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INFLUENCE OF MALTODEXTRIN DEXTROSE EQUIVALENT VALUE ON RHEOLOGICAL AND DISPERSION PROPERTIES OF SUNFLOWER OIL IN WATER EMULSIONS

Petar P. Dokić, Ljubica P. Dokić, Verica J. Sovilj and Jaroslav M. Katona

Effect of dextrose equivalent (DE) of maltodextrin present in continuous phase on flow along with dispersion properties of sunflower oil in water emulsions has been investigated. Both, rheological and disperse characteristics of the emulsions were greatly influenced by continuous phase viscosity and thus by the DE value of maltodextrin.. The smaller DE value, the greater high shear viscosity and the smaller the droplet size. Irrespective of the amount and DE value of maltodextrin used was, all the emulsions showed a pseudoplastic behaviour.

KEYWORDS: Emulsion; rheology; hydrocolloid; maltodextrin

INTRODUCTION

Maltodextrins are acid/enzymatic hydrolysis products of starches with a dextrose equivalent (DE) value lower than 20. They represent a mixture of saccharides with a broad molecular weight distribution, ranging from oligosaccharides to polysaccharides. The DE value (a measure of total reducing power of all sugars present relative to glucose as 100, and expressed on a dry-weight basis) is a principal factor affecting maltodextrin's properties. However, maltodextrins with the same DE value might have very different properties, depending on hydrolysis procedure, botanical source of starch (maize, potato, rice), amylose/amylopectin ratio, etc. (1).

Maltodextrins have been found highly suitable for obtaining desirable organoleptic (texture, fat-like mouthfeel, etc.) as well so as physical properties (water holding, gelling, crystallization prevention, freezing control, etc.) of various food products (2). On the other hand, they have been widely used as fat replacers in calorie reduced foods ("light" mayo-

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nnaise, butter, margarine, salad dressing, etc.) (3). A vast majority of these products are either oil in water or water in oil emulsions.

Nevertheless, the introduction of maltodextrin (4) as a hydrocolloid to an already complex system such as food emulsion, causes different kinds of interactions among its components (5-7), and consequently has a dominant influence on the final product's properties. Many of these attributes are directly related to the product's texture properties (e.g. creaminess, thickness, smoothness, spreadability, pourability, flowability, brittleness and hardness).

In this paper, the investigations of influence of DE value of commercial corn starch maltodextrin on rheological properties of sunflower oil in water emulsions stabilized with non-ionic emulsifier have been presented. Correlation between DE value and dispersion characteristics of the emulsions has been investigated, too.

EXPERIMENTAL

Sunflower oil (obtained from the factory "Sunce" Sombor) in water emulsions were prepared using polyoxyethylene (20) sorbitan monooleat (Tween 80) as emulsifier. Commercially available maltodextrins (Maltrin®, 1991, Grain Processing Corporation, Iowa, USA) M040, M100, M150, M200 with average DE value 5, 10, 15 and 20 respectively, were used.

Emulsions were prepared using Ultraturax T- 25 (Janke- Kunkel, Germany) adjusted at 6000 rpm. They were homogenized for 30 min at 25°C.

Each emulsion contained 30% (w/w) of the oil. The emulsifier concentration was 3% (w/w), calculated on the oil mass. Control emulsion had no maltodextrin in continuous phase, while the others contained 5% or 25% (w/w) of maltodextrins M040, M100, M150 and M200, calculated on continuous phase mass.

Continuous phases (CPs) were composed of 5 or 25% (w/w) water solutions of different maltodextrins (M040, M100, M150 and M200) and 3% (w/w) of the emulsifier, calculated on the oil mass.

Droplet sizes were determined by electronic counter TAII (Coulter Electronics, England), using 50-μm orifice tube, and were expressed as volume surface droplet mean diameter d_{vs} (μm), along with the specific surface area $S=6/d_{vs}$ (m^2/cm^3).

Rheological measurements were carried out on a Rotovisco RV20 (Haake, Germany) apparatus at 20°C, immediately after the emulsion preparation. An NVST measuring sensor was used.

RESULTS AND DISCUSSION

Continuous phases CPs as well as sunflower oil in water emulsions, both having different types and amounts of maltodextrins, were made and their rheological behaviour was determined. The interdependence of the flow behaviour and dispersion characteristics of the emulsions was also examined.

It has been already reported that continuous phases containing laboratory-made maltodextrin (Mdx-13/E, DE = 14) and Tween 80 showed a Newtonian- flow properties (8).

However, rheological investigations presented in this paper showed both CPs containing 25% (w/w) maltodextrins, as well as all the emulsions to be shear thinning fluids (Figs. 1 and 2). The CPs having 5% of M040, M100, M150 and M200 were found to be Newtonian, with the viscosities 2.07, 1.59, 1.45 and 1.42 mPas, respectively.

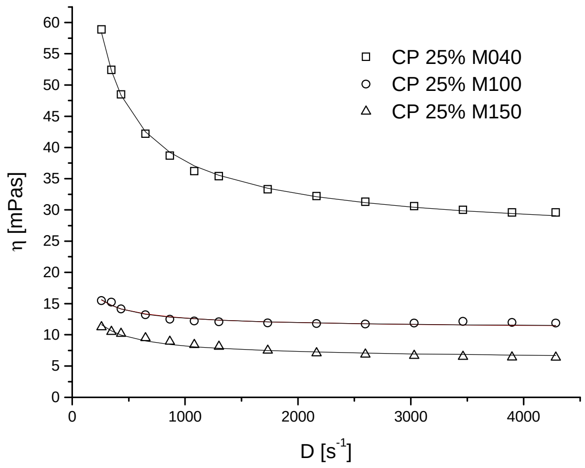

Fig.1. Shear thinning behaviour of CPs containing 25% of maltodextrins

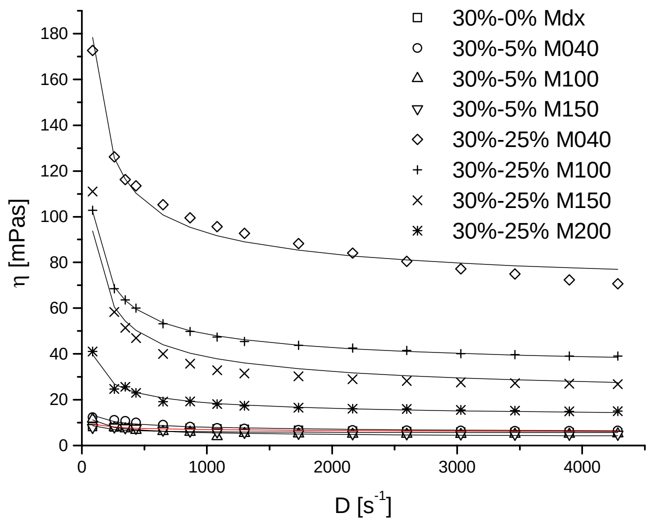

Fig. 2. Shear thinning behaviour of 30% sunflower oil in water emulsions containing 0%, 5% and 25% of maltodextrins

Fig.2 depicts the influence of the amount and the type of maltodextrin (DE value) present in the continuous phase on rheological behaviour of 30% emulsions. It can be seen that the rheological behaviour of the emulsions having 25% of maltodextrin is fully determined by the DE value of the maltodextrin present. On the other hand, when it was present in 5%, the DE value of maltodextrin had no significant effect on the emulsions flow behaviour, which was almost identical to the control emulsion.

Comparing Fig.1 with Fig.2, it is evident that the governing factor affecting flow properties of the emulsions is continuous phase viscosity, which is not surprising when bearing in mind that these are not concentrated emulsions. However, in view of the fact that the control emulsion was also shear thinning, deformation of oil droplets caused by shear rate was also found to contribute to pseudoplasticity of the emulsions.

Yet, it should be taken into account that the shear thinning flow properties of an emulsion could also be a result of oil droplets flocculation (6, 9). Whether the flocculation effect was involved in these emulsions or not, has yet to be investigated.

In order to determine the degree of pseudoplasticity together with the high shear viscosity (viscosity when the shear rate $D \rightarrow \infty$), experimental data were fitted to the following equitation:

$$\eta = \frac{\eta_0 - \eta_{\text{inf}}}{(D+1)^a} + \eta_{\text{inf}} \qquad [1]$$

Where η is the apparent viscosity; D is the shear rate; η_0 is the viscosity when D = 0; η_{inf} is the high shear viscosity and *a* is the degree of pseudoplasticity.

The parameters obtained are presented in Table 1.

Table 1. The parameters *a*, η_{inf}, η_0 from the viscosity equitation [1]

System	*a*	η_{inf} [mPas]	η_0 [mPas]
30%-25% M040	0.57	64.7	1529.0
30%-25% M100	0.56	30.6	929.6
30%-25% M150	0.53	18.0	835
30%-25% M200	0.53	10.8	323.6
30%-5% M040	0.69	5.4	75.9
30%-5% M100	0.44	2.7	62.7
30%-5% M150	0.31	3.5	43.0
30%-0% Mdx	0.22	3.8	18.3
C.P. 25% M040	0.68	23.9	1505.8
C.P. 25% M100	0.69	10.8	240.5
C.P. 25% M150	0.63	5.7	207.5

The values of the high shear viscosity versus DE have been plotted in Fig. 3. The trendline agreement of the curves representing 30%-25% Mdx emulsions and CP 25% Mdx continuous phases clearly indicates a dominant influence of DE of the maltodextrin present in the continuous phase. The oil in the emulsions in the concentration of 30% influenced only the height of high shear viscosity.

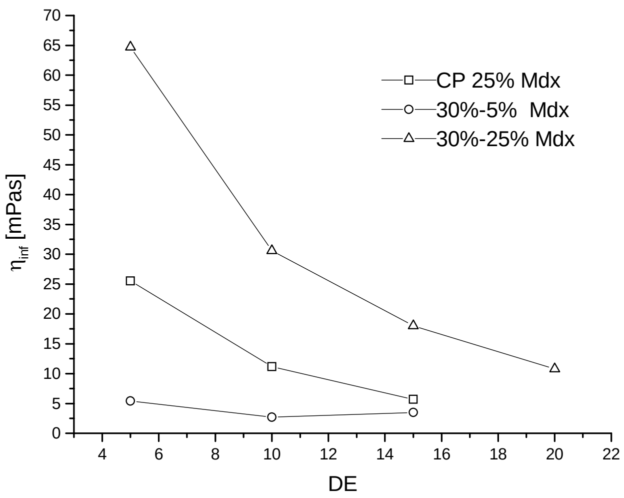

Fig. 3. Influence of DE value on viscosity η_{inf} of CPs containing 25% of maltodextrins (CP 25% Mdx), emulsions containing 5% of maltodextrins (30%-5% Mdx), and emulsions containing 25% of maltodextrins (30%-25% Mdx)

A less steep decrease in high shear viscosity was observed when maltodextrin concentration was lower (30%-5% Mdx), showing the concentration effect of maltodextrin. Somewhat steeper decrease in the viscosity (for all of the systems in Fig. 3) can be noticed for the DE values smaller than 10. This fact can be attributed to the maltodextrin's polydispersity. Namely, long-chain glucose units fractions, which have major effect on viscosity, increase in content rapidly with decreasing DE value.

Investigation of emulsification dynamics showed that there were no significant changes in droplet size parameters during a homogenization period of 30 minutes. This is presented in Figure 4 by the specific surface area dependence on emulsification time. Only 5 minutes of emulsification (except for 30%-25% M040) were needed to attain the equilibrium between dispersion and coalescence of the droplets (10).

As it can be seen from Fig. 4, the content of 5% of M040 in the continuous phase was insufficient to bring about significant changes in specific surface area of the droplets. However, specific surface area and the droplet diameter (d_{vs}) were strongly influenced in the emulsions having 25% of maltodextrin. The smaller the maltodextrin DE value, the higher the effect on size parameters. This can be attributed to the viscosity effect, because greater viscosities of continuous phases favoured formation of smaller droplets and higher specific surface area. The relationship between the droplet size of different emulsions and η_{inf} values of corresponding continuous phases, plotted in Fig. 5, shows a trend-line agreement to a great extent.

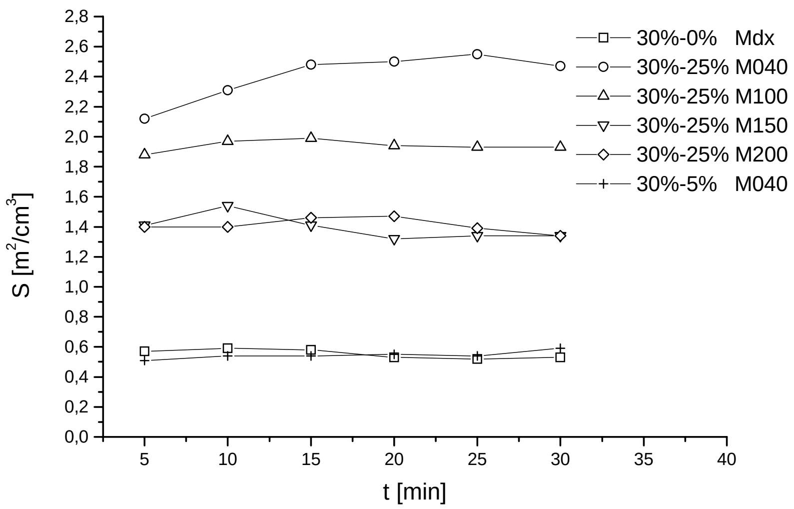

Fig. 4. Dependence of specific surface area S on emulsification time

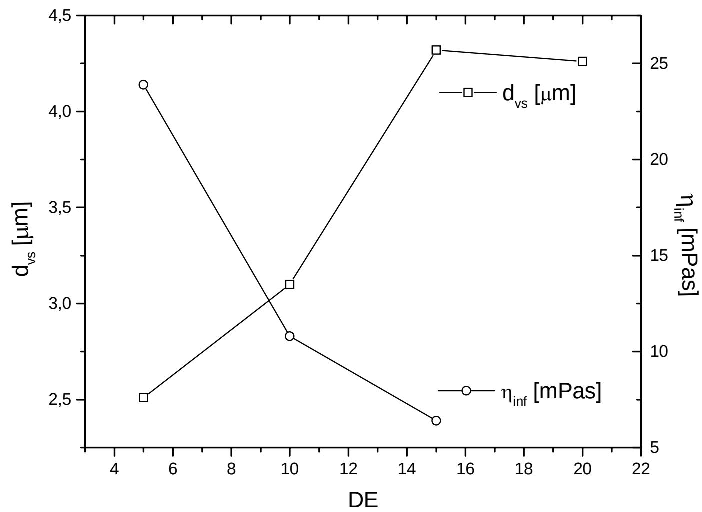

Fig. 5. Relationship between DE value and droplet size (d_{vs}) and η_{inf} in 30%-25% Mdx emulsions

CONCLUSION

The influence of dextrose equivalent of maltodextrin present in the continuous phases on flow and dispersion properties of sunflower oil in water emulsions was investigated. Each emulsion showed shear thinning (pseudoplastic) behaviour, while the flow properties of continuous phases were determined by the amount of maltodextrin present. Already after 5 minutes of emulsification, equilibrium between dispersion and coalescence of the droplets has been reached. This time can be taken as optimal one. It has been shown that both flow properties and dispersion characteristics of the emulsions have been largely determined by the continuous phase viscosity, and thus by the DE value of maltodextrin used.

REFERENCES

1. Dokic-Baucal, Lj., P. Dokic, and J. Jakovljevic: Influence of different maltodextrins on properties of O/W emulsions, Food Hydrocoll. **18** (2004) 233- 239.
2. Chronakis I. S.: On the molecular characteristics, compositional properties, and structural-functional mechanisms of maltodextrins: a review, Crit. Rev. Food Sci. **38,** 7 (1998) 599-637.
3. Akoh C. C.: Fat replacers, Food Technol. **52**, 3 (1998) 47-53.
4. Kasapis, S., E. R. Morris, I. T. Norton, and A. H. Clark: Phase equilibria and gelation in gelatin/ maltodextrin systems- part I: gelation of individual components, Carbohydr. Polym. **21** (1993) 243-248.
5. McClements, D. J., and K. Demetriades: An integrated approach to the development of reduced-fat food emulsions, Crit. Rev. Food Sci. Nutr. **38**, 6 (1998) 511- 536.
6. Dickinson, E.: Hydrocolloids at interfaces and the influence on the properties of dispersed systems, Food Hydrocoll. **17** (2003) 25-39.
7. Chronakis, I. S.: Structural-functional and water holding studies of biopolymers in low fat content spreads, Lebensmittel- Wissenschaft und Technologie **30** (1997) 36-44.
8. Dokic-Baucal, Lj.: Influence of maltodextrin on disperse and rheological properties of food emulsions, MSc thesis, University of Novi Sad, Faculty of Technology, 1999.
9. Sherman, P.: Rheological properties of emulsions, in Encyclopedia of Emulsion Technology- Basic Theory. Ed. P. Becher, Marcel Dekker, New York (1983) pp. 405- 439.
10. Dokić, P., Lj. Djaković, and V. Sovilj: The adsorption of an anionic surfactant at the oil in water interface during emulsion homogenization, J. Disp. Sci. and Technol. **3** (1982) 379-394.

УТИЦАЈ ДЕ ВРЕДНОСТИ МАЛТОДЕКСТРИНА НА РЕОЛОШКЕ И ДИСПЕРЗИОНЕ ОСОБИНЕ ЕМУЛЗИЈЕ СУНЦОКРЕТОВОГ УЉА У ВОДИ

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Малтодекстрини, производи ниског степена хидролитичке конверзије нативног скроба, употребљавају се као замена за масну фазу у производњи нискокалоричних прехрамбених производа. По свом колоидном карактеру ови производи су емулзиони системи. Малтодекстрини овим производима дају потребне текстуралне особине.

У овом раду приказани су резултати испитивања утицаја декстрозног еквивалента (ДЕ вредности) малтодекстрина присутног у континуалној фази на реолошке и дисперзионе особине емулзија сунцокретовог уља у води. Утврђено је да су како реолошке, тако и дисперзионе особине емулзија пре свега дефинисане вискозитетима одговарајућих континуалних фаза, односно ДЕ вредношћу употребљеног малтодекстрина. Повећање ДЕ вредности малтодекстрина погодује стварању капљица са већим средњим пречником, услед смањења вредности граничног вискозитета датих континуалних фаза. Без обзира на ДЕ вредност и количину употребљеног малтодекстрина, све емулзије су показивале псеудопластичан тип протицања. Испитивања динамике емулговања показала су да се већ након 5 минута хомогенизовања постиже динамичка равнотежа процеса коалесценције са једне и разарања капи са друге стране, те је ово време узето као оптимално за дате услове емулговања.

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