# A Method for Measuring Stickiness of Bread Dough

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ABSTRACT

Wheat flour doughs of differing softness and stickiness levels were subject to uniaxial compression. Energy per unit area for non-lubricated uniaxial compression between set strains has shown strong correlations with stickiness as assessed by a baker.

## INTRODUCTION

Within the baking industry sticky dough is of economic concern as it builds up on machinery leading to loss of both time and product. As there is currently no universal measure for stickiness[1] bakers make a subjective assessment based on the feel of the dough.

The attributes "softness" and "stickiness" are scored separately by bakers. A soft material is often stickier as it can flow, giving better surface coverage and therefore stronger adhesion, while also tending to be cohesively weaker. It is desirable for a dough to be soft but not sticky and it is therefore important to separate these two attributes. This is still a common method for assessing dough properties.

The Chen-Hoseney method is a currently available method for measuring dough stickiness[2]. It involves the extrusion of dough through a mesh. A probe is then brought into contact with the dough before pulling the probe off the dough and measuring the force[2]. The extrusion stage allows a more reproducible surface to be produced. Despite this the method still suffers from issues of repeatability[3]. The probe material is Perspex which is not a commonly used material commercially and therefore raises questions about the commercial applicability of the method. The speed and material are chosen to encourage clean separation of probe and sample in the test which implies that the surface behaviour is more important than rheological behaviour.

Stickiness is a combination of adhesion, the interaction between a material and a surface, and cohesion, the interactions within the material[4]. It is therefore a result of a combination of surface and bulk rheological properties[1; 5]. The aim of this study was to develop a method to measure dough stickiness that also takes into account the rheological aspect.

## METHOD

Non-yeasted doughs with different levels of softness and stickiness were prepared from a single type of wheat flour by the use of additional ingredients and by varying mixing time. Softness and stickiness were assessed by a baker. Softness was scored on a scale of 1 - 5, firm to soft, with 3 being optimum. Stickiness was scored from 0 - 2, with 0, not sticky, being optimum.

Doughs were mixed on the Brabender Farinograph and then allowed to rest for 40 minutes before testing. Samples of a set mass were rolled into a ball. The samples were then compressed in two stages (see Fig. 1); first a precompression stage at a constant rate of 0.2 mm/s followed by a pause, then a final compression at the same constant rate. The precompression stage improved the reproducibility of the shape of the dough piece.

Figure 1. Video images for: end of precompression, end of test and pull-off.

The stickiness measurement was based on the energy per unit area for the compression from an initial Hencky strain of 0.51, following precompression, to a Hencky strain of 0.71. Hencky strain was calculated as shown in Eq. 1, where $H$ is initial sample height and $h$ is sample height. Video analysis was used to determine the contact radius. The contact area was then calculated by assuming an axisymmetric shape. Stress was calculated using the contact area, $A_{contact}$ (see Eq. 2).

$$\varepsilon_h = ln\left(\frac{H}{h}\right) \quad (1)$$

$$\sigma = \frac{F}{A_{contact}} \quad (2)$$

Energy per unit area was calculated as the area under a stress – distance curve up to a specified Hencky strain. These measurements were compared to baker's subjective assessment of the dough.

RESULTS

Doughs with a range of softness and stickiness scores, as determined by a baker, were produced through a combination of ingredient and mixing variations.

Preliminary tests used two levels of water addition creating a soft, sticky dough and a firm, non-sticky dough. Replicates were done at these two levels and showed good consistency (see Fig. 2). Results showed a clear difference between the energy per unit area for a compression of a soft, sticky dough and a firm, non-sticky dough (see Fig. 2).

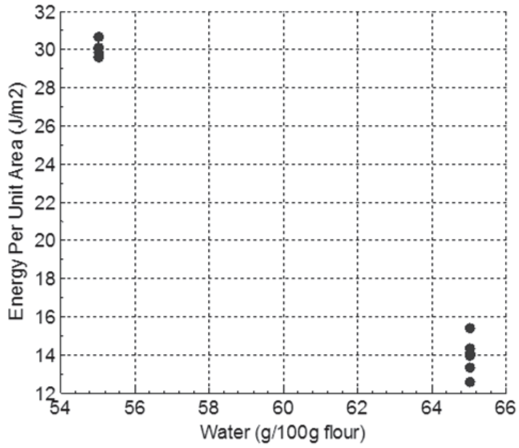


Figure 2. Energy per unit area for compressions of dough with low and high water additions.

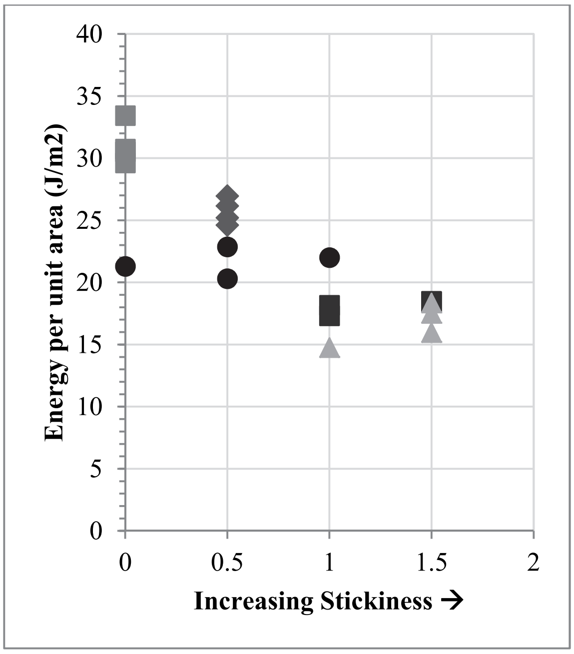


Figure 3. Correlation of energy measured during a compression test with baker's stickiness scores for 5 samples (n = 4). Stickiness is on a scale of 0 (not sticky) to 2 (very sticky).

In order to establish whether the test was measuring stickiness or softness, doughs were made in which these two attributes both varied.

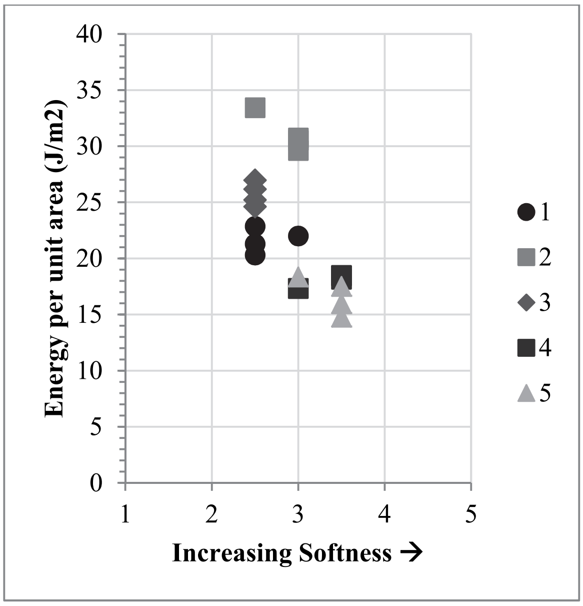


Figure 4. Correlation of energy measured during a compression test with baker's softness scores for 5 samples (n = 4). Softness is rated 1 – 5 (tight to soft) where 3 is optimum.

As seen in Fig. 3, a significant correlation (-0.830 at $p < 0.001$) was observed between baker's stickiness scores and the energy per unit area required to compress the sample to a target strain. These results were also compared with baker's softness scores, seen in Fig 4. which showed a less significant and weaker correlation (-0.586 at $p = 0.007$).

## DISCUSSION

Uniaxial compression has been used previously to study rheology of dough. Studies have largely focused on lubricated compression which has been used to estimate biaxial extensional viscosity[6; 7; 8] and to study stress relaxation behaviour[9]. Both non-lubricated and lubricated platens have been used to look at creep behaviour in dough[6; 9] and attempts have been made at modelling stress strain behaviour in both lubricated and non-lubricated compression of doughs[10]. Here non-lubricated compression is instead being investigated as a means of assessing dough stickiness.

Consistent sample preparation is difficult to achieve with sticky doughs. Highly variable sample shapes are produced when using cutters or moulds as sticky doughs adhere to the surfaces. Previous work on lubricated compression tests, and some non-lubricated compression as well, has used complex preparation processes that required a lubricant to separate the dough from the cutter or mould[8; 10]. For a technique that relies on the surface interaction, as in the case of non-lubricated compression, this lubrication step cannot be performed. It was therefore deemed impractical to produce a perfect cylinder for these tests. Instead an approximately spherical sample was produced by rolling. This was then compressed, in the precompression stage of the test, in order to produce a consistent shape.

Non-lubricated uniaxial compression will subject the sample to a combination of biaxial extension and shear as the dough surface adheres to the plates. The energy per unit area for a compression will be the result of overcoming adhesive forces at the interface and cohesive forces as the dough piece extends biaxially. This means the energy to compress the dough piece is a result of both surface interaction and rheology. As mentioned previously, stickiness is a combination of these two factors. This explains why a strong correlation can be observed between compression energy and stickiness.

Further work is required to separate out the adhesive and cohesive contributions to the energy of compression.

## CONCLUSIONS

A strong and significant correlation was demonstrated between results from the compression of dough samples and stickiness. The results also showed a weaker and less significant correlation with softness. This suggests that, with further development, the technique could allow separation of the parameters stickiness and softness.

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