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Effect of blending sorghum flour on dough rheology of wheat bread

K.P. KHATING, R.N. KENGHE, G.B. YENGE, V.M. INGALE AND **SHUBHANGI D. SHELAR**

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See end of the Paper for authors' affiliation

Correspondence to :

G.B. YENGE
Department of Agricultural Processing Enginering, Dr. A.S. College of Agricultural Engineering, Mahatma Phule Krishi Vidhyapeeth, Rahuri, AHMEDNAGAR (M.S.) INDIA
Email : govindyenge89@gmail.com

■ **ABSTRACT :** The present investigation was carried out to study the changes in rheological qualities of the composite flour. Wheat flour was mixed by sorghum flour at 5, 10, 15, 20 and 25 %. The rheological studies *viz.*, farinographic, extensographic and amylographic characteristics were studied. The study revealed that the water absorption of flour was found to be increased (67.70 to 73.40 %) with a higher percentage of sorghum flour substitution. An increase in sorghum flour proportion resulted in increase in the extension of dough development time from 2.80 to 3.40 min. On the basis of evaluation of dough energy the quality of dough at the 5, 10 and 15 % addition of sorghum flour was demonstrated to be average while it was weaker at higher levels of addition of sorghum flour. Incorporation of sorghum flour decreased the extensibility of the dough's by 45, 57 and 48 % for proving time 30, 60 and 90 min, respectively. The resistance to extension (BU) was found to decreased 7.2 % for proving time 30 min while it increased to 27 and 32 % for proving time 60 and 90 min, respectively. The ratio number and ratio number (max.) were increased to 100, 240 and 288 % and 78, 209 and 218 % for proving time 30, 60 and 90 min, respectively. The beginning of gelatinization was increased 3.36 % as proportion of sorghum flour increased, while gelatinization temperature and gelatinization maximum (AU) decreased 3 and 29 %, respectively as proportion of sorghum flour increased in the supplemented flour. The overall results indicated the positive response of sorghum flour substitution to wheat *maida* up to 15 per cent level because of its low gluten content in formulation of high fiber and low moisture containing bread without affecting their overall quality.

■ **KEY WORDS :** Maida, Rheology, Bread, Gelatinization, Sorghum flour

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In present day's economic scenario, emerging globalization and growing consumers have changed the perception of food. Partial substitution of wheat *maida* with sorghum flour can produce the bread with good chemical and sensory attributes along with excellent nutritional qualities that deviate from that of conventional foods.

Wheat (*Triticum aestivum*) is staple food crop which occupies important place next to rice in India. India stands second in wheat production in the world next to China. In India, Punjab produces maximum wheat grain. India's wheat production was 78.40 million tons, area under wheat cultivation was 28.15 million ha, yield was 2785 kg /ha in the year 2010-11 (Anonymous, 2010a), whereas Maharashtra's share in the India's wheat production was 2081 thousand tons and area was 1237 thousand ha (Anonymous, 2010b), during the year 2010-11. Wheat is used for various food purposes after grinding wheat kernel into flour. The wheat flour is major ingredient in chapatti, bread and the bakery products such as cakes, cookies, crackers, doughnuts, sweet rolls, and biscuits etc. due to their inherited property to form dough and retain gases. The use of white flour derived from the processing of whole wheat grain, which is aimed at improving the aesthetic value of white bread, has also led to the drastic reduction in the nutritional density and fibre content when compared to bread made from whole grain cereals (Maneju *et al.*, 2011). Wheat is mainly used as a dietary staple, averaging two-thirds of total consumption (Anjum and Walker, 2000). Owing to shortage of wheat, several developing countries have devised programs to assess the feasibility of alternate sources for substituting or blending with wheat flour (Abdel-Kader, 2000).

Sorghum [*Sorghum bicolor* (L.) Moench] and maize (*Zea mays*) are closely related members of the subfamily

Panicoideae in the family Gramineae. Sorghum originated in Central Africa and used as a major cereal in the semi-arid regions of the world where it is an important food and feed crop. Sorghum species (*Sorghum vulgare* and *Sorghum bicolor*) are members of the grass family. Sorghum is one of the major cereal crop consumed in India after rice (*Oryza sativa*) and wheat (*Triticum aestivum*). Sorghum is commonly called as jowar or great millet. The crop is primarily produced in Maharashtra, Karnataka and Andhra Pradesh. These three states together account for close to 80 % of the all India production. Madhya Pradesh, Gujarat and Rajasthan are the other states producing sorghum.

Composite flour technology refers to the process of mixing various flours to make use of local raw material to produce high quality food products in an economical way. Formulation of composite flour is vital for development of value-added products with optimal functionality (Rehman *et al.*, 2007). A variety of wheat flour substitutes have been tried in bakery formulations with varying success; for example, soy or defatted soy flour (Junqueira *et al.*, 2008), defatted wheat germ (Arshad *et al.*, 2007), flaxseed (Koca and Anil, 2007), sunflower seed (Skrbic and Filipcev, 2008), and lupin flour (Hall and Johnson, 2004).

Rheology is now well established as the science of the deformation and flow of matter. It is the study of the manner in which materials respond to applied stress or strain. All materials have rheological properties. Dough rheological properties have an important effect on baking characteristics, their study is important for both product quality and process efficiency. Thus, knowledge of rheological behaviour and dough properties is becoming more important as the baking industry becomes more automated (Amani *et al.*, 2005).

Rheological tests as applied in cereal research and industry have been classified as empirical or fundamental. Fundamental tests provide information on the basic rheological properties of the material, such as viscosity (the ease of deformation) and elasticity (the ease of recovery). Wheat flour dough exhibits a combination of these properties and therefore, is classed as a viscoelastic material. It is revealed that parameters such as the addition of salt, temperature and time etc. affect these properties. To predict final products quality, having a good knowledge about these properties and their related parameters is necessary. So choosing instruments and models, which can provide us this knowledge, is a very important step in the prediction of product quality.

METHODOLOGY

Determination of rheological properties:

Rheology is particularly important technique in revealing the influence of flour constituents and additives on dough behavior during bread making. Rheological properties of dough are very important in bread baking quality. Knowledge of the rheological behavior of bread dough is very important to understand mechanical properties of the dough and finished products. The instruments such as farinograph, extensograph and amylograph etc. are used for the measurement of dough rheological properties (due to viscoelastic behavior of dough). The dough mixture (sorghum four + wheat *maida*) used for preparation of composite bread were evaluated for dough rheology using garinograph, extensograph and amylograph.

Farinographic characteristics:

The instrument most frequently used all over the world for determining the water absorption and mixing characteristics of wheat and sorghum flour (Plate 1). 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 are 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 is added to the flour in amount which ensures the dough consistency of 500 BU (Arbitrary Brabender units).

Plate 1 : Farinograph

Water absorption (%), dough development time (min.), dough stability (min.) and the degree of softening (BU) were determined using the established software in farinograph machine.

Extensographic characteristics:

The Brabender extensograph (Plate 2) is an internationally accepted standard method. Curves characterized by low resistance to extension indicates the small baking volume and *vice versa*. Hence, the dough with the balanced ratio between the resistance and extensibility was considered as a raw material of a suitable quality for baking production and recorded in the form of diagram.

Plate 2 : Extensograph

Plate 3 : Amylograph

Extensograph measurement procedure comprises of several steps as follows:

– Preparation of dough (with 2 % salt based on flour weight) in the Brabender earinograph mixer, usually at 2 % less than its optimum absorption to compensate the salt addition.

– Moulding of dough pieces on the extensograph into a cylindrically shaped dough pieces.

– Resting of the dough pieces for a fixed period of time (30, 60, 90 min.)

– Stretching the dough pieces until they rupture and recording the extensibility of the dough and its resistance to stretching as per the method suggested by (Kent and Evers, 1994; Rasper and Walker, 2000; Sahin and Sumnu, 2006).

– The force exerted is measured and recorded. This procedure is repeated.

– The energy (cm^2), resistance to extension (BU), extensibility (mm), ratio number and ratio number (Max.) were determined with the help of extensograph through in-built software system.

Amylographic characteristics :

The baking properties of flour depend on the gelatinization of the starch and on the enzyme activity (α-amylase) in the flour. The beginning of gelatinization, gelatinization temperature (°C) and gelatinization maximum (AU) were determined with amylographmachine (Plate 3) which is equipped with its own programming software.

Statistical design and analysis:

The data obtained were analyzed statistically to determine statistical significance of treatments. Completely Randomized Design (CRD) was used to test the significance of results as per the method suggested by (Panse and Sukhatme, 1967 and Nigam and Gupta, 1979).

■ RESULTS AND DISCUSSION

The experimental findings obtained from the present study have been discussed in following heads:

Rheological properties:

Rheology is the study of deformation and flow properties of solid, semisolid and liquid. The viscoelastic properties of dough have a profound effect on dough machinabiliy and textural qualities of finished baked products. Wheat flour contains special types of storage proteins, which, when combined with water and manipulated, develop into dough that can both stretch and flow. Dough rheological properties have an important effect on baking characteristics. It is revealed that parameters such as the addition of salt, temperature, time etc. affect these properties to predict final product quality. The results obtained with respect to rheological properties are discussed below.

Farinographic characteristics of wheat-sorghum supplemented flour:

The following parameters such as water absorption (%), dough development time (min.), dough stability (min.) and the degree of softening (BU) were studied with the help of farinograph.

Water absorption (%):

Water absorption is important parameter, and is defined as the amount of water required to center the peak area of a farinographic curve on the 500 Brabender unit (BU) line for flour-water dough. Effect of different levels of sorghum flour on farinographic characteristics of wheat-sorghum supplemented flour is tabulated in Table 1.

It was observed from data that the water absorption increased linearly with increase in incorporation of sorghum flour. This increase must be due to the high fibre content of

Table 1 : Effect of different levels of sorghum flour on Farino graphic characteristics of wheat-sorghum supplemented flour

Treatments	Water absorption (%)	Dough development time (min)	Dough stability (min)	Degree of softening (BU)
T_0	67.70	2.80	1.80	84
T_1	68.70	2.90	1.50	111
T_2	69.90	2.70	1.60	145
T_3	71.60	2.90	1.90	125
T_4	73.30	3.40	2.20	116
T_5	73.40	3.00	2.30	128
S. E.	0.15	0.07	0.1	1.01
C.D. (P=0.05)	0.45	0.23	0.30	3.11

T_0, T_1, T_2, T_3, T_4 and T_5 are 0, 5, 10, 15, 20, 25 % sorghum flour respectively

sorghum.

Mean values of water absorption (%) of supplemented flour with samples (T_0, T_1, T_2, T_3, T_4 and T_5) showed significant variations among the treatments. The highest water absorption (73.40 %) was observed in T_5which was at par withT_4(73.30%) while lowest water absorption (67.70 %) was found in T_0 *i.e.* supplemented flour with 0 per cent sorghum flour. In general, there was increase in water absorption, with increased levels of sorghum flour. The water absorption (%) in dough containing 5, 10,15, 20 and 25 % of sorghum flour were increased to 68.70, 69.90, 71.60, 73.30 and 73.40 %, respectively in comparison with the control dough (T_0) 67.70 %. The findings of Selvaraj and Shurpalekar (1982) showed that the water absorption increased by about 1% for every 4 % increase of soya flour in wheat flour.

Dough development time (min):

The time interval in minutes from addition of water to the point of maximum consistency, before start of weakening process, is recorded as dough development time (min).Mean values of dough development time (min) of supplemented flour with samples (T_0, T_1, T_2, T_3, T_4 and T_5) as furnished in Table 1, showed significant variations among the treatments. The highest dough development time (3.40 min) was observed in treatment T_4,while lowest dough development time (2.70 min) was found in T_2 *i.e.* supplemented flour with 10 per cent sorghum flour.In general; there was increase in dough development time, with increased levels of sorghum flour.The development time in dough containing 5, 10, 15, 20 and 25 % of sorghum flour was increased to 2.90, 2.70, 2.90, 3.40 and 3.00 min, respectively in comparison with the control dough (T_0) 2.80 min.The results are in agreement D' Appolonia and Youngs (1978) observed the difference in the effect of fiber on dough development time, and concluded that the dough development time was increased by adding bran.

Dough stability (min):

It was observed from the results that the dough stability increased linearly with increase in incorporation of sorghum flour percentage.

From Table 1, the dough stability (min) ranged between 1.50 to 2.30 min for different treatments.The minimum (1.50 min) dough stability was recorded for T_1 and significantly maximum (2.30 min) dough stability was recorded for T_5 compared with control sampleT_0 (1.80 min). Dough mixing stability (min) containing 5, 10, 15, 20 and 25 % of sorghum flour showed an increase of 1.50, 1.60, 1.90, 2.20, and 2.30 min, respectively in comparison with the control dough (T_0) 1.80 min.These results are similar with the findings of Symons and Brennan (2004) reported that for dough containing 5, 10, 15 and 20 % rice bran increased dough stability time to 1.6, 2.2, 4.1 and 5.2 %, respectively in comparison with the control dough (1.2 %).

The degree of softening (BU):

The degree of softening from Table 1, showed that dough containing 5, 10, 15 20 and 25 % sorghum flour increased to 111,145,125,116 and 128 (BU), respectively when compared with the control dough(T_0) 84 (BU). The degree of softening was observed significantly minimum 84 at 0% level of sorghum flour (T_0), whereas it was observed significantly maximum 145at(T_2). An increase in degree of softening with an increase in winged bean flour in wheat flour (Kailasapathy and Macneil, 1985).

Extensographic characteristics of wheat-sorghum supplemented flour:

Wheat flour could be classified in terms of dough energy measured with an Extensograph.As weak, medium, strong and very strong (Preston and Hoseney, 1991). The following parameters were studied with the help of extensograph.

Energy (cm^2):

The mean observations of energy (cm^2) obtained through extensograph are given in Table 2. It was observed from theresults that energy (cm^2) of supplemented flour explicated significant differences with varying levels of sorghum flour for all the proving times (30, 60 and 90 min). In case of Proving time 30 min the mean energy values (cm^2) significantly varies from 59 to 26 (cm^2). Significantly high energy 59 (cm^2) was

Table 2 : Effect of different levels of sorghum flour on energy (cm^2) of supplemented flour

Treatments	Proving time (min)		
	30	60	90
T_0	59	70	72
T_1	46	35	56
T_2	44	55	60
T_3	38	44	52
T_4	30	43	56
T_5	26	33	40
S. E.	0.577	0.849	0.577
C.D (P=0.05)	1.778	2.618	1.778

T_0, T_1, T_2, T_3, T_4 and T_5 are 0, 5, 10, 15, 20, 25 % sorghum flour, respectively

Table 3 : Effect of different levels of sorghum flour on resistance to extension (BU) of supplemented flour

Treatments	Proving time (min)		
	30	60	90
T_0	179	213	242
T_1	153	185	188
T_2	180	229	252
T_3	185	274	351
T_4	162	271	344
T_5	166	272	321
S. E.	0.58	0.88	0.70
C.D. (P=0.05)	1.77	2.71	2.17

T_0, T_1, T_2, T_3, T_4 and T_5 are 0, 5, 10, 15, 20, 25 % sorghum flour, respectively

observed in supplemented flour containing 0% sorghum flour (T_0) and supplemented flour containing 25 per cent sorghum flour (T_5) contains significantly less energy *i.e.* 26 (cm^2).

In case of 60 min proving time energy (cm^2) values decreased progressively as proportions of sorghum flour increased. Significantly highest energy 70(cm^2) was observed in supplemented flour containing 0 % sorghum flour (T_0) and supplemented flour containing 25 % sorghum flour (T_5) was found significantly lowest energy 33 (cm^2).Whereas, in proving time 90 min; the means of energy values (cm^2) decreased as percentages of sorghum flour increased in supplemented flour, significantly highest energy 72 (cm^2) was recorded in supplemented flour containing 0 % sorghum flour (T_0) and supplemented flour containing 25 per cent sorghum flour (T_5) found significantly lowest energy 40 (cm^2).

The energy of the dough decreased significantly as sorghum flour percentage increased in the wheat *maida* blends. The energy values for control sample (T_0) were significantly more in proving time 90 min *i.e.* (72 cm^2) followed by 60 minproving time (70 cm^2) and proving time 30 min (59 cm^2), respectively. Rasool (2004) reported the significant effect on the energy and mixing time with the 10 % addition of cotton seed flours in wheat flours, energy decreased as percentage of cotton seed flour in supplemented flour increased.

Resistance to extension (BU):

Effect of blending sorghum flour in wheat *maida* in response to resistance to extension (BU) is given in Table 3. From mean values for the resistance to extension (BU), for proving time of 30 min it was found to be ranged between 153 to 185, the significantly highest value (185) was observed in supplemented flour containing 15 per cent sorghum flour T_3, while significantly lowest value (153) was recorded in supplemented flour containing 5 per cent sorghum flour T_1.

In case of proving time 60 min the mean values of the resistance to extension (BU**)** ranged between185 to 274. The significantly highest value of resistance to extension 274(BU**)** was observed inT_3 while that of significantly lowest (185) was found in T_1.

Whereas for proving time of 90 min the value pertinent to the resistance to extension (BU**)** varied between 188 to 351, the significantly highest value (351) of the resistance to extension (BU**)** was observed inT_3, while that of significantly lowest (188) was found in T_1. With similar to above findings, Rosell *et al*. (2001)informed that extensographic analysis gives information about the viscoelastic behaviour of a dough and measures dough extensibility and resistance to extension. A combination of good resistance and extensibility results in desirable dough properties. The resistance to extension measured with an extensograph increased linearly following the addition of 3 and 6 % of high-protein oat flour to wheat flour as a function of province period.

Extensibility (mm):

Table 4 shows effect of addition ofdifferent levels of sorghum flour onextensibility (mm) of supplemented flour. It is revealed from data that mean values of extensibility (mm) of supplemented flour explicated significant differences with varying levels of sorghum flour for all the proving times.In case of proving time 30 min the mean values of extensibility

Table 4 : Effect of different levels of sorghum flour on extensibility (mm) of supplemented flour

Treatments	Proving time (min)		
	30	60	90
T_0	193	194	179
T_1	198	188	200
T_2	156	163	159
T_3	135	116	109
T_4	119	109	119
T_5	105	84	93
S. E.	0.57	0.81	0.57
C.D. (P=0.05)	1.77	2.51	1.77

T_0, T_1, T_2, T_3, T_4 and T_5 are 0, 5, 10, 15, 20, 25 % sorghum flour, respectively (mm) varied from 105 to 198. Significantly highest extensibility 198 mm value was observed in supplemented flour containing 5 per cent sorghum flour (T_1) and supplemented flour containing 25 per cent sorghum flour (T_5) contained significantly lowest (105) value. In case of 60 min proving time, extensibility (mm) values decreased progressively as proportions of sorghum flour increased. Significantly highest extensibility (mm) value was found in supplemented flour containing 0 % sorghum flour (T_0) 194 mm, while significantly lowest value was observed in supplemented flour containing 25 % sorghum flour (T_5) *i.e.* 84 mm.whereas, in proving time 90 min, the mean values of extensibility (mm) decreased as proportion of sorghum flour increased in supplemented flour. Significantly highest extensibility 200 mm value was observed in supplemented flour containing 5 per cent sorghum flour (T_1) and supplemented flour containing 25 per cent sorghum flour (T_5) contained significantly lowest 93 mm extensibility values. These results are analogous with the results of Rao and Vakil (1980) reported that 10 % replacement of the defatted peanut flour in the wheat flour altered the water absorption capacity and reduction in extensibility (mm) of the dough mix depending as a function of proving time.The effect of addition of lupine and cephalariasyriaca flour to wheat flour on extensographic extensibility and concluded that extensibility of dough significantly decreased by polymeric protein structure (Karaoglu, 2006).

Ratio number:

Effect of blending sorghum flour in wheat *maida* in response to ratio number is given in Table 5. It was observed that the ratio number for proving time 30 min between 0.80 to 1.60, the significantly highest value 1.60 was observed insupplemented flour containing 25 per cent sorghum flour (T_5) while lowest value 0.80 was recorded in supplemented flour containing 5 per cent sorghum flour (T_1).

Table 5 : Effect of different levels of sorghum flour on ratio number of supplemented flour

Treatments	Proving time (min)		
	30	60	90
T_0	0.90	1.10	1.40
T_1	0.80	1.00	0.90
T_2	1.20	1.40	1.60
T_3	1.40	2.40	3.20
T_4	1.40	2.50	2.90
T_5	1.60	3.40	3.50
S. E.	0.05	0.05	0.06
C.D. (P=0.05)	0.17	0.17	0.18

T_0, T_1, T_2, T_3, T_4 and T_5 are 0, 5, 10, 15, 20, 25 % sorghum flour, respectively

In case of 60 min proving time the mean values of the ratio number ranged between 1.00 to 3.40. The significantly highest value 3.40 of ratio number was observed in (T_5) while that of significantly lowest 1.00 values was found in (T_1). Whereas, for proving time 90 min the value pertinent to the ratio number varied between 0.90 to 3.50, the significantly highest value 3.50 of the ratio number was observed in (T_5) while that of significantly lowest value 0.90 was found in (T_1). The present results are in close agreement with the finding of Hoseney and Finney (1974) who reported that the extensograph provides an indication of the mixing requirements of flour.

Ratio number (max.):

Table 6 shows effect of addition ofdifferent levels of sorghum flour onratio number (max.) of supplemented flour.

Table 6 : Effect of different levels of sorghum flour on ratio number (max.) of supplemented flour

Treatments	Proving time (min)		
	30	60	90
T_0	1.10	1.30	1.60
T_1	0.90	1.10	1.10
T_2	1.20	1.50	1.80
T_3	1.40	2.40	3.20
T_4	1.40	2.50	3.00
T_5	1.60	3.40	3.50
S.E.±	0.05	0.05	0.05
C.D. (P=0.05)	0.177	0.177899	0.177

T_0, T_1, T_2, T_3, T_4 and T_5 are 0, 5, 10, 15, 20, 25 % sorghum flour, respectively

In case of proving time 30 min the means of ratio number (max.) values were varied from 0.90 to 1.60. The lowest 0.90 ratio number (max.) value was observed in supplemented flour containing 5 % sorghum flour (T_1) and supplemented flour containing 25 per cent sorghum flour (T_5) contained highest 1.60 value. For 60 min proving time,ratio number (max.) values increased progressively as proportions of sorghum flour increased. The lowest 1.10 ratio number (max.) value was found in supplemented flour containing 5 % sorghum flour (T_1), while significantly highest value (3.40) was observed in supplemented flour containing 25 % sorghum flour (T_5). The lowest 1.10 ratio number (max.) was observed in supplemented flour containing 5 % sorghum flour (T_1) and supplemented flour containing 25 per cent sorghum flour (T_5) contained highest 3.50 ratio number (max.) value. Olatunji *et al*. (1980) reported the analogous fact that the substitution of wheat flour beyond 20 % with non wheat flours results in significant changes and adversely affects rheological properties such as stability, extensibility, resistance to extension and recoveryof the dough.

Amylographic characteristics of wheat-sorghum supplemented flour:

Pasting properties of wheat and sorghum flour, starch properties solely as well as α-enzymatic activity were determined using BrabenderAmylograph (Duisburg, Germany). Three parameters were recorded *viz.*, beginning of gelatinization, gelatinization temp (ºC) and Gelatinization max. (AU).Table 7 shows effect of addition of different levels of sorghum flour on amylographic characteristics of wheat-sorghum supplemented flour.

Table 7 : Effect of addition of sorghum flour on amylographic characteristics of supplemented flour

Treatments	Beginning of gelatinization	Gelatinization temperature (°C)	Gelatinization maximum (AU)
T_0	59.50	93.60	1920
T_1	61.00	93.90	1761
T_2	61.00	92.80	1677
T_3	61.50	92.20	1589
T_4	61.80	92.10	1436
T_5	61.50	90.80	1366
S.E.±	0.44	0.34	3.34
C.D. (P=0.05)	1.35	1.06	10.29

T_0, T_1, T_2, T_3, T_4 and T_5 are 0, 5, 10, 15, 20, 25 % sorghum flour, respectively

Beginning of gelatinization:

It was observed from data that the beginning of gelatinization of supplemented flour with samples (T_0, T_1, T_2, T_3, T_4 and T_5) showed significant variations among the treatments. The significantly highest value (61.80) for being of gelatinization was observed in T_4 at par with the T_5 (61.50). Whereas the significantly lowest value (59.50) was found in T_0.There was increase in beginning of gelatinization, with increased levels of sorghum flour. The beginning of gelatinization in supplemented flour containing 5, 10,15, 20 and 25 % of sorghum flour increased to 61.00, 61.00, 61.50, 61.80 and 61.50, respectively in comparison with the control *maida* flour (T_0) 59.50. The effect of gelatinization on dough rheological properties was mainly due to the effect of temperature on gluten (Gelinas and Mckinnon, 2004).

Gelatinization temperature (°C):

It is revealed from data that supplemented flour incorporated with sorghum flour had significantly affected the gelatinization temperature (°C). In general, it was observed that increased in levels of sorghum flour decreased the gelatinization temperature (°C). The significantly highest gelatinization temperature (°C) value (93.90) was observed in T_1 at par with control T_0 (93.60) While significantly lowest (90.80) value was found in supplemented flour containing 25 per cent of sorghum flour (T_5). The gelatinization temperature (ºC) insupplemented flour containing 5, 10, 15, 20 and 25 % of sorghum flour decreased to 93.90, 92.80, 92.20, 92.10 and 90.80°C, respectively in comparison with the control *maida* flour (T_0) 93.60° C.

The gelatinization induces more hydrogen band between starch and gluten. Complex module increased during gelatinization and all of them were caused by increasing temperature (Kim and Cornillon, 2001).

Gelatinization maximum (AU):

It could be seen from the data that the T_0 (1920) *i.e.* supplemented flour without sorghum flour was statistically significant followed by the T_1 (1761) *i.e.* supplemented flour with 5 per cent sorghum flour. It was observed, that the gelatinization max. (AU) of supplemented flour decreased with increase in levels of sorghum flour. The significantly lowest (1366) gelatinization max (AU) was found at T_5 *i.e.* supplemented flour with 25 per cent sorghum flour at par with T_4 (1436) while the highest (1920) gelatinization max. (AU) was observed forT_0 *i.e.* supplemented flour without sorghum flour (100 % *maida*).

Weakening of dough, resulting from the addition of sorghum, could be due to decrease in wheat gluten content (dilution effect) and competition between proteins of sorghum and wheat flour for water results in decrease of gelatinization max.as percentage incorporation increased (Deshpande *et al.*, 1983).

Conclusion:

Incorporation of sorghum flour improves the rheology of dough which supplies the information on dough behavioral characteristics. These characteristics will provide scientific data to the bakery industries which are on the path of automation.

Authors' affiliations:
K.P. KHATING, R.N. KENGHE, V.M. INGALE AND **SHUBHANGI D. SHELAR,** Department of Agricultural Processing Engineering, Mahatma Phule Krishi Vidyapeeth, Rahuri, AHMEDNAGAR (M.S.) INDIA

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