Evaluation of crispness in food systems: An example using meringue made with egg or milk protein.

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ABSTRACT

We have compared the instrumental and sensoric crispness of model meringues made with four protein products. The surface tension in the initial protein solutions before whipping and the foam stability after whipping was also measured.

A good correlation between sensoric and instrumentally determined crispness was found and stable foams resulted in the crispest meringues. The stiffest foams were obtained with the protein preparations that most effectively lowered the surface tension.

INTRODUCTION

Crispness is an important sensory parameter in many foods, and evaluation of the jaggedness of force-displacement curves obtained from uniaxial compression measurements can be used to quantify this important quality attribute. Several methods have been used for this: Norton et al.[1] used fractal characterisation of the force-deformation curves (line lengths of curves at different scales) to discern between crispiness and crackliness. Suwonsichon and Peleg[2] fitted the curves to a 4th degree polynomium and then used the mean magnitude of the power spectrum of the normalised residuals as an apparent fractal dimension. They also used Richardson plots to extract the fractal dimension. Both of these studies show good correlations with sensoric determined crispness.

Meringue occurs in many baked goods and crispness is the most important sensory attribute. It is commonly produced by whipping egg white with sugar and subsequently baking the resulting whipped foam at relatively low temperature (100°C). Other proteins with good foamability and foam stability can be used as egg white replacers in meringue, and whey protein products have been utilised for this purpose[3].

The present study evaluates the use of two whey protein products as possible egg white replacers in meringue by analysis of the properties of the initial protein solutions, the whipped foam and the final product.

MATERIALS AND METHODS

Protein products:

The following protein products were used: Spray dried egg white (Sanovo Foods A/S, Odense DK), Nutrilac BK-8310 (ultrafiltered and spray dried whey protein with a pH of 4.6-5 in a 10% solution) and PSDI-4200 (a α-lactalbumin rich whey protein isolate with a pH of 6,4-7 in a 10% solution) from MD Foods Ingredients amba (Nr. Vium, DK). Fresh egg white purchased in a local store was used as control.

Meringue:

Meringue was made by adding 60 g of powdered sugar to 100 g of protein solution (11%) and whipping for 5 min using a kitchen mixer at the highest speed. Egg white controls were only whipped for 3 min.

140 g powdered sugar was then added and the whipping continued for 1 min at low speed. Solutions were made at native pH and also after adjusting the pH to 4.6 using 10% citric acid. The resulting meringue mix was then extruded on baking paper in portions of 8 g using an icing bag and baked for 2 hrs. at 100°C in a hot air oven.

Surface tension:

Surface tension was measured using the Wilhemy-plate method (Sigma 7.03, KSV Instruments, Helsinki, SF) in 11% protein solutions diluted 100 times with distilled water

Foam stability:

Foam stability was determined in foam with and without sugar. Cloth with a mask size of 1x1 mm was placed in a funnel, which was then filled with foam. The foam was allowed to drain for 30 min, the amount of drainage weighed and foam stability calculated from the weight of the initial foam as:

$$\text{Foam stability (\%)} = \frac{100*(\text{Foam(g)} - \text{drainage(g)})}{\text{Foam(g)}}$$

Foam stiffness:

Foam stiffness was determined in 50 ml portions of foam containing sugar using a Texture Analyser (TA-XT2, Stable Micro Systems, Surrey, UK) fitted with a 10 mm probe. A test speed of 0.5mm/sec was used and the probe was allowed to progress 10 mm into the foam. The maximum force was used as an expression of foam stiffness. 5 repetitions were done on each sample.

Instrumental crispness:

Using a Texture Analyser fitted with a Warner-Bratzler shear device 4 individual meringues of each type was sheared through at a speed of 0.8 mm/sec. An example of a measurement is shown in Fig. 1.

The force-deformation data was fitted to a 6th degree polynomium, and the residuals of observation Y_i plotted as a function of Y_{i+1}. The difference $|Y_{i+1} - Y_i|$ expresses the magnitude of the deviation from the fitted curve and can hence be taken as a measure of jaggedness at a given deformation. In order to obtain a single value, the width of the 95% confidence interval of observation Y_i plotted as a function of Y_{i+1} can be used to characterise the average jaggedness of the curve and hence the crispness. This is illustrated in Fig. 2.

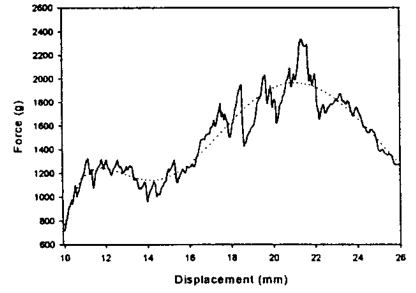

Figure 1. An example of a force-displacement curve obtained for a single meringue. The fitted 6th degree polynomium is indicated by the hatched line.

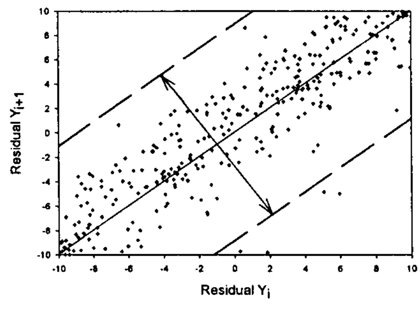

Figure 2. Part of a plot of residual Y_i vs Y_{i+1} obtained from a measurement on a single meringue and polynomial fitting. The double arrow indicates the width of the 95% confidence interval, which can be taken as a measure of the jaggedness of the force-displacement curve.

Sensory evaluation:

The meringues were evaluated by 8 untrained judges using a 15 cm scale. The meringue made from egg white at pH 4.6 was used as reference and indicated in the middle of each scale. Four parameters were evaluated: colour (white-yellow), surface sheen (dull-shiny), surface feel (smooth-rough) and texture (soft-crisp). The intensity of each property was expressed in cm.

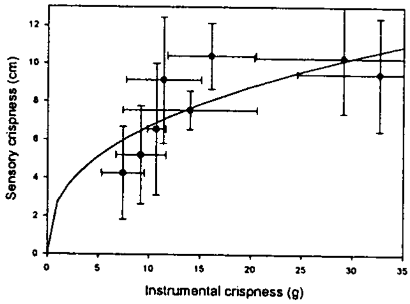

Figure 3. Instrumental vs sensory crispness for experimental meringues made with 4 different protein preparations at native pH and at pH 4.6. The full line represents fit of the data to a power law equation ($S = k^{*} I^{n}$).

RESULTS

The relation between sensory (S) and instrumental measurements (I) should generally follow a power law relationship[4] :

$$S = k^{*} I^{n}$$

For our data, rather large standard deviations are found (Fig. 3). This is due to the use of untrained panellists and the limited number of samples tested. However, the general trend in our data is analogous to what is expected from the above equation, i.e. a more or less linear relation at low crispness followed by a flattening of the curve. This points difficulties for an untrained sensory panel in differentiating between samples with a high degree a crispness, whereas this is possible by using an instrumental method.

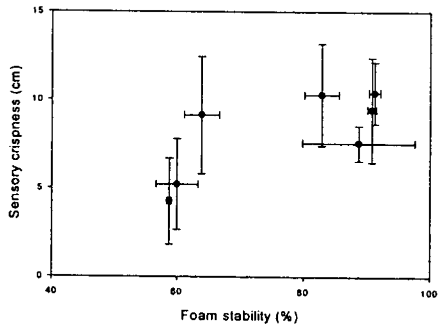

Figure 4. Sensory crispness as a function of foam stability for experimental meringues made with 4 different protein preparations at native pH and at pH 4.6.

Meringues made with fresh egg white or Nutrilac whey protein concentrate had the highest degree of crispness.

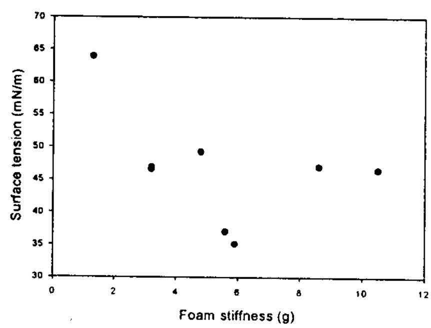

Figure 5. The relation between surface tension in 0.11% protein solutions and foam stiffness in foams whipped with sugar made from 4 different protein preparations at native pH and at pH 4.6.

The foam stability in the whipped foams made with sugar , i.e. the ability of the foam to withstand drainage, relates to the crispness of the final meringues in a manner indicating that a stable foam results in a crisp meringue (Fig. 4). Crispness in a meringue thus seems to depend on the ability of the foam to maintain its structure during extrusion and the initial stages of baking. The inability of the panellists to discern between samples with high crispness in again reflected in the results, but there is a clear indication of a stable foam being a prerequisite for high crispness.

The stiffness of the foams whipped with sugar could not directly be related to properties in the final meringue. However, there is a correlation between foam stiffness and the efficiency of the protein preparation in solution (without sugar) to lower the surface tension (Fig. 5). This is in accordance with Lorient et al.[5], who studied the foaming of caseins and observed that a rapid increase in surface pressure (i.e. a decrease in surface tension) was directly correlated with foam stability.

Two samples exhibit very high stiffness values, without correspondingly low surface tensions. These samples are whey protein preparations at pH 4.6, i.e. near the isoelectric point, and it is expected that this enhances interactions between protein molecules and results in higher stiffness.

CONCLUSION

Although the present investigation was done on a small amount of samples and an untrained sensory panel was used, we believe it does provide some insight into the relation between instrumentally determined parameters and the sensory quality of meringues:

- Sensory and instrumental measurements of crispness in meringues exhibit good correlation, although the panel was unable to differentiate between samples with high crispness.
- High foam stability was a prerequisite for high crispness in the model meringues tested.
- The ability of the protein preparations used in lowering the surface tension related to the stiffness of the whipped, sugar-containing foams before baking.
- Our study confirms that whey protein preparations have much potential as egg white replacers in sugar-rich food systems.

ACKNOWLEDGEMENTS

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