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Methods for Optimizing the Composition and Properties of Milk and Dairy Products Fat Bases

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Abstract: As a result of our scientific research we developed a method for optimizing the composition and properties of milk and dairy products fat bases by mixing milk fat with non-dairy fats of various fatty acid groups. According to the mentioned, it is necessary to implement some plans in way of use of nature of clean energies with approach of sustainable development and create some powerful foundations for this purpose through an overview of Iran's traditional architecture which has paid specific attention to climate and the designations and constructions have been based on climatic approaches. Have been studied the chemical composition and physicochemical properties of edible fats. The obtained data made it possible to theoretically substantiate the possibility of using fats of animal and vegetable origin in the production of fat-containing dairy products with partial replacement of milk fat with vegetable oils, animal fats or their mixtures, taking into account the formula for the balance of fatty acid composition. This method is available and convenient for use in production conditions.

Key words: Fatty acid composition, animal fats, vegetable oils, PUFA, dairy products

INTRODUCTION

All over the world the production of functional products is developing most actively, many of them contains added substances that exert the required physiological or health-improving effect on the body. But it is necessary to take into account that the range of products suitable for enrichment is essentially limited by a number of factors-technological and organoleptic requirements, price and preferences of consumers. Therefore, the application of PUFAs of the omega-3 family and omega-6 for the enrichment of dairy products seems to be the most promising both from a technological point of view and taking into account consumer preferences (Tutelyan *et al*., 2009).

One of the key directions of the planned problem is the development and introduction of products balanced by fatty acid composition. The ratio of fatty acids is one of the indicators of the biological and nutritional value of fats.

Traditional fats of agricultural animals do not meet the requirements of biologically complete fat, balanced by fatty acid composition. In the human body, fat has two functions: nonspecific-as a source of energy and specific-as a source of essential fatty acids, fat-soluble vitamins, a material for biosynthesis and the construction of body fat. The living component of the daily diet should provide no more than 30% of the energy requirement, including approximately equal amounts of fatty acid fractions that is SFA: PUFA: MUFA-1:1:1 (Tutelyan *et al*., 2009).

Saturated Fatty Acids (SFA): laurenic C12:0, myristic C14:0, palmitic C16:0 and stearic C18:0 increase the concentration of harmful cholesterol (low density) (Kazimirko and Maltsev, 2004).

Attention to Polyunsaturated Fatty Acids (PUFA), belonging to the family of omega-6 and 3, increased after establishing their role in cholesterol metabolism and prevention of atherosclerosis (Kazimirko and Maltsev, 2004). The optimal intake level of essential fatty acids omega-6 and 3 in the human body is 4-6% of caloric intake.

The peculiarities of the metabolism of linoleic and linolenic acids, differences in their biological effect, served as the basis for the separation of two families of essential fatty acids: the family of linoleic acid C18:2 or omega-6 (linoleic, arachidonic and γ-linolenic) and families of linolenic acid or Omega 3 (α-linolenic, eicosapentaenoic, docosahexaenoic). The essential fatty acid of the Omega 6 family is linoleic acid C18:2 what is a part of the cell membranes is involved in the metabolism and synthesis of prostaglandins what is necessary for the growth and regeneration of cells (the daily requirement is about 7 g). From linoleic acid, γ-linolenic acid C18:3 omega-6 is formed in the body, it is also necessary for the synthesis of prostaglandins. From γ-linolenic acid in the

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body β-synthesized arachidonic acid C20:4 omega-6. Arachidonic acid is an important component of cell membranes and phospholipids plays a significant role in the passage of inflammatory processes and immune responses. The plants contain α-linolenic acid C18:3 omega-3, from which two acids of the omega-3 family are synthesized: eicosapentaenoic C20:5 and decosahexaenoic C22:6. Both acids are contained in the body of fish inhabited in the cold waters of the oceans and seas. According to the WHO recommendation, daily intake of acids omega-3 family should be about 2 g. The ratio of omega-6-3 PUFA should be 7-4:1 (8:3), the optimal ratio is 4:1. These acids do not exceed 10:1 in the human body, usually in a ratio of 10-30:1 (Tutelyan *et al*., 2009).

Thus, part of the useful fatty acids of the omega-3 group to prevent age-related diseases should be as much as possible. People consumed a lot of seafood with a high content of omega-3 fatty acids, differ not only in longevity but also in a lower incidence in old age.

MATERIALS AND METHODS

The separation and identification of fatty acid esters was carried out by gas chromatography using a chronos 1000 chromatograph.

Gas chromatographic analysis of concentrate omega-6 and 3 fatty acids was carried out on Chronos 1000 gas chromatograph with a flame ionization detector after being transferred to methyl esters according to the interstate standard (GOST 30418-96) by re-identification of fat with sodium methoxide in methanol. Separation of methyl esters was carried out on a 100 m long capillary column and 0.25 mm inner diameter. The separation was carried out on polar stationary phase with an increase in temperature from 60-180°C at a speed of 20°C/min the maximum column temperature being 230°C. The polar stationary phase provides the separation of methyl esters of fatty acids by the number of carbon atoms and the degree of unsaturation. As a standard calibration mixture was ethyl esters of individual fatty acids-saturated from C4: 0 (oily) to C21: 0 (geneicocene), monounsaturated from C10: 1 (caproline) to C20: 1 omega-9 (gondoin) and polyunsaturated C18: 2 omega-6 (linolenic) γ18: 3 omega-6 (α-linolenic) C18:3 omega-3 (α-linolenic), C 20:4 omega-6 (arachidonic). The calculation of the fat of all samples was carried out by the internal normalization method.

RESULTS AND DISCUSSION

We used the method of gas-liquid chromatography to determine the fatty acid composition of dairy (mare, cow, camel and goat) and food animals (beef, horse, sheep, goat and camel) fats. We recorded chromotograms of vegetable oils (sunflower and flaxseed) containing the maximum amount of PUFA omega-6 and 3 (Tultabayeva *et al*., 2014; Tahmassebpour, 2016; Chomanov *et al*., 2014a, b; Esfahani *et al*., 2013). Comparative data on fatty acid composition (group and basic individual acids, determination of the biological and nutritional value) of dairy, edible animal fats and vegetable oils (which will be used as sources of essential omega-6 and 3 acids for fat additives) are given in Table 1 and 2.

To form a balanced fatty acid composition of the finished product we conducted studies of animal fats, sunflower and olive vegetable oils and studied the possibility of enriching dairy products PUFA, in particular the family of omega-3 and 6.

Thus, the combination of milk fat with vegetable oils and fats of a particular group makes it possible to approximate the fatty acid composition of the product being created to the "hypothetically ideal fat". Adjusting the optimal ratio of milk fat: vegetable oil, it is important to take into account not only the structural and rheological characteristics of the product being produced but also the medical and biological requirements for the consumption of one or the other essential acid.

The design of binary and multicomponent compositions for the purpose of regulating their fatty acid composition is expediently carried out in two stages: the determination of the optimum ratios of the ingredients and the evaluation of the effectiveness of the lipid component of the designed composition.

At the first stage of practical development as raw components in the design of fat bases to optimize their fatty acid composition we considered binary compositions consisting of milk fat and liquid vegetable oils of various fatty acid groups.

To develop fat additives, firstly developed fat emulsions based on vegetable oils like a sunflower and linseed with a different percentage: Linol-1, Linol-2 and Linol-3 (Table 3).

The composition uses oils of various fatty acid groups-sunflower and linseed oil. The share of vegetable oil in the binary composition ranged from 20-35%. The introduction of 20-25% of vegetable oil into the composition makes it possible to obtain a fat base, characterized by a rather soft consistency and having a hardness of 25-42 g/cm, depending on the oil used. The highest value of hardness has a base in what partially hydrogenated oils were used. Reducing the share of vegetable oil to 5-10% makes it possible to obtain a product of a dense consistency with a hardness of 80-98 g/cm. The best quality characteristics have fat compositions with oils-sunflower and linen "Linol-1".

Table 1: Fatty acid composition of animal fats and vegetable oils

		Fatty acids content (%) mass						
Acid code	Classification	Beef	Mare	Sheep	Goat	Camel	Sunflower oil	Linseed oil
Saturated fatty acids								
$C_{8:0}$	H-	1.43	-	0.11	-	-	-	-
$C_{10:0}$	H-	2.32	0.30	0.62	-	-	-	-
$C_{11:0}$	-	2.02	0.21	-	-	-	-	1.04
$C_{12:0}$	-	1.82	0.14	0.18	-	-	-	2.26
$C_{13:0}$	-	-	-	0.66	-	-	-	-
$C_{14:0}$	-	2.81	3.76	7.09	3.91	4.76	0.15	-
$C_{15:0}$	-	0.40	0.27	0.66	0.98	0.67	0.02 (cπ)	-
$C_{16:0}$	-	22.72	29.67	23.80	27.11	26.27	8.01	6.08
$C_{17:0}$	-	1.04	0.45	0.93	0.53	1.33	0.02 (cπ)	0.18
$C_{18:0}$	-	30.45	6.10	10.97	36.43	25.78	3.17	4.19
$C_{20:0}$	H-	0.09	-	0.06 (cπ)	0.20	0.17	0.39	0.39
$C_{21:0}$	H-	-	1.20	-	-	-	-	-
Branched (iso-anteiso) saturated fatty acids								
$C_{14:0}$	iso-	0.57	0.13	-	-	-	-0.20	-
$C_{15:0}$	iso-	0.27	-	0.14	0.33	0.30	-	-
$C_{15:0}$	anteiso-	0.24	-	0.17	0.31	0.09	-	-
$C_{16:0}$	iso-	-	0.11	0.18	0.41	-	-	-
$C_{17:0}$	iso-	0.52	-	0.55	0.53	1.33	0.03 (tr)	-
$C_{17:0}$	anteiso-	0.16	-	0.47	0.99	0.26	0.28	0.18
$C_{18:0}$	iso-	0.31	-	0.20	-	0.27	-	0.09
Monounsaturated fatty acids (fatty acids)								
$C_{14:1}$	ω5	0.40	0.30	0.66	-	1.37	-	-
$C_{15:1}$	ω5	0.34	-	0.03 (tr)	0.11	0.54	0.24	0.23
$C_{16:1}$	ω9	0.21	-	0.73	0.69	1.08	0.10	0.07 (tr)
$C_{16:1}$	ω7	1.18	4.89	2.58	0.68	1.50	-	0.14
$C_{17:1}$	ω7	0.35	0.45	0.78	0.41	0.48	0.04 (tr)	0.09 (tr)
$C_{18:1}$	ω9	23.89	36.24	38.89	15.91	23.89	26.85	17.38
$C_{18:1}$	ω7	5.04	1.50	1.93	4.61	5.17	1.39	0.80
$C_{20:1}$	ω9	0.20	0.51	0.34	0.07 (tr)	0.15	0.14	0.04 (tr)
Polyunsaturated Fatty Acids (PUFA)								
$C_{18:2}$	ω6	4.28	6.59	5.45	3.26	2.76	58.06	15.02
$C_{18:3}$-γ	ω6	0.40	0.12	1.33	0.91	0.75	0.24	0.93
$C_{18:3}$-α	ω3	0.20	6.80	0.48	0.02 (tr)	0.94	0.68	51.10
$C_{20:4}$	ω6	-	0.20	-	-	-	-	-

Table 2: Fatty acid content in animal fats

	Fatty acids content (%) mass						
Fatty acid group	Beef	Mare	Sheep	Goat	Camel	Sunflower oil	Linseed oil
Saturated, incl	63.50	42.37	46.80	75.28	61.44	14.21	12.27
H-acids	61.43	42.13	45.0	72.71	58.19	13.94	11.76
Branched (iso-anteiso)	2.07	0.24	1.71	2.57	3.25	0.27	0.51
Unsaturated. incl.:	36.50	57.63	53.20	24.78	38.56	85.79	87.73
Monounsaturated	31.62	44.00	45.94	20.59	34.11	18.74	28.73
Monounsaturated ω9 incl.	24.21	36.79	39.96	16.67	25.05	17.49	27.09
polyunsatured, incl.	4.88	13.63	7.26	4.19	4.45	67.05	58.98
Dienic	4.28	6.60	5.45	4.17	2.76	15.02	58.06
Trienoic	0.60	6.83	1.81	0.02	1.69	52.03	0.92
Irreplaceable polyunsaturated fatty acids							
ω6, incl.:	4.68	6.91	6.78	4.17	3.51	15.95	58.30
Linoleic ω6 $C_{18:2}$	4.28	6.59	5.45	3.26	2.76	15.02	58.06
γ-linolenic ω6 $C_{18:3}$	0.20	0.12	1.33	0.91	0.75	0.93	0.24
Arachidonic ω6 $C_{20:4}$	-	0.20	-	-	-	-	-
ω3. incl.:	0.40	6.80	0.48	0.02	0.94	51.10	0.68
α-linolenic ω3 $C_{18:3}$	0.40	6.80	0.48	0.02	0.94	51.10	0.68

Table 3: Fatty acid content in vegetable oils and fatty emulsions

Fatty acids	Linol-1 (%)	Linol -2 (%)	Linol-3 (%)
SFA	12.5	12.87	12.3
USFA	87.5	87.10	87.7
MUFA	22.7	25.70	20.7
PUFA	64.8	61.40	67.0
ω6	52.1	45.60	48.6
ω3	12.7	15.80	18.4
ω9	22.1	24.20	20.0

Table 3: Continue

Fatty acids	Linol-1 (%)	Linol -2 (%)	Linol-3 (%)
C18:1 W9	22.1	27.10	19.8
C18:2 W6	52.0	45.20	48.1
C18:3 γ-ω6	-	0.40	0.45
C18:1 α-ω3	12.7	15.80	18.5
C14:0	0.45	0.83	0.90
C16:0	7.50	7.30	6.60
C18:0	4.20	3.50	4.10

Table 4: Comparative table of fatty acids content in enriched milk lipids of different animal species (% by weight)

	Mare		Camel		Goat		Cow	
Acid codes	Control	Test	Control	Test	Control	Test	Control	Test
Saturated fatty acids								
$C_{10:0}$	3.6	-	0.1	0.42	7.2	-	1.7	0.02
$C_{12:0}$	4.6	-	0.7	-	3.7	-	2.1	0.02
$C_{14:0}$	5.2	2.73	8.5	2.53	9.3	1.21	9.3	0.97
$C_{16:0}$	18.2	20.61	27.5	17.56	24.7	13.21	25.7	15.58
$C_{18:0}$	1.0	4.80	16.1	15.29	4.5	17.75	11.4	21.60
Monounsaturated								
$C_{14:1}$	0.5	0.11	0.4	0.18	0.2	0.24	0.7	0.14
$C_{16:1}$	6.1	2.24	5.4	0.91	0.6	0.65	1.0	1.43
$C_{18:1}$	17.0	24.50	18.0	20.84	14.8	19.99	21.1	20.25
Polyunsaturated								
$C_{18:2}$ ω 6	8.2	35.78	2.7	27.97	1.7	35.32	1.9	32.04
$C_{18:3}$	12.9	-	2.1	0.49	0.5	0.29	1.2	0.25

Table 5: Total fatty acid content

	Mare		Camel		Goat		Cow	
Fatty acids	Control	Test	Control	Test	Control	Test	Control	Test
SFA	40.2	28.3	61.4	41.5	72.9	33.5	67.2	38.9
UFA	59.6	71.7	38.5	58.5	27.0	66.5	32.8	61.1
MUFA	31.3	27.7	33.1	23.1	23.6	21.7	29.2	21.5
PUFA	28.4	44.0	5.5	35.3	3.4	44.8	3.6	39.6
Omega 6 (W6)	28.1	36.1	4.7	28.4	3.1	35.6	2.8	32.3
Omega 3 (W 3)	0.3	7.9	0.8	6.8	0.3	9.2	0.7	7.3
Omega 9 (W 9)	20.1	24.5	20.3	21.3	20.7	20.1	23.1	20.4
W6:W9:W3	93.6:1:67	4.6:3.1:1	5.8:1:25.3	4.1:1:3.1	10.3:1:69	3.9:2.2:1	4:1:33	4.5:1.75:1
SFA:MUFA:PUFA	1.4:1.11	1:1:1.6	11.2:6:1	1.8:1:1.5	21.4:6.9:1	1.5:1:2.1	18.7:8.1:1	1.6:1:1.4

Fat additives containing omega-6 (linoleic) and omega-3 (α-linolenic) polyunsaturated fatty acids, for the enrichment of dairy products were obtained by mixing animal fats (beef, horse, goat, camel) and fatty emulsion "Linol-1'' (sunflower and linen) taken in different ratios.

Thus, the composition of new fat supplements with a balanced composition of polyunsaturated fatty acids of the family omega-3 and 6 was developed.

The developed fat additives are introduced into skim milk in such an amount that the content of the mass fraction of fat in the milk or dairy product is a standard amount-1; 2.5; 3 or 6%.

To obtain cow's milk by fat content of 2.5% with a balanced fatty acid composition and enriched PUFA omega-6 and 3 under laboratory conditions, experimental studies were carried out.

In the low-fat cow milk with a temperature of 30-320C, an equal amount of 15.2 g of fat additive "Linol 1" was added. Milk was intensively mixed on a dispersant JKA ultra-tarrent-18-6 min to a monotonous thick foam and the disappearance of added fat. Then it was sonicated 20 kHz for 2 min (Sonoplus HD 2200 ultrasound homogenizer) and finally mixed on the dispersant for 5 min until a thick foam formed. The mass fraction of fat in the test milk was 2.5%.

Fatty acid composition of enriched milk lipids, obtained by adding fatty supplements, in comparison with the fatty acid composition of the control sample are given in Table 4.

The optimal ratio between SFA: MUFA: PUFA, according to different sources is 1:1:1, the ratio of omega 3-6 is from 1:2 to 1:4 (Tutelyan *et al*., 2009). The new enriched dairy products as can be seen from Table 5 are as close as possible to such a ratio and in the control sample it exceeds, for example in cow milk fat omega 3-6 is 1:8 (Ghasemi, 2017.).

CONCLUSION

Enriched with all kinds of milk (cow, goat, mare, camel) with new developed fat additives it is possible to achieve the optimal ratio of fatty acids, improve the balance of fatty acid composition, increase its antiatherogenic, lipotropic and antisclerotic properties in comparison with control samples Table 5. The content of SFA and MUFA in enriched milk has changed: by 8.5 and 12.3%, in goats by 7 and 14.5%, in camel-by 16 and 16.7% and in mare-by 28.5 and 9%, respectively, lower than in control samples and PUFA content in all types of milk is 1.5-2 times higher than in the control. This indicates a higher biological efficiency of enriched milk.

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