Finely dispersed spicy-aromatic and carotene containing raw materials as surfactants for oil in water emulsion

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Abstract

Introduction. The processes of structure formation in emulsion-type sauces using phyto- and oil carotene containing semi-finished product - a mixture fine powders of spicy-aromatic and carotene containing raw materials and oil in the environment. The prospect of using the technology developed semi low-calorie sauces emulsion type is the manifestation of surface-active properties of said plant material.

Material and methods. Structural and mechanical properties of the finished sauce was studied using a rheometer AR 2000ex. Forms of communication research in water samples sauces determined on derivatograph Q -1500D. Emulsifying properties of powders spicy-aromatic and carotene containing materials described by phase inversion points.

Results and discussion. Due to the content of polysaccharides and essential oils, crushed and dried raw of spicy-aromatic and carotene containing able to create stable colloidal systems - emulsion type oil in water. Research emulsifying ability and fine powders of spicy-aromatic and carotene containing raw materials in emulsion oil in water showed that the emulsifying ability parsley powder is 16% and 36%, which is higher than the powder with dill and carotene containing raw materials respectively.

A determination of rheological properties depending on the concentration sauces phyto- and oil carotene containing semi-finished product. Ready sauce with a mass fraction phyto- and oil carotene containing semi-finished product 30% shear rate of 200 s^{-1} has an effective viscosity in the range of 22-50 Pa · s, which is optimal for the type of emulsion sauces.

Value Relations moisture in the form of emulsion-type sauces approaching the optimal concentration phyto- and oil carotene containing semi-finished product 30% by weight of the sauce. Thus there is a stronger binding moisture promotes aggregative stability system prevents their separation.

Conclusions. Sauces emulsion type, made on the basis of the developed intermediate product, have optimal rheological parameters. We can recommend phyto- and oil carotene containing semi-finished product for sauces emulsion type of high nutritional value without the use of additional emulsifiers, structure-synthetic nature.

Introduction

Expanding a range of the restaurant products and creating a competitive product to the market that corresponds to the concept of healthy food deal with the use of new raw materials and development of new technologies.

Creating a new product in the segment of universal dishes such as dressings, sauces, broths, bases and semi-finished products of widespread use is rational in restaurant business. The interest of the population in low-calorie sauces and dressings is growing in recent years due to the popularization of healthy diet. The main advantages of such sauces of the emulsion type are their high digestibility, low calorie and versatility that are useful for the consumer and convenient in the technological process of the restaurant production.

Taking this into account, scientific work is conducted on the development of sauces of the emulsion type that include a wide range of spicy-aromatic and carotene containing raw materials at the Department of Molecular and Avant-garde Gastronomy of National University of Food Technologies. A universal phyto- and oil carotene containing semi-finished product (PhOCSP) as a suspension of the finely dispersed powders of spicy-aromatic and carotene containing raw materials in the oil has been developed to unify the technological process of the production of suggested sauces in terms of the restaurant institutions (Arsenieva L., Dotsenko V., Havrysh A., Liavynets G. (2013), Pat. UKR u201301755).

Material and methods

Powder from spicy-aromatic and carotene containing raw materials, sauces of the emulsion type of higher nutritional value with different mass content of moisture and concentration of PhOCSP were objects at various stages of the research.

Emulsifying ability of the powders of spicy-aromatic and carotene containing raw materials was characterized by method, defining the point of phase inversion. For this purpose, 10 ml suspension was poured into 100 ml glass, then using divisible burette oil was added at a speed of 70...80 drops per minute until the time of phase inversion, which is the transition of the emulsion “water/oil” in the emulsion “oil/water”. The emulsion type was determined by dilution. The volume of water used from the burette was consistent to the point of phase inversion.

The rheometer of the model AR 2000ex was used to determine the structural and mechanical properties (effective viscosity, shear rate, shear stress) of sauces of the emulsion type.

The study of the forms of moisture linking in sauces was performed using the derivatograph of the model Q – 1500D.

Results and discussion

The analysis of the chemical composition of the finely dispersed powders of spicy-aromatic and carotene containing raw materials (Fig. 1) affords ground to formulate a scientific hypothesis, according to which dried herb raw material detects surface-active properties because it contains substances with hydrophilic active (polysaccharides) and hydrophobic (essential oils) groups. In other words, to create the emulsion of oil in water type, dried herb raw material with some dispersion can act as an emulsifier and stabilizer.

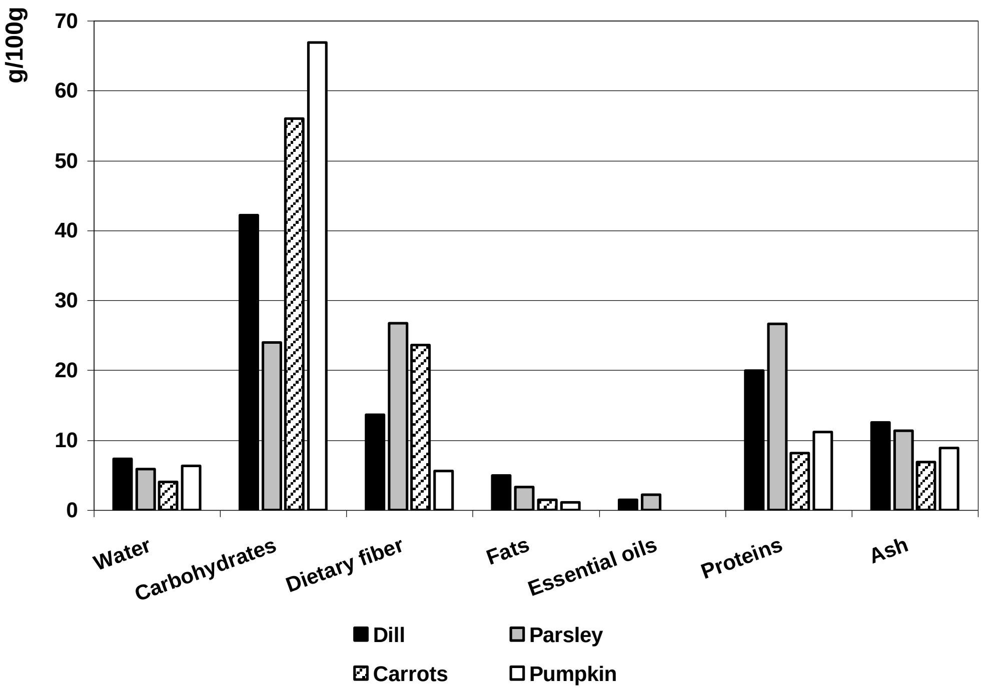

Figure 1. Chemical composition of the powders of spicy-aromatic and carotene containing raw materials

The scheme of the hypothetical expression of the surface-active properties of the finely dispersed spicy-aromatic and carotene containing raw materials is shown in Fig. 2.

Suggested continued drying of the plant raw materials at the temperature mode 30...35 °C enables to keep the substances with hydrophobic groups (essential oils, phenol compounds) inside the porous-capillary structure (Fig. 2 I).

Grinding the raw materials to the dispersion 7...20 mm increases the contact area with the dispersed environment and the number of active centres of the hydrophobic linkages and a small mass of the particles enables to create sedimentative stable structured systems (Fig. 2 II).

Using the described methods the suspension has been obtained that consists of the disperse phase (30 % of total mass) – finely dispersed powders of spicy-aromatic and carotene containing raw materials and dispersion medium (70 % of total mass) – oil. Water binding by the powder particles appears when adding water to PhOCSP, the absorption process is accompanied by swelling and recovery. Thus, the powder of the plant raw materials holds water and oil preventing from the stratification of the system (Fig. 2 III).

The suggested scientific hypothesis and the established scheme are experimentally confirmed by the results of determining the emulsifying ability of the plant powders (Fig. 3), the rheological properties (Fig. 4 and 5) and the forms of moisture linking in sauces of the emulsion type using them as part of PhOCSP (Fig. 6).

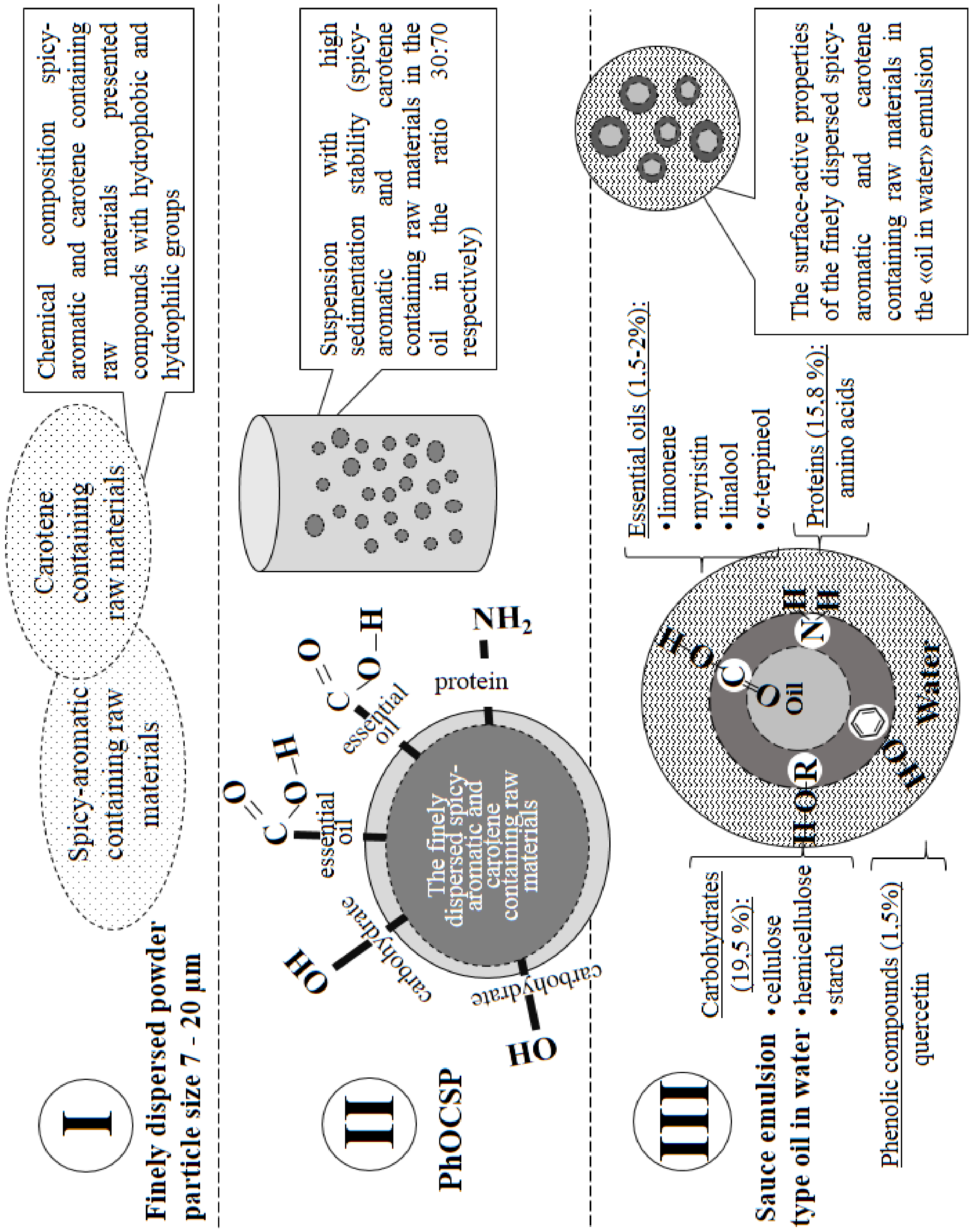

Figure 2. Hypothetical expression of the surface-active properties of the finely dispersed spicy-aromatic and carotene containing raw materials

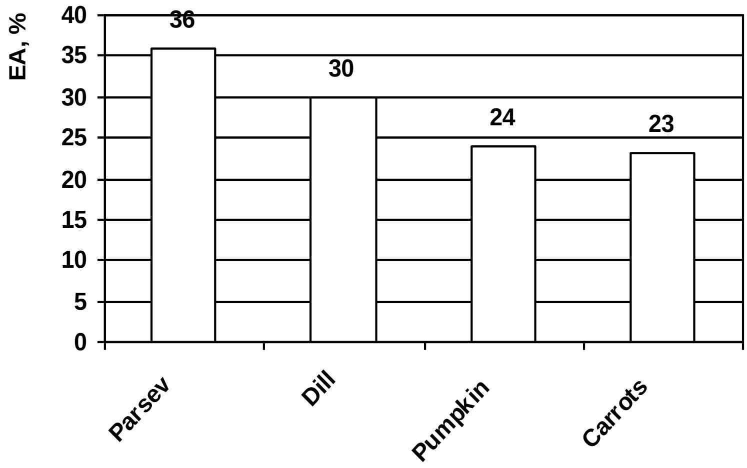

Figure 3. Emulsifying ability of the powders of spicy-aromatic and carotene containing raw materials

As shown in Fig. 3, parsley shows the highest emulsifying ability (EA) – 35 % in comparison with other testing samples, dill and basil have lower rates of the emulsifying ability – 30 and 28 % respectively. Carotene containing raw material has lower indicators of EA in comparison with the spicy-aromatic raw material: for pumpkin – 26 %, for carrot – 25 %.

It is obviously due to the fact that parsley contains more essential oils that contain hydrophobic groups COOH in comparison with other spicy-aromatic raw materials. EA of the carotene containing raw materials is primarily associated with the capillary-porous structure and protein content in it.

Thus, the results of the studies demonstrate the feasibility of using dried spicy-aromatic and carotene containing raw materials in the production of sauces of the emulsion type that are the emulsions of "oil in water" type.

Complete information on the structural and mechanical properties of sauces is provided by the curve of effective viscosity and flow. Scientists O. Davidova [2] A. Ziolkovska [3] found out that effective viscosity at shear rate 200 s^{-1} is within 22...50 Pa·s for the studied systems (sauces) [4]. Therefore during the development of new sauces of the emulsion type it is necessary to achieve exactly these intervals of the indicator values of structural and mechanical properties that provide appropriate texture such as homogeneity, toughness.

In accordance with the objectives of the research the first series of the experiments is conducted determining the structural and mechanical properties of the finished sauces depending on the mass fraction of PhOCSP from the total weight of the sauce.

Shown in Fig. 4 the flow curves for all kinds of sauces enable to be attributed to the non-Newtonian fluids, in which there is disproportionate relationship between shear rate and shear stress. All studied samples are slowly leaking after the application of shear stress, and with further increase of the speed there is a disproportionate increase of shear stress that can be explained by the presence of suspended solid powder particles of the plant raw materials in sauces causing uneven flow fluidity. Fig. 3 shows that sauce samples with higher concentration have higher indicators of shear stress at the same shear rates.

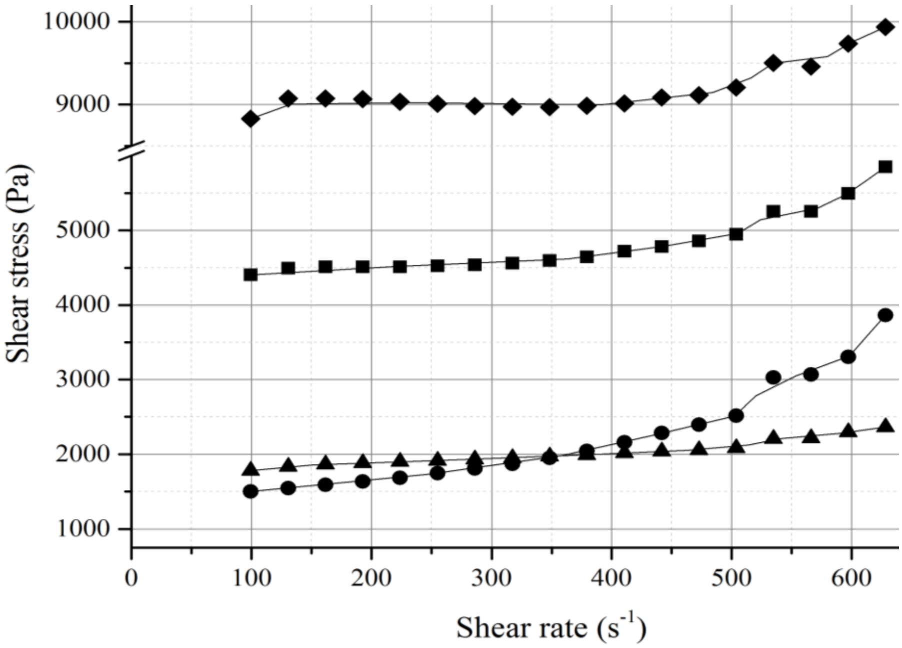

Figure 4. Curves of sauce fluidity depending on the concentration of PhOCSP

◆ 1 – sauce with the mass fraction of PhOCSP 60 %
■ 2 – sauce with the mass fraction of PhOCSP 50 %
● 3 – sauce with the mass fraction of PhOCSP 40 %
▲ 4 – sauce with the mass fraction of PhOCSP 30 %

As shown in the rheological curves (Fig. 4) finished sauce with the mass fraction of PhOCSP 30 % at shear rate 200 s^{-1} has the values of the effective viscosity within 22-50 Pa·s that is an optimal indicator for sauces of the emulsion type [2, 3]. Therefore further studies were carried out with sauces and concentration of PhOCSP 30 %.

The values of effective viscosity of sauces increase by increasing the concentration of PhOCSP. It can be explained by the fact that increasing the content of PhOCSP the content of polysaccharides increase too, and their macromolecules interact and form associates hindering the flow, so it is necessary to make greater shear stress.

Stabilizing properties of the finely dispersed powders of spicy-aromatic and carotene containing raw materials depend on the ability to bind moisture in the finished sauces. The forms of moisture linking were determined by the thermogravimetric method. The studies were conducted with the sauce samples with moisture content 50 %, 70 % and 90 %. 20 % were chosen for a visual comparison of the research results. During the analysis of thermograms their division was observed into four ranges with different temperature intervals that correspond to different binding energy – Fig. 6.

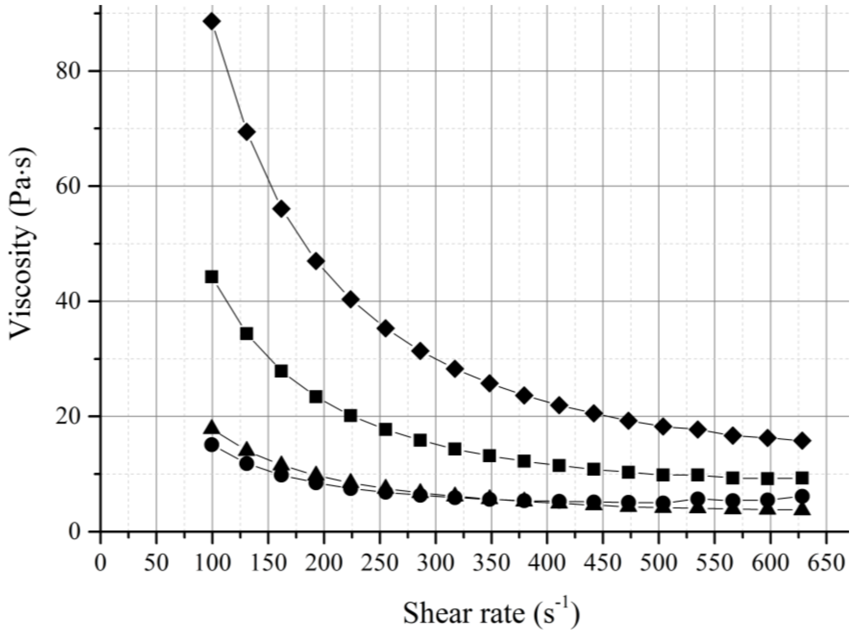

Figure 5. Curve of shear stress to determine resistance to destruction depending on the concentration of PhOCSP

◆ 1 – sauce with the mass fraction of PhOCSP 60 %
■ 2 – sauce with the mass fraction of PhOCSP 50 %
● 3 – sauce with the mass fraction of PhOCSP 40 %
▲ 4 – sauce with the mass fraction of PhOCSP 30 %

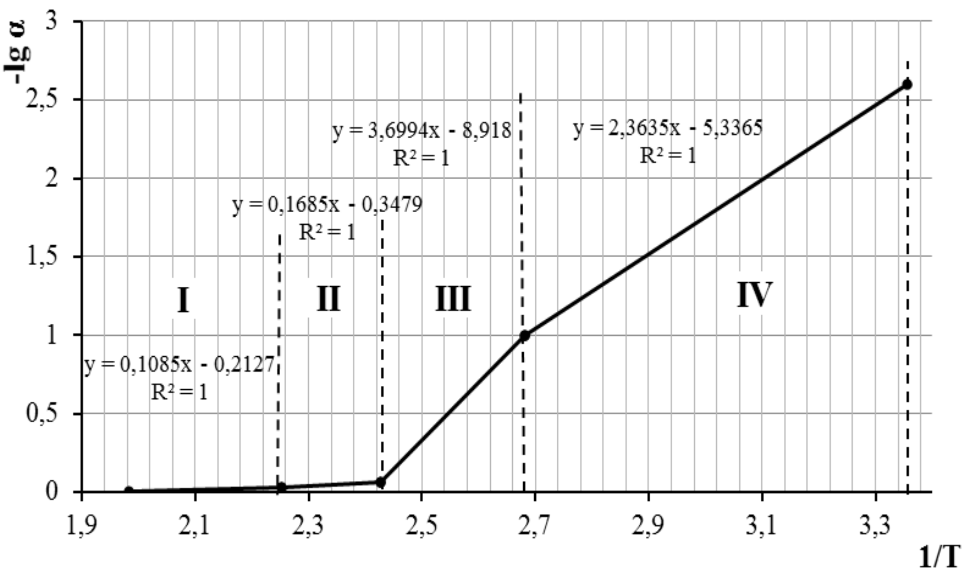

Figure 6. Piecewise and linear function of removal of free and bound moisture in sauce of emulsion type with 30% of phocsp

I – adsorption of the molecular layers; II – osmotically bound moisture;
III – adsorption of the polymolecular layers; IV – mechanically bound moisture.

As shown in Fig. 6, the least rapid removal of moisture is observed in the temperature range I and that is from 20 to 110 °C (the peak is observed at 97 °C). This range corresponds to the removal of free moisture provided by physical and mechanical ties – moisture of macro- and microcapillary.

The second period is observed in the temperature range 110...140 °C (the peak is at 144 °C), the speed of moisture removal increases. This range is characterized by the endothermic effect. This bound moisture is likely to be osmotically bound.

The main condition for osmotic moisture binding is selective diffusion of water through a semipermeable membrane of osmotic cells. Osmotic cells can be micelles of the classic colloidal particles or associates of macromolecular compounds. Macromolecular compounds form membranes available to the penetration of water molecules and impermeable to macromolecular fractions. Diffuse infiltration of water molecules to the internal structure of the biopolymer enables the change of entropy.

III temperature range is typical for the temperature range from 140 to 200 °C (the peak is for the temperature range 192...214 °C) and is characterized by the exothermic effect and the change of the speed of moisture removal. It is also bound moisture but adsorption as mono- and polymolecular layers.

The temperature range 200...240 °C is the fourth period in which chemically bound moisture is removed [5].

The maximum peak of the endothermic effect is observed at 113 °C. The results are presented in the table.

Table

Number of free and bound moisture in sauces using PhOCSP

Concentration of PhOCSP, % to the sauce weight	Mechanically bound moisture, %	Osmotically bound moisture, %	Adsorption moisture of the polymolecular layers, %	Adsorption moisture of the molecular layers, %	Activation energy of water J/mol
50	5,13	82,05	6,84	5,98	56,7
30	4,26	87,94	5,67	2,13	38,7
10	4,57	89,61	5,08	0,74	70,25

The analysis of thermograms has showed that the amount of free moisture in sauce with the concentration of 30 % is less than the number in the sauce sample with 10 % of PhOCSP.

Thus in the process of the sauce structure formation by adding PhOCSP with the amount of 30 % to the sauce weight there is stronger moisture binding that enables to increase aggregate stability of the systems. It keeps moisture content in the finished sauce and prevents stratification.

Thus, based on the complex studies a scientific hypothesis of the work about the manifestation of the surface-active properties of the finely dispersed spicy-aromatic and carotene containing raw materials in the “oil in water” emulsion which helps to ensure a stable system is proven.

Conclusions

1. A scientific hypothesis of the work about the manifestation of the surface-active properties of the finely dispersed spicy-aromatic and carotene containing raw materials in the “oil in water” emulsion is experimentally proven.

2. Emulsifying ability of the powders of spicy-aromatic and carotene containing raw materials has been researched. It is shown that due to the high content of essential oils in powders from parsley and dill such raw materials have the highest index value among the studied samples.
3. Structural and mechanical characteristics of sauces depending on the concentration of PhOCSP are determined. It is shown that the investigated samples of sauces according to the type of their structure are related to non-Newtonian fluids, in which there is disproportionate relationship between shear rate and shear stress. Increasing the concentration of PhOCSP contributes to the values of the effective viscosity of sauces. A sauce sample with the concentration of PhOCSP 30 % to the sauce weight has been selected as optimal in terms of stress shear and effective viscosity.
4. The forms of moisture linking in sauces are determined by the thermogravimetric method. It is shown that by adding PhOCSP 30 % to the sauce weight stronger moisture linking is observed in it that increases aggregate stability system, prevents disintegration.

References

1. Zhang C., Quek, S.Y., Lam G., & Easteal A.J. (2008), The rheological behaviour of low fat soy-based, *International Journal of Food Science & Technology*, 43(12), pp. 2204-2212.
2. Nilova L., Kalinina I., Naumenko N. (2013), Metod differentsial'no-termicheskogo analiza v otsenke kachestva pishchevykh produktov, *Vestnik Yuzhno-Uralskogo Gosudarstvennogo Universiteta*, 1, p. 43.
3. Fernández-García E., Carvajal-Lérida I., Jarén-Galán M., Garrido-Fernández J., Pérez-Gálvez A., Hornero-Méndez D. (2012), Carotenoids bioavailability from foods: From plant pigments to efficient biological activities, *Food Research International*, 46(2), pp. 438-450.
4. Paraskevopoulou D., Boskou D., Paraskevopoulou A. (2007), Oxidative stability of olive oil–lemon juice salad dressings stabilized with polysaccharides, *Food Chemistry*, 101(3), pp 1197-1204.
5. Leto M.J. (2006), *Salad Dressings and Cold Sauces (Les Salades, Assaisonnements et Sauces Froids)*, Butterworth-Heinemann, Oxford.
6. Roca E., Guillard V., Broyart B., Guilbert S., Gontard N. (2008), Effective moisture diffusivity modelling versus food structure and hygroscopicity, *Food Chemistry*, 106(4), pp. 1428-1437.
7. Fredrick E., Walstra P., Dewettinck K. (2010), Factors governing partial coalescence in oil-in-water emulsions, *Advances in Colloid and Interface Science*, 153(1–2), pp. 30-42.
8. Chung C., Degner B., McClements D.J. (2012), Rheology and microstructure of bimodal particulate dispersions: Model for foods containing fat droplets and starch granules, *Food Research International*, 48(2), pp. 641-649.
9. Charoen R., Jangchud A., Jangchud K., Harnsilawat T., Decker E.A., McClements D.J. (2012), Influence of interfacial composition on oxidative stability of oil-in-water emulsions stabilized by biopolymer emulsifiers, *Food Chemistry*, 131(4), pp. 1340-1346.

10. Waraho T., Cardenia V., Decker E.A. & McClements D.J. (2010), Lipid oxidation in emulsified food products, *Technology and Nutrition*, pp. 306-343.
11. Waraho T., McClements D.J.,. Decker E.A. (2011), Mechanisms of lipid oxidation in food dispersions, *Trends in Food Science & Technology*, 22(1), pp. 3-13.
12. Milda E. Embuscado (2015), Herbs and spices as antioxidants for food preservation, In Woodhead Publishing Series in Food Science, *Technology and Nutrition*, pp. 251-283.
13. Kim T.S., Decker E.A., Lee J.H. (2012), Effects of chlorophyll photosensitisation on the oxidative stability in oil-in-water emulsions, *Food Chemistry*, 133(4), pp. 1449-1455.
14. An S., Lee E., Choe E. (2011), Effects of solubility characteristics of sensitiser and pH on the photooxidation of oil in tuna oil-added acidic O/W emulsions, *Food Chemistry*, 128(2), pp. 358-363.
15. Sheldrake P. (2003), Controlling textures in soups, sauces and dressings, *Technology and Nutrition*, pp. 389-421