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Authors(s)	Gormley, T. R. (Thomas Ronan)
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Fracture Testing of Cream Cracker Biscuits

T. R. Gormley

An Foras Talúntais, Kinsealy Research Centre, Malahide Road, Dublin 17, Ireland

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ABSTRACT

A modified shear press fitted with a 70×3 mm perspex blade proved satisfactory for measuring the resistance to fracture of cream cracker biscuits. The results indicated that biscuit orientation in relation to the fracture edge had a bearing on the fracture force obtained. Tests on five commercial cream cracker brands showed statistically-significant different resistance to fracture between the brands and some packs also showed high within-pack variation in fracture resistance. Over-baked cream crackers were more resistant to fracture than under-baked ones.

INTRODUCTION

Cream crackers are a popular biscuit in a number of countries and are normally eaten singly with a spread such as butter or preserves, or with meat, fish or poultry; alternatively they may be consumed as a sandwich with a spread or filling between. Fracturing, or breaking-up on the plate, during the application of a spread is sometimes a problem and it was decided to measure the difference in resistance to fracture both between and within packs of five commercial brands purchased in supermarkets in the Dublin area. The effect of biscuit orientation on resistance to fracture was also investigated.

Previous work on textural aspects of biscuits includes that of Brennan *et al.* (1974) who measured brittleness and crispness in a range of biscuit types, including cream crackers, using sensory and Instron tests, while Andersson *et al.* (1973) have given details of fracture force, hardness and brittleness testing in crispbreads using an Instron. Francis and Hastings (1963) measured biscuit hardness using a circular saw technique and Davis (1921) used a texture device called a 'shortometer' for measuring

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the breaking or crushing strength of cookies. The present study made use of a modified shear press for fracture testing of cream crackers.

MATERIALS AND METHODS

Testing procedure; bridge span

A modified Kramer shear press (Keppel and Gormley, 1975) (90 kg proving ring) was fitted with a perspex blade 70 mm long × 3 mm thick and individual cream cracker biscuits were supported under its descending edge (speed 4 mm s^{-1}) by two perspex blocks to form a bridge (see Fig. 1). The force required to fracture each biscuit was measured.

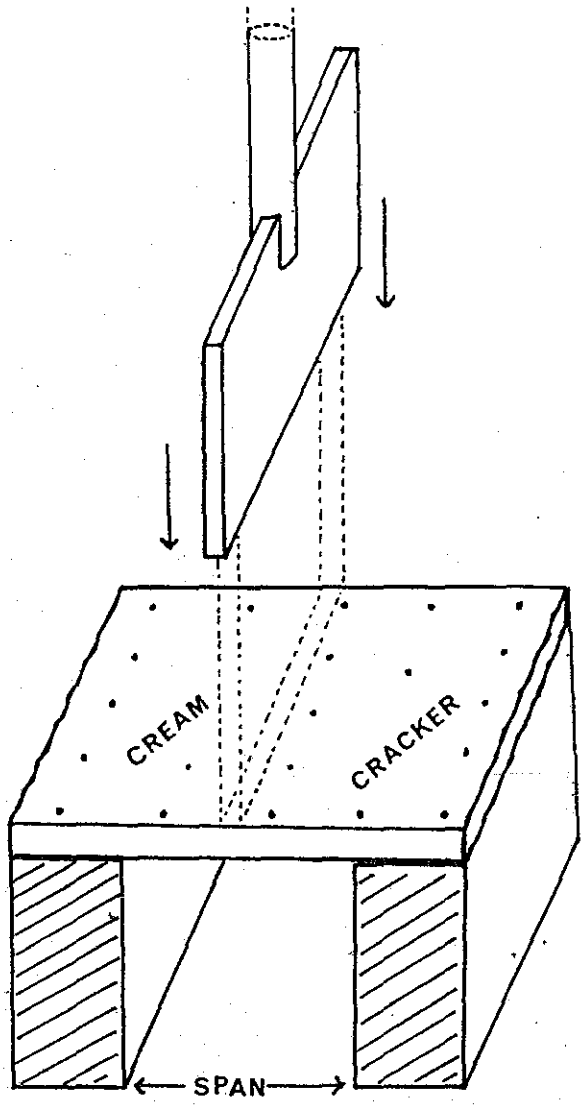

Fig. 1. Cream cracker fracture test system.

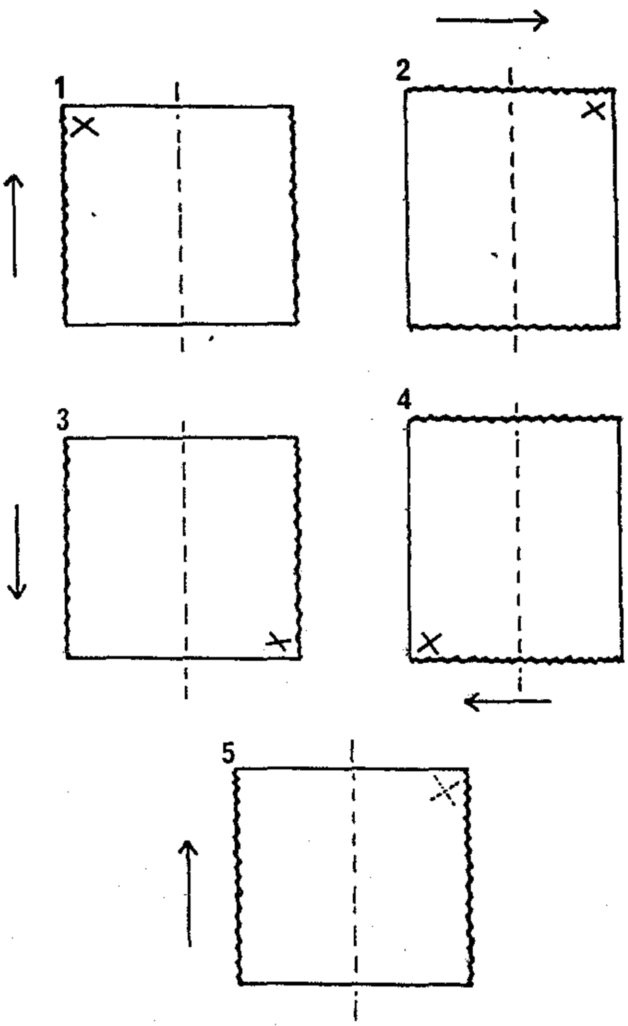

Fig. 2. Cream cracker orientation and line of fracture; arrows indicate the machine direction.

Bridge spans of 36, 23 and 11 mm were tested using a total of 108 cream crackers (36 biscuits for each span value). Biscuit orientation 1 (see Fig. 2) was used for each measurement. A 36 mm bridge span was used for all subsequent testing.

Cream cracker orientation

Five different cream cracker orientations in relation to the blade edge were compared using five sets each of 15 biscuits to study the effect of biscuit orientation on resistance to fracture. The 75 biscuits were chosen from five packs of the same brand by taking three biscuits from each of the five packs for each orientation test. Orientation 1 was that in which the cream cracker rough edges (as distinct from the rounded edges) were supported and the biscuit was fractured along the machine direction (see Fig. 2). In the manufacture of cream crackers the final dough sheet (*ca.*

0·7 m wide) is the result of a complex laminating procedure. The continuous sheet is cut into separate rows (not columns) about 10 biscuits wide (the 10 biscuits still attached to each other) and the rows proceed through the oven. The leading and trailing edges of the 10 biscuits in each row are rounded during baking. The eight inside biscuits in each row then have two unrounded (rough) edges where they are separated from their neighbours after baking.

The second, third and fourth orientations were obtained by turning the biscuits through 90, 180 or 270° while orientation 5 was the same as orientation 1 except that biscuits were turned upside down, i.e. the lettering on the biscuit was facing downwards during fracture testing. In relation to the machine direction, biscuit orientations 1, 3 and 5 are equivalent as are 2 and 4 (see Fig. 2).

Fracture values for different brands

In this test the fracture values for the five different brands of cream crackers were obtained. Five packs of each brand were tested corresponding to a total of 25 packs and approximately 650 individual biscuits. All the biscuits, *ca.* 26 in each pack, were fractured (using orientation 1) which enabled a mean fracture value to be calculated for each pack and also the variation in fracture value from biscuit to biscuit within each pack.

Fracture value versus biscuit colour

Samples of cream crackers classed as 'pale', 'normal' and 'over baked' were obtained from one manufacturer. The colour (topside) of 20 biscuits in each category (a total of $3 \times 20 = 60$ biscuits) was measured on a Hunter D25A Colour Meter fitted with a 5 cm specimen port. Hunter L, a, and b values were recorded and each biscuit was fractured using orientation 1 and a 36 mm bridge span. Regression analyses were carried out on the data to study the relationship between cream cracker colour and fracture force.

RESULTS

Fracture force increased ($p < 0{\cdot}001$) as bridge span decreased, values ranging from 7·9 N at a 36 mm span to 13·8 N at 11 mm (Table 1). However, this increase did not follow the simple and well known analytical relationship between span and maximum stress or deflection in a simple beam (i.e. maximum stress $\propto (ws/4)$; maximum deflection $\propto (ws^3/8)$ where w is the load on the centre of the beam and s is the span).

Cream cracker orientation

The orientation of the biscuits in relation to the blade had a significant effect ($p < 0{\cdot}001$) on the fracture force values. Orientations 2 and 4, in which biscuits were fractured at right angles to the machine direction, resulted in the highest values, and positions 1 and 3 in the lowest values (Table 2). However, biscuits were most easily fractured in the inverted position (orientation 5). These results show that the process of covering a cream cracker with a spread should be done at right angles to the machine direction and with the lettering uppermost.

TABLE 1
Fracture Force Values[a] for Cream Crackers at Three Different Bridge Spans

Bridge span (mm)	*Fracture force (N)*	*s.d.*[b]
36	7·9	2·43
23	10·5	3·19
11	13·8	2·75
F-test	p < 0·001	
s.e.	0·78	

[a] Values are means for 36 biscuits.
[b] Standard deviation of the mean.

TABLE 2
Effect of Cream Cracker Orientation on Fracture Force Values[a]

Orientation[b]	*Fracture force (N)*	*s.d.*[c]
1	10·1	2·18
2	12·7	3·50
3	9·5	2·04
4	11·9	2·11
5	8·3	2·09
F-test	p < 0·001	
s.e.	0·64	

[a] Values are means for 15 cream crackers.
[b] See Fig. 2 for orientation.
[c] Standard deviation of the mean.

Fracture and colour data for five brands of cream crackers

Mean fracture force values (Table 3) were considerably greater for brands B and C than for brands D and E; biscuits of brand A had an intermediate fracture value. There were no statistically-significant differences in the fracture force values between the five samples of each brand tested (Table 3). The coefficients of variation (Table 3) for within-pack variation in biscuit resistance to fracture showed a range in values for the five packs of each brand but the greatest within-pack variability was for brand C.

TABLE 3
Fracture Force Values[a] in Newtons (% coefficients of variation)[b] for Five Brands of Cream Crackers

Pack	*Brand*				
	A	*B*	*C*	*D*	*E*
1	9·1 (28)	11·6 (27)	11·7 (36)	7·8 (30)	8·6 (32)
2	9·8 (26)	10·6 (30)	13·1 (28)	7·8 (27)	7·6 (33)
3	10·3 (32)	9·9 (26)	10·5 (30)	8·1 (27)	8·3 (31)
4	9·7 (27)	9·6 (31)	10·2 (39)	9·1 (27)	7·9 (25)
5	9·6 (27)	11·6 (25)	10·9 (24)	8·9 (31)	7·8 (27)
Mean	9·7	10·7	11·3	8·3	8·0
	F-test (fracture force means), $p < 0{\cdot}001$, s.e. 0·36				

[a] Each pack contained 24–29 biscuits.
[b] Standard deviation ÷ mean × 100.

Differences in Hunter L values between the brands were small (Table 4) except for brand D which had a lighter colour and an L value of 72. Within-pack variation in lightness of biscuits was also small and coefficients ranged from 1·5 to 3·8% (Table 4).

Fracture values versus biscuit colour

Regression analyses of fracture force values versus Hunter L, a, and b, readings indicated statistically-significant relationships. There was an inverse relationship ($p < 0{\cdot}001$; correlation coefficient $-0{\cdot}58$) between fracture values and Hunter L readings and positive relationships between fracture values and Hunter a ($p < 0{\cdot}001$; $r = +0{\cdot}57$) and b readings ($p < 0{\cdot}01$; $r = +0{\cdot}39$). The equations were as follows:

TABLE 4
Hunter L Values[a] (% coefficients of variation) for Five Brands of Cream Crackers

Pack	*Brand*				
	A	*B*	*C*	*D*	*E*
1	64 (2·8)	63 (2·6)	65 (2·9)	73 (1·7)	64 (1·5)
2	58 (3·2)	63 (2·0)	64 (3·0)	73 (2·7)	64 (2·1)
3	59 (2·8)	62 (2·7)	64 (2·8)	72 (2·2)	66 (3·8)
4	64 (2·7)	62 (2·6)	64 (3·1)	70 (2·6)	65 (2·5)
5	64 (2·5)	62 (2·9)	65 (3·5)	72 (2·5)	66 (1·7)
Mean	62	62	64	72	65

F-test (Hunter L means), $p < 0{\cdot}001$, s.e. $p < 0{\cdot}71$)

[a] Footnotes as in Table 3.

$$\text{Fracture value (N)} = 4258 - 41{\cdot}1\,L$$
$$\text{Fracture value (N)} = 1131 + 88{\cdot}0\,a$$
$$\text{Fracture value (N)} = -2862 + 180\,b$$

These results indicate that fracture force value increases with increasing darkness in the cream crackers and presumably with degree of baking.

DISCUSSION

The shear press testing system adapted for these experiments proved satisfactory and while not possessing the versatility of, e.g. an Instron, still provided a fast and reliable method for measuring cream cracker resistance to fracture. Presumably it could be applied equally well to other types of biscuits. The significant differences found in the ease of fracturing cream cracker biscuits of the various brands may be due to variations in recipe and/or processing conditions and in the complex rolling and laminating process used to form the dough sheet.

The results for the tests using different biscuit orientations in relation to the fracture blade showed clearly the effect of the machine direction. Discussions with a commercial cream cracker manufacturer (Luke, 1986, personal communication) suggest that biscuits which are formed by cutting a sheet of dough which has been rolled to reduce thickness are usually found to break easier along the machine direction. It is not possible to explain this effect with current knowledge. However, one could postulate that gluten fibrils may tend to line up in the machine direction as a result of the reduction of sheet thickness which is a stretching action in the machine direction; perhaps electron microscopy could provide some of the answers.

The data show that cream crackers should be in orientations 2 or 4 when 'knifing-on' a spread. In this orientation the longer biscuit dimension (*ca.* 7 cm) is in the top-to-bottom direction on the plate and the shorter dimension is in the side-to-side direction. The data show that inverted biscuits (bottom side up — no lettering on this side) fracture most easily. This could be due in whole or in part to the fact that cream crackers are less well-cooked on the underside and the results have shown that under-baked biscuits fractured more easily than over-baked ones.

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