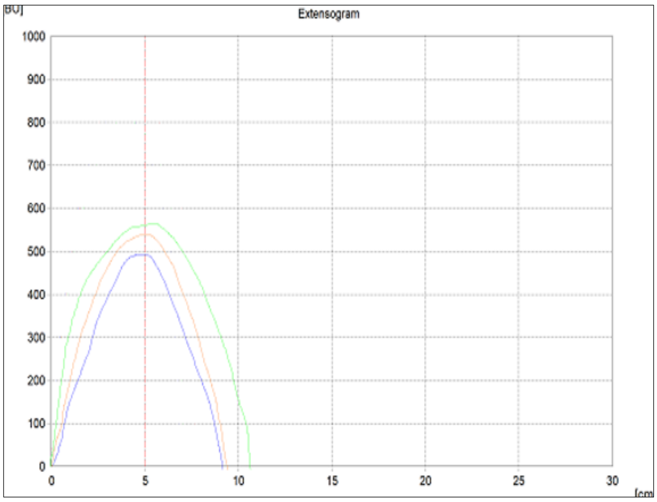

Fig 14: Treatment (T_1) (96:04)

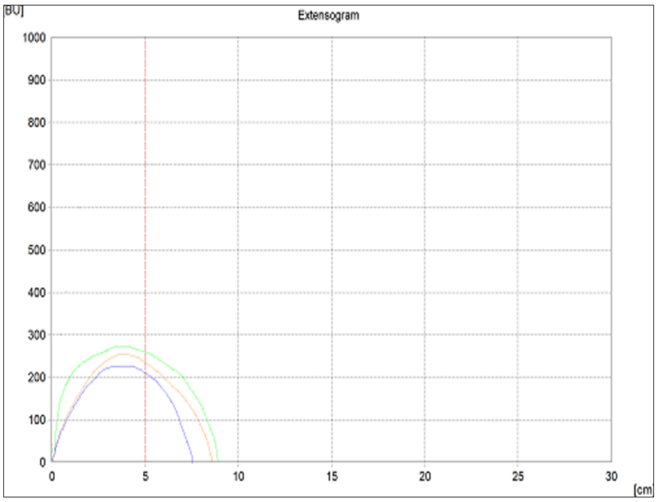

Fig 16: Treatment (T_3) (92:08)

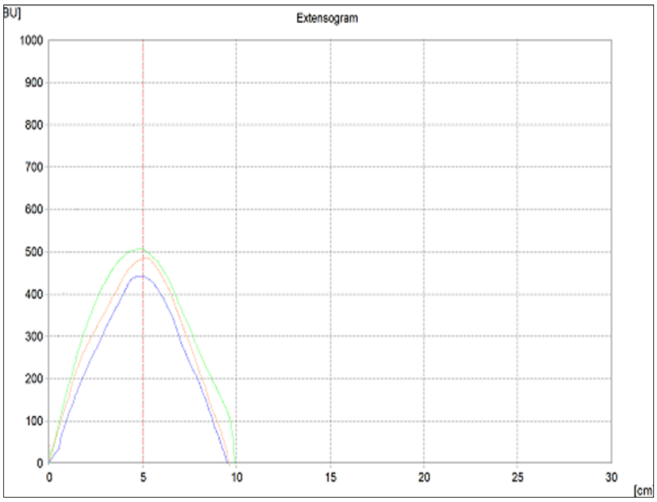

Fig 15: Treatment (T_2) (94:06)

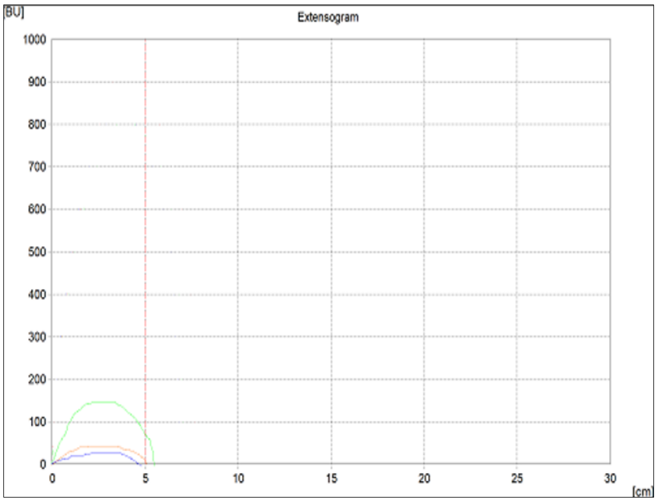

Fig 17: Treatment (T_4) (90:10)

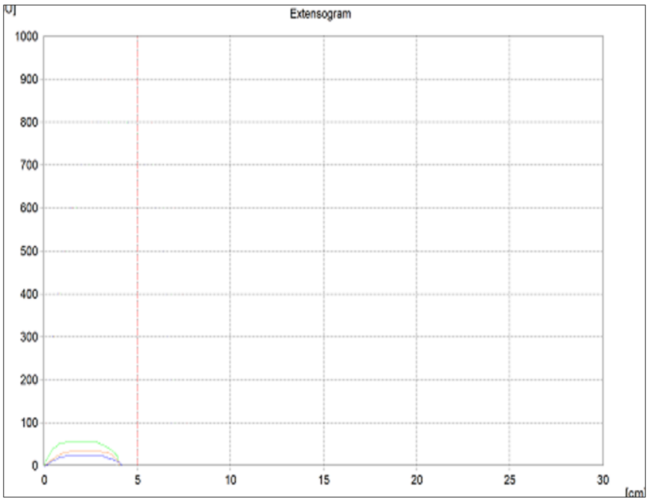

Fig 18: Treatment (T_5) (88:12)

4. Conclusions

The results showed that the composite flour's beginning of gelatinization temperatures initially increased significantly then slightly decreased with the increasing proportion of JLP. In the Fairnographic study, results showed that the composite flour's water absorption capacity decreased significantly with the increasing proportion of JLP. The energy required to stretch the dough decreased significantly with the increasing proportion of JLP. Although Jamun leaf powder with wheat flour shows strong dough-developing characteristics, its viscoelastic and stretching characteristics appeared to be affected adversely, resulting in a weak dough, meaning it is suitable for making cookies.

5. References

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