Rheological properties of African prolamin systems

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ABSTRACT

Kafirin was formed into a viscoelastic dough and compared to a viscoelastic zein dough. Rheological measurements showed that kafirin dough increased in storage modulus whereas zein dough had an almost constant viscoelasticity over time. The doughs were found to have strain hardening properties and high extensional viscosities.

INTRODUCTION

The traditional staple foods in southern Africa are based on different types of sorghum and millets, which are cooked to porridges of varying consistencies. However, the fast urbanisation has reduced the consumption of traditional foods and increased the consumption of bread. Bread is mainly produced from the temperate cereal wheat. Since wheat cannot be cultivated economically in southern Africa, this leads to increased imports of wheat which is devastating for the local economies. The reduced use of sorghum and millets, which are well suited for the dry and hot climate, also contributes to an impaired food security[1].

Compared to wheat, all other cereals have poor baking qualities, at least under traditional baking conditions[2], which motivates the finding of alternative routes for making leavened bread products from sorghum.

During wheat dough mixing, wheat proteins are hydrated and form a three-dimensional network, gluten, responsible for the unique rheological properties of wheat flour dough[3]. It has been shown that good bread making doughs have significant extensional viscosity and strain hardening properties[4].

Gluten consists mainly of prolamin and glutenin proteins[3]. Kafirins are the prolamins of sorghum and represent around 80% of the total protein content[5]. They are analogous to zeins, the prolamins of maize[6], and show similar chemical composition. Zein and kafirin differ from gluten in structure and amino acid composition[7]. They are also very hydrophobic, thus they are poorly soluble in water[2].

MATERIALS AND METHODS

Kafirin was kindly supplied by CSIR, Pretoria, South Africa, and zein was from Zigma-Aldrich. All chemicals were of analytical quality.

Zein and kafirin doughs were prepared in accordance with Lai and Padua[8]. Dynamic measurements were performed in a Stresstech Rheometer (Rheologica Instruments, Lund, Sweden) using parallel plates with a diameter of 15 mm. Samples were applied between the plates with a gap of 3 mm and the periphery of the sample was covered with paraffin oil. The mechanical spectra were obtained at

frequencies 10-0.1Hz. The applied stress was 50Pa which was well within the linear region. Time sweeps were performed at 4Hz, at a constant stress well within the linear area for each material, and the shift in phase angle and storage and loss moduli were recorded.

The extensional properties were determined with contraction flow[9,10] using an Instron 5542 (Instron Corporation, Canton, USA). The shear contribution was small and compensated for assuming Power Law behaviour of the dough using K and n parameters extracted from the mechanical spectra using Cox Merz' relation.

RESULTS AND DISCUSSION

Zein formed into a dough as predicted[8] and so did kafirin. Oscillation time sweep showed that both zein and kafirin had viscoelastic properties but kafirin increased its storage modulus with time and thus became more elastic, whereas zein had an almost constant viscoelasticity.

Kafirin dough showed strain hardening properties and high extensional viscosities, but since the consistency of the dough changed with time, measurements were not replicable.

Zein dough also showed strain hardening and high extensional viscosities. The aging effects in kafirin dough also excluded the possibility of making a comparison between the extensional properties of kafirin and zein dough.

CONCLUSIONS

Zein formed into a dough as predicted[8], as did kafirin. Dynamic time sweeps showed that kafirin and zein doughs were viscoelastic, but kafirin dough increased its storage modulus with time whereas zein kept an almost constant viscoelasticity. Both zein dough and kafirin dough were found to have strain hardening properties and high extensional viscosities.

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