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Creep-recovery and oscillatory measurements of biscuit dough in evaluating baking quality

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ABSTRACT

Dough from eight biscuit wheat cultivars was characterised by creep-recovery and oscillation. Results were significantly ($P<0.001$) influenced by the cultivar, and phase angle δ was the best parameter to distinguish between the cultivars tested. Results indicate correlation between rheological measurements and dimensional characteristics of the baked biscuits.

INTRODUCTION

During the biscuit manufacturing process the dough is sheeted and laminated in several reduction steps. The sheeting applies significant stresses to the dough, and due to the elastic components the dough sheet will contract[1]. Predicting the tendency of the biscuit to contract is important when evaluating biscuit wheat quality. Empirical methods as the Extensograph (ICC 114[2]), which is developed for measurement of bread wheat with a strong gluten-structure, is also applied to biscuit wheat dough which has a weak gluten-structure.

Dynamic oscillatory measurements and creep-recovery has been used to characterise the mechanical properties of proteins, starch, lipids in the dough, and the interactions between the components[3,4]. The complexity of the dough makes it difficult to use fundamental methods in characterising differences in flour qualities and predicting baking performance[3, 5]. Only few studies have been done relating fundamental rheological measurements to biscuit baking performance and dough handling properties. The aim of this work is to characterise dough from different biscuit wheat varieties by using creep-recovery and oscillation, and relate rheological data to biscuit baking performance.

MATERIALS AND METHODS

Wheat

Six wheat cultivars and two breeding lines were used in this study. These cultivars were selected on the basis of their wide diversity in biscuit-making properties. Samples were harvested in September 99 and stored for two month before being milled.

Rheological testing

A standard biscuit dough was prepared from 200 g flour, 40 g granulated sugar, 20 g hardened vegetable fat, and tap water at 20 °C. As the water absorption capacity varies for different cultivars the amount of water added is adjusted to the water absorption measured on the Farinograph. This was done in order to equalise the consistency of the different doughs.

A controlled stress rheometer (Bohlin CVO) equipped with a 40 mm parallel plate (serrated) measuring geometry was used in

both creep-recovery and oscillatory tests. Creep- and recovery-time was 300 sec. Creep-recovery parameters included extensibility (γ_{max}), recovery (γ_r), and % recovery. Frequency sweep was performed in the range from 0.1-30 Hz, and mean values of G' (storage modulus) and δ (phase angle) from 0.1 to 10 Hz was calculated. Target strain was 0.1 %, which was in the linear region. Creep-recovery and oscillation was done consecutively after 10 min ageing of the dough.

Baking tests

'Marie'-biscuits were produced in a pilot bakery using a standard formulation and baking practice. The eccentricity of the baked biscuits were expressed as the ratio between length and width, and area and volume was calculated from the dimensions.

RESULTS AND DISCUSSION

Creep-recovery curves are showed in Fig. 1. For all doughs a steady viscous flow was obtained after 300 sec. Both extensibility. γ_{max} and elastic recovery γ_r varied between the cultivars.

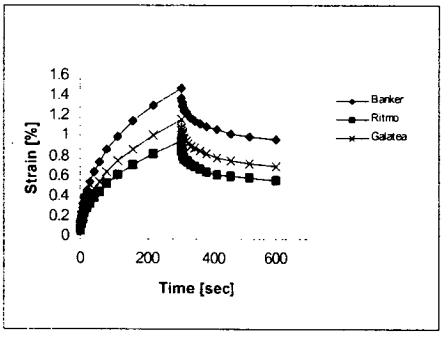

Figure 1. Strain as a function of time for two cultivars in a creep-recovery test.

Results from a frequency sweep are showed in Fig. 2. G' increases for increasing frequencies, but δ increases too, reflecting that the dough behaves more viscous at high frequencies. Safari-Ardi and Phan-Thien[5] stated that for flour-water dough δ decreases for high frequencies. This means that the sugar and fat added to the biscuit dough has a great influence on the viscoelastic behaviour of the dough.

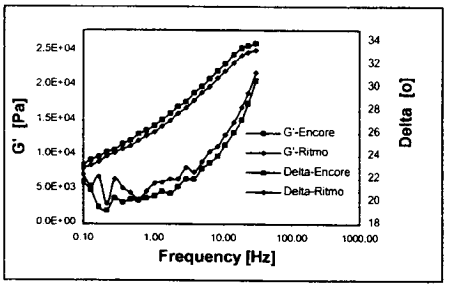

Figure 2. G' and δ as a function of frequency.

Rheological data for all cultivars and lines are showed in Table1.

Table1. Results from creep-recovery and oscillation from different cultivars.

Cultivar	γ_{max} %	γ_r %	G'[a] 10^4 Pa	δ[a] °
Banker	1.29a[b]	0.52a	1.34e	22.3b
Encore	1.16a	0.41b	1.53de	21.3c
Galatea	1.32a	0.46ab	1.89c	23.4a
Claire	0.78b	0.31c	1.80cd	19.0f
Ritmo	0.43c	0.27c	2.76a	21.5c
Reaper	1.19a	0.51a	1.41e	24.2a
NSL 959183	0.71b	0.29c	2.30b	20.8d
Sj 977435	0.59bc	0.24c	2.67a	19.9e

[a] Mean values from 0.1-10 Hz

[b] Values followed by the same letter are not significantly different

Characteristics from both creep-recovery and oscillation measurement differ significantly ($P<0.001$) between the cultivars and lines tested. Comparison between creep-recovery and oscillation showed, that mean values of G' and δ gave the best differentiation between the cultivars.

The eccentricity of the baked biscuits are showed in Fig. 3. Eccentricity is a measure of the elastic recovery after cutting and during the baking, mainly in the direction of stretching.

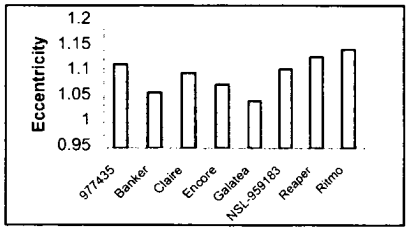

Figure 3. Eccentricity of biscuits from different cultivars.

A principal component analysis, PCA, was carried out for rheological and dimensional characteristics, additionally protein content of the flour was added. From the PCA scores plot in Fig. 4 it is seen, that all cultivars, with exception of NSL 959183 and Claire, have different characteristics. From the corresponding loadings plot in Fig. 5 it can be seen that cultivars to the right have high values of extensibility (γ_{max}), recovery (γ_r), phase angle (δ), and area, whereas cultivars to the left have high values of G', % recovery, and eccentricity. Furthermore it can be seen that % recovery is inversely correlated to area, and recovery (γ_r) and δ to volume, respectively. Eccentricity is correlated to % recovery.

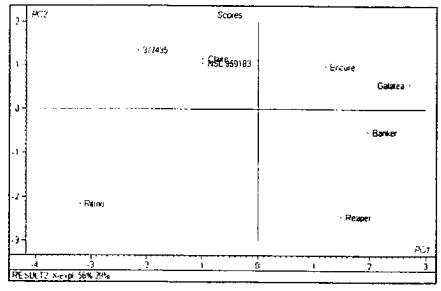

Figure 4. PCA scores plot for eight wheat cultivars.

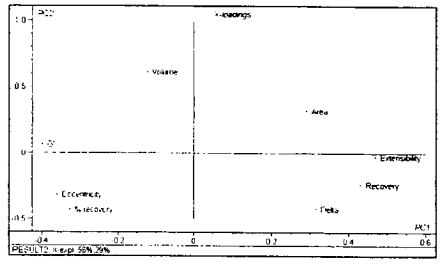

Figure 5. PCA loadings plot for rheological and dimensional characteristics.

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