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FACTORS THAT DETERMINE THE SHELF LIFE OF A BUTTER-LIKE SPREAD BASED ON WALNUT OIL

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Abstract. The article describes the manufacturing stages for a new functional product that can enrich human diet with essential lipids – spread based on walnut oil. Due to the fact that its content of polyunsaturated fatty acids is in 3-4 times higher than in a classic milk-based butter, the problem of preserving spread biological value appeared. The analysis of product`s physico-chemical, structural, organoleptic and microbiological proprieties showed that the spread is stabile 10 days at (3 ± 2)°C and within up to one month at – (6 ± 3)°C. Polyunsaturated fatty acids in product composition were noticeably subjected to oxidative degradation only after 4 weeks of storage. It has been proven that namely microbiological stability is the determining factor, which affects the shelf life of a spread.

Keywords: *functional product, dairy and vegetable lipids, polyunsaturated fatty acids, storage period.*

Introduction

The problem of rational and healthy nutrition is far from being solved and only worsens over the years. The consumption of both animal and vegetable fats is considered one of the aspects of balanced diet. It is known that polyunsaturated fatty acids (PUFA) have antioxidant and antiradical activity, being essential for the proper functioning of human immune and nervous systems [1, 2]. At the same time, generally available food items, namely dairy products, contain a small amount of triglycerides of polyunsaturated fatty acids [3, 4]. This problem was proposed to be resolved as by saturating the diet of dairy cows with lipids rich in cis-9, trans-11 conjugated linoleic acid [5, 6], so as by the elaboration of food products – spreads, in which dairy fat is partially or completely replaced by vegetable oils [7, 8].

Spread is a fat-containing composition based on milk components and vegetable lipids, similar in physical and chemical structure to a milk-based butter. Usually, sunflower seed oil, olive oil, soybean oil and palm oil are used to produce spreads [9]. The introduction of the latter is very widespread in food industry, however, due to the saturated nature of palm oil, the optimal ratio of fatty acids with different saturation degrees is not achieved in such kind of spreads. From this point of view, it seems extremely interesting to obtain a spread using a virgin walnut oil as a vegetable component rich in essential lipids.

The analysis of the chemical composition of walnut oil produced in France, Hungary, Italy, Spain and Moldova has shown that the content of linoleic acid (*ω-6*) varies in limits 53...70%, linolenic acid (*ω-3*) – in 10...15% , and oleic acid (*ω-9*), belonging to the group of monounsaturated fatty acids (MUFA), constitutes about 14...30% [10]. Due to the high content of unsaturated fatty acids, walnut oil is subjected to rapidly oxidation (rancidity), losing consumer and functional properties. We suggest that the introduction of walnut oil in spreads lipid phase will help to stabilize polyunsaturated fatty acids and will lead to the obtaining of a healthy affordable product.

Spread based on walnut oil

Methods of the elaboration of functional products with an optimal ratio between saturated (SFA) and unsaturated fatty acids are based on the obtaining of multicomponent food systems using physiologically important ingredients [11, 12]. Spreads represent a part of the food group, for which a scientific and technological base is currently developing very intensively because of the possibility to improve their nutritional properties by the increase of polyunsaturated fatty acids, macro- and microelements, vitamins, pro- and prebiotics [13].

Butter, being an emulsion of W/O type, is obtained by lipids separation from a sweet cream. The method of a new functional spread obtaining was elaborated, accompanying by the solidification of the mixture of sweet cream and O/W direct emulsion of walnut oil (vegetable lipids, water, emulsifier) [14]. The formation of a vegetable lipid emulsion before its mixing with the source of dairy fat and the subsequent mixture stirring allowed to stabilize the composition by crystallization process and to exclude the overdose of saturated fatty acids. As a result, a new food product with a butter-like texture can be obtained, which content of polyunsaturated fatty acids is 3-4 times higher than in a classic butter [15] (Table 1).

Table 1

Characteristics of spread based on walnut oil.

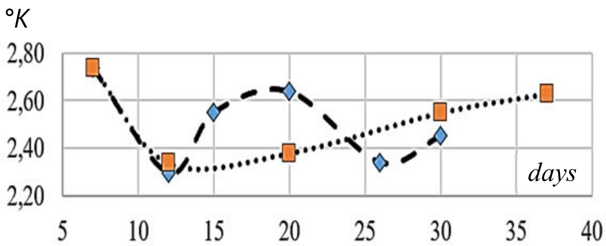
Analyzed characteristics	Values
Lipids, % *including*	72.5 ± 0.5
ω3 and ω6 polyunsaturated fatty acids, %	19…46
Water, %	25.0 ± 0.5
Proteins,%	<1
Carbohydrates, %	<1.5
Melting temperature, ºC	30…32
Thermostability, %	85 ± 5
Taste and smell	sweet cream taste with a pleasant aftertaste of walnut oil
Consistence at 12 ± 2ºC	compact, plastic, homogeneous, with a glossy surface in the section
Color	light yellow color, uniform throughout the product

Thus, walnut oil can indeed be used to obtain food compositions with functional properties; however, unresolved questions remain: what is the shelf life of obtained product and whether is its biological value preserved during storage.

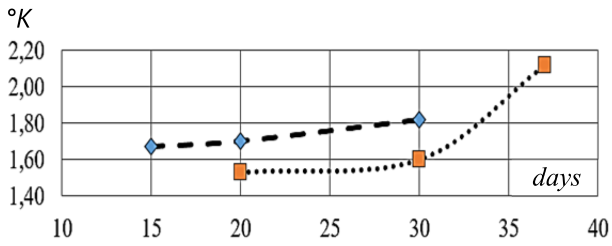
Determining the shelf life of spread

To provide research, spread samples were prepared according to the elaborated method [14]. The optimal ratio of dairy and vegetable lipids in spread was determined depending on the content of saturated and unsaturated fatty acids, as well as it is based on organoleptic properties of obtained product. The thermo-stability of samples, up to 0.83, considered satisfactory [16], was obtained for the spread with 53.1% of saturated fatty acids (SFA), 25.9% of monounsaturated fatty acids (MUFA) and 21.0% of polyunsaturated fatty acids (PUFA). Because PUFA contains linolic (ω3), linolenic (ω6) and other PUFA with a priori different biological activity, it was important to estimate a ω3 : ω6 ratio. So, calculated ω3 : ω6 ratio corresponds to 1 : 6, which correlate to recommended value [1, 3]. It should be noted, that the content of saturated fatty acids in spread decreased non-essential compared to a classic milk-based butter.

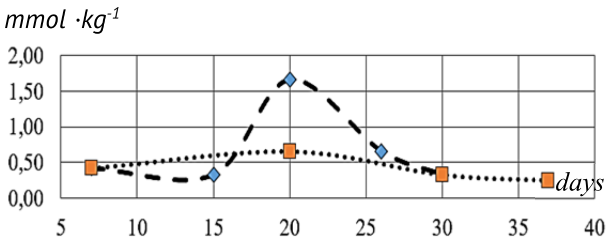
The obtained samples were packaged in aluminum foil with 10 - 40 g mass in each and stored at two temperature regimes: t = (3 ± 2)°C and t = – (6 ± 3)°C. The shelf life of spread was determined according to its physico-chemical (Figure 1), structural (Figure 2), organoleptic and microbiological (Table 2) stability.



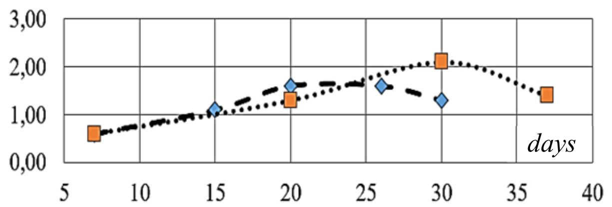
A) Dynamics of spread acidity index, 3.5 being maximum acceptable limit (MAL) [16]



B) Dynamics of the acidity index of lipid phase separated from spread, 2.5 being MAL [16]



C) Dynamics of the peroxide index of lipid phase separated from spread, 10.0 being MAL [17]



D) Dynamics of the p-anisidine index of lipid phase separated from spread, 3.0 being MAL [18]

Figure 1. The evaluation of spread stability against oxidative degradation during storage:

spread, t = (3 ± 2)°C   spread, t = – (6 ± 3)°C

The analysis of Figure 1 shows that obtained spread does not undergo oxidative degradation within 40 days. Analyzed indexes do not cross maximum acceptable limits. Considering the oxidation of polyunsaturated fatty acids as an irreversible process, the simultaneously formation of primary and secondary compounds was demonstrated. It has been noticed the visible variation of hydroperoxides accumulation (Figure 1.C) and the simultaneously growing of secondary compounds concentration during storage (Figure 1.D). Thus, the character of hydroperoxides concentration changes shows that these compounds are intermediates in PUFA oxidation reaction and represent the substrate of reactions for secondary compounds formation [10].

Generally, changes of physicochemical properties of the samples kept at t = – (6 ± 3)°C are less pronounced, than in spread kept at t = (3 ± 2)°C. Whiles the process of Ostwald ripening [19], accompanied by coalescence and water phase elimination, manifested in 30 days of spread storage at t = (3 ± 2)°C (Figure 2) and in 37 days at t = – (6 ± 3)°C (Figure 3).

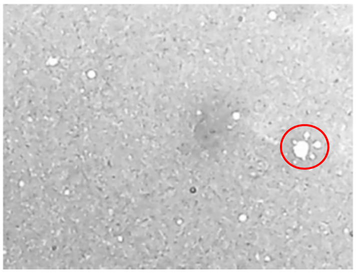


Figure 2. The microstructure of spread kept 30 days at t = (3 ± 2)°C.

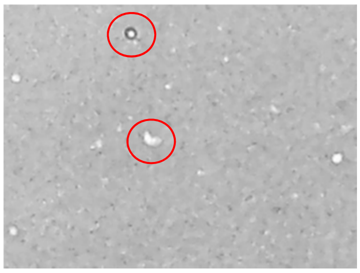


Figure 3. The microstructure of spread kept 37 days at t = – (6 ± 3)°C.

The microscopic study demonstrates substantial changes of spread texture properties, manifested organoleptically as product softening because of water micelles coalescence.

The dynamic evaluation of spread microbiological stability was performed for samples with 10.0 ± 0.5g mass (Table 2).

Table 2

Dynamic evaluation of microbiota development in spread.

Microbiota, cfu·g^{-1}·	Maximum acceptable limits, cfu·g^{-1}·	Validity, days	
		t = (3 ± 2)°C	t = – (6 ± 3)°C
The total bacteria count (TBC)	1,0*10^5	10	>30
Coliform bacteria	in 0,01g of sample	20	>30
Yeast	100	>30	>30
Mold	100	>30	>30

The exceed of maximum acceptable limits for TBS was determined in 10 days in spread kept at t = (3 ± 2)°C. Experimental samples kept at t = – (6 ± 3)°C were found to be inoffensive within up to one month. Based on the fact that the analysis was performed for samples with 10.0 ± 0.5g mass each, the time of spread microbiological degradation in a consumer pack (50 - 1000g) may be at least 2 times longer [20].

The dependence of spread shelf life on its rate of physical-chemical, organoleptic and microbiological degradation is presented in Figure 4.

The analysis of Figure 4 shows that the main criterion in the determination of the shelf life of elaborated spread is the speed of microbiota development in product. That is, the main risk while spread storage, despite expectations, is not its fizico-chemical instability, characteristic for walnut oil, but it is the influence of microbiological and technological factors, caused by the presence of dairy products in spread composition.

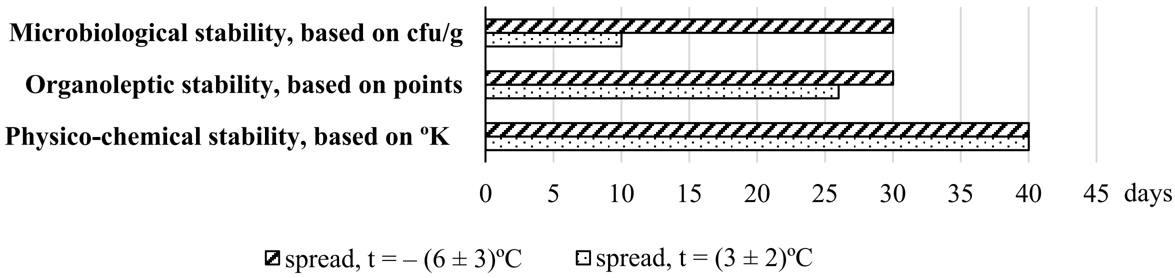


Figure 4. Factors contribution that determine spread shelf life.

Conclusions

It has been elaborated a new functional product of spread type with a more than 20% content of polyunsaturated fatty acids, which can enrich daily human diet with essential lipids. The rate of oxidative degradation of the spread falls within the recommended storage term for a classic milk-based butter [16, 20], the analysis of its microbiota development being the main principle of product shelf life estimation.

The main risk while spread storage represents not the instability of walnut oil, but the presence of dairy raw material and water phase in product composition. Spread retains its functionality and high biological value within two weeks at temperature regime up to 5ºC.

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