Development of Iso-Viscous, Iso-Sweet Emulsions for the Determination of Sensory Difference Thresholds

Karin Hoppert, Antje Puschmann, Susann Zahn, and Harald Rohm

[1]Institute of Food Technology and Bioprocess Engineering, Technische Universität Dresden, 01069 Dresden, Germany.

ABSTRACT

The fat content of emulsions, and the distribution of fat globule size are important parameters which determine the rheological behaviour of emulsions such as custard or mayonnaise. To obtain iso-viscous emulsions with different fat content for sensory experiments, locust bean gum (LBG) was used as thickener. It was possible to adjust the amount of LBG in the system in a way so that flow curves of emulsions with a fat content of 1 % - 29 % were comparable in the shear rate range which applies during in-mouth assessment. To ensure sensory iso-sweetness of the emulsions it was also necessary to correct the amount of sugar in the system with respect to its oil content. The resulting emulsions were used for the determination of the sensory threshold of fat.

INTRODUCTION

Fat is the major food constituent with the highest energy content, and can be regarded as the most important source of fat-soluble vitamins and essential fatty acids. Fat does also serve as a carrier of lipophilic aroma compounds and acts as texturizer. Because of the continuous rise of overweight people all over the world there is an increasing pressure for the food industry to reduce the fat content of foods while maintaining sensory properties.

In complex foods such as emulsions fat is incorporated as liquid disperse phase. The viscosity of emulsions is mainly determined by fat content, fat droplet size, and the addition of hydrocolloids.[1] Some of the sensory descriptors which are related to fat content or fat droplet size are creaminess, thickness or mouthfeel which either result from stress and strain exerted through oral manipulation, or from interactions between oil droplets and oral tissue.[2] It is also known that similar sensations may be triggered by polymeric carbohydrates. Interactions between fat content of emulsions and chemical sensations are evident for taste and flavour release.[3,4]

The extent to which the content of a particular food constituent can be modified without being noticed by the consumer is reflected by the just-noticeable-difference (JND) or difference threshold, which usually is a fraction of the absolute magnitude of that compound.[5] To determine such differences, it is strictly necessary to work with model foods which differ only in the sensory continuum which is under study. It was therefore the aim of the study to develop a dairy-based model emulsion which is suitable for difference threshold determination.

MATERIALS AND METHODS

Emulsion preparation

To obtain a reference emulsion, 16.5 g of 3 % aqueous LBG solution were mixed with 40 g of 10 % reconstituted skim milk

(RSM), 9.7 g water, 2.67 g sucrose, 2.0 g carotene solution and 0.13 g vanilla aroma.[6] Sweetness (sucrose equivalents in water) of this emulsion is 5 %. 20 g oil were added, and the system was homogenized at 20,000 rpm for 15 min with an ultra-turrax. Upon measuring the rheological properties of that emulsion, another emulsion with 20 % fat was prepared. Sucrose concentration was increased to maintain sweetness on the required level, and the amounts of LBG solution and additional water in the system were varied until the measured flow curves were almost identical. This adjustment step was also repeated for emulsions which contained 1 % or 10 % fat. The relationship between emulsion fat content and LBG solution necessary to thicken the system was then used to calculate LBG concentration in emulsions with 5, 15 and 25 % fat.

<u>Rheological measurements</u>

Flow curves of the emulsions were measured at 10 °C with a rheostress 1 rheometer equipped with a cone/plate geometry (Gebr. Haake GmbH, Karlsruhe, Germany). After loading the sample and 15 min equilibration, the emulsion was pre-sheared for 10 min at a shear stress of 50 Pa. Subsequently, shear stress was reduced to 0.5 Pa in a logarithmic ramp, and shear rate was recorded in 1.2 s increments. Flow curves of each of the emulsions were, after independent preparation, measured in duplicate.

To obtain information on rheological properties at small deformation, amplitude sweeps were performed. Stress was increased from 0.01 to 100 Pa at constant frequency (1 Hz) in logarithmic increments (10 data points per decade), and G' and G" were recorded as a function of shear stress.

Emulsion images were taken in a light microscope with a digital camera (Carl Zeiss Microimaging, Göttingen, Germany) at a 400x magnification. Droplet diameter was estimated using an image processing software.

RESULTS AND DISCUSSION

The measurements of shear viscosity of the reference emulsion showed a pronounced shear-thinning behaviour without incidence of a yield value. It can be seen from Fig. 1 that the adjustment of the amount of LBG solution which was used for the preparation of emulsions with a lower fat content resulted in flow and viscosity functions which, in the entire shear rate region, were almost identical.

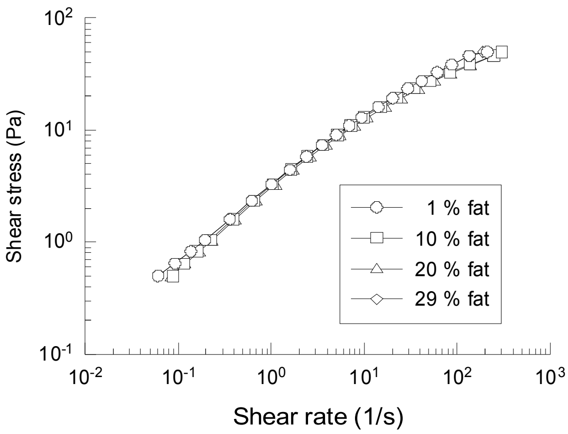

Figure 1. Flow curves of emulsions with different fat and LBG content. For LBG content, see Fig. 2.

A plot of emulsion fat content versus LBG solution showed a highly significant, linear correlation ($P<0.01$; Fig. 2). The regression function estimates were subsequently used to calculate the specific LBG concentrations for the emulsions with a fat content of 5, 15 or 25 %.

From the averaged flow curves of all the custards, apparent viscosity at 10, 50 and 150 1/s was extracted; this is the assumed shear rate range of in-mouth manipulations of liquids with a moderate viscosity.[7] At a shear rate of 10/s, we observed the lowest apparent viscosity of 1.17±0.08 Pa.s for the emulsion with 29 % fat, and the highest viscosity (1.31±0.05 Pa.s) for the emulsion with 20 % fat. Whereas the viscosity difference between these two samples was significant at $P<0.05$, all other samples exhibited apparent viscosities between these values (Fig. 3). Apparent viscosity at a shear rate of 50/s ranged between 0.51 Pa.s and 0.56 Pa.s, and for a shear rate of 150/s, the corresponding viscosity borders were 0.26 and 0.29 Pa.s (see Fig. 3).

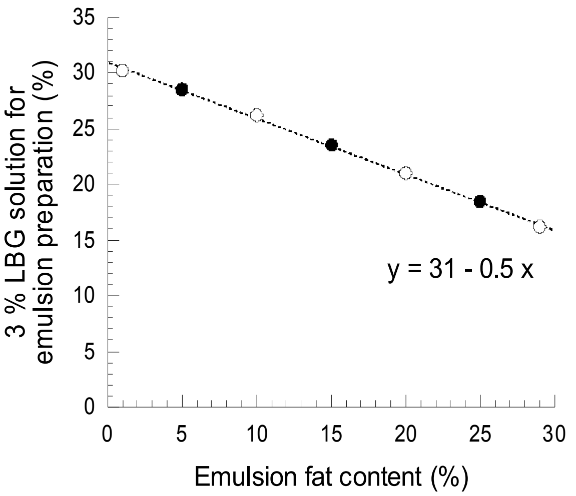

Figure 2. Relationship between emulsion fat content and the amount of 3 % LBG solution in an emulsion to obtain identical apparent viscosity. Open symbols, from experiments; closed symbols, estimated using the regression equation.

A general outcome of the oscillation experiments was that, for the different emulsions, the loss modulus varied between 21.8 and 24.4 Pa. Viscous contributions dominated over elastic contributions, and G' of the emulsions ranged between 12.3 and 17.7 Pa. The evaluation of the microphotographs showed that the fat globule size distributions were neither affected by fat content nor by LBG content. d50, which refers to the median fat globule diameter, ranged between 6.5 μm and 8.2 μm.

In preliminary experiments we observed that, upon incorporating a constant amount of sucrose in a defined total amount of emulsion, perceived sweetness was judged higher in the systems which had a higher fat content (data not shown). This is presumably because the concentration of sugar in the aqueous phase increased. When the amount of sucrose was reduced with increasing fat content on the basis of a constant sucrose concentration index, no distinction between the different emulsions on the basis of their sweetness was possible in sensory analysis.

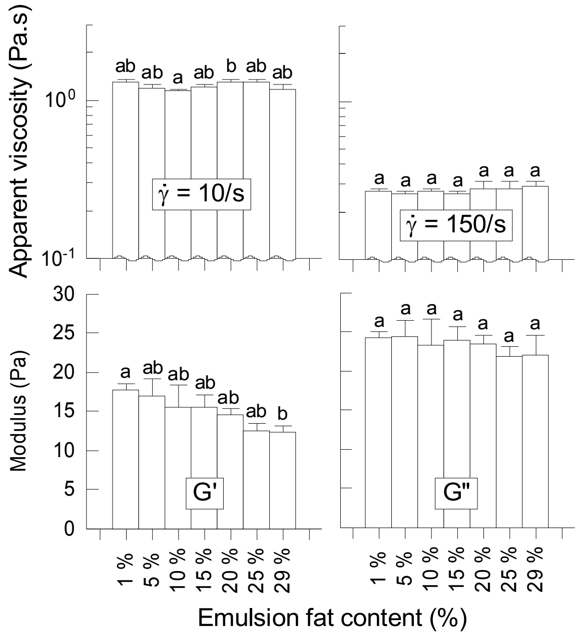

Figure 3. Apparent viscosity of emulsions with different fat content measured at a different shear rate (upper figures) and moduli from oscillation experiments (lower figures). Each bar represents mean ± standard deviation of (n=4) measurements.

CONCLUSION

The formulation of such emulsions allows their use in experiments which aim to determine difference thresholds in complex systems (for example, fat and sweetness). Corresponding experiments will be reported elsewhere.[8]

ACKNOWLEDGMENTS

The study was supported by grant 0315670 "*Innovative Strategies to Overcome Implicit Product-based and Personality-based Obstacles to Consume Healthy Food",* funded by the Federal Ministry of Education and Research, Berlin.

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