RHEOLOGY OF COMMERCIAL MAYONNAISES AND MAYONNAISE SAUCES: A CHEMOMETRIC ANALYSIS

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Many food products are manufactured as emulsion systems. However, macroemulsion is thermodynamically unstable system. Over time, they undergo various destabilization processes such as creaming, flocculation, coalescing and Ostwald ripening, which leads to the separation of the oil and water phases. The modern task of a healthy diet is associated with a reduction in the calorie content of foods. For emulsion foods, reducing the oil content is challenging in terms of system stabilization. Its solution requires an understanding of the interparticle interactions of the chemical compounds of the food matrix and the influence of the functional and technological properties of each of the main ingredients on the sensory characteristics of the final product. It is known that the size of droplets as a microstructural characteristic directly depends on the stability of the emulsion and correlates with the rheological properties of emulsions. Thus, the study of the rheological properties of the material becomes one of the important factors in predicting the properties of the developed emulsions with different nature of the main ingredients.

The object of the study was a series of mayonnaises and mayonnaise sauces with an oil content of 25 to 67% from different producers in several countries. The total amount of samples was 10. The apparent viscosity of emulsions was determined by using a rotation viscometer Visco QC 300R (Anton Paar, Austria) with thermostat Peltier PTD 175 temperature device (Anton Paar, Austria) and an absolute measuring system/spindle with concentric cylinder CC12 at temperature 20 ˚C in the range of 0.1-5.00 s^{-1}. Shear rate was increased logarithmic over the period of 120 s. All experiments were performed in triplicate. In addition, the static yield strength was measured and the thixotropic behavior of the emulsion at low shear rates was studied using the classic and three-stage (3ITT) tests.

The rheological data were analyzed within the framework of the structural approach based on the generalized rheological Casson model:

$$\eta^{1/2} = \frac{\tau_c^{1/2}}{\chi + \gamma^{1/2}} + \eta_c^{1/2}$$

where the coefficient τ_c characterizes the degree of aggregation of the emulsion; the coefficient χ indicates a tendency towards the formation of an

Table 1

Principal component factor analysis (factor loadings)

Variable	Factor1	Factor2	Factor3
τ_c	0.956	-0.260	-0.138
χ	0.174	0.984	-0.048
η_c	-0.987	-0.078	-0.142
Variance	1.9176	1.0409	0.0415
% Variance	0.639	0.347	0.014

infinitely large aggregate of drops and it determines the plastic χ=0 or pseudoplastic (χ>0) behavior of a structured emulsion, and viscosity coefficient η_c can be considered as the total viscosity of a structurally destroyed system. These parameters were used as input data in the sample-variable matrices. Prior to multivariate analysis, all matrix elements were scaled by centering and divided by their standard deviation to ensure the same weight of elements in the results. As grouping methods of multivariate statistics methodology such as principal components analysis (PCA) and hierarchical cluster analysis (HCA) are used. The HCA used The Ward's linkage method with Euclidean distance to select objects.

The PCA provides the possibility of analysing the relationships between the principal components and the original descriptor variables. This information is encoded in coefficients loadings, a high absolute value of which indicates that a given original variable has an important contribution. According to Table. 1, the first factor mainly correlated with the content of τ_c (0.956) and there is a negative correlation with η_c (-0.987). Second factor was mainly correlated with the χ (0.984). The results obtained correspond to the concept of mayonnaises and mayonnaise sauces as structured emulsions that exhibit both fluid (viscous) and solid (elastic) behavior. From a joint interpretation of score and loading plots, it can be deduced that, since factor 1 is mainly responsible for the differentiation between mayonnaises and mayonnaise sauces. Variables τ_c and η_c are the most important for such a differentiation. Conversely, the differentiation of some mayonnaise samples into separate classes is mainly related to factor 2. Therefore, variable χ can be considered as the main responsible for the characterization of this class. The first and second principal factors accounted for 63.9% and 34.7% of the total variation.

The pattern captured by PCA is confirmed by the data of the HCA analysis with the selection of the appropriate clusters.

The influence of the nature of emulsion food ingredients on the results of multivariate analysis is discussed.