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Rheological properties of sprouted wheat flour dough on addition of gluten substitute cereal flour

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Abstract

Wheat flour is the basic ingredient mainly used in bakery and confectionary industries. However, due to great public awareness of celiac disease and gluten intolerance as well as consumers demands for healthy food and variety in food products, bakery industries are coming with suitable replacement to produce more nutritive and longer shelf life products. The aim of this study was to predict the suitability of alternative crops such as barley, oat and rye flour with sprouted wheat flour for the production of quality bread. Their rheological properties were studied, and compared to the properties of wheat flour which served as a benchmark. According to Grains and Legumes Nutrition Council, the tested alternative cereals were selected in order to represent the widely used ones in gluten-free products as well as the ones found to be nutritionally improved.

The determination of rheological properties of sprouted wheat flour dough as well as the dough from other raw materials (barley, oat and rye) was performed by dynamic rheometry. Samples of barley, rye and oat (40% by wt) with sprouted wheat flour expressed the most similar rheological behaviour (G' and G" Pa) to wheat flour. However, the viscosity of barley added with sprouted wheat flour dough showed a higher viscosity at 60% water content at lower shear rate.

Keywords: spouted wheat flour, gluten, rheology, elasticity, viscosity

INTRODUCTION

Wheat is one of the most common cereals used in bakery industry. However, bread prepared from wheat flour dough is considered to be nutritionally poor. Now-a-days mechanization, large scale production and increased consumer demand for high quality, convenience and longer shelf life have created the need for functional food additives such as emulsifiers and antistaling agents in bread to achieve those desired quality (Stampfli and Nersten, 1995). New materials and ingredients were introduced in bread composition while research generated a constant and impressive progress in bread making. Continuous improvement in baking technology is worth investigating primarily for better quality product, development of nutritionally superior product and economic consideration. Partial replacement of wheat flour with non-wheat flours improves the nutritional quality of bakery products and satisfies consumers' demands for healthy food and variety in food products. Moreover, in recent years there has been increasing interest in replacing common gluten-free formulations made from refined gluten-free flour, starch and hydrocolloids with those enriched with functional gluten-free ingredients. Namely, application of pseudocereals such as amaranth, quinoa and buckwheat resulted in gluten-free breads with an increased content of important nutrients such as protein, fiber, calcium, iron, vitamin E and polyphenols.

Recently, it has been shown that cereals sprouts are more nutritious in terms of vitamins, minerals, and phenolic compounds when compared with their native counterparts because grain's mobilized energy reservoir is readily available in its active form (Hung et al., 2001; Plaza et al., 2003; Koehler et al., 2007; Hung et al., 2011). This research project aims on

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application of sprouted wheat flour as a primary source in bread making with different inclusion rates as well as the structural and functional characteristics of dough made with sprouted wheat. However, substitution of wheat flour with flours from other raw materials will alter rheological properties of dough, as well as the quality of baked product. It is well known that proteins encountered in non-wheat flours lack the ability to form the gluten network responsible for holding the gas produced during the fermentation. As off, sprouting has been reported to adversely affect the rheological properties (dough elasticity and viscosity) of wheat due to enzymatic hydrolysis of starch, protein and fibre catalyzed by the increased activity of various enzymes especially of α-amylase and protease in the germinated wheat (Edwards et al., 1989), bread making with use of 100% flour from sprouted wheat may produce poor bread quality and loaf volume. It requires some substitution with some suitable flour which enhances the gluten network matrixes.

A rheological knowledge of these materials is essential to control the processes better (extrusion, baking) and to produce high quality final products. The rheological properties of a material come from the relationship between stress, strain (deformation) and time. Different types of rheometrical tests are commonly used; they can be extensional or shear ones. In order to obtain a better understanding of the viscoelastic changes during gelatinization, model systems have been studied; these show that dynamic methods are very useful for studying viscoelastic changes during starch gelatinization (Eliasson, 1986). Oscillatory rheometers allow temperature to be brought into the tests as an experimental factor with relative ease, avoiding the difficulties encountered in arranging for simultaneous, uniform heating and testing of the dough. Dynamic rheological results would provide valuable information on how the composition of flour and various ingredients affect machinability and baking performance (Dogan, 2002).

The suitability of alternative cereals for the production of quality bread is mainly examined by measuring the properties of their blends with wheat or some other flour. However, the purpose of this study is to examine the dynamic behaviour of a basic wheat flour–water (control) dough and the influence of adding different levels of gluten containing cereals such as oat, rye and barley (as per Grains and Legumes Nutrition Council) on its rheological properties under oscillatory tests at ambient temperature (at 30^0 C).

MATERIALS AND METHODS

Ingredients and sample preparation

A bread-quality commercial wheat flour (Pusa Wheat-105, Bihar, India) was used for dough preparation. The other grains flour viz. oat, barley and rye were purchased from local market for the current study. The normal wheat flour was germinated and dried to produce flour for rheometrical studies. The proximate composition of the sprouted wheat flour sample is given in Table 1. The amount of water to be added (60% dry flour basis) was determined in a Farinograph (to obtain a peak centered on the 500 Brabender unit line) and was kept constant for all dough samples. Dough samples with other cereal flours (30% dry flour basis) were prepared separately in order to evaluate the effect of each ingredient on the rheological properties of the final systems. The composite flours were mixed in a Farinograph mixer (Brabender, Duisburg, Germany) using 200 g of flour and allowing 5 min for the dough to develop.

Table 1. Proximate composition (% db).

Sources	Carbohydrate	Protein	Fat	Crude fibre	Ash	M.C
WF	75.24±0.17[a]	10.97±0.23[a]	2.10±0.12[b]	2.21±0.08[b]	1.15±0.18[a]	8.33±0.22[a]
SWF	72.34±0.13[b]	14.37±0.54[a]	1.46±0.14[a]	3.65±0.64[a]	1.57±0.29[a]	6.61±0.28[b]

*WF- Wheat flour, SWF-Sprouted wheat flour

[a]The results are significant with a significance level of 95% ($p < 0.05$). Values are mean values of nine replicates (±standard deviations). Mean values followed by the same letter are not significantly different from each other.

[b]The standard deviation was <0.015 in all samples.

Dynamic rheological measurement

Oscillation and viscosity measurements were performed using a Dynamic controlled stress rheometer (Bohlin, Malvern, U) equipped with a distilled water refrigeration circulation bath. The parallel plate system was used with a diameter of 40 mm and a gap between plates of 1 mm. A serrated plate was used to eliminate slippage during the test. Vaseline oil was used to prevent the exposed edge of the sample from drying during testing. Stress sweep tests (1 Hz at 30^0 C) were made to determine the linear viscoelastic region (LVR) of all samples; a stress value of 1 Pa was chosen for all the frequency tests. Frequency sweep tests (mechanical spectra) from 0.01 to 100 Hz were performed at 30^0 C for all samples. This test was performed at a fixed strain of 0.001 and a frequency of 1 Hz (6.28 rad/s) within the linear viscoelastic region. Any portion of dough was removed from the rheometer once it was measured, and a new portion was placed for any new measurement. Three replicates of each oscillatory dynamic test were conducted for each formulation. The storage (G') and loss moduli (G") values used to determine the average data turned out to be accurate to better than ± 10%. The viscometry tests were performed at 0.01 Hz to 100 Hz for all samples.

RESULTS AND DISCUSSION

Chemical characteristics

The wheat flour and sprouted wheat flour samples had 10.97 % and 14.37 % (db) which clearly demarked that the protein content of sprouted wheat flour has been significantly increased upto 30.99 % from whole wheat flour. Similarly, there was a decrease in total carbohydrate content by 3.85 % as well the fat content reduced by 30.48 % from whole wheat flour (Table 1).

Rheological characteristics of control samples

The evolution with frequency (mechanical spectra) of control sample G' and G" at 30^0 C is shown in Figure 1-3. The elasticity modulus (G') and viscous modulus (G") for sprouted wheat flour varies abruptly in comparison to normal wheat flour (Figure 1 & 2) with increase in frequency of oscillation at 30^0 C. However, it has been noted that greater predominance of the elastic component (G') over the viscous component (G") was observed at higher frequency levels (Figure 3). This may be caused due to protein hydrolysis and starch degradation during sprouting where the indigenous enzymatic activities increased significantly (Song and Zheng, 2007).

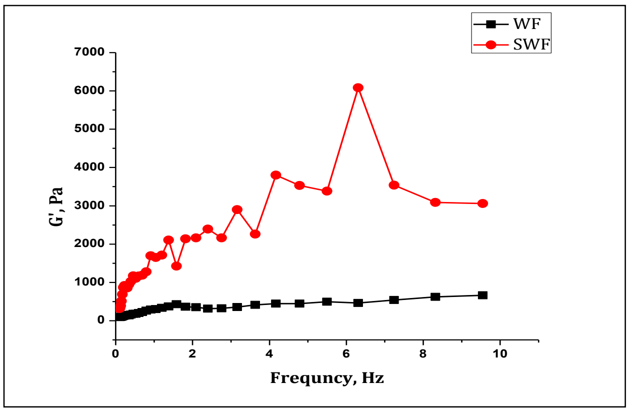

Figure 1. Change in G' with increasing frequency. WF- Wheat Flour; SWF- Sprouted Wheat Flour.

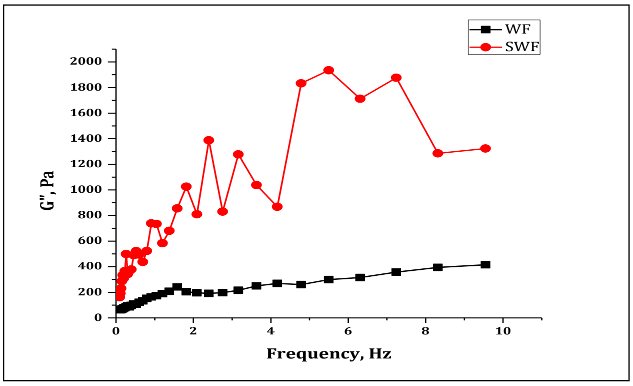

Figure 2. Change in G” with increasing frequency. WF- Wheat Flour; SWF- Sprouted Wheat Flour.

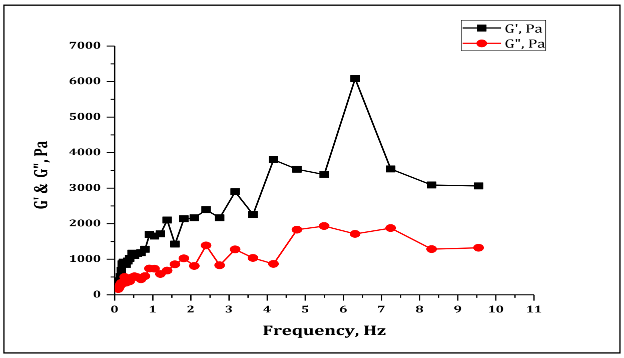

Figure 3. Change in G’ and G” with frequency for sprouted wheat flour (SWF).

Effect of substitution on rheological characteristics of sprouted wheat flour

The addition of barley and rye caused a lowering of bread dough consistency, as could be observed through the drop in the G’ and G” viscoelastic constants; the values for both moduli fell as the quantity of barley and rye added (Figure 4 and 5). However, a similar fashion was observed in either frequency dependence or the relative contribution of the values of the two components, elastic and viscous, to the rheological behaviour of the system, which indicates that barley and rye do not induced more structural changes to the. The presence of above cereal flours in the dough caused increased stickiness, lower tenacity and improved extensibility; consequently, it may be affirmed that the addition of these flour entailed a significant modification of the rheological properties of the composite dough. The viscosity of the composite flours decreased with increasing shear rate. However, spouted wheat having similar trend as normal wheat flour which improved the dough quality (Figure 6).

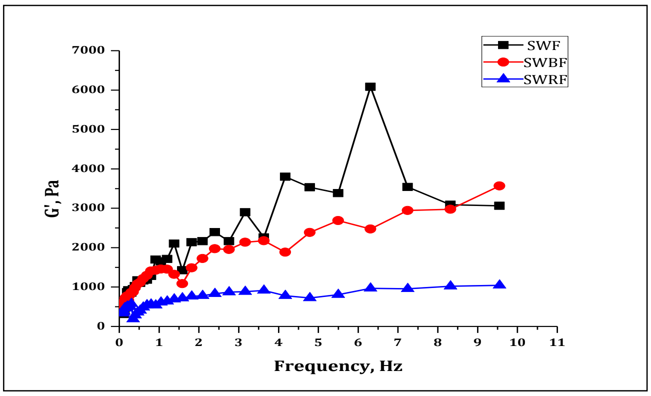

Figure 4. Changes in G’ with increasing frequency. SWF- Sprouted wheat flour, SWBF- Sprouted Wheat + Barley Flour; SWRF- Sprouted Wheat + Rye flour.

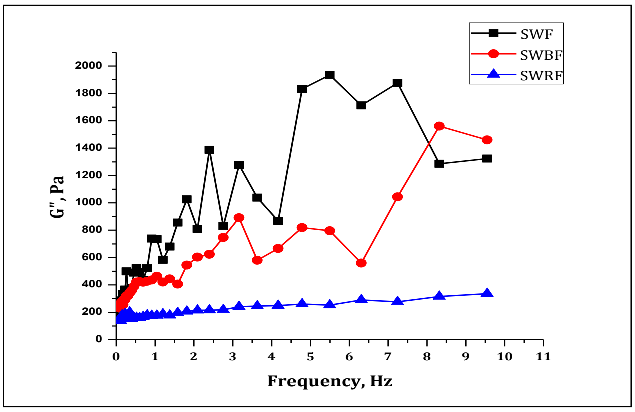

Figure 5. Changes in G' with increasing frequency. SWF- Sprouted wheat flour, SWBF-Sprouted Wheat + Barley Flour; SWRF- Sprouted Wheat + Rye flour.

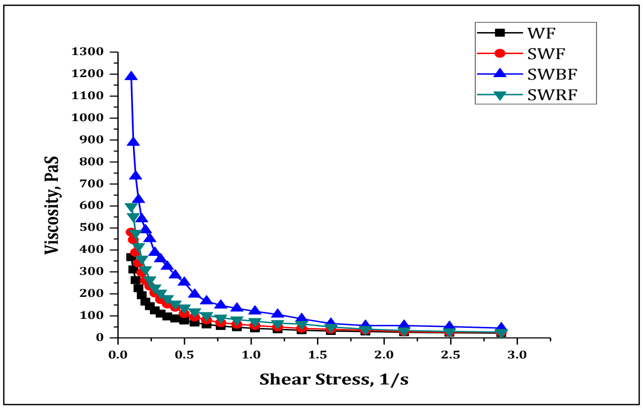

Figure 6. Changes in viscosity with varying shear rate. WF- Wheat Flour, SWF- Sprouted Wheat Flour, SWBF-Sprouted Wheat + Barley Flour; SWRF- Sprouted Wheat + Rye flour.

CONCLUSIONS

The dynamic rheological studies of the composite dough revealed the viscoelastic nature of the system and how it varied with frequency and varying cereal content. The sprouted what flour + rye flour system possessed a greater extent towards the nature of normal wheat flour which is good for bread baking. The elasticity and viscous moduli (G' & G") for both the composite flour varied in a similar way to the normal flour. So, it can be concluded that spouted wheat flour along with some gluten containing cereal flour viz. barley, rye and oat has been used for bread production in bakery industries.

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