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Cocoa spreadable products based on flax seed oil organogels – textural characterization and proposed production technology

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Abstract

Different oleogels samples were prepared from highly unsaturated oils, sunflower or flax seed oils and 5% lipid structurants, as binary and ternary mixtures including sunflower wax (SFW), beeswax (BW) and lecithin, in order to replace totally or partially palm oil in cocoa spread products. Oleogels are new lipid systems that show a solid structure, while the oil inside remain mainly a liquid entrapped by using different oleogelation strategies (crystallization, self-assemble molecules, templated emulsions, etc.) The cocoa spread samples were obtained in a laboratory ball mill. The texture profile analysis of oleogels and cocoa spreads was performed by CT3 Brookfield Texture Analyzer. Based on studied texture parameters, the oleogels samples showing the highest hardness values (141g) were selected for further use in cocoa spreads. Cocoa spread samples optimum composition was found for 53% sugar, 25% flax seed oil oleogel structured by SFW and BW, 10% flax seed oil oleogel structured by SFW, BW and lecithin, 7% cacao powder and 5% roasted hazelnuts.

Keywords: unsaturated fatty acids, flax seed oil, waxes, lecithin, cocoa spread

1. Introduction

Fats are soft plastic materials with different structuring levels that lead to specific macroscopic properties. Sensorial and textural properties of foods, such as smooth, creamy or rich texture, the appearance, the desirable flavor and even the satiating effects resulting after consumption, are influenced by the type of fats in food product composition and their droplets size [1]. Saturated fats are responsible for the gustatory properties and textural properties (plasticity, firmness and hardness) of many foods, including cocoa products. Recent dietary guidelines of leading bodies in health and nutrition domain, have suggested a reduction of saturated fat consumption to a maximum of 10% of daily energy, while increasing mono and polyunsaturated fatty acids (and vegetable oil) consumption.

Due to this limitations, scientist focused on exploring mechanisms to introduce healthy fats in the composition of the food instead of *trans* and saturated fatty acids, without altering the original food structure. Simple replacement of solid fats with vegetable oil is impossible due to the drastic texture differences between the new products and the original. Converting vegetable oils to solid fats by means of hydrogenation, fractionation, or inter esterification are well known practices, but it turned out to cause *trans* fatty acids problems (partial hydrogenation), or high saturated fat intake and sustainability production issues (fractionation, or inter esterification). For improving the nutritional characteristics while also maintaining the specific physical properties, but also to solve some problems relates to liquid oils utilization such as fat migration or “oiling out”, novel approaches have been applied to fat structuring.

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As respect to cocoa products, some vegetable fats are similar to cocoa butter triacylglycerols and they can be used as fat alternatives in cocoa products in any amount, without affecting the texture. Cocoa fat replacers such as lauric fatty acids, palm oil or coconut oil, are commonly used to 100% substitute cocoa butter. Replacers are also used considering the fact that about 30% of the world's cocoa crops are destroyed by pests and diseases and cocoa butter fat content is depending on tropical climate and it is deteriorating due to climate change, transforming cocoa butter into an unstable and sometimes unavailable, expensive ingredient [2]. But because of the similar triacilglicerols profile between cocoa butter and its replacers which also contain high amounts of saturated fats, there is a high urge to reformulate cocoa composition, in order to comply with the future trends in nutrition and food production.

Oleogelation is a new fat structuring method for formulating food products where the functionality provided by saturated fats texturing, oil binding, rheological characteristics, organoleptics and stabilizing properties) can be replicated by fat or non-fat components used as gelling agents for liquid oils [3]. At the moment, numerous potential organogelators and oleogel strategies exist: including monoglycerides, phytosterols, lechitin, sorbitan monostearate, long chain fatty acids and alcohols, waxes and wax esters, peptides, carbohydrates [4] and even anorganic compounds (fummed silicagel) [5]

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Wax based oleogelation turned out to be an efficient fat structuring alternative. Wax-based gelation arises from the crystallization of wax particles, which are basically made of a mixture of straight chain alkanes, long-chain fatty acids, long-chain fatty alcohols, wax esters, aldehydes, ketones, glycerol esters or di-esters [6]. Oleogelation with waxes was efficient even at very low concentrations such as 0,5% [7] and the oleogels were successfully introduced in some food products formulation like ice cream, cookies, margarines, frankfurters [8-11], and even cocoa products or confectionery fillings [12-14].

In the present work, different oleogels samples were prepared from highly unsaturated oils binary and ternary mixtures of lipids including waxes and lecithin, to obtain a synergistic effect in the fat structuring and better textural parameters for the new cocoa spread formulation.

A synergistic interaction between the waxes and a non-gelling component (lecithin) can alter the microstructural network and enhance the strength of the solid-like systems, hereby reducing the need of high amounts of wax [6].

2. Materials and Methods

For the oleogel formation, sunflower and flaxseed oil were structured with different mixtures of the following waxes: rice bran wax, shellac wax, beeswax and sunflower wax, with or without the use of lecithin. For the cocoa spread preparation, beside the above mentioned, sugar, cocoa and hazelnut were also used. A cocoa spread was also bought from a local shop to be used as a reference.

2.1. Oleogel formulation

Oils and waxes with or without lecithin were heated on a magnetic stirrer at 380 rpm until the melting temperature of waxes was reached. Then, the mixtures were transferred to plastic recipients and were stored to refrigeration temperature (4°C) for cooling and network formation.

The following waxes were used for gelling vegetable oils with binary and ternary mixtures of organogelators: rice bran wax (RBW), sunflower wax (SFW), beeswax (BW), shellac (ShW), carnauba wax (CRW) but also the soy lecithin (L) for the ternary system development. The melting temperature and the concentrations involved in the oleogel formation were summarized in table 1.

Structurants were used in a total amount of 5% of the oil. The highest melting temperature was corresponding to the shellac – rice bran wax – lecithin mixture (84°C) and the lowest to the sunflower wax - bees wax mixture (75°C).

2.2 Cocoa spread formulation

For the novel cocoa spread 53% sugar, 25% oleogel with flaxseed oil and a mixture of beeswax and sunflower wax, 10% flaxseed oil oleogel gelled with beeswax and sunflower wax and lecithin, 7% cacao, 5% hazelnut paste were used. The ingredients were introduced in a ball mill equipment, with a capacity of 200 g per batch. On a laboratory scale, three different milling duration were explored, namely 30, 45 and 50 minutes, the last one being the optimal for obtaining a fine and glossy cocoa spread.

The proposed technological scheme for the cocoa spread production is represented in figure 1 and the process flow diagram proposed for oleogel based cocoa spreads is represented in figure 2.

2.3 Textural analysis

Texture analysis were conducted on the oleogel samples, as well as on the novel flax seed oil cocoa spread. Oleogels were analyzed at refrigeration temperature (4±0.5°C), while the cocoa spread at ambient temperature (21±0.5°C). Texture analysis was performed by using the Brookfield CT3 Texture analyzer equipped with 10 kg load cell and TA18 sphere probe (12.7mm diameter, stainless steel, 30g) was used in a texture profile analysis test (5 mm target value for deformation, 1 mm · s^{-1} test and return speed). Texture Pro CT V1.6 software was used for computing the specific texture parameters.

2.4 Sensorial analysis and marketing test

The sensory analysis evaluated the acceptability of the consumers towards the new cocoa spread containing oleogel. This was tested in comparison with a commercial available product from cocoa spreads category. Hedonic test was used on the two samples given for tasting to an untrained panel represented by 28 persons, students and teachers of the Faculty of Food Science and Technology in Cluj-Napoca.

The samples involved in the test were coded with three different random letters (LKM, TZW). The samples were served on rectangular white bread slices (2x3 cm), at ambient temperature. Instructions were given to the panel upon the tasting of the samples and upon the gentle and long chewing of the probe to maintain it long enough in the oral cavity and perceive the taste. Water was consumed between the samples testing. The appreciation or the negative could be expressed on a hedonic scale with 9 points, were 1 is „extremely unpleasant" and 9 „extremely pleasant". For the marketing test, the online survey included question with regard to demographical aspects (age, gender, income), but also to consuming habits of the cocoa spreads.

The marketing test analyzed the consumers preferences and consuming habits and 53 persons responded to the online survey, from which 38 were woman and 15 man, 1 person under 18, 48 persons with age between 18 – 40 years old and 4 persons with age over 40 years old.

3. Results and Discussions

3.1 Textural analysis of the oleogels

The textural analysis of the oleogel samples revealed that the beeswax and sunflower wax oleogels (O3) was the most suitable for incorporation in the cocoa spread, having highest values for adhesive force [g], adhesiveness [mJ], hardness and total work cycle 2 [mJ], as well as gumminess [g] and chewiness [mJ], in comparison to the other binary or ternary mixture oleogels (Table 2). Even if rice bran wax and sunflower wax oleogel had the highest hardness value, the other characteristics were lower enough not to choose this mixture for the cocoa spread formulation. The sunflower wax and beeswax mixture showed the second hardness value among studied oleogels, with good textural parameters in terms of gumminess [g] and chewiness [mJ]. The results of the oleogel textural analysis is summed up in the Table 2.

Table 1. The concentrations of lipid structurants mixture involved in the oleogels samples formulation

Sample	RBW	SFW	BW	CRW	ShW	L	Mixture melting T [°C]
O1	1.66	1.66	-	-	-	1.66	82.6
O2	2.5	2.5	-	-	-	-	83
O3	-	2.5	2.5	-	-	-	75
O4	-	1.66	1.66	-	-	1.66	75.6
O5	-	-	-	2.5	2.5	-	77
O6	2.5	-	-	-	2.5	-	80
O7	1.66	-	-	-	1.66	1.66	84

RBW – rice bran wax; SFW – sunflower wax; BW – beeswax; CRW – carnauba wax; ShW – shellac; L – lecithin.

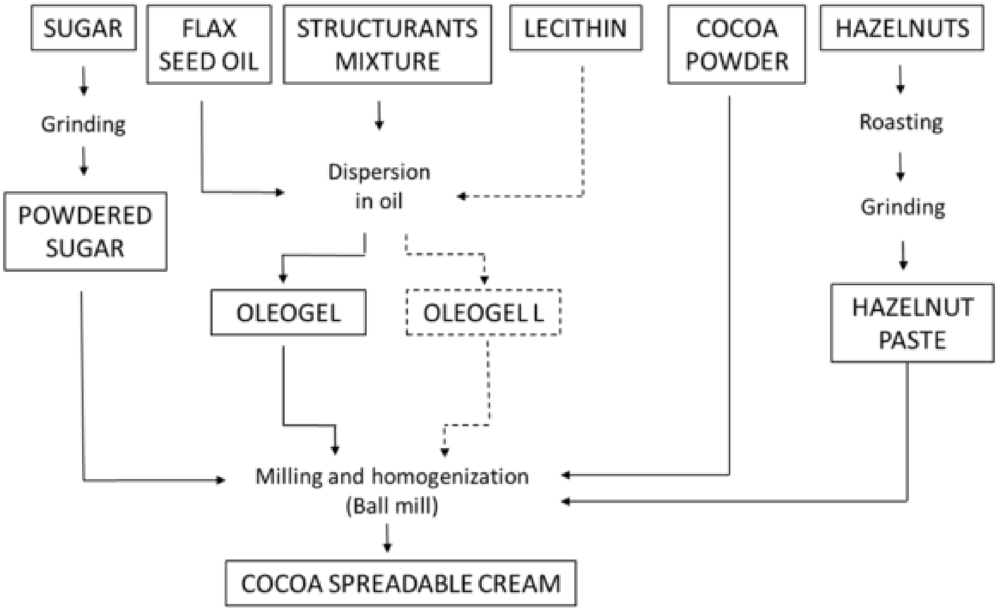

Figure 1. Technological flow chart for the flax seed oil cocoa spread production

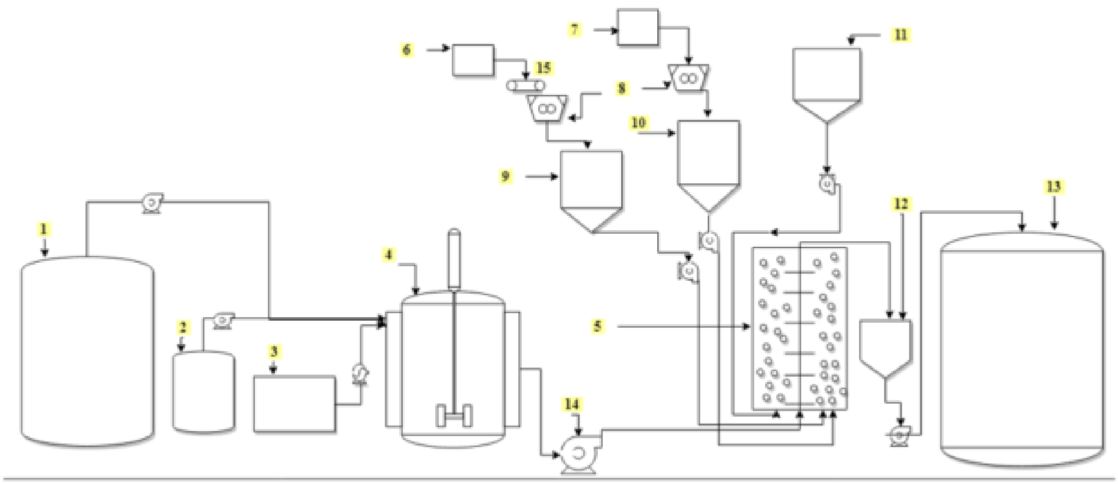

Figure 2. Process flow diagram proposed for the flax seed oil oleogel based cocoa spreads: 1 – Oil tank; 2 – Lecithin tank; 3 – Waxes tank; 4 – Oleogel preparation; 5 – Ball mill; 6 – Hazelnut storage; 7 – Sugar storage; 8 – Mill for sugar/hazelnut; 9 – Hazelnut paste tank; 10 – Powdered sugar; 12 – Cocoa; 13 – Cocoa spreadable cream; 14 – Circulating pumps; 15 – Conveyor belt

Table 2. Textural parameters measured for oleogel samples

Sample	Total Work Cycle 1 [mJ]	Hardness cycle 1 [g]	Hardness Work Cycle 1 [mJ]	Adhesive force [g]	Adhesiveness [mJ]	Hardness cycle 2 [g]	Hardness Work Cycle 2 [mJ]	Total Work Cycle 2 [mJ]	Gumminess [g]	Chewiness [mJ]
O1	1.0	31	0.9	6	0.1	19	0.1	0.1	4	0.1
O2	5.1	141	4.9	21	0.4	107	0.9	0.9	26	0.5
O3	4.3	105	4.2	26	0.6	73	1.1	1.1	27	2.0
O4	0.7	24	0.6	6	0.1	15	0.1	0.2	6	0.3
O5	1.9	60	1.9	12	0.3	40	0.4	0.5	13	0.5
O6	1.2	40	1.2	8	0.2	26	0.2	0.2	8	0.2
O7	0.1	4	0.1	5	0	3	0	0.1	4	0.1

Table 3. Textural parameters measured for spreadable cocoa cream samples

Sample	Total Work Cycle 1 [mJ]	Hardness cycle 1 [g]	Hardness Work Cycle 1 [mJ]	Adhesive force [g]	Adhesiveness [mJ]	Hardness cycle 2 [g]	Hardness Work Cycle 2 [mJ]	Total Work Cycle 2 [mJ]	Gumminess [g]	Chewiness [mJ]
S_O	0.1	5	0.1	4	0.1	5	0.1	0.1	3	0.2
S_C	0.2	14	0.2	8	0.2	7	0.1	0.1	4	0.1

S_O – spreadable cocoa cream based on flax seed oil oleogel; S_C –spreadable cocoa cream commercial available.

3.2 Textural analysis of the cocoa spreads

The hardness of the oleogel cocoa spread is lower in comparison with the commercial available reference sample, since the oleogel spread presents a very smooth texture. The chewiness registered slightly higher values in the oleogel cocoa spread. It can be observed that the oleogel cocoa spread has a twice softer texture then the reference. The results are summed up in Table 3.

3.3 Sensorial and marketing analysis

The panel gave a better score to the reference spread in terms of general aspect, color, texture, but also in terms of smell, taste and aroma, but the differences of the scores are small in comparison to the oleogel cocoa spread.

The cocoa spread consumption frequency was of 2-3 times per month for 34% of people responding to the survey, while 20,8% consumes it weekly, 7,5% daily and 37,7 % seldom. 41,5% of people responding to the survey have an average monthly income of 2000-4000 ron, 28,3% between 4000-6000 ron, 17,0% under 2000 ron, and 13,2% above 6000 ron. The question that evaluates the consumers' awareness to the nutritional insufficiencies revealed that 71,7% of the persons are informed about the saturated fatty acid consumption to the consumers health. The survey revealed that 80,0% would consume a healthier cocoa spread formulation if it would be available, while 7,5% responded that they would not opt for a healthier alternative and 9,4% of the persons responding to the survey refrained from expressing their choice. From people responding to the survey, 56% would pay between 10-15 lei for a healthier cocoa spread, 26,4% would pay between 5-10 lei, and 17,0% would pay no matter how much for a healthier cocoa spread.

4. Conclusion

A novel cocoa spread formulation with similar structural and textural properties was developed using flax seed oil organogel instead of palm oil. Flaxseed oil was used due to the Omega 3 fatty acid content its highly polyunsaturated fatty acids in composition and it was gelled with a binary mixture of gelators beeswax (2,5%) and sunflower wax (2,5%) but also with a ternary mixture of beeswax (1,66%), sunflower wax (1,66%) and soy lecithin (1,66%). The saturated fat reduction and the nutritional profile improvement was achieved for the cocoa spread. The marketing survey revealed that consumers are aware of the nutritional insufficiencies of cocoa spreads and they would be willing to pay between 10-15 Ron for a healthier formulation of the spread.

Further analysis can be conducted on the novel cocoa spread in order to observe the oil migration during storage, one of the most frequent quality defect occurring in cocoa based products. Also, for a better storage of the cocoa products in tropical climate areas, the melting temperature of the cocoa products might be manipulated.

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Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

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