Predicting sensory potato texture quality using full uniaxial compression curves

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ABSTRACT

This study is a review of previous work[5]. The prediction of six sensory texture attributes from uniaxial compression curves and curve features is investigated. Force-deformation curves on raw potatoes are shown to give slightly better predictions than stress-strain curves and curve parameters such as stress, strain and moduli.

INTRODUCTION

Texture is a sensory attribute of very high importance for the consumer's perception of potato quality. Uniaxial compression is widely used for texture determination of fruits, vegetables, gels, cheeses and potatoes to determine mechanical properties[1-5]. However, the relation between mechanical properties determined instrumentally such as stress, strain and moduli and the sensory quality is only sparsely treated in the literature[4,5]. Since many sensory texture attributes are obtained during the first chew and during the chewing process, it may be too restricted to use only a very few curve features in the correlation analysis with many sensory texture attributes. Therefore the aim of this presentation is to investigate if more information with relevance for sensory texture quality in cooked potatoes is found in the full uniaxial compression curves compared with the information given by stress, strain and moduli determined on either raw or cooked potatoes. This study is meant to open up a debate on interpreting the information in uniaxial compression curves in relation to sensory texture quality. The work is a review of a paper by Thybo & van den Berg[5], where more details can be found. Food Nutrition Press has permitted a presentation of results and illustrations.

EXPERIMENTAL

Twenty-seven potato samples (varieties * dry matter fractions * storage times) were analysed by descriptive sensory texture analysis and uniaxial compression.

Uniaxial compression was performed on ten replicates of raw and cooked potato cylinders (d=12mm, h=10mm), respectively, at deformation rates of 100mm/min with 75% compression. Full compression curves in force-deformation mode were collected, and a recalculation into stress-strain curves was performed. Stress at fracture point (σ_f = force x H_t / (A_0 x H_0)), strain at fracture point ($\varepsilon_f = \ln|H_0 / H_t|$), steepest slope before fracture (E_{max}) and modulus of deformability (E_d, initial slope) were calculated.

Sensory texture quality of cooked potatoes was determined by the attributes hardness, cohesiveness, adhesiveness, graininess, mealiness and moistness by 10 trained sensory assessors using a 1-15 cm scale.

Multivariate data analysis was performed on mean data using The Unscrambler (v7.5 CAMO A/S, Norway). Partial Least Squares

Regression (PLSR) was used to predict the sensory texture attributes from the instrumental data, and the correlation coefficient between measured sensory attribute (r) and predicted sensory attribute from the compression data was used as a measure of correlation between sensory and instrumental attributes. The instrumental data included were the 1) full force-deformation curves, 2) full stress-strain curves and 3) the curve features from force-deformation curves; all for cooked and raw samples.

RESULTS AND DISCUSSIONS

Prediction of sensory texture quality from uniaxial compression curves

A large variation in most of the sensory texture attributes among the 27 potato samples is seen in Table 1. The largest span is observed for cohesiveness, mealiness and moistness. A large variation in each sensory texture attribute forms the basis for studying correlation with uniaxial compression data.

Table 1. Variation in sensory attributes for 27 samples

Attribute	Mean	S.d.	Min	Max
Hardness	6.1	1.6	3.4	8.3
Cohesiveness	5.2	1.8	2.5	8.2
Adhesiveness	7.5	1.5	5.0	9.6
Mealiness	8.8	2.2	5.3	12.6
Graininess	6.3	1.4	3.6	8.8
Moistness	4.1	1.7	1.5	8.5

Fig. 1 illustrates an example of force-deformation curves for one potato sample in ten replicates in a raw (a) and a cooked (b) state.

In Fig. 2 the stress-strain curves are given for the same sample in raw (a) and cooked (b) state. A large variation between the ten replicates is more pronounced for the cooked samples than for the raw samples.

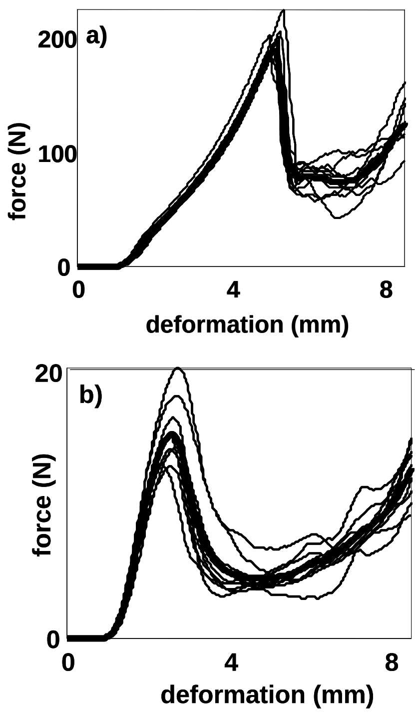

Fig. 1. Force-deformation compression curves for one potato sample in ten replicates in a) raw and b) cooked state.
(thin line: ten replicates, bold line: average)

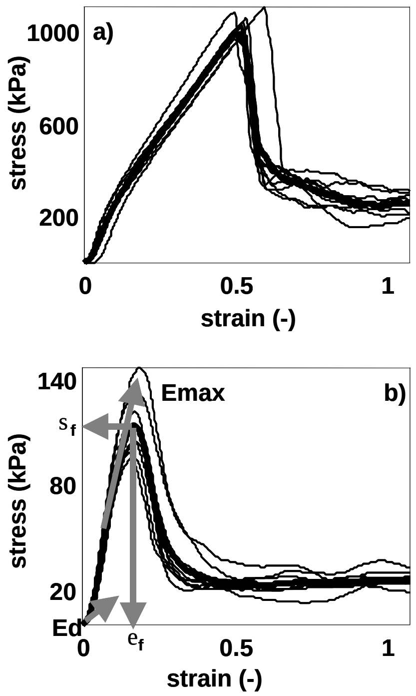

Fig. 2. Stress-strain compression curves for one potato sample in ten replicates in a) raw and b) cooked state.

Table 2 gives an overview of the predictions of the sensory attributes from full uniaxial compression curves, full uniaxial stress-strain curves and extracted curve features; stress, strain and moduli. The correlation coefficients (r) indicate that the sensory texture attributes are better predicted by compression measurement on raw potatoes than compression measurements performed on cooked tubers. However, it should be noted that a higher correlation between hardness and stress, strain and moduli was obtained previously (r = 0.70-0.85, Thybo et al., 2000). Prediction of sensory texture attributes from full curves, either as force-deformation curves or stress-strain curves, seems to be a better predictor of most of the texture attributes than are stress, strain and moduli. Therefore it appears that more information about texture is present in the entire curve compared with curve features. Furthermore the force-deformation curves are better correlated to the texture attributes than is the stress-strain curves, which could be due to the alignment of the initial slope caused by minor differences in sample surfaces or size. For force-deformation curves the correlation coefficients (r) range from 0.74 to 0.90 (Table 2).

Table 2. Prediction of sensory texture attributes from uniaxial compression curves or curve features measured on raw and cooked potatoes. The predictions are given by correlation coefficients (r)

Attribute	Raw 1	Raw 2	Raw 3	Cooked 1	Cooked 2	Cooked 3
	r	r	r	r	r	r
Hardness	0.90	0.57	0.81	0.41	0.48	0.43
Cohesiveness	0.84	0.56	0.82	0.45	0.48	0.43
Adhesiveness	0.78	0.60	0.63	0.71	0.49	0.58
Mealiness	0.81	0.77	0.77	0.72	0.66	0.46
Graininess	0.77	0.76	0.75	0.56	0.52	0.45
Moistness	0.74	0.57	0.81	0.64	0.48	0.43

1: Force-deformation curves
2: Stress-strain curves
3: Stress, strain and moduli parameters

These results indicate that there may be some potential in using the full force-deformation curves, as these raw data 1) seem to cover much information about texture quality and 2) allow a more uniform comparison of different experiments, as variations in calculations of curve feature (e.g. moduli) are omitted, and curve shifts can be handled. On the other hand, data analysis of multiple curve data requires multivariate data analysis techniques and knowledge in this field.

<u>Interpretation of the sensory information in the deformation curves</u>

The use of multivariate regression techniques (PLSR) offers the possibility to investigate the way in which a predictive model uses the information from the uniaxial compression curves. A prediction model has the following form:

$$s_{feature} = \mathbf{c'}_{uniax} \times \mathbf{b}_{PLSR}$$

where $s_{feature}$ is the sensory feature to be predicted, $\mathbf{c}_{uniax}$ either the four features extracted or the full compression curve, and $\mathbf{b}_{PLSR}$ is a regression vector coefficients (regression coefficient). Sensory hardness primarily uses information from the initial slope of the compression curves given by a positive regression vector in the initial part of the curve (Fig. 3a). The last part of the regression vector (after app. 4.2mm) appears to be more irregular. An equal predictive performance for hardness is found when removing this last part of the curve (results not shown here), indicating that most of the information was found at the beginning of the compression and especially around fracture. This confirms what several authors have stated: that most of the mechanical properties in a product are to be determined at fracture and before fracture as either fracture features, slopes of the curves or area below the curves[1-5].

In this study most of the relevant information on mealiness (Fig. 3b) and moistness (Fig. 3c) in the compressions are found at the fracture point. The mealiness regression vector is almost entirely positive, whereas the regression vector for moistness shows a ‘derivative-like’ pattern, which makes the latter difficult to interpret. These specific observations do, however, not imply that other parts of the compression curves are unimportant.

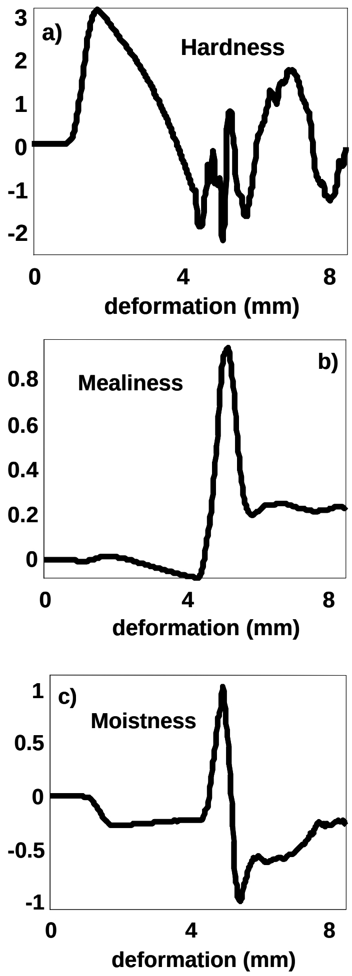

Fig. 3 Regression vectors for PLSR-model on raw potato samples a) hardness, b) mealiness and c) moistness.

CONCLUSION

This study shows a new way of analysing uniaxial compression curves and predicting sensory quality parameters using a holistic approach to interprete the texture information in a continuous compressing curve, which is comparable with a chew in the mouth. With this approach methods can be developed to better utilise the information in the deformation curve and separate the noise in the curves. These initial investigations indicate that:

· Full uniaxial compression curves seem to give better predictions compared with using the curve features stress, strain and moduli. However, most of the information is found at fracture point.
· Good predictions for most of the texture attributes on cooked potatoes can be obtained from uniaxial compression on raw potatoes.

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