Rheological Profiles™ of Salad Dressings

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ABSTRACT

A screening of the rheological properties of 11 commercial salad dressings has been performed. The results have been analysed by statistical and multivariate analysis to point out the best suited parameters for differentiating this group of products. The group of selected parameters has been used to create a Rheological Profile™ of each of the 11 salad dressings. The profiles will be used in the discussion of the functionality of non-fat, low-fat and regular products.

INTRODUCTION

The texture and consistency of a food product are seldom fully described by the use of a single parameter. The description often involves several rheological measurements and often the use of more than one parameter from each measurement. However, which measurements and parameters best describe the differences between a certain group of products are not always obvious. In this study a screening of a wide range of measurements on a Texture Analyzer and a CS-rheometer was made and the data from these were then evaluated using both statistical and multivariate data analysis to obtain the most appropriate set of parameters.

When a product is characterised by several rheological parameters, we have found that the best way of comparing the rheological qualities is to present the information in Rheological Profiles™ for each of the products.[1]

INSTRUMENTATION

The CS-rheometer used was a Bohlin CVO Rheometer (Bohlin Instruments) and the compression instrument a Texture Analyzer TA-XT2 (Stable Micro Systems). The software used for Principal Component Analysis, PCA, was The Unscrambler 6.11b (CAMO ASA). Theoretical background for the use can be found in Martens and Næs.[2] The software used for analysis of variance was Statgraphics Plus 2.0 (Statistical Graphics Corp.).

MATERIALS AND METHODS

Eleven dressings commercially available in Denmark were characterised. They were Long Island Creme Fraiche Classic (D01) and Light (D02, Company 1), Long Island Salad Dressing Light (D11, Company 1), Creme Fraiche Classic (D03) and Light (D04, Company 2), Thousand Island Classic (D05), Light (D06) and Fat Free (D07, Company 2), Dijon/Honey Classic (D08, Company 3), Oriental Curry/Pine Light (D09, Company 3) and Burger Dressing (D10, Company 3). In the following the dressings will be referred to with their DXX number.

The following measurements were peformed on the 11 dressings. Using the CS-rheometer a strain sweep, a frequency sweep,

a yield point (ramp viscosity), and a creep measurement were performed. A penetration measurement was made using the compression instrument.[3] From each of the measurements several key points were chosen for further data analysis. These key points were selected solely on the basis of rheological experience. However, the key points selected to be present in the Rheological Profiles™ might differ if different or more key points were investigated. Though, it has been the aim to include both the most obvious and well documented points from the curves as well as some guesses as to where information of the products might be represented.

The following seventeen key points were selected: *Stress sweep*; G'_{lin} (the linear elastic modulus), σ_{90} (breakdown stress at a G' value of 90% of G'_{lin}). *Frequency sweep*; $\delta_{0.2}$ and $\delta_{2.3}$ (phase angles at 0.207 and 2.340 Hz), $G'_{0.2}$, $G''_{0.2}$, $G^*_{0.2}$, $G'_{2.3}$, $G''_{2.3}$ and $G^*_{2.3}$ (elastic, viscous and complex modulus at 0.207 and 2.340 respectively). *Yield point*; δ_y (stress at yield point). *Creep*; η_0 (steady state viscosity), J_{0C} (creep compliance), J_{0R} (recoverable compliance). *Penetration*; M (maximum peak), G (gradient), A (area under the curve from 0 sec. to the time it reach the peak point).

Each measurement was performed in replicates of three on the same bottles of dressings, respectively.

SELECTION OF VARIABLES

PCA was used to select the minimum number of parameters that sufficiently describe the difference between the textural properties of the products. The PCA was based on the average of the replicates.

Figure 1 illustrates Principal Component 1, PC1, and Principal Component 2, PC2, for the PCA score plot representing the samples D01 to D11. Figure 2 illustrates PC1 and PC2 of the loading plot representing the variables.

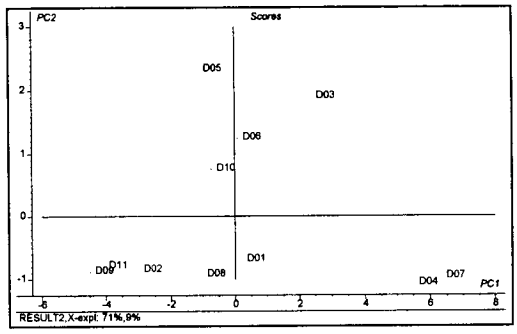

Figure 1. Score plot of eleven commercial dressings based on a screening of seventeen rheological variables.

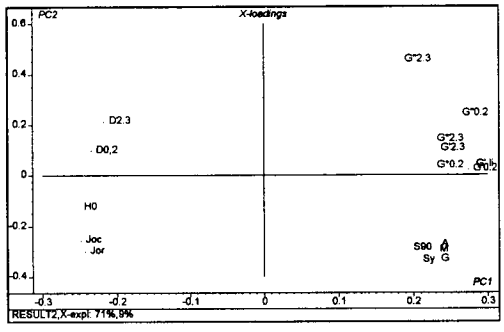

Figure 2. Loading plot of seventeen rheological variables based on analysis of eleven dressings.

By visual interpretation of the loading plot in Figure 2 and the successive principal components, nine variables were chosen as representing the rheological characteristics with the greatest variation and giving information different from the other variables.

The nine variables are: *Stress sweep*; G'_{lin} and σ_{90}. *Frequency sweep*; $\delta_{2.3}$, $G''_{0.2}$ and $G''_{2.3}$. *Yield point*; δ_y. *Creep*; η_0 and J_{0R}. *Penetration*; A.

RESULT FROM THE PCA

Based on the nine selected variables a new PCA was performed. The score plot is shown in Figure 3 and the loading plot in Figure 4. The PCA was made using the data produced for the Rheological Profiles™ described later. The data was normalised as for the profiling.

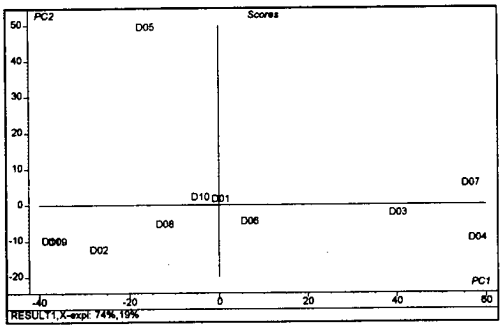

Figure 3. Scores plot for PCA based on the nine selected variables.

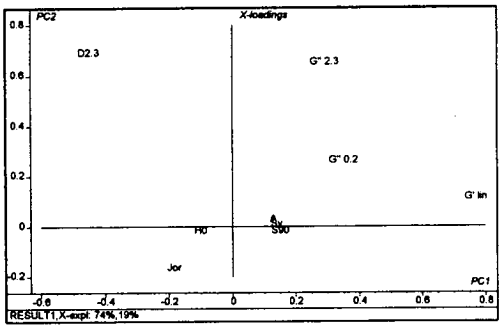

Figure 4. Loadings plot from the PCA based on the nine variables.

From Figure 3 it can be seen that the dressings can be arranged in four groups. Group One containing D05. Group Two containing D03, D04 and D07. Group Three containing D02, D09 and D11, and Group Four containing D01, D06 and D10. Finally product D08 might form a group of its own or be included in either group Three or Four. As it will be seen later this grouping is in good agreement with the visual impressions obtained by the Rheological Profiles™.

Figure 4 might indicate that the number of variables could be reduced even further. Though, inspection of the succeding PC's have shown that in this study the variables, which in Figure 4 are situated at the same locations, might be of interest.

If a reduction of variables is found to be acceptable the best choice would be to exclude the variables A and σ_y. This will reduce the total number af analysis by two and thereby leave only three analysis for a full characterisation.

In this study it was chosen to keep the nine variables as key variables.

RHEOLOGICAL PROFILES™

To obtain suitable Rheological Profiles™ the variables must be normalised. In this paper the following normalisation has been used.

$$x' = \frac{x - average}{std.\,deviation}$$

The std. deviation refers to the error of the analysis, x to the original value and x' to the new value. The same normalisation has been used for PCA in Figure 3. Using the nine key values and the above normalisation the following plots were formed.

RESULTS AND DISCUSSION

By comparing the Rheological Profiles™ of the same type of products in fat-free, light and classic and not knowing whether the companies actually have aimed at the same textural characteristics of their products the following can be noticed.

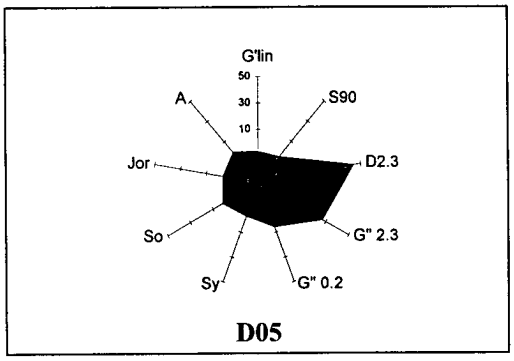

Figure 5. Group One.

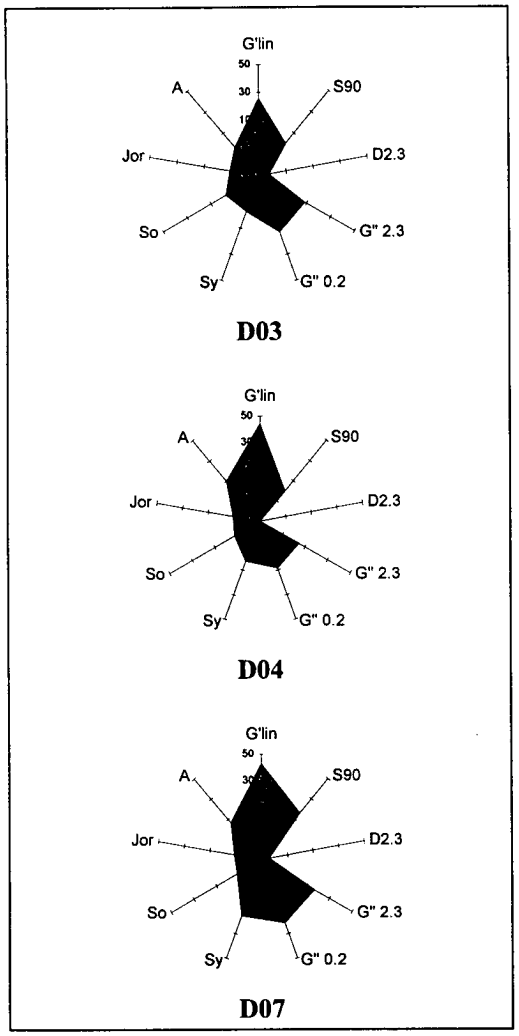

Figure 6. Group Two.

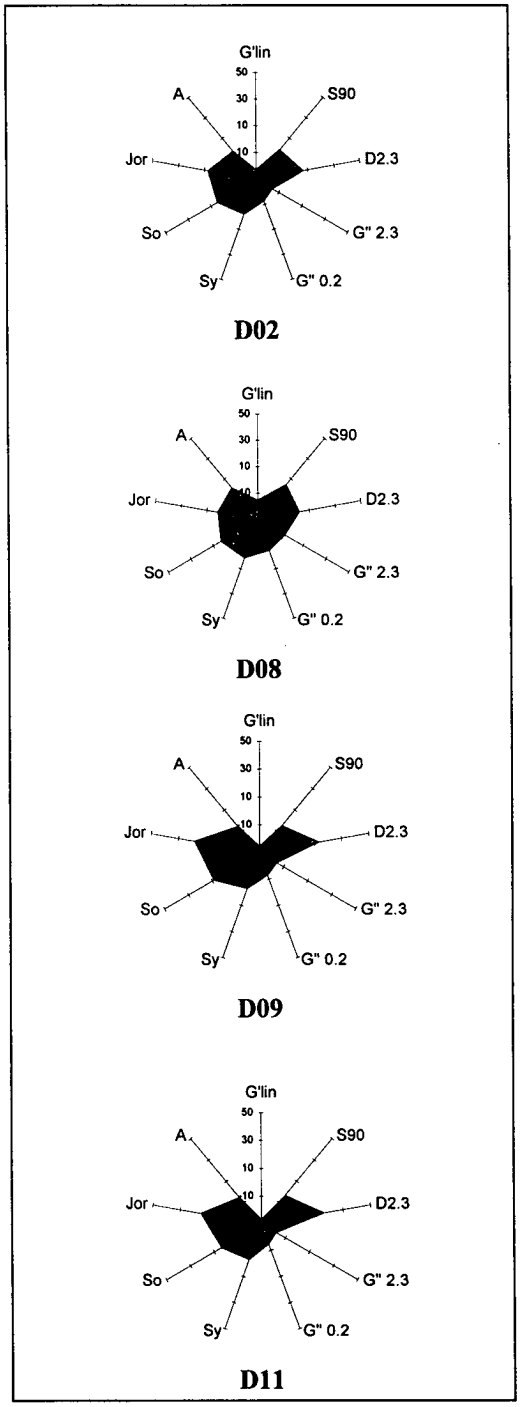

Figure 7. Group Three.

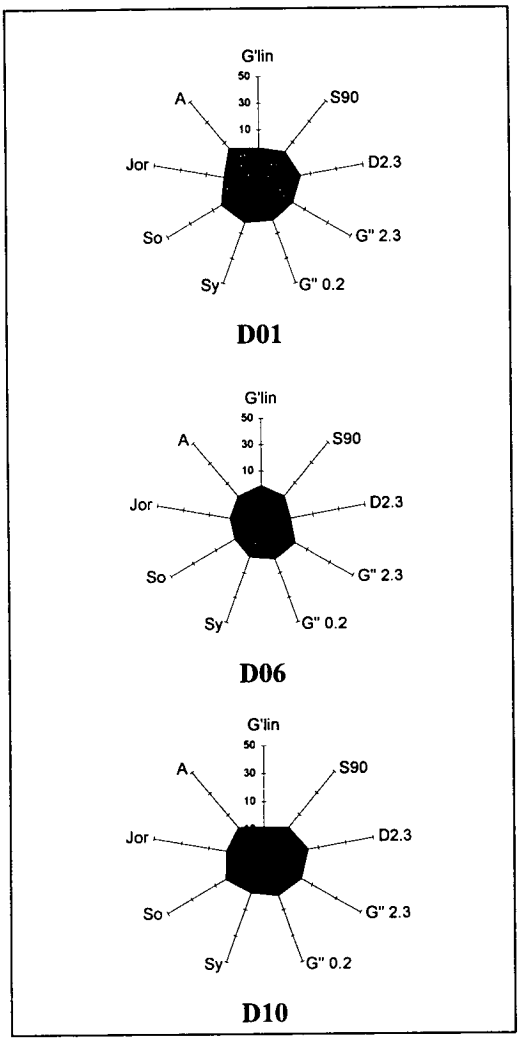

Figure 8. Group Four.

The Long Island Creme Fraiche Classic (D01) and Light (D02) from company One did fall into two different groups. Long Island Salad Dressing (D11) from Company One belongs to the same group as D02 from the same company. Creme Fraiche Classic (D03) and Light (D04) from Company Two do belong to the same group. Thousand Island Classic (D05), Light (D06) and fat-free (D07) did fall into three different groups and are the dressings that differ most within the same type of product. The dressings D08, D09 and D10 are of different types, but from the same company. Whether the objectives of these were to reach products with similar consistencies is not known. Nevertheless, the products show a great deal of similarities in this test.

CONCLUSION

There seems to be a trend in the dressing industry to present the same type of dressing in versions with different fat contents. Often it is divided into a classic product, high in fat, a light product with reduced fat and a fat-free product. Presumably, the industry aims at obtaining similar consistencies for each type of dressing.

As can be seen from the above tests this objective is not always achieved. The presentation of the Rheological Profiles™ clearly visualises some of the differences. Though, further use of this technique might help the industry in adjusting the consistencies and thereby obtaining products with similar rheological characteristics within the same type of products.

The tests in this paper are only based on instrumental methods. Therefore it does not include any priority of the parameters. A consumer test might even conclude that some of rheological differences are of only slight or no importance at all for the acceptance of the products. Therefore a study, as described in this paper, might be greatly improved by the addition of some consumer studies.

REFERENCES

1. Isaksen, A. and Kragh, H. (1997), "Rheological Profiles and Fingerprints of Food Products", *Annual Transactions of the Nordic Rheology Society*, **5**, 22-25.

2. Martens. H. and Næs, T. (1989). "Multivariate Calibration". John Wiley & Sons Ltd., Chichester, pp. 419.

3. "Comparison of Penetration Forces and Consistency of Full-Fat and Low-Fat Mayonnaise using a Cylinder Probe". (1995) *TA-XT2 Application Study from Stable Micro Systems LTD.*

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