Rheology of Confectionery Products

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ABSTRACT

A screening of rheological methods has been made in the effort to find the methods that best characterise the rheological properties of chewing gums and wine gums in relation to consumer preferences. The screening was made using CR- and CS-rheometers and a compression instrument.

INTRODUCTION

Even though confectionery products can be considered as luxury products, it is a considerable industry employing more than 5000 people in Denmark. The turnover of the Danish confectionery industry is more than DKK 2.2 billions a year.

The texture and consistency are important parameters for confectionery products. However, no manufacturers specify these parameters in their marketing. Therefore the consistency is a hidden parameter which in combination with the taste, smell and appearance makes the consumer buy the products.

Due to the importance of texture and consistency the industry would benefit if it was possible to use some easy-to-handle and rapid methods for quality control and product development.

This paper describes the effort to quantify some rheological methods and link the results to sensory evaluations. The correlations between rheological and sensory evaluations thereby help in the interpretation of the rheological methods.

Due to the wide variety of confectionery products the aim of this study was to provide a physical characterisation of only chewing gum and wine gum. This paper only describes the characterisation of the final products with no respect to the ways the consistencies were obtained.

INSTRUMENTATION

The CR-rheometer used was a Bohlin VOR Rheometer, the CS-rheometer a Bohlin CVO Rheometer and the compression instrument a Texture Analyzer TAXT2. The software used for multivariate analysis was the Unscrambler (CAMO AS).

OVERALL METHODS

Due to the big differences between chewing gum and wine gum the two products have been dealt with separately.

The procedure for both products has been the same as the start was a screening of a wide variety of both methods and sample preparations. The evaluation of this screening was made solely on basis of reproducibility and repeatability.

The methods that passed this first screening were then used at sets of products where the textural properties were varied according to an experimental set-up. The same products were subjected to sensory evaluations. The test results were then evaluated statistically, firstly by analyses of variances and secondly by principal component analysis (PCA) of rheological and sensory results separately. Finally, sensory results were correlated to rheological data by means of partial least squares regression (PLS).

RHEOLOGICAL METHODS

There are two categories of rheological methods characterising chewing gum - one characterising a chewed products and one characterising the unchewed products. For wine gum only the unchewed products were characterised.

To obtain a standardised chewing the products were chewed the desired time by a test person at a frequency of 1 chew per second (1 Hz). Alternatively a "chewing machine" was used at the same rate (1 Hz). The chewed product was characterised by a strain sweep and a frequency sweep. The strain sweep was performed from 0.1-10, the frequency sweep from 0.1-20 Hz.

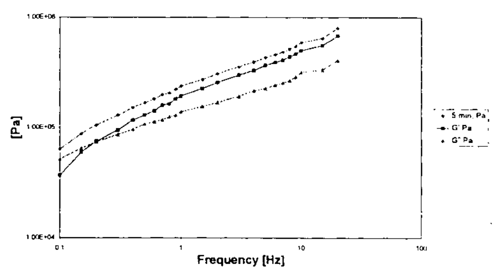

Figure 1. Frequency sweep of chewing gum that has been chewed for 5 minutes at 1 chew a second.

Fig. 1 illustrates a frequency sweep of chewed chewing gum. At the lower frequencies G" dominates and at higher frequencies G' dominates. The cross over frequency at $\delta = 45°$ is increasing with increasing chewing time.

Comparison of G* from frequency sweeps of the same product but different chewing times reveals that these curves are basically parallel. The main difference is the level of the curves. Statistical evaluation has proven that the main information of these curves can be represented by only one frequency. In this project 1 Hz was chosen as the frequency. The slope of G* from the frequency sweep was shown to be important in characterising the difference between products.

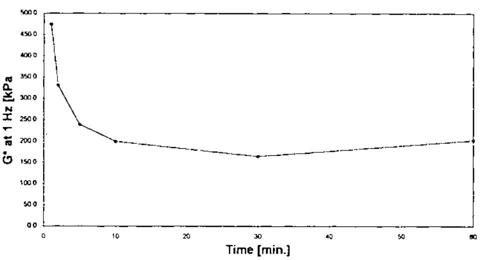

Figure 2. Chewing profile where the G*-values at 1 Hz from the frequency sweep plotted as function of the chewing time.

Using G* at 1 Hz and plotting it against the chewing time we got a curve that we name a chewing profile. The profile at this stage represents an overall firmness of the products. As Fig. 2 illustrates, this chewing gum has a firmness that decreases for the first minutes and then starts rising again. Other chewing gums have similar chewing profiles differing in the slope of the first minutes and in the level of the plateau.

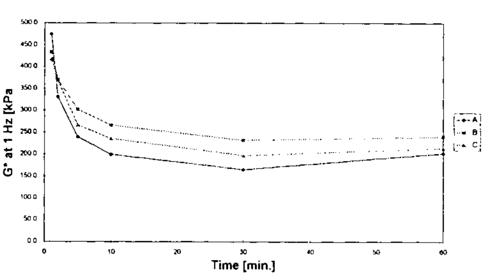

Figure 3. Chewing profile made on the same starting material but chewed by three different persons.

An ideal chewing gum would have a more or less flat profile.

As seen from Fig. 3 different chewing profiles will be obtained using different persons. Therefore a chewing machine has been used in the standardisation of the methods.

RESULTS

Principal component analysis of rheological measurements on chewing gum showed that 72 % of the variances among samples could be explained by means of three principal components. The first principal component accounted for 39 % and correlated mainly to data relating to the hardness of the samples (i.e. G* and data from penetration and shear from the Texture Analyzer). Thus, the most important source of variation between samples was to be found in rheological hardness. The second most important cause of differences between the samples (20 % of the total variation) related to a change in the phase angle with chewing time. Finally the third principal component, describing 13 % of the total variation, mainly related to G* values measured at the short chewing times. Hence, by means of this PCA the different chewing gum samples could be separated into subgroups by means of their rheological behaviour.

Correlation of sensory and rheological data using PLS showed, that sensory hardness, sensory softness and sensory "crumbleness" correlated to rheological data. Upon optimisation of the correlation models it was found that simple relationships involving a linear combination of four to five different rheological parameters would provide a good model for prediction of the sensory attributes.

The data obtained from measurements on wine gum were also subjected to a principal component analysis. Hereby it was found, that two components could describe 86 % of the total variation among the samples. The first and most important source of variation (describing 61 % of the total variation) related to parameters derived from penetration and relaxation measurements made with the Texture Analyzer. Thus, according to the PCA all data found from these analyses contained the same type of information about the differences between the samples. Data from frequency sweeps and stress sweeps correlated to the second principal component and thus accounted for 25 % of the total variation in the data set. Consequently, data from measurements on wine gum gave a very simple model compared to data from measurements on chewing gum. Despite the simple model the different wine gums were well separated into subgroups.

The correlations between sensory and rheological measurements from wine gum have not yet been established but the work is still ongoing.

CONCLUSION

By combination of rheological and sensory measurements and statistical evaluations it has been possible to single out rheological analysis that describes some of the physical differences between chewing gums respectively wine gums as experienced by the consumer.

On basis of these methods a model for prediction of some sensory characteristics has been established.

ACKNOWLEDGEMENTS

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