Rheology of Crispy Textures

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ABSTRACT

The focus of this work has been to fully determine the texture of extruded corn starch products. The two objectives have been to prove that neither puncture test nor three point bending are sufficient methods alone. A combination of the two, on the other hand, produces results comparable with other materials and results that fully describe the heterogeneous products.

INTRODUCTION

All over the world crispy food products are consumed in different forms, ranging all from breakfast cereals to snacks. The raw material used is often different types of starch, as for instance corn, wheat, rice and potato or combinations of starches. It is important to achieve just the right crispiness in the product, why great efforts are made to fully analyze the texture.

The focus of this work has been to determine the texture of extruded cornstarch products. The two main objectives in this project has been to show that the texture in extruded starch products is not homogeneous throughout the product, and that it takes a combination of methods to fully characterize the texture. Methods used are puncture test to characterize the texture of the exterior of the samples and three-point bending to characterize the texture of the interior of the samples.

METHODS

One of the most common methods for texture measurements is the *puncture test*. A cylindrical test probe is used to penetrate the material as the force required is recorded (see Fig 1). The result depends on several different factors, some of them being: the shape of the probe end, the probe diameter and the probe speed. The results are hereby only comparable with samples that have been analyzed during the exact same conditions with exactly the same settings of the analyzing instruments.

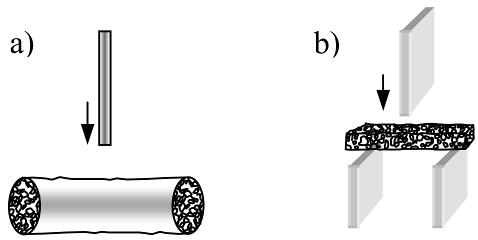

Figure 1. Illustrations of the two methods used. a) puncture test of the exterior of a slightly bent cylindrically shaped sample. b) three-point bending of a cuboid sample of the interior.

In material testing *three-point bending* is widely used. A cuboid sample is placed across two parallel bars whereupon a third bar is pressed down, from above, in the centre of the two parallel ones (see Fig. 1). The top bar is to reach, press onto and break the sample. During this time parameters such as strain, ε, and stress, σ, are recorded. From these, other useful parameters can be calculated, for instance the Young's modulus, E, see Eq 1.

$$E = \left[\frac{slope \cdot L^3}{4 \cdot b \cdot a^3} \right] \quad (1)$$

$$Slope = \frac{d\sigma}{d\varepsilon}\Big|_{\varepsilon \to 0}$$

L is the sample length.
b is the sample width.
a is the sample thickness.

EXPERIMENTAL

One standard formulation for the product in question has been used as a reference to be able to evaluate four alternative formulations. The samples are cylindrically shaped, slightly bent with a diameter of approximately 1 cm.

As the formulation is changed so is also the texture. To measure the hardness of the outermost layer of the cylindrical samples, a puncture test was used. The test probe was penetrated through the material without any modifications to the shape of the samples. To measure the texture of the interior of the samples three-point bending was used. Cuboid pieces, where the outermost layer was excluded, were used for the three-point bending test.

RESULTS

It is clear that the texture of both the interior and the exterior of the samples changes with the different formulations. However, the changes of the interior texture do not follow the same trend as the changes of the texture of the exterior as shown in Fig. 2. The accuracy is calculated using a confidence interval with p=0.9.

See for instance sample A, which has a higher modulus than the reference and would therefore be considered stiffer than the reference. However, the puncture test shows the opposite since the force required to penetrate the outermost layer is lower than for the reference, which shows that both methods are necessary.

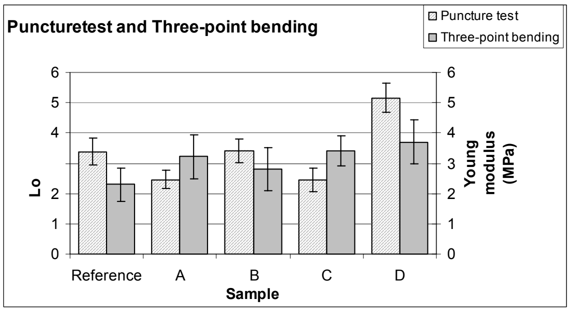

Figure 2. The results from the puncture tests, striped columns, and the three-point bending, grey columns, tests. The units are (N) for puncture test and (MPa) for three-point bending test.

Samples C and D also clearly show that one test is not enough. The results from three-point bending are very similar, that is the values of Young's modulus are very similar, but the results from puncture testing reveals that the exterior of sample D is harder than the exterior of sample C as is shown by the load required.

CONCLUSIONS

The texture is not homogeneous in extruded cornstarch products. The texture of the exterior, is different from the texture of the interior, and is preferably measured using the puncture test, which clearly shows the difference between the samples. The texture of the interior is preferably measured using three-point bending, which also clearly shows the difference between the samples, however the results are also comparable with other products. Comparing the two sets of results it is obvious that the texture changes of the interior and the exterior of the samples do not follow the same trends.

It is therefore clear that in order to fully evaluate the texture, it is necessary to combine several methods. There is no single way to determine the texture sufficiently.

ACKNOWLEDGMENTS

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