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ORIGINAL ARTICLE

Effect of yeast on functional and rheological characteristics of whole wheat flour and its effect on quality of chapati

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Abstract Chapati is unleavened flat bread originated from Indian sub-continent and is considered as staple product in everyday meals. Its quality attributes are dependent on number of factors including the wheat used, ingredients added and processing parameters. The study was aimed to observe the effect of yeast addition on functional, rheological, and sensory characteristics on whole wheat flour and chapati at varying percentage (0.25–1.0). All the experiments conducted were compared with a control flour/chapati without yeast addition. The results showed that all the attributes were favourably affected with yeast addition when compared with control samples. It was noticed that the peak viscosity, setback, breakdown and final viscosity decreased with yeast addition and the paste obtained had higher gel strength. Alveogragh results also depict the increase in tensile strength and decrease in extensibility of dough on yeast incorporation. Textural and sensory studies revealed that yeast concentration upto 0.75% w/w in whole wheat flour resulted in chapati with good overall acceptability.

Keywords Yeast · Chapati · Dough rheology · Texture · Sensory

Abbreviations

%	Percentage
˚C	Degree Celsius
AOAC	Association of analytical communities
AACC	American association of clinical chemistry
w/w	Weight by weight
w/v	Weight by volume
kg	Kilogram
g	Gram
mL	Millilitre
rpm	Revolutions per minute
mm	Millimetre
cP	Centipoise
sec	Second
N	Newton
Nmm	Newton Millimetre

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Introduction

Wheat is considered one among ‘big three’ cereal crops that is being harvested annually around the world. There is no denial that wheat’s adaptability and high yields have aided in its success, but that does not fully explain its dominancy in most of the temperate world. The distinctive properties of dough formed from whole wheat flour, which enable it to be processed into a variety of products given it an advantage over other crops. These characteristics are determined by the arrangements and interactions of the grain storage proteins, which collectively make up the protein fraction known as "gluten” (Shwery 2009). Wheat has been raw material in many household and bakery products that requires milling into fine flour before using in end product preparation. Chapati, being one of it is a circular flat unleavened bread that is consumed majorly by Indian subcontinent and parts of Middle East population. It is prepared using whole wheat flour also known as *atta* as major ingredient which is then baked and served hot. The desirable characteristics of chapati are soft texture, baked wheaty aroma, slight creamish brown in color and a greater pliability (Rao et al. 1986). Conventional method that is kneading and baking are practiced by majority of population has resulted in lower shelf life chapati. And the major concern associated with chapati is retrogradation of starches that results in staling process which further impacts the palatability of chapaties (Hemalatha et al. 2014). With increasing urbanization and trend towards ready to eat foods, public demands for convenience food products. Large scale production units for flat breads need marketing and mechanization of product with suitable packaging units. Therefore when it reaches to consumers, the flatbreads should retain their organoleptic characteristics (Cheng and Bhat 2015). Thus in recent years studies have been conducted in order to retain the desirable textural properties of chapati by addition of various constituents, subjecting to processing techniques and modifications. Since these characteristics are majorly dependent of the wheat used, its quality parameters are also taken into consideration. Dough is a complex matrix and its rheology is a key factor that determines its processability and the quality of end product. The rheology of dough has been studied with addition of various substances and viewing its effects. One such ingredient that has significant influence on dough rheology is yeast. It is a major factor in causing fermentation that allows the dense mass of dough to form into well-rised loaf of bread. *Saccharomyces cerevisiae*, also known as baker's yeast is available in different forms such as active dry yeast, fresh yeast, rapid yeast and instant yeast. All forms have been used for similar purpose that is as leavening agent in baking industry. In fermentation, the yeast cells release carbon dioxide (CO_2) which retains in the dough complex within viscoelastic gluten-starch network. Thus it gives the volume to final product. The purpose of yeast however is not limited to production of gas in bread making, as there are several secondary metabolites of yeast fermentation that alter and has an impact on final product characteristics (Jayaram et al. 2013). The secondary metabolites detected include glycerol, succinic acid and acetic acid in fermented dough had effect on rheology of dough such as based on rheological techniques (Chopin Alveograph, Kieffer extensibility rig). The study established that the extensibility and resistance to deformation (tensile strength) of dough had been affected by these metabolites in dough (Jayaram et al. 2014 a,b; Aslankoohi et al. 2015). Furthermore, findings by Verheyen et al. (2015) demonstrate that glutathione, which may leak from dead yeast cells and lead into the dough matrix, considerably causes the dough softening as demonstrated by a significant drop in mixing stability and a strong fall in the complex modulus G*. Considering the impact of yeast on wheat dough rheology, the study was planned to establish how yeast addition in chapati at varied concentration affected its overall quality characteristics.

Materials and methods

Materials

Whole wheat flour, skimmed milk powder, salt, sugar powder, refined oil and instant dry yeast were procured from local market of Mysore, Karnataka.

Methods

Flour samples preparation

1 kg of whole wheat flour with different percentage of yeast (0.25%, 0.5%, 0.75% and 1.0%) was mixed well in a bowl to obtain a uniform mixture of the sample (Table 1). Yeast concentration was selected based on preliminary work with. A control sample that is only whole wheat flour was used as a reference throughout the studies.

Chapati preparation

The chapaties were prepared as per the method by Arya et al. (1977). The ingredients included whole wheat flour, salt (2.2% w/w), sugar powder (3.0% w/w), milk powder (2.0% w/w), refined oil (10% w/v) and yeast according to its percentage weight. The control chapaties were prepared with all the above ingredients excluding the yeast. Once the chapaties were baked and cooled, it was packed in polyethylene packaging material and further used for analysis.

Table 1 Formulation of flour samples

Samples	Formulation	
	Wheat flour (kg)	Dry yeast (g)
CWF	1	0
0.25% w/w	1	2.5
0.5% w/w	1	5
0.75% w/w	1	7.5
1.00% w/w	1	10

Determination of moisture content and water activity

The flour samples were analysed for their moisture content using Hot air oven method (AOAC 2005 a, b). Homogenous mixture of sample was taken upto 5 g and analysed at 105˚C for 5 h. The dry weights of sample were noted until it gave constant results. The water activity of flour and chapati samples were analysed using Aqualab Pre Water Activity Meter following a standard method (AACC 1995).

Water absorption capacity

The flour samples were analysed for its water absorption capacity by following Sosulski et al. (1976) method. To pre-weighed centrifuge tubes, one gram of sample and 10 ml of distilled water was added. It was mixed well and allowed to stand for 30 min at room temperature. The tubes were centrifuged for 30 min at 3000 rpm and further supernatant was decanted and tubes were weighed. The results were interpreted as percent water bound to per gram of flour. All the tests were done in triplicates to obtain a constant result.

Pasting properties, gel strength and falling number

Rapid Visco Analyser (Perten RVA 4800 System) was used to analyze the pasting properties of flour samples according to AACC method 61–02 (AACC 1995). Further the canisters with hot paste were cooled overnight in refrigerator and was analysed for its gel strength using texture analyser (TA-XT Plus, Stable Micro systems, Hampshire, UK) by following accurate method (Santana et al. 2013).

The falling number (FN) values of flours are analysed to detect the sprout damage in flour due to alpha- amylase activity upon starches. It is an important parameter to determine the intended use of particular flour in baking industry. Perten Falling Number system was used to determine the falling number values of the samples according to AACC approved method 56–81.03 (AACC 1995).

Alveograph characteristics of flour

The samples with different yeast concentration along with control whole wheat flour was measured for rheology parameters using Alveolab (Chopin Technologies) by following standardized procedure.

(AACC 54–30, 1995). Samples with known moisture content was weighed and salted water calculated based upon the moisture content of the flour samples were added into semi-automatic dough making chamber. The dough was analysed for its tenacity (P), extensibility (L), elasticity (Ie.), baking strength (WA) and other parameters. The alveograph data is mainly used to understand and interpret the properties of dough.

Color analysis

The color measurements of chapaties were conducted using Colorflex-spectrophotometer (Hunter Lab Technologies Inc, VA, USA). The instrument was pre-calibrated with black and white reference tiles before each analysis. Sample cell containing homogenized sample was placed above the light sources after sensor calibration and post processing *L*, a*, b** values along with other parameters were recorded analyzed using EasymatchQC (Hunter Lab Technologies Inc, VA, USA) for chapaties.

Product was measured for L value indicated as degree of darkness or lightness (L = 100 specified for perfect white, L = 0 specified for perfect black); 'a' designated for degree of redness (+) & greenness (-) and 'b' for degree for blueness (-) and yellowness (+). About 3 readings were taken and average values were calculated (Inamdar et al. 2015).

Sensory analysis

Chapaties prepared was analysed for its appearance, color, texture, taste, aroma and overall acceptability by twelve panellists. Sensory scores were given according to 9 point hedonic scale method rating '1' for dislike extremely and '9' being extremely like for all the chapati samples (Khan et al. 2013).

Texture profile analysis

Chapaties after baking were cooled were analysed for its textural parameters such as hardness, cohesiveness, springiness and gumminess using Texture Analyzer Plus (Model No.01/TALS/LXE/UK; LLOYD Instruments, Hampshire.UK).The bite test on chapati was done with a volodkevitch bite set, which is meant to resemble incisor teeth shearing through food. The set consists of upper and lower teeth that puncture the sample twice throughout the test to get the peak force and textural profile at the predetermined speed and position. The chapati strips (2 × 15 mm) were axially compressed to 90% of their original height, avoiding fracture, force–time deformation curve was derived with a 50.0 kg load cell applied at a crosshead speed of 10.0 mm/ min, trigger force and clearance was 15gF and 5–6 mm respectively. Hardness was calculated as the peak force (N) of the first compression of the sample; cohesiveness was calculated as the area of work during the second compression divided by the area of work during the first compression (dimensionless); springiness was calculated as the distance (mm) that the sample recovers after the first compression; chewiness (N mm) was calculated as the product of the attributes gumminess and springiness, which in sensory terms corresponds to the energy required to chew the sample. Up to ten consecutive readings were taken to obtain constant values for all the chapaties (Khan et al. 2013).

Result and discussion

Effect of yeast on moisture content, water activity (a_w) water absorption capacity (WAC) of whole wheat flour

Table 2 shows the effect of yeast on moisture content, water activity and water absorption capacity of flour samples. From the table it is found that moisture content varied from 8.37 to 8.8%. The water activity of whole wheat flour was not significantly effected with addition of yeast.Whereas the water absorption capacity in whole wheat flour increased with the increase in the concentration of yeast. The increase in WAC may be due to porous nature of yeast cells which has the ability to absorb water from its environment. Yeast tends to breakdown the starch into simpler sugars upon activating with water. These simpler sugars absorb more water compared to starch granules. Thus with increasing the yeast percentage, the water absorption capacity of whole

Table 2 Effect of yeast on physiochemical characteristics of wheat flour

Parameters	Samples				
	CWF	0.25%	0.5%	0.75%	1%
Moisture (%)*	8.37^{a}	8.74^{b}	8.77^{b}	8.8^{b}	8.57^{c}
Water absorption capacity (g/g)*	112.85^{a}	113.75^{a}	115.86^{b}	117.24^{c}	118.95^{d}
Water Activity (a_w)*	0.377^{a}	0.401^{a}	0.408^{a}	0.411^{a}	0.428^{a}
Gel strength(g)*	27.75^{a}	28.88^{a}	31.13^{b}	32.79^{c}	28.77^{a}
Falling number (sec)*	437^{a}	432^{a}	405^{b}	391^{c}	444^{a}

*Mean ± SD ($n = 3$)

$^{a-d}$Values within the same row with different superscripts differ significantly ($p \leq 0.01$)

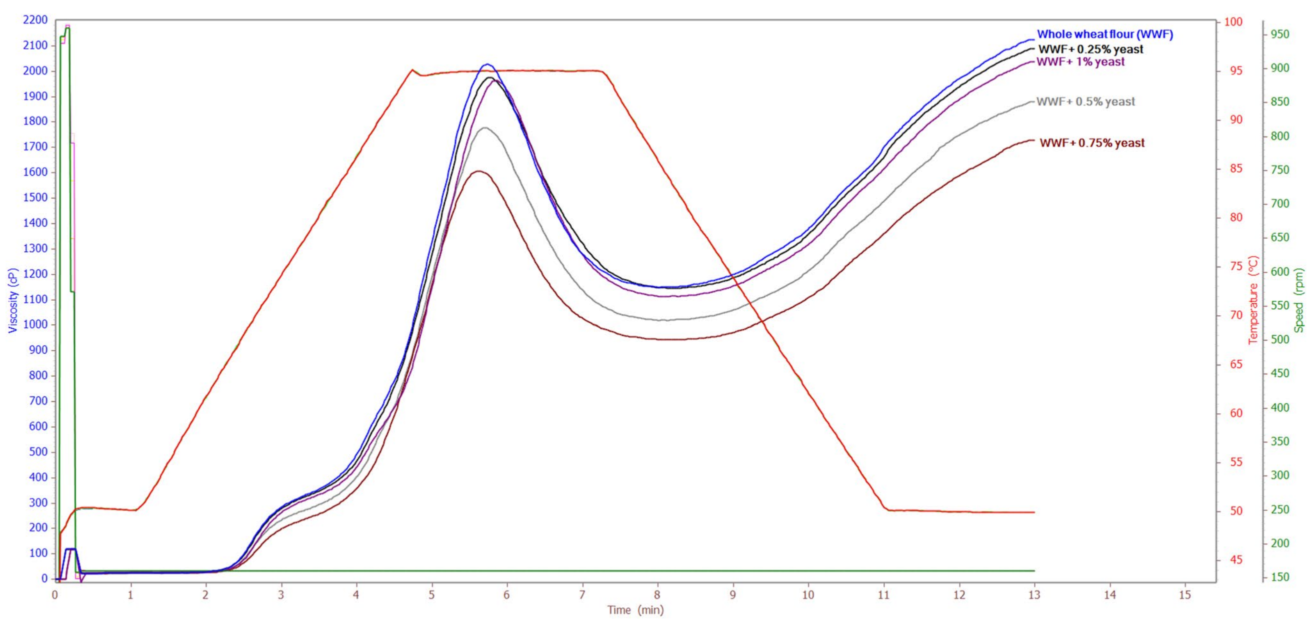

Fig. 1 Effect of yeast on the pasting properties of wheat flour

wheat flour increased. The water activity ranges from 0.377 to 0.428 whereas WAC from 112.85 to 118.95 g/g.

Effect of yeast on pasting properties, gel strength and falling number values of whole wheat flour

Effect of yeast on pasting properties, gel strength and falling number of whole wheat flour is represented in Fig. 1. It is clear from the figure that with the increase in the concentration of yeast, pasting properties like peak viscosity, breakdown, final viscosity and setback decreased significantly ($p \leq 0.05$). Peak viscosity which shows the ability of starch granules to swell freely before their physical break down decreases from 2204 to 1959 cP. The decrease in peak viscosity may be due to the fact that partial gelatinisation of starch and denaturation of proteins and also due to the less availability of water for initial swelling of starch granule resulted in decrease in peak viscosity (Jane et al. 1999). They also explained that the amylopectin short chains promote swelling due to their ability in formation of crystalline structure, which leads to increase in peak viscosity. Breakdown value generally refers to the degree of viscosity reduction during heating process and it is used as an indicator for determining stability of the paste during heating and stirring process decreased from 899 to 777 cP. The setback viscosity which measures the recrystallisation of gelatinised starch during cooking and also represents the effect of cooking and tendency to retrograde decreased from 1235 to 1128 cP. The pasting property results were also similar to that of earlier research work (Yang and Tao 2008) which reported that due to lactic acid fermentation, there was decrease in breakdown and setback in rice flour samples and also due to the fact that increase in yeast concentration delays the phenomenon of starch retrogradation of the end product. There was no significant changes in pasting temperature were observed when the yeast concentration was increased.

The gel formed during the RVA test was used for the determination of gel strength using cylinder probe (p/5) in texture analyser. The results (Table 2) showed that gel strength increased from 27.75 g to 32.79 g. This can be correlated with the higher stability and increased water absorption capacity of flour samples with yeast addition. Thus yeast tends to favour in retention of water in the food systems which leads to maintaining the freshness of product.

Effect of yeast on the falling number which measures the presence of amylase activity in flour is shown in Table 2. From the table it is clear that with the increase in the yeast concentration, there was a significant decrease in falling number from 437 to 391 upto 0.75% yeast concentration. Addition of yeast beyond 0.75% concentratition had no significant difference when compared with whole wheat flour. The changes in falling number values may be as a result of yeast's activity on breakdown of starches into simpler sugars which is similar to that of alpha-amylase

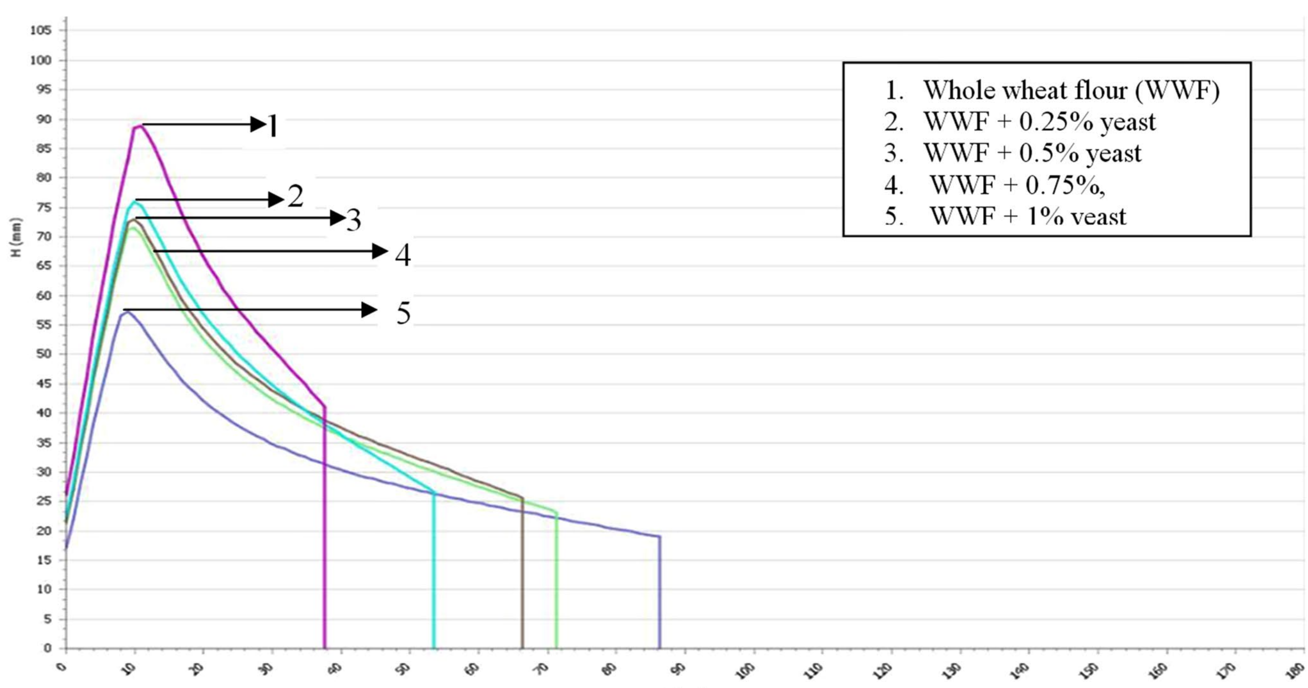

Fig. 2 Effect of yeast on alveographic characteristics of wheat flour

mechanism on starches in flours. Thus this explains the reduction in FN upon yeast addition to whole wheat flour.

Effect of yeast addition on alveographic characteristics of whole wheat flour

Alveolab which is used for the determination of rheological characteristics of whole wheat flour and in the present study it was used to evaluate the effect of yeast on the dough characteristics like tenacity (P), which is the ability of dough to resist deformation when stretched, extensibility of dough (L), elasticity (le) and baking strength (W). From the Fig. 2 it is clear that with the increase in the yeast concentration, there was a increase in the ability to resist deformation as represented by P, whereas extensibility of dough (L) which is a predictor of the processing characteristics of the dough decreased significantly with the increase in the yeast concentration from 86 to 37 mm. Connelly and McIntier (2008) and Chang et al. (2006) also observed the same trend in their study on rheological properties of yeasted wheat dough. Their study using Kieffer rig extensional test resulted reported a lower extensibility and high tenacity compared with non-yeasted flour samples. The graph also depicts the dough strengthening with increase in yeast concentration which is indicated as P/L index (ratio of dough elasticity to its extensibility). This is a useful effect especially for production of low moisture content baked goods or products which require short-growing gluten flour (Marukhnenko et al. 2020). The baking strength (W) represented by the area under the curve formed during the calculation of tenacity and extensibility decreases from 181 to 153 kJ.

Effect of yeast on the colour values of chapaties

Chapaties prepared using whole wheat flour incorporated with different concentrations of yeast and the changes in colour values as measured by Hunter colour meter and the results are shown in Table 3. From the table it is clear that significant effect was observed in color values of chapaties with 0.5–1% yeast concentration. Increase in the concentration of yeast has improved the whiteness of chapaties thus resulting in the increase in L value as compared to chapaties prepared by using whole wheat flour only. This is in according to the findings of Lu et al. (2005) and Chinma et al. (2014) who reported enhancement of whiteness of the product due to natural fermentation of rice flour and also colour of rice bran protein concentrates which were fermented naturally & with yeast had lighter appearance when compared with unfermented samples.

Table 3 Effect of yeast on colour, textural and sensory attributes of chapaties

Parameters	Samples				
	CWF	0.25%	0.50%	0.75%	1%
Hunter colour values*					
L	60.15[a]	61.89[a]	63.88[b]	63.90[c]	63.90[d]
a	3.38[a]	3.55[a]	4.72[b]	4.71[c]	4.89[d]
b	22.2[a]	22.9[a]	23.9[b]	25.3[c]	25.3[d]
Instrumental texture profile*					
Hardness(N)	11.17[a]	5.53[b]	4.5[c]	1.02[d]	10.88[e]
Springiness (mm)	1.96[a]	1.006[b]	0.2[c]	0.31[d]	1.33[e]
Chewiness (Nmm)	1.37[a]	0.58[b]	0.06[c]	0.04[d]	0.41[e]
Gumminess (mm)	0.92[a]	0.55[b]	0.27[c]	0.14[d]	0.53[e]
Sensory Attributes**					
Colour	7.63[a]	7.8[a]	7.82[a]	8.15[a]	6.79[b]
Aroma	7.68[a]	7.79[a]	7.27[a]	7.98[a]	6.81[b]
Taste	7.81[a]	7.63[a]	7.02[b]	7.83[a]	6.85[c]
Texture	7.58[a]	7.53[a]	7.46[a]	7.81[b]	7[c]
Overall acceptability	7.52[a]	7.64[a]	7.55[a]	7.97[b]	7.06[c]

* Mean ± SD ($n = 3$)

** Mean ± SD ($n = 10$)

[a–e]Values within the same row with different superscripts differ significantly ($p \leq 0.01$)

Effect of yeast on the sensory attributes of chapaties

Incorporation of yeast at different concentration has resulted in the changes of sensory attributes of chapaties prepared by using whole wheat flour and the results are reported in Table 3. It is clear from the table that addition of yeast up to 0.75% improved the acceptability of chapaties and further increase in the concentration adversely affected the texture, colour, taste and overall acceptability. It is therefore concluded that, highly acceptable quality chapaties can be prepared using 0.75% yeast and beyond 0.75% levels of yeast resulted in the decrease in the overall acceptance of chapaties.

Effect of yeast on the textural attributes of chapaties

Effect of yeast on the textural properties of chapaties is shown in Table 3. From the table it is found that with the increase in yeast concentration, there was a significant decrease in hardness, gumminess, chewiness and springiness upto 0.75% yeast concentration. Beyond 0.75% yeast concentration, all above mentioned textural attributes significantly increased. The changes in textural attributes may be due to the fact that fermentation of yeast results in releasing of CO_2 which in turn help in puffing and softening of chapattis. The findings can be in accordance with the earlier research workers findings (Meerts et al. 2018 and Razaei et al. 2016) on yeast metabolites effect on dough rheological matrix. According to study, the succinic acid, one of the yeast metabolite tend to reduce the pH of dough which results in repelling of gluten chains thus the gluten networks tends to experience overall loss of cohesiveness, leading to smaller aggregates of gluten.

Conclusion

Yeast has been a major ingredient in several food products. It has been used in baking industry due to its effect on dough characteristics and the quality of end product. The study concludes that, the addition of yeast at different concentration in whole wheat flour resulted in improved characteristics of chapati upto certain level (0.75%). The texture characteristics w.r.t. softness and pliability of chapati as well as sensory characteristics including colour of the chapati were improved. The addition of yeast in whole wheat flour impacted the pasting properties, rheological and functional parameters in positive way. After analysing all the findings of experiments conducted, yeast at 0.75% addition in whole wheat flour had comparatively better overall results than other. The study indicates that there is potential for further studies on shelf life extension of yeast incorporated chapatti as the setback and breakdown viscosity were decreased upon yeast addition which is an indicator for delaying starch retrogradation in the chapati.

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Author contributions KMA, CK, MC and HPT were involved in conceptualization, formal analysis and data acquisition. WDD was involved writing original draft. SAD was involved in supervision and resource allocation.

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Data availability Studies relating to the present study and mentioned in this MS was derived from public domain resources.

Code availability Not applicable.

Declarations

Conflict of interest This has reference to our manuscript all the authors involved in this paper declare that they have no known competing financial interests or personal relationship that could have appeared to influence the work reported in this paper.

Ethics approval Not applicable.

Consent to participate Not applicable.

Consent for publication Not applicable.

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