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SciVerse ScienceDirect
Procedia Food Science 1 (2011) 275 – 280
Procedia Food Science

11th International Congress on Engineering and Food (ICEF11)

Flaxseed additive application in dairy products production

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Abstract

Nowadays the special attention of scientists is focused on flaxseed that is rich in polyunsaturated fatty acids ω-3 and ω-6, proteins, water-soluble polysaccharides, dietary fibre, lignin, vitamins, minerals and phenolic compounds. Paying attention is caused by flaxseed ability to have a great influence on human health, prevent cardiovascular diseases, gastrointestinal problems and cancer. New butter with flaxseed additive and flaxseed additive technology were developed by us. The suspension microstructure of flaxseed additive was studied. It was revealed that microstructure of flaxseed additive is multicomponent and structured system. It consists of uninterrupted phase of polysaccharides solution and structural elements such as particles of flaxseed, globules and areas with a cellular structure from polygonal cells. As a result the mechanism of microstructure suspension formation was proposed. It has a few stages. They are the formation of dispersion of globules, the aggregation of globules and formation of areas with a cellular structure. Sensory evaluation has shown that butter with flaxseed additive has pure creamy flavour and odor without flavour and odor of additive, yellow color and good spreadability and plasticity. It was proven that addition of structured suspension of flaxseed additive makes structure destruction decrease and plasticity increase. It was also revealed that recovering ability of butter structure soars when flaxseed additive dose increases. This fact indicates that butter with the flaxseed additive has coagulation-crystallization structure with domination of the coagulation one. Decrease of structure destruction and increase of recovering ability of butter structure apparently due to the formation of additional intermolecular bonds between the components of flaxseed additive and butter.

Keywords: Flaxseed additive; butter; microstructure; cellular structure; coagulation-crystallization structure.

1. Introduction

In recent years, physicians all over the world state the fact of health deterioration of the world's population, reduction in life expectancy, decrease in working capacity and body's resistance to infection.

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doi:10.1016/j.profoo.2011.09.043

The possible solution to this problem is physiologically balanced, healthy diet that is rich in biologically active substances, including essential components. Nowadays there are over a thousand items of functional ingredients that are used for creating therapeutic food products. Polyunsaturated fatty acids (PUFA) ω-3 and ω-6 have attracted the special attention of physicians because these acids have an ability to participate in the structural and functional organization of cell membranes, they regulate fat metabolism, reduce blood cholesterol level and have the cardioprotective effect [1]. PUFA ω-3 and ω-6 can be found abundantly in flaxseed. In recent years, scientists and nutritionists around the world pay attention to the health benefits of flaxseed. According to its physical-chemical composition, flaxseed is a multicomponent system with plant biologically active substances such as oil (it is rich in essential fatty acids ω-3 (α-linolenic acid) and ω-6 (linoleic acid)), protein, dietary fibre, soluble polysaccharides, lignin, phenolic compounds, vitamins A, C, F, E and mineral elements P, Mg, K, Na, Fe, Cu, Mn, Zn [2, 3]. In flaxseed oil PUFA ω-3 and ω-6 are contained in the optimum ratio 1:10. Currently flaxseed and flaxseed preparations are widely used in medicine as an enveloping and wound-healing agent in the treatment of gastrointestinal, cardiovascular, nervous diseases and cancer. It is particularly useful for the elderly, weakened children and postsurgical patients. Flaxseed is needed for all healthy people during their mental and physical activities, for students and pupils in order to improve their academic achievement, for everyone who works with the computer or is exposed to various radiations. A detailed analysis of published data has shown the applicability of multicomponent flaxseed system in food technology. It is corresponds to world tendencies of food industry development.

Taking the above mentioned into consideration a new kind of butter with flaxseed additive and flaxseed additive technology were developed at the National University of Food Technologies. Flaxseed additive adds to butter as a suspension in buttermilk. Previous studies [4] have revealed that the addition of plant additives affects significantly the formation of butter micro-and nanostructure. Therefore, to better understand the micro-and nanostructure of butter with flaxseed additive it is necessary to study the microstructure of water suspension of flaxseed additive.

2. Materials & Methods

Microstructure of aqueous suspension of flaxseed additive was studied by the optical microscope. The suspension was prepared by stirring flaxseed additive with distilled water in a ratio 1:4 at 20 ± 2 °C, the stirrer speed was 250 rpm. Model samples of butter with flaxseed additive were manufactured. The percentage of additive in butter were 0,8; 1,2; 1,6%. Butter without additive was used as a control sample. The moisture content in all samples was 25%. Butter samples were stored at +5 °C. The degree of structure destruction and the relaxation behaviour of butter structure (butter structure restoration) were measured at +18 °C as had been described in [5].

3. Results & Discussion

The effect of stirring on the microstructure formation of the flaxseed additive suspension was investigated. After the first 5 minutes of stirring suspension microstructure (Fig. 1,a) contains flaxseed particles **F** (up to 10 micrometers), globules **G** (d~2-10 micrometers) and uninterrupted phase of polysaccharides solution. Globules are mostly spherical in shape, and only some of them are ellipsoid. The formation of aggregate **A** from globules is viewed near the flaxseed particle $\mathbf{F_1}$. Stirring the suspension for 10 minutes cause the further microstructure formation (Fig. 1,b). Particles of additive swell, they increase in size 2 times, and globules **G** form aggregates in size 20-40 micrometers. After 20 minutes of stirring the formation of the cellular structure **K** (Fig. 1, c) in microstructure of flaxseed additive suspension is observed. The cellular structure consists of polyhedral cells 17-30 micrometers. There are small globules d~2-6 micrometers at the periphery of the cells. Fig. 1, d shows an area of the cellular structure, which was formed in the suspension after 25 minutes of stirring. In Fig. 1,d well-defined cell’s bonds and cell’s internal structure is seen. There is more compact packing of globules in the internal structure than in Fig. 1, c. The formation of globules and cellular structure apparently are due to the heterogeneous composition of water-soluble flaxseed polysaccharides. According to the literature [3, 6], they are heterogeneous and consist of two fractions: an acidic pectin-like and a neutral arabinoxylan fractions. As a result of researches the mechanism of microstructure formation of flaxseed suspension was proposed (Fig. 2). In the early stages of the suspension preparation particles of additive swell, molecules of water diffuse into the particles. Hydration leads to the destruction of weak bonds between macromolecules, therefore macromolecules of flaxseed soluble polysaccharides and proteins diffuse into the aqueous phase. In this case, the diffusion of the acidic pectin-like fraction passes before the neutral one because of their smaller molecular mass. Hydrated films of oriented aqueous dipoles around the -COOH groups of acidic polysaccharides shield some parts of macromolecules and reduce the electrostatic repulsion between them. It leads to a twisting of molecules and to the formation of globular structures [7] at the earlier stage of suspension microstructure formation (a). The convergence of globules and the formation of aggregates (b) take place in the suspension of flaxseed additive during the stirring process. It is due to the forces of intermolecular interaction. Further thermal conditioning of the suspension increases the concentration of neutral arabinoxylan fraction in the suspension. Accordingly, the amount of hydrophobic groups -CH2- also raises. The presence of those macromolecule's part unprotected by hydrated films leads to the interpenetration of hydrocarbon chains and to the formation of intermolecular bonds. Acording to A.D. Zimone [7] such kind of structures have frame-like form that looks like polyhedral cells. The initial stage of forming a cellular structure is (a) and cellular structure is (d). Therefore the suspension of flaxseed additive is multicomponent and structured.

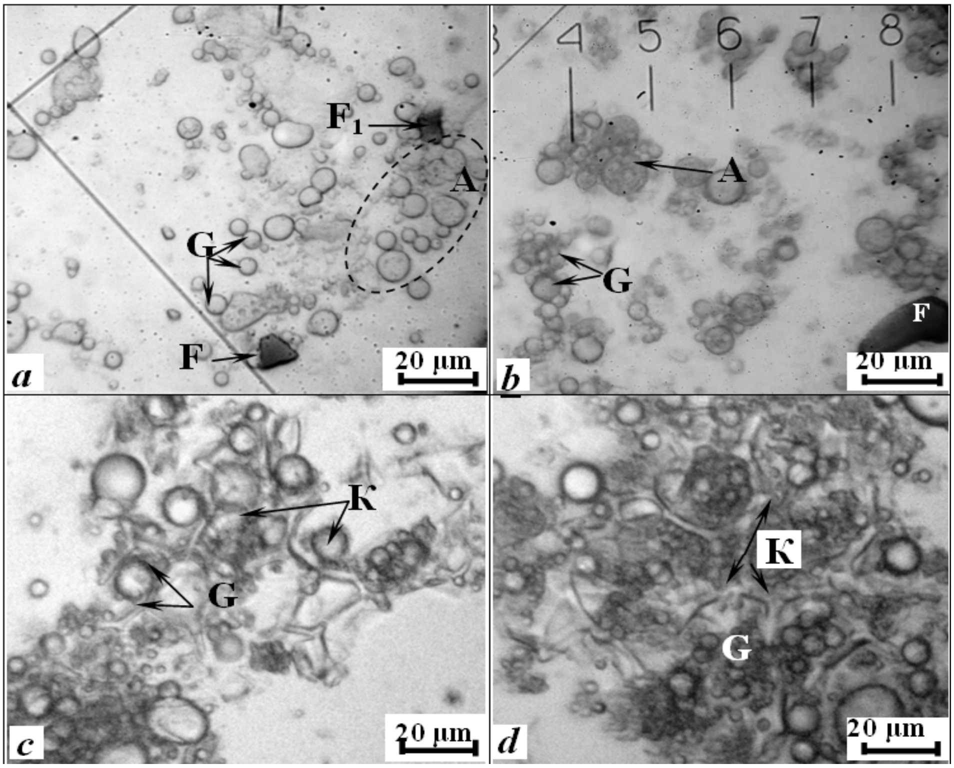

Fig. 1. Microstructure of the aqueous suspension of flaxseed additive. Stirring duration: *a* – 5, *b* – 10, *c* – 20, *d* – 25 min; A – aggregates, G – globules, F – particles of flaxseed additive, K – area of the cellular structure

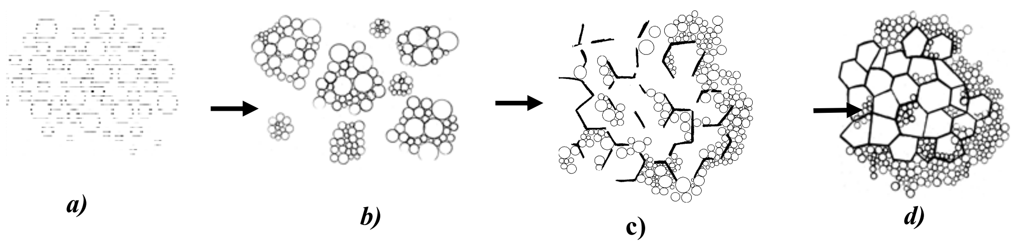

Fig. 2. The mechanism of microstructure formation of flaxseed additive suspension: a - dispersion of globules; b - the aggregation of globules; c – the initial stage of cellular areas formation; d – cellular structure

Previously, based on the results of integrated studies of butter with plant food additives it was found that introduction of structured solutions of additives significantly affects the structure and texture of butter, and improves its quality [4, 8].

Sensory evaluation has shown that butter with flaxseed additive has pure creamy flavour and odor without flavour and odor of additive, homogeneous yellow color and a good spreadability and plasticity. The excellent combination of flaxseed additive with butter was noted.

The main structural and mechanical characteristics of butter include the degree of destruction and the restoration of structure. According to A.J. Haighton [5] the structure destruction degree of 70 - 75% (at t = 18° C) indicates the optimum hardness and plasticity of butter. Coagulation structure is dominant in this butter, and when the destruction degree is 80% and more the dominant structure is the crystallization one. Fig. 3 shows, that only the butter samples with flaxseed additive are characterized by the optimum hardness (according to A.J. Haighton). At the same time with the increase of the percentage of flaxseed additive the degree of structure destruction decreases, which indicates the strengthening of coagulation bonds in butter samples with higher content of additive and improvement of its plasticity. Consequently, the application of flaxseed additive into butter promotes the formation of coagulation-crystallization structure with dominant coagulation structure.

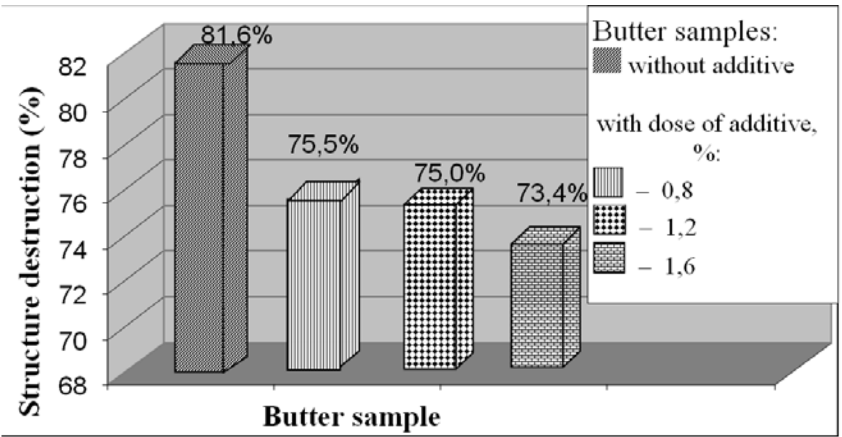

Fig. 3. Degree of structure destruction of butter with flaxseed additive

Results of research of restoration of butter structure with different doses of flaxseed additive during the thermostating at +18°C are illustrated in Figure 4. Restoration process of the structure of all butter samples with flaxseed additive is faster than of the control one. Therefore at 11th day of thermostating the restoration degree of the control sample structure is 47.0%, while butter samples with 0,8%, 1,2% and

1,6% dose of additive is 68,5%, 70,9% and 76 2% respectively. Thus with an increase of the dose of applied additive the butter structure ability to restoration improves. It confirms that in all butter samples with flaxseed additive the coagulation-crystallization structure is formed with domination of coagulation structure. The reduction of destruction degree and improvement of restoration ability of butter structure with the increase of dose of applied flaxseed additive can be explained by an increase of the number of additive particles in butter structure. It leads to appearance of additional intermolecular and hydrophilic bonds between the components of additive and butter, as a result the density of secondary spatial grid in butter structure increases.

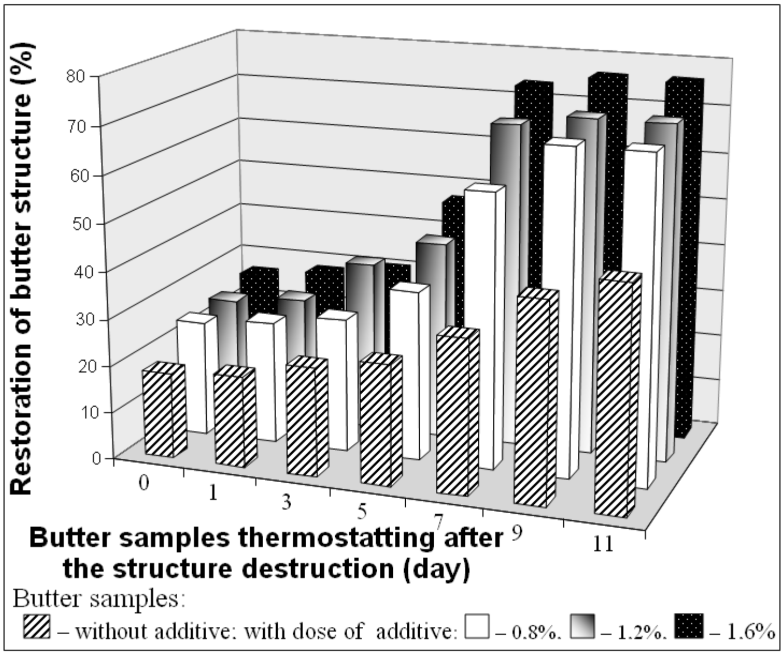

Fig. 4. Restoration of butter structure with different doses of flaxseed additive

4. Conclusion

The results of the researches have shown that microstructure of the multicomponent suspension of flaxseed additive is structured. Microstructure includes particles of flaxseed, globules, aggregates and has a cellular microstructure. The formation mechanism of the suspension microstructure of flaxseed additive was proposed, which includes such stages as a formation of globules, an aggregation of globules in aggregates, the formation of areas with cellular structure.

It was stated that the application of structured suspension of flaxseed additive helps to improve characteristics of butter structure: the degree of destruction decreases and the restoration of butter structure after mechanical destruction increases.

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Presented at ICEF11 (May 22-26, 2011 – Athens, Greece) as paper FMS1226.